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SUSTAINABLE ENERGY FOR ALL

GLOBAL TRACKING FRAMEWORK


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EVEREADY

GLOBAL TRACKING FRAMEWORK

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FOREWORD

At the 2012 Rio+20 Conference on Sustainable Development, world leaders agreed to develop a set of Sustainable Development Goals. For many, the Sustainable Energy for All (SE4ALL) initiative launched that year—a year designated to highlight that same theme—and backed by a global coalition of public and private sector organizations, as well as civil society, is an illustration of what a Sustainable Development Goal for the energy sector would look like.

SE4ALL seeks to achieve, by 2030, universal access to electricity and safe household fuels, a doubled rate of improvement of energy efficiency, and a doubled share of renewable energy in the global energy mix. As the Millennium Development Goals process has shown, measurable goals that enjoy widespread consensus can mobilize whole societies behind them. An issue for any set of goals is how to measure progress towards their achievement. This can be tricky on methodological and political grounds. In the light of this challenge, the rigor and even-handedness evident in this first SE4ALL Global Tracking Framework is all the more welcome.

A team of energy experts from 15 agencies worked under the leadership of the World Bank and the International Energy Agency to produce this comprehensive snapshot of the status of more than 170 countries with respect to energy access, action on energy efficiency and renewable energy, and energy consumption. The report's framework for data collection and analysis will enable us to monitor progress on the SE4ALL objectives from now to 2030. It is methodologically sound and credible. It produces findings that are conclusive and actionable.

The report also shows how different countries can boost progress toward sustainable energy. Reaching universal energy access depends decisively on actions in some 20 "high-impact" countries in Africa and Asia. Attaining the global objectives for energy efficiency and renewable energy hinges on efforts in some 20 developed and emerging economies that account for 80 percent of global energy consumption. Finally, the report identifies a number of "fast-moving" countries whose exceptionally rapid progress on the triple energy agenda since 1990 provides not just inspiration, but know-how that can help us replicate their success elsewhere.

In many respects, what you measure determines what you get. That is why it is critical to get measurement right and to collect the right data, which is what this report has done. It has charted a map for our achievement of sustainable energy for all and a way to track progress. Let the journey begin!

—Kandeh Yumkella
Secretary General's Special Representative for Sustainable Energy for All

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Members of the Steering Group include the Global Alliance for Clean Cookstoves ("the Alliance"), the International Institute for Applied Systems Analysis (IIASA), the IEA, the International Partnership for Energy Efficiency Cooperation (IPEEC), the International Renewable Energy Agency (IRENA), Practical Action, the Renewable Energy Network for the 21st Century (REN21), UN Energy, the United Nations Development Programme (UNDP), the United Nations Environment Programme (UNEP), the United Nations Foundation, the United Nations Industrial Development Organization (UNIDO), the World Bank, the World Energy Council (WEC), and the World Health Organization (WHO).

The Steering Group's collaboration was made possible by agreement among the senior management of the member agencies, many of whom were represented on the Sustainable Energy for All High Level Group in 2012. Vijay Iyer (World Bank) and Fatih Birol (IEA), with Rohit Khanna (ESMAP), oversaw the development of the Global Tracking Framework. Directors of other Steering Group agencies provided important strategic input: Radha Muthiah (GACC); Nebojsa Nakicenovic (IIASA); Amit Bando (IPEEC); Adnan Amin (IRENA); Simon Trace (Practical Action); Christine Lins (REN21); Kandeh Yumkella (UN Energy); Richenda van Leeuwen (UN Foundation); Veerle Vanderweerd (UNDP); Mark Radka (UNEP); Marina Ploutikhina (UNIDO); Christoph Frei (WEC); and Maria Neira (WHO).

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The report has also benefitted from dialogue with the following government agencies:

Germany (Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung – BMZ, Deutsche Gesellschaft für Internationale Zusammenarbeit – GIZ, Kreditanstalt für Wiederaufbau – KfW);

Netherlands (Energieonderzoek Centrum Nederland – ECN); Norway (Ministry of Foreign Affairs – MFA);

United Kingdom (Department for International Development – DFID); and

United States (Department of State – DOS, Office of Energy Efficiency and Renewable Energy – EERE).

The design and publication of the final documents was coordinated by Ryan Hobert and Daniel Laender at the UN Foundation in collaboration with Nicholas Keyes of ESMAP. The creation of the online data platform was undertaken by Shaida Badiee, Neil Fantom, and Shelley Liu and Jonathan Davidar of the World Bank.

The report was edited by Steven B. Kennedy and designed by Eighty2degrees. The communications and launch process was coordinated by Christopher Neal at the World Bank and Cynthia Scharf at the United Nations.

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COORDINATORS

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

In declaring 2012 the "International Year of Sustainable Energy for All," the UN General Assembly (2011) established—at the personal initiative of the UN Secretary General—three global objectives to be accomplished by 2030. Those goals are to ensure universal access to modern energy services (including electricity and clean, modern cooking solutions), to double the global rate of improvement in energy efficiency, and to double the share of renewable energy in the global energy mix. Some 70 countries have formally embraced the Sustainable Energy for All (SE4ALL) initiative, while numerous corporations and agencies have pledged tens of billions of dollars to achieve its objectives. As 2012 drew to a close, the UN General Assembly announced a "Decade of Sustainable Energy for All" stretching from 2014 to 2024.

Sustaining momentum for the achievement of the SE4ALL objectives will require a means of charting global progress over the years leading to 2030. Construction of the necessary framework has been coordinated by the World Bank/Energy Sector Management Assistance Program (ESMAP) and the International Energy Agency (IEA), in collaboration with 13 other agencies (see logos on final page). The process has benefited from public consultation with more than a hundred stakeholder groups.

A new framework for tracking progress toward the goal of "Sustainable Energy for All"

The Global Tracking Framework described in this report provides an initial system for regular global reporting based on indicators that are both technically rigorous and feasible to compute from current global energy databases, and that offer scope for progressive improvement over time. Although the identification of suitable indicators required for the framework posed significant methodological challenges, those challenges were no more complex than those faced when attempting to measure other aspects of development—such as poverty, human health, or access to clean water and sanitation—where global progress has long been tracked. In all these aspects of development, a sustained effort of building analytical capability and data capacity has been required across most countries.

For energy access, household survey evidence is used to determine the percentage of the population with an electricity connection and the percentage of the population who primarily use non-solid fuels for cooking. Aggregate energy intensity has long been used as a proxy for energy efficiency. The framework adopts this approach but moves beyond this initial proxy, using statistical analysis to get closer to underlying energy efficiency, as well as complementing national energy intensity indicators with equivalent indicators for four key economic sectors. For renewable energy, the indicator is the share of total final energy consumption[1] derived from all renewable sources (bioenergy, aerothermal, geothermal, hydro, ocean, solar, wind).

To make it possible to track progress, SE4ALL has compiled a global data platform from the full range of available household surveys and national energy balances. Those sources encompass a large group of countries—ranging from 181 for clean energy and 212 for modern energy services—that cover an upwards of 98 percent of the world's population over the period 1990–2010. Indicators for individual countries can be found in a data annex to the Global Tracking Framework, as well as online through the World Bank's Open Data platform: http://data.worldbank.org/data-catalog.

[1] Though technically energy cannot be consumed, in this report the term energy consumption means "quantity of energy applied", following the definition in ISO 50001:2011 and the future standard ISO 13273-1 Energy efficiency and renewable energy sources - Common international terminology Part 1: Energy Efficiency.

> *Electricity powers a garment factory in Guatemala.* ***Photo:*** *Maria Fleischmann / World Bank*

Recent progress has been too slow to reach the new objectives

By the indicators identified above, the world made major advances on the energy front during the last 20 years. An additional 1.7 billion people (equivalent to the combined population of India and Sub-Saharan Africa) gained the benefits of electrification, while 1.6 billion people (equivalent to the combined population of China and the United States) secured access to generally less-polluting non-solid fuels. Energy intensity has dropped significantly, avoiding the cost of developing 2,300 exajoules of new energy supply over the past 20 years, cutting cumulative global energy demand by more than 25 percent over 1990–2010, and leaving 2010 consumption more than a third lower than it would otherwise have been. Renewable energy supplied a cumulative total of more than 1,000 exajoules globally over 1990–2010, an amount comparable to the cumulative final energy consumption of China and France over the same period.

Yet rapid demographic and economic growth over the last 20 years has to some extent diluted the impact of these advances. For example, the population with access to electricity and non-solid fuels grew respectively at 1.2 and 1.1 percent annually over 1990-2010, yet this was slightly behind global population that grew at 1.3 percent per year over the same period. This held back the growth of energy access rates to around just one percentage point of population annually. While renewable final energy consumption grew at 2 percent annually over 1990-2010, this was only slightly ahead of the 1.5 percent annual growth rate in total final energy consumption. As a result, the corresponding share of renewable energy increased only slightly from 16.6 percent in 1990 to 18.0 percent in 2010.

The Global Tracking Framework has set starting points against which progress will be measured under the SE4ALL initiative (table ES.1). The rate of access to electricity and of use of non-solid fuel as the primary fuel for cooking will have to increase from their 2010 levels of 83 and 59 percent, respectively, to 100 percent by 2030. The rate of improvement of energy intensity will have to double from –1.3 percent for 1990–2010 to –2.6 percent for 2010–30. The share of renewable energy in the global final energy consumption will have to double from an estimated starting point of at most 18 percent in 2010, implying an objective of up to 36 percent by 2030.

The world made major advances on the energy front in the last 20 years … yet rapid demographic and economic growth has to some extend diluted the impact of these advances.

	Objective 1		Objective 2	Objective 3
	Universal access to modern energy services		Doubling global rate of improvement of energy efficiency	Doubling share of renewable energy in global energy mix
Proxy indicator	Percentage of population with electricity access	Percentage of population with primary reliance on non-solid fuels	Rate of improvement in energy intensity*	Renewable energy share in TFEC
Historic reference 1990	76	47	–1.3	16.6
Starting point 2010	83	59		18.0
Objective for 2030	100	100	–2.6	36.0

TABLE ES.1 **SE4ALL OBJECTIVES IN HISTORICAL PERSPECTIVE**

SOURCE: AUTHORS.
NOTE: TFEC = TOTAL FINAL ENERGY CONSUMPTION
*MEASURED IN PRIMARY ENERGY TERMS AND GDP AT PURCHASING POWER PARITY

Groups of "high-impact" and "fast-moving" countries hold the key

While progress in all countries is important, achievement of the *global* SE4ALL objectives will depend critically on the efforts of certain *high-impact countries* that have a particularly large weight in aggregate global performance. Two overlapping groups of 20 such countries in Asia and Africa account for about two-thirds of the global electrification deficit and four-fifths of the global deficit in access to non-solid fuels (figure ES.1). Meeting the universal access objective globally will depend critically on the progress that can be made in these countries. A third group of 20 high-income and emerging economies accounts for four-fifths of global energy consumption. Thus, the achievement of the global SE4ALL objectives for renewable energy and energy efficiency will not be possible without major progress in these high-impact countries.

> *Electricity use in classroom to support use of information technology in Namibia.* ***Photo:*** *John Hogg / World Bank*

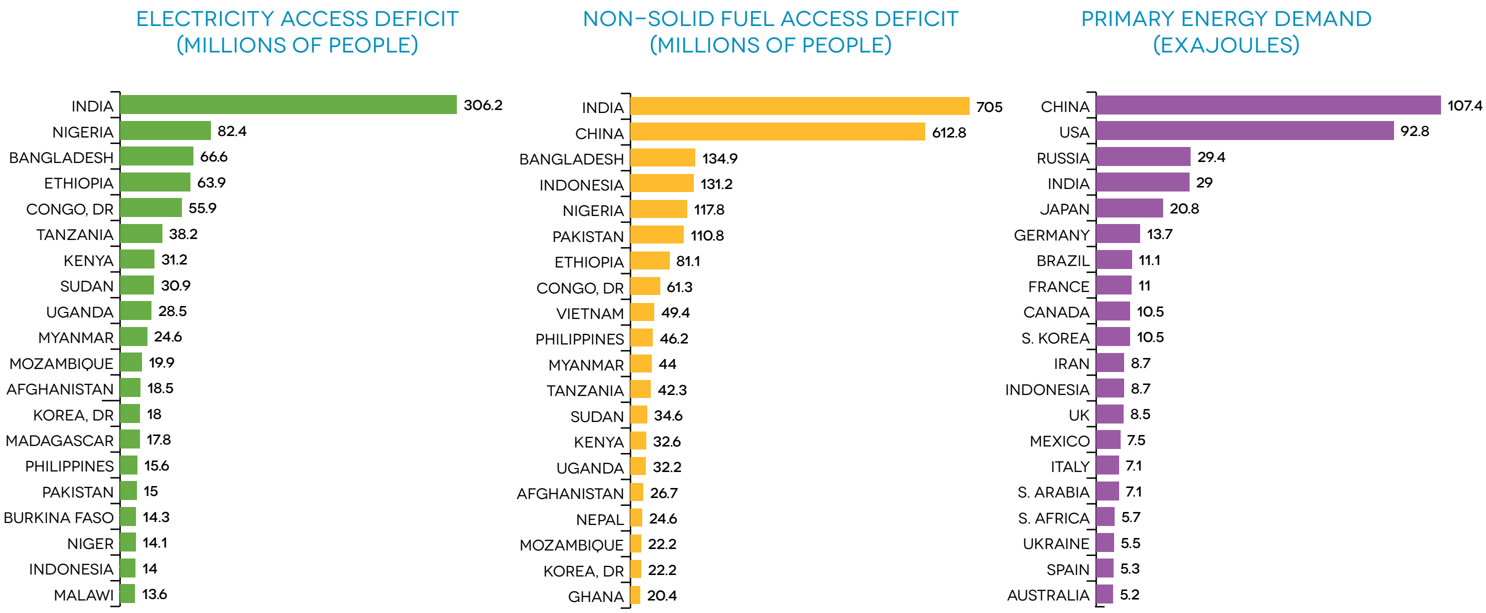

FIGURE ES.1 **OVERVIEW OF HIGH-IMPACT COUNTRIES, 2010**

SOURCE: AUTHORS.
NOTE: DR = "DEMOCRATIC REPUBLIC OF."

In charting a course toward the achievement of the SE4ALL objectives, it will also be important to learn from the experience of *fast-moving countries* that made particularly rapid progress on the three energy indicators over the period 1990–2010. In the case of electrification and cooking fuel, the most fast-moving countries have expanded access by around 3–4 percentage points of their population each year. The most rapid improvements in energy intensity, amounting to a compound annual growth rate of minus 4–8 percent, have been achieved in countries that began with high levels of energy intensity, where efficiency gains were relatively easy to make. In the case of renewable energy, the fastest-moving countries have experienced compound annual growth rates of 10–15 percent in the consumption of energy from renewable sources (excluding traditional biomass), albeit from a very low base.

On all three aspects of energy sector development, China, and to a lesser extent India, stand out as being both high-impact *and* fast-moving countries.

The achievement of the global SE4ALL objectives will depend critically on the efforts of certain high-impact countries that have a particularly large weight in aggregate global performance.

> *Electric lighting supports evening commerce in Morocco.* **Photo:** *Arne Hoel / World Bank*

Gauging the scale of the sustainable energy challenge …

What will it take to achieve SE4ALL's three energy objectives globally by 2030? Scenarios based on global energy models make it possible to gauge the scale of the global effort required to meet the three objectives. Those scenarios make it plain that business as usual will not remotely suffice. With regard to universal access, business as usual would leave 12 percent and 31 percent of the world's population in 2030 without electricity and modern cooking solutions, respectively. With regard to energy efficiency, implementing all currently available measures with reasonable payback periods would be enough to meet or even exceed the SE4ALL objective. However, barriers hold back the adoption of many of those measures, with the result that their current uptake is relatively low, ranging from about about 20 percent for power generation and building construction to about 40 percent for manufacturing and transportation. With regard to renewable energy, few scenarios point to renewable energy shares above 30 percent by 2030.

Actual global investment in the areas covered by the three SE4ALL objectives has been estimated at about $400 billion in 2010. The investments required to *achieve* the three objectives are tentatively estimated to be at least $600–800 billion per year *over and above* existing levels, entailing a doubling or tripling of financial flows over current levels. The bulk of those investments are associated with the energy efficiency and renewable energy objectives, with access-related expenditures representing a relatively small percentage of the incremental costs (10–20 percent). Achieving such a steep increase in financing for energy is unlikely to be possible without substantial investment from the private sector.

The global energy models also help to clarify the kinds of policy measures that would be needed to reach the three sustainable energy objectives. The IEA's *World Energy Outlook* (WEO) and the Global Energy Assessment (GEA) of the International Institute for Applied Systems Analysis (IIASA) coincide in highlighting the importance of phasing out fossil fuel subsidies, pricing energy to fully reflect all the associated local and global environmental costs, embracing consistent global technology standards for energy efficiency, and carefully designing targeted subsidies to increase access to electricity and clean cooking fuels.

Business as usual will not remotely suffice … achieving the three global SE4ALL objectives will require bold policy measures to stimulate a doubling or tripling of financial flows over current levels.

… and the shortest paths to the goal

The Global Tracking Framework also clarifies the likely pattern of efforts across geographical regions toward the achievement of the three objectives, based on their starting points, their potential for improvement, and their comparative advantage. For energy efficiency, the highest rates of improvement—about minus 4 percent annually—are projected for Asia (particularly China) and the countries of the former Soviet Union. For renewable energy, Latin America and Sub-Saharan Africa (the latter owing to its strong reliance on traditional biomass) emerge as the regions projected to reach the highest share of renewable energy in 2030—in excess of 50 percent, while much of the rest of the world will be in the 20–40 percent range.

Moreover, the global energy models clarify how the three SE4ALL objectives interact with each other (generally in a complementary way) and how they affect climate change and other global concerns. The achievement of the renewable energy objective, for example, will be facilitated by strong progress on energy efficiency that dampens growth in overall energy demand. Moreover, the IEA finds that neither energy efficiency nor renewable energy measures alone will be sufficient to contain global warming to within two degrees Celsius by 2030, but that the two, in tandem, could bring that objective much closer. At the same time, achieving universal access to modern energy would raise global carbon dioxide emissions by a negligible 0.6 percent over business as usual. The GEA estimates that the probability of limiting global warming to two degrees Celsius increases to between 66 and 90 percent when the SE4ALL objectives for renewable energy and energy efficiency are *simultaneously* met—higher than if either objective were met individually. The achievement of the universal access objective for modern cooking, which would increase reliance on typically fossil-based non-solid fuels for cooking, would have a small offsetting effect, reducing the share of renewable energy in the global mix by some two percentage points, with a negligible impact on the probability of achieving the two degree Celsius target.

Better statistical methods for better tracking

Looking ahead, while the methodology of the SE4ALL Global Tracking Framework provides an adequate basis for basic global tracking, the framework could be vastly improved. To effectively monitor progress through 2030, incremental investments in energy data systems will be essential, both at the global and national levels. These cost-effective, high-impact improvements could be implemented over the next five years contingent on the availability of financial resources. For energy access, the focus will be to go beyond binary measures to a multi-tier framework that better captures the quantity and quality of electricity supplied, as well as the efficiency, safety and convenience of household cookstoves, including those that make use of biomass. For energy efficiency, the main concern is to strengthen countries' capacity to produce disaggregated data on sectoral and subsectoral energy consumption that are fully integrated with measures of the output of those same sectors. In the case of renewable energy, the main priority will be to improve the ability to gauge the sustainability of various forms of renewable energy, particularly traditional biomass. All of these statistical improvements are required to support the conception and execution of policies that produce tangible results. Developing the capacity of countries to develop and respond to improved indicators is in itself a significant task.

> *Electricity powers critical health equipment to support delivery of newborn baby in Argentina.* ***Photo:*** *Nahuel Berger / World Bank*

Bold policy and an enabling environment for investment and innovation

Finally, given the scale of the challenge of meeting the three SE4ALL objectives for energy, it is clear that bold policy measures, combined with a regulatory and institutional environment that supports innovation and encourages investment, will be required to produce the requisite increases in the energy sector's capacity to widen access, boost the output derived from a given unit of energy, and raise the share of renewable energy in the overall energy mix. A detailed analysis of the policy environment at the country level lies beyond the immediate scope of this Global Tracking Framework, which has focused on the monitoring of global progress toward the stated SE4ALL objectives. However, it will be an important focus for future work in support of the critical social, economic, and environmental goals that the SE4ALL initiative addresses.

ACRONYMS AND ABBREVIATIONS

ADEME	Agence de l'Environnement et de la Maîtrise de l'Énergie, France (French Agency for Environment and Energy Management)
adt	air dry tonne
AGECC	Advisory Group on Energy and Climate Change
bcm	billion cubic meters
BLEN	biogas-LPG-electricity-natural gas
BNEF	Bloomberg New Energy Finance
BP	British Petroleum
CAGR	compound annual growth rate
CCA	Caucasian and Central Asia region
CCS	carbon capture and storage
CIF	cost, insurance and freight
CIS	Commonwealth of Independent States
CPA	Centrally Planned Asia region
CPS	Current Policies Scenario (International Energy Agency)
CSP	concentrating solar thermal power
DCF	discounted cash flow
DHS	Demographic and Health Survey
EA	East Asia region
EE	Eastern Europe region
EIA	Energy Information Administration, U.S. Department of Energy
EJ	exajoule (one million trillion joules, 1018J)
EREC	European Renewable Energy Council
EU	European Union
EUEI	European Union Energy Initiative
Eurostat	Statistical Office of the European Union
EWS	Efficient World Scenario of the International Energy Agency
FAO	Food and Agriculture Organization
FITP	feed-in tariff policy
FOB	free on board
FSU	former Soviet Union region
GBEP	Global Bioenergy Partnership
GDP	gross domestic product
GEA	Global Energy Assessment (IIASA)
GHG	greenhouse gas

GJ	gigajoule (one billion joules, 109J)
GNI	gross national income
GW	gigawatt (one billion watts, 109W)
GWEC	Global Wind Energy Council
GWh	gigawatt-hour (one billion watt-hours)
HAP	household air pollution
HIC	high-income country
IAEA	International Atomic Energy Agency
ICP	International Comparison Program
IEA	International Energy Agency
IHA	International Hydropower Association
IIASA	International Institute for Applied Systems Analysis
ILUC	indirect land use change
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
IRENA	International Renewable Energy Agency
ISIC	United Nations International Standard Industrial Classification of All Economic Activities
ISO	International Standards Organization
IWA	International Workshop Agreement
kWh	kilowatt-hour (one thousand watt-hours)
LAC	Latin America and Caribbean region
LCOE	levelized cost of energy
LIC	low-income country
LMDI	logarithmic mean divisia index
LMIC	lower middle-income country
LPG	liquefied petroleum gas
LSMS	living standards measurement survey
MDG	Millennium Development Goal
MER	market exchange rate
MICS	middle-income countries
Mtce	million tons of coal equivalent
Mtoe	million tons of oil equivalent
MW	megawatt (one million watts, 106W)
NAF	North Africa region
NAM	North America region
NCRE	nonconventional renewable energy (i.e. renewable energy excluding biomass and hydro)

NGO	nongovernmental organization
NPS	New Policies Scenario of the International Energy Agency
NSS	National Sample Survey
OECD	Organisation for Economic Co-operation and Development
PAT	perform, achieve, and trade
PJ	petajoule (one thousand trillion joules, 1015J)
PLDV	passenger light duty vehicle
PLI	price level index
PPEO	Poor People's Energy Outlook
PPP	purchasing power parity
PV	photovoltaic
R&D	research and development
RE	renewable energy
REN21	Renewable Energy Policy Network for the 21st Century
RPS	Renewables Portfolio Standard
SA	South Asia region
SARA	serviceability and readiness assessment
SAS	South Asia region
SE4ALL	Sustainable Energy for All
SEA	Southeast Asia region
SIDS	small island developing states
SSA	Sub-Saharan Africa region
T&D	transmission and distribution
TFC	total final consumption
TFEC	total final energy consumption
TJ	terajoule (one trillion joules, 1012J)
tn	Trillion
TPED	total primary energy demand
TWh	terawatt-hour (one trillion watt-hours)
UK	United Kingdom
UMIC	upper middle-income country
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific, Cultural Organization
UNIDO	United Nations Industrial Development Organization

VA	value added
WA	West Asia region
WACC	weighted average cost of capital
WDI	World Development Indicators (World Bank)
WEC	World Energy Council
WEO	World Energy Outlook (IEA) or World Economic Outlook (IMF)
WEU	Western Europe region
WHO	World Health Organization
WHS	World Health Survey
WWF	World Wide Fund For Nature

TON / TONNE = METRIC TONS (INTERNATIONAL SYSTEM).
$ = U.S. DOLLAR UNLESS OTHERWISE INDICATED.

REGIONAL CLASSIFICATIONS USED IN THIS REPORT

The table below allows interested readers to quickly check the regional classification of any country with respect to the data appearing in any part of the SE4ALL Global Tracking Framework (GTF). Following the country table are four short tables presenting the four regional classifications found in this volume.

The GTF analyzes data on countries and regions. Those data are obtained from a variety of sources. When aggregating data and reporting the results of its analyses, SE4ALL has followed, wherever possible, the regional classification devised by the United Nations for tracking progress on the Millennium Development Goals (http://mdgs.un.org/unsd/mdg/host.aspx?content=data/regionalgroupings).That rule holds for the first three sections of chapters 2–4 of this report. The fourth section of those chapters, however, relies on data and analysis from the International Energy Agency (IEA) and the International Institute for Applied Systems Analysis (IIASA), whose outputs are aggregated according to regional classifications defined and followed by the two organizations. Those classifications do not correspond with those of the United Nations, either in name or in scope. Because the IEA and IIASA outputs studied in section 4 for chapters 2–4 are available only in regionally aggregated form, the GTF could not convert them into the UN-MDG classification. For that reason, they are presented according to the original regional classifications used by the IEA and IIASA.

Sections 1–3 of chapter 2 deviate slightly from the same sections of chapters 3 and 4 in that they use the designation "developed countries" to refer to all countries whose populations are assumed to have 100 percent access to electricity and modern cooking fuels, so that these countries are not included in the aggregates for their respective geographical regions. Chapters 3 and 4, break the developed countries down by region.

Regional classifications used in chapters 2–4 of SE4ALL Global Tracking Framework, by country

COUNTRY	REGION		
	Sections 1–3	Section 4	
		International Energy Agency, World Energy Outlook 2012	International Institute for Applied Systems Analysis, Global Energy Assessment 2012
Afghanistan	Southern Asia	Developing Asia	South Asia
Albania	Chapter 2: Developed Chapters 3-4: Europe	Eastern Europe / Eurasia	Central and Eastern Europe
Algeria	Northern Africa	Africa	Middle East and North Africa
American Samoa	Chapter 2: Oceania Chapters 3-4: n.a.	n.a.	Other Pacific Asia
Andorra	Chapter 2: Developed Chapters 3-4: n.a.		Western Europe
Angola	Sub-Saharan Africa	Africa	Sub-Saharan Africa
Antigua and Barbuda	Latin America and Caribbean	South America	Latin America and the Caribbean
Argentina	Latin America and Caribbean	South America	Latin America and the Caribbean
Armenia	Caucasus and Central Asia	Eastern Europe / Eurasia	Former Soviet Union

COUNTRY	REGION		
	Sections 1–3	Section 4	
		International Energy Agency, World Energy Outlook 2012	International Institute for Applied Systems Analysis, Global Energy Assessment 2012
Aruba	Chapter 2: Latin America and Caribbean Chapters 3-4: n.a.	South America	n.a.
Australia	Chapter 2: Developed Chapters 3-4: Oceania	Asia Oceania	Pacific OECD
Austria	Chapter 2: Developed Chapters 3-4: Europe	Europe	Western Europe
Azerbaijan	Caucasus and Central Asia	Eastern Europe / Eurasia	Former Soviet Union
Bahamas	Latin America and Caribbean	South America	Latin America and the Caribbean
Bahrain	Western Asia	Middle East	Middle East and North Africa
Bangladesh	Southern Asia	Developing Asia	South Asia
Barbados	Latin America and Caribbean	South America	Latin America and the Caribbean
Belarus	Chapter 2: Developed Chapters 3-4: Eastern Europe	Eastern Europe / Eurasia	Former Soviet Union
Belgium	Chapter 2: Developed Chapters 3-4: Europe	Europe	Western Europe
Belize	Latin America and Caribbean	South America	Latin America and the Caribbean
Benin	Sub-Saharan Africa	Africa	Sub-Saharan Africa
Bermuda	Chapter 2: Developed Chapters 3-4: n.a.	South America	Latin America and the Caribbean
Bhutan	Southern Asia	Developing Asia	South Asia
Bolivia, Plurinational State of	Latin America and Caribbean	South America	Latin America and the Caribbean
Bosnia and Herzegovina	Chapter 2: Developed Chapters 3-4: Europe	Eastern Europe / Eurasia	Central and Eastern Europe
Botswana	Sub-Saharan Africa	Africa	Sub-Saharan Africa
Brazil	Latin America and Caribbean	South America	Latin America and the Caribbean
Brunei Darussalam	Southeastern Asia	Developing Asia	Other Pacific Asia
Bulgaria	Chapter 2: Developed Chapters 3-4: Eastern Europe	Eastern Europe / Eurasia	Central and Eastern Europe
Burkina Faso	Sub-Saharan Africa	Africa	Sub-Saharan Africa
Burundi	Sub-Saharan Africa	Africa	Sub-Saharan Africa
Cambodia	Southeastern Asia	Developing Asia	Centrally planned Asia and China
Cameroon	Sub-Saharan Africa	Africa	Sub-Saharan Africa

COUNTRY	REGION		
	Sections 1–3	Section 4	
		International Energy Agency, World Energy Outlook 2012	International Institute for Applied Systems Analysis, Global Energy Assessment 2012
Canada	Chapter 2: Developed Chapters 3-4: North America	North America	North America
Cape Verde	Sub-Saharan Africa	Africa	Sub-Saharan Africa
Cayman Islands	Chapter 2: Latin America and Caribbean Chapters 3-4: n.a.	South America	n.a.
Central African Republic	Sub-Saharan Africa	Africa	Sub-Saharan Africa
Chad	Sub-Saharan Africa	Africa	Sub-Saharan Africa
Channel Islands	Chapter 2: Developed Chapters 3-4: n.a.		Western Europe
Chile	Latin America and Caribbean	South America	Latin America and the Caribbean
China	Eastern Asia	Developing Asia	Centrally planned Asia and China
China, Hong Kong SAR	Eastern Asia	n.a.	Centrally planned Asia and China
China, Macau SAR	Eastern Asia	Developing Asia	
Colombia	Latin America and Caribbean	South America	Latin America and the Caribbean
Comoros	Sub-Saharan Africa	Africa	Sub-Saharan Africa
Congo	Sub-Saharan Africa	Africa	Sub-Saharan Africa
Congo, Democratic Repub-lic of	Sub-Saharan Africa	Africa	Sub-Saharan Africa
Costa Rica	Latin America and Caribbean	South America	Latin America and the Caribbean
Cote d'Ivoire	Sub-Saharan Africa	Africa	Sub-Saharan Africa
Croatia	Chapter 2: Developed Chapters 3-4: Europe	Eastern Europe / Eurasia	Central and Eastern Europe
Cuba	Chapter 2: Latin America and Caribbean Chapters 3-4: n.a.	South America	Latin America and the Caribbean
Curaçao	Chapter 2: Latin America and Caribbean Chapters 3-4: n.a.	n.a.	n.a.
Cyprus	Chapter 2: Developed Chapters 3-4: Western Asia	Eastern Europe / Eurasia	Western Europe
Czech Republic	Chapter 2: Developed Chapters 3-4: Eastern Europe	Europe	Central and Eastern Europe
Denmark	Chapter 2: Developed Chapters 3-4: Europe	Europe	Western Europe

COUNTRY	REGION		
	Sections 1–3	Section 4	
		International Energy Agency, World Energy Outlook 2012	International Institute for Applied Systems Analysis, Global Energy Assessment 2012
Djibouti	Sub-Saharan Africa	Africa	Sub-Saharan Africa
Dominica	Latin America and Caribbean	South America	Latin America and the Caribbean
Dominican Republic	Latin America and Caribbean	South America	Latin America and the Caribbean
Ecuador	Latin America and Caribbean	South America	Latin America and the Caribbean
Egypt	Northern Africa	Africa	Middle East and North Africa
El Salvador	Latin America and Caribbean	South America	Latin America and the Caribbean
Equatorial Guinea	Sub-Saharan Africa	Africa	Sub-Saharan Africa
Eritrea	Sub-Saharan Africa	Africa	Sub-Saharan Africa
Estonia	Chapter 2: Developed Chapters 3-4: Europe	Europe	Central and Eastern Europe
Ethiopia	Sub-Saharan Africa	Africa	Sub-Saharan Africa
Faeroe Islands	Chapter 2: Developed Chapters 3-4: n.a.	n.a.	Western Europe
Fiji	Oceania	Developing Asia	Other Pacific Asia
Finland	Chapter 2: Developed Chapters 3-4: Europe	Europe	Western Europe
France	Chapter 2: Developed Chapters 3-4: Europe	Europe	Western Europe
French Polynesia	Chapter 2: Oceania Chapters 3-4: n.a.	Developing Asia	Other Pacific Asia
Gabon	Sub-Saharan Africa	Africa	Sub-Saharan Africa
Gambia	Sub-Saharan Africa	Africa	Sub-Saharan Africa
Georgia	Caucasus and Central Asia	Eastern Europe / Eurasia	Former Soviet Union
Germany	Chapter 2: Developed Chapters 3-4: Europe	Europe	Western Europe
Ghana	Sub-Saharan Africa	Africa	Sub-Saharan Africa
Greece	Chapter 2: Developed Chapters 3-4: Europe	Europe	Western Europe
Greenland	Chapter 2: Developed Chapters 3-4: n.a.	n.a.	Western Europe
Grenada	Latin America and Caribbean	South America	Latin America and the Caribbean
Guam	Chapter 2: Oceania Chapters 3-4: n.a.	n.a.	n.a.
Guatemala	Latin America and Caribbean	South America	Latin America and the Caribbean

COUNTRY	REGION		
	Sections 1–3	Section 4	
		International Energy Agency, World Energy Outlook 2012	International Institute for Applied Systems Analysis, Global Energy Assessment 2012
Guinea	Sub-Saharan Africa	Africa	Sub-Saharan Africa
Guinea-Bissau	Sub-Saharan Africa	Africa	Sub-Saharan Africa
Guyana	Latin America and Caribbean	South America	Latin America and the Caribbean
Haiti	Latin America and Caribbean	South America	Latin America and the Caribbean
Honduras	Latin America and Caribbean	South America	Latin America and the Caribbean
Hungary	Chapter 2: Developed Chapters 3-4: Eastern Europe	Europe	Central and Eastern Europe
Iceland	Chapter 2: Developed Chapters 3-4: Europe	Europe	Western Europe
India	Southern Asia	Developing Asia	South Asia
Indonesia	Southeastern Asia	Developing Asia	Other Pacific Asia
Iran, Islamic Republic of	Southern Asia	Middle East	Middle East and North Africa
Iraq	Western Asia	Middle East	Middle East and North Africa
Ireland	Chapter 2: Developed Chapters 3-4: Europe	Europe	Western Europe
Isle of Man	Chapter 2: Developed Chapters 3-4: n.a.	n.a.	Western Europe
Israel	Chapter 2: Developed Chapters 3-4: Western Asia	Europe	Middle East and North Africa
Italy	Chapter 2: Developed Chapters 3-4: Europe	Europe	Western Europe
Jamaica	Latin America and Caribbean	South America	Latin America and the Caribbean
Japan	Chapter 2: Developed Chapters 3-4: Eastern Asia	Asia Oceania	Pacific OECD
Jordan	Western Asia	Middle East	Middle East and North Africa
Kazakhstan	Caucasus and Central Asia	Eastern Europe / Eurasia	Former Soviet Union
Kenya	Sub-Saharan Africa	Africa	Sub-Saharan Africa
Kiribati	Oceania	Developing Asia	
Korea, Dem. Rep.	Chapter 2: Developed Chapters 3-4: n.a.	Developing Asia	Centrally planned Asia and China
Korea, Rep. of	Eastern Asia	Asia Oceania	Other Pacific Asia
Kosovo	Chapter 2: Developed Chapters 3-4: n.a.	n.a.	n.a.

COUNTRY	REGION		
	Sections 1–3	Section 4	
		International Energy Agency, World Energy Outlook 2012	International Institute for Applied Systems Analysis, Global Energy Assessment 2012
Kuwait	Western Asia	Middle East	Middle East and North Africa
Kyrgyzstan	Caucasus and Central Asia	Eastern Europe / Eurasia	Former Soviet Union
Laos	Southeastern Asia	Developing Asia	Centrally planned Asia and China
Latvia	Chapter 2: Developed Chapters 3-4: Europe	Eastern Europe / Eurasia	Eastern Europe / Eurasia
Lebanon	Western Asia	Middle East	Middle East and North Africa
Lesotho	Sub-Saharan Africa	Africa	Sub-Saharan Africa
Liberia	Sub-Saharan Africa	Africa	Sub-Saharan Africa
Libya	Northern Africa	Africa	Middle East and North Africa
Liechtenstein	Chapter 2: Developed Chapters 3-4: n.a.	n.a.	Western Europe
Lithuania	Chapter 2: Developed Chapters 3-4: Europe	Eastern Europe / Eurasia	Central and Eastern Europe
Luxembourg	Chapter 2: Developed Chapters 3-4: Europe	Europe	Western Europe
Macedonia, Former Yugo-slav Republic of	Chapter 2: Developed Chap-ters 3-4: Europe	Eastern Europe / Eurasia	Central and Eastern Europe
Madagascar	Sub-Saharan Africa	Africa	Sub-Saharan Africa
Malawi	Sub-Saharan Africa	Africa	Sub-Saharan Africa
Malaysia	Southeastern Asia	Developing Asia	Other Pacific Asia
Maldives	Southern Asia	Developing Asia	South Asia
Mali	Sub-Saharan Africa	Africa	Sub-Saharan Africa
Malta	Chapter 2: Developed Chapters 3-4: Europe	Eastern Europe / Eurasia	Western Europe
Marshall Islands	Chapter 2: Developed Chapters 3-4: n.a.	n.a.	n.a.
Mauritania	Sub-Saharan Africa	Africa	Sub-Saharan Africa
Mauritius	Sub-Saharan Africa	Africa	Sub-Saharan Africa
Mexico	Latin America and Caribbean	North America	Latin America and the Caribbean
Micronesia, Fed. States of	Chapter 2: Oceania Chapters 3-4: n.a.	n.a.	n.a.
Moldova, Republic of	Chapter 2: Developed Chapters 3-4: Eastern Europe	Eastern Europe / Eurasia	Former Soviet Union
Monaco	n.a.	n.a.	Western Europe
Mongolia	Eastern Asia	Developing Asia	Centrally planned Asia and China

COUNTRY	REGION		
	Sections 1–3	Section 4	
		International Energy Agency, World Energy Outlook 2012	International Institute for Applied Systems Analysis, Global Energy Assessment 2012
Montenegro	Chapter 2: Developed Chapters 3-4: Europe	n.a.	n.a.
Morocco	Northern Africa	Africa	Middle East and North Africa
Mozambique	Sub-Saharan Africa	Africa	Sub-Saharan Africa
Myanmar	Chapter 2: Southeastern Asia Chapters 3-4: n.a.	Developing Asia	Other Pacific Asia
Namibia	Sub-Saharan Africa	Africa	Sub-Saharan Africa
Nepal	Southern Asia	Developing Asia	South Asia
Netherlands	Chapter 2: Developed Chapters 3-4: Europe	Europe	Western Europe
New Caledonia	Chapter 2: Oceania Chapters 3-4: n.a.	Developing Asia	Other Pacific Asia
New Zealand	Chapter 2: Developed Chapters 3-4: Oceania	Asia Oceania	Pacific OECD
Nicaragua	Latin America and Caribbean	South America	Latin America and the Caribbean
Niger	Sub-Saharan Africa	Africa	Sub-Saharan Africa
Nigeria	Sub-Saharan Africa	Africa	Sub-Saharan Africa
Norway	Chapter 2: Developed Chapters 3-4: Europe	Europe	Western Europe
Oman	Western Asia	Middle East	Middle East and North Africa
Pakistan	Southern Asia	Developing Asia	South Asia
Palau	Oceania	n.a.	n.a.
Panama	Latin America and Caribbean	South America	Latin America and the Caribbean
Papua New Guinea	Oceania	Developing Asia	Other Pacific Asia
Paraguay	Latin America and Caribbean	South America	Latin America and the Caribbean
Peru	Latin America and Caribbean	South America	Latin America and the Caribbean
Philippines	Southeastern Asia	Developing Asia	Other Pacific Asia
Poland	Chapter 2: Developed Chapters 3-4: Eastern Europe	Europe	Central and Eastern Europe
Portugal	Chapter 2: Developed Chapters 3-4: Europe	Europe	Western Europe
Puerto Rico	Chapter 2: Latin America and Caribbean Chapters 3-4: n.a.	n.a.	North America

COUNTRY	REGION		
	Sections 1–3	Section 4	
		International Energy Agency, World Energy Outlook 2012	International Institute for Applied Systems Analysis, Global Energy Assessment 2012
Qatar	Western Asia	Middle East	Middle East and North Africa
Romania	Chapter 2: Developed Chapters 3-4: Eastern Europe	Eastern Europe / Eurasia	Central and Eastern Europe
Russian Federation	Chapter 2: Developed Chapters 3-4: Eastern Europe	Eastern Europe / Eurasia	Former Soviet Union
Rwanda	Sub-Saharan Africa	Africa	Sub-Saharan Africa
Saint Lucia	Latin America and Caribbean	South America	Latin America and the Caribbean
Samoa	Oceania	Developing Asia	
San Marino	Chapter 2: Developed Chapters 3-4: n.a.	n.a.	n.a.
Sao Tome and Principe	Sub-Saharan Africa	Africa	Sub-Saharan Africa
Saudi Arabia	Western Asia	Middle East	Middle East and North Africa
Senegal	Sub-Saharan Africa	Africa	Sub-Saharan Africa
Serbia	Chapter 2: Developed Chapters 3-4: Europe	Eastern Europe / Eurasia	
Seychelles	Sub-Saharan Africa	Africa	Sub-Saharan Africa
Sierra Leone	Sub-Saharan Africa	Africa	Sub-Saharan Africa
Singapore	Southeastern Asia	Developing Asia	Other Pacific Asia
Slovak Republic	Chapter 2: Developed Chapters 3-4: Eastern Europe	Europe	Central and Eastern Europe
Slovenia	Chapter 2: Developed Chapters 3-4: Europe	Europe	Central and Eastern Europe
Solomon Islands	Oceania	Developing Asia	Other Pacific Asia
Somalia	Chapter 2: Sub-Saharan Africa Chapters 3-4: n.a.	Africa	Sub-Saharan Africa
South Africa	Sub-Saharan Africa	Africa	Sub-Saharan Africa
South Sudan	Chapter 2: Sub-Saharan Africa Chapters 3-4: n.a.	n.a.	n.a.
Spain	Chapter 2: Developed Chapters 3-4: Europe	Europe	Western Europe
Sri Lanka	Southern Asia	Developing Asia	South Asia
St. Kitts and Nevis	Latin America and Caribbean	South America	Latin America and the Caribbean

COUNTRY	REGION		
		Section 4	
	Sections 1–3	International Energy Agency, World Energy Outlook 2012	International Institute for Applied Systems Analysis, Global Energy Assessment 2012
St. Martin (French part)	Chapter 2: Latin America and Caribbean Chapters 3-4: n.a.	n.a.	n.a.
St. Vincent and the Gren-adines	Latin America and Caribbean	South America	Latin America and the Caribbean
Sudan	Sub-Saharan Africa	Africa	Middle East and North Africa
Suriname	Latin America and Caribbean	South America	Latin America and the Caribbean
Swaziland	Sub-Saharan Africa	Africa	Sub-Saharan Africa
Sweden	Chapter 2: Developed Chapters 3-4: Europe	Europe	Western Europe
Switzerland	Chapter 2: Developed Chapters 3-4: Europe	Europe	Western Europe
Syrian Arab Republic	Western Asia	Middle East	Middle East and North Africa
Tajikistan	Caucasus and Central Asia	Eastern Europe / Eurasia	Former Soviet Union
Tanzania, United Republic of	Sub-Saharan Africa	Africa	Sub-Saharan Africa
Thailand	Southeastern Asia	Developing Asia	Other Pacific Asia
Timor-Leste	Southeastern Asia	Developing Asia	n.a.
Togo	Sub-Saharan Africa	Africa	Sub-Saharan Africa
Tonga	Oceania	Developing Asia	Other Pacific Asia
Trinidad and Tobago	Latin America and Caribbean	South America	Latin America and the Caribbean
Tunisia	Northern Africa	Africa	Middle East and North Africa
Turkey	Western Asia	Europe	Western Europe
Turkmenistan	Caucasus and Central Asia	Eastern Europe / Eurasia	Former Soviet Union
Turks and Caicos Islands	Chapter 2: Latin America and Caribbean Chapters 3-4: n.a.	South America	n.a.
Tuvalu	Chapter 2: Oceania Chapters 3-4: n.a.	n.a.	n.a.
Uganda	Sub-Saharan Africa	Africa	Sub-Saharan Africa
Ukraine	Chapter 2: Developed Chapters 3-4: Eastern Europe	Eastern Europe / Eurasia	Former Soviet Union
United Arab Emirates	Western Asia	Middle East	Middle East and North Africa
United Kingdom of Great Britain and Northern Ireland	Chapter 2: Developed Chapters 3-4: Europe	Europe	Western Europe

COUNTRY	REGION		
	Sections 1–3	Section 4	
		International Energy Agency, World Energy Outlook 2012	International Institute for Applied Systems Analysis, Global Energy Assessment 2012
United States of America	Chapter 2: Developed Chapters 3-4: North America	North America	North America
Uruguay	Latin America and Caribbean	South America	Latin America and the Caribbean
Uzbekistan	Caucasus and Central Asia	Eastern Europe / Eurasia	Former Soviet Union
Vanuatu	Oceania	Developing Asia	Other Pacific Asia
Venezuela	Latin America and Caribbean	South America	Latin America and the Caribbean
Vietnam	Southeastern Asia	Developing Asia	Centrally planned Asia and China
Virgin Islands (U.S.)	Chapter 2: Latin America and Caribbean Chapters 3-4: n.a.	n.a.	North America
West Bank and Gaza	Chapter 2: Western Asia Chapters 3-4: n.a.	n.a.	n.a.
Yemen	Western Asia	Middle East	Middle East and North Africa
Zambia	Sub-Saharan Africa	Africa	Sub-Saharan Africa
Zimbabwe	Chapter 2: Sub-Saharan Africa Chapters 3-4: n.a.	Africa	Sub-Saharan Africa

UN-MDG regions and regional abbreviations appearing in sections 1–3 of chapter 2

REGION	ABBREVIATION	REGION	ABBREVIATION
Caucasus and Central Asia	CCA	Oceania	n.a.
Developed countries	DEV	Southern Asia	SA
Eastern Asia	EA	Southeastern Asia	SEA
Latin America and Caribbean	LAC	Sub-Saharan Africa	SSA
Northern Africa	NA	Western Asia	SAS

UN-MDG regions and regional abbreviations appearing in sections 1–3 of chapters 3 and 4

REGION	ABBREVIATION	REGION	ABBREVIATION
Caucasus and Central Asia	CCA	Northern Africa	NAf
Eastern Asia	EA	North America	NAm
Eastern Europe	EE	Oceania	n.a.
Europe	EU	Southeastern Asia	SEA
Latin America and Caribbean	LAC	Southern Asia	SA
Middle East and North Africa	MEA	Sub-Saharan Africa	SSA
		Western Asia	WA

IEA regions appearing in section 4 of chapters 2–4:

REGION	REGION
Africa	Europe
Asia Oceania	Middle East
Developing Asia	North America
Eastern Europe/Eurasia	South America

IIASA regions and regional abbreviations appearing in section 4 of chapters 2–4

REGION	ABBREVIATION	REGION	ABBREVIATION
Central and Eastern Europe	EEU	North America	NAM
Centrally planned Asia and China	CPA	Pacific OECD	PAO
Former Soviet Union	FSU	Other Pacific Asia	PAS
Latin America and Caribbean	LAM	South Asia	SAS
Middle East and North Africa	MEA	Sub-Saharan Africa	AFR
		Western Europe	WEU

OVERVIEW

OVERVIEW

In declaring 2012 the "International Year of Sustainable Energy for All," the UN General Assembly established three global objectives to be accomplished by 2030: to ensure universal access to modern energy services,[1] to double the global rate of improvement in global energy efficiency, and to double the share of renewable energy in the global energy mix. Some 70 countries have formally embraced the Secretary General's initiative, while numerous corporations and agencies have pledged tens of billions of dollars to achieve its objectives. As 2012 drew to a close, the UN General Assembly announced a "Decade of Sustainable Energy for All" stretching from 2014 to 2024. The Secretary General provided a compelling rationale for SE4ALL in his announcement of the new program. For further information about the SE4ALL initiative, please go to www.sustainableenergyforall.org. The SE4ALL Global Tracking Framework full report, overview paper, executive summary and datasets can be downloaded from: www.worldbank.org/se4all.

The SE4ALL objectives are global objectives, applying to both developed and developing countries, with individual nations setting their own domestic targets in a way that is consistent with the overall spirit of the initiative. Because countries differ greatly in their ability to pursue each of the three objectives, some will make more rapid progress in one area while others will excel elsewhere, depending on their respective starting points and comparative advantages as well as on the resources and support that they are able to marshal.

The three SE4ALL objectives, though distinct, form an integrated whole. Because they are related and complementary, it is more feasible to achieve all three jointly than it would be to pursue any one of them individually. In particular, achievement of the energy efficiency objective would make the renewable energy objective more feasible by slowing the growth in global demand for energy. Tensions between the goals also exist, though they are less pronounced than the complementarities. One possible tension between the objectives is that the achievement of universal access to modern cooking solutions will tend to shift people from reliance on traditional biomass, a renewable source of energy, to greater reliance on non-solid fuels that are typically (though not always) based on fossil fuels.

To sustain momentum for the achievement of the SE4ALL objectives, a means of charting global progress over the years leading to 2030 is needed. The Global Tracking Framework described in this report provides a system for regular global reporting, based on rigorous—yet practical—technical measures. Although the technical definitions required for the framework pose significant methodological challenges, those challenges are no more complex than those faced when attempting to measure other aspects of development—such as poverty, human health, or access to clean water and sanitation—for which global progress has long been tracked.

For the time being, the SE4ALL tracking framework must draw upon readily available global databases, which vary in their usefulness for tracking the three central variables of interest. Over the medium term, the framework includes a concerted effort to improve these databases as part of the SE4ALL initiative (table O.1). This report lays out an agenda for the incremental improvement of available global energy databases in those areas likely to yield the highest value for tracking purposes.

While global tracking is very important, it can only help to portray the big picture. Appropriate country tracking is an essential complement to global tracking and will allow for a much richer portrait of energy sector developments. Global tracking and country tracking need to be undertaken in a consistent manner, and the Global Tracking Framework provides guidance that will be of interest to all countries participating in the SE4ALL initiative.

[1] The SE4ALL universal access goal will be achieved only if every person on the planet has access to modern energy services provided through electricity, clean cooking fuels, clean heating fuels, and energy for productive use and community services.

	IMMEDIATE	MEDIUM TERM
Global tracking	Proxy indicators already available for global tracking, with all data needs (past, present, and future) already fully met	Indicators that are essential for global tracking and that would require a feasible incremental investment in global energy data systems over the next five years
Country-level tracking	Not applicable	Indicators highly suitable for country-level tracking and desirable for global tracking

TABLE O.1 **A PHASED AND DIFFERENTIATED APPROACH TO SELECTING INDICATORS FOR TRACKING**

The SE4ALL Global Tracking team was able to construct global energy databases that cover a large group of countries —ranging from 181 for clean energy and 212 for modern energy services—that cover an upwards of 98 percent of the world's population (table O.2). The data on energy access (electrification and cooking fuels) draw primarily on household surveys, while those pertaining to renewable energy and energy efficiency are primarily from national energy balances. Indicators for individual countries can be found in the data annex to this report, as well as on-line through the World Bank's Open Data Platform: http://data.worldbank.org/data-catalog.

CATEGORY	DATA SOURCES	COUNTRY COVERAGE (% OF GLOBAL POPULATION)
Electrification	Global networks of household surveys plus some censuses	212 (100)
Cooking fuels	Global networks of household surveys plus some censuses	193 (99)
Energy intensity	IEA and UN for energy balances WDI for GDP and sectoral value added	181 (98)
Renewable energy	IEA and UN for energy balances REN 21, IRENA, and BNEF for complementary indicators	181 (98)

TABLE O.2 **OVERVIEW OF DATA SOURCES AND COUNTRY COVERAGE UNDER GLOBAL TRACKING**

NOTE: IEA = INTERNATIONAL ENERGY AGENCY; UN = UNITED NATIONS; REN 21 = RENEWABLE ENERGY NETWORK FOR THE 21ST CENTURY; IRENA = INTERNATIONAL RENEWABLE ENERGY AGENCY; BNEF = BLOOMBERG NEW ENERGY FINANCE; WDI = WORLD DEVELOPMENT INDICATORS (WORLD BANK); GDP= GROSS DOMESTIC PRODUCT.

The SE4ALL global tracking framework sets 2010 as the starting point against which the progress of the initiative will be measured. The framework provides an initial system for regular global reporting, based on indicators that are technically rigorous and at the same time feasible to compute from current global energy databases, and that offer scope for progressive improvement over time. For energy access, household survey evidence is used to determine the percentage of the population with an electricity connection and the percentage with access to non-solid fuels.[2] Solid fuels are defined to include both traditional biomass (wood, charcoal, agricultural and forest residues, dung, and so on), processed biomass (such as pellets and briquettes), and other solid fuels (such as coal and lignite). As a proxy for energy efficiency, the framework takes the compound annual growth rate of energy intensity of gross domestic product (GDP) measured in purchasing power parity (PPP) terms, complemented by supporting analysis of underlying factors as well as sectoral disaggregation. For renewable energy, the indicator is the share of total final

[2] *Non-solid fuels* include (i) liquid fuels (for example, kerosene, ethanol, and other biofuels), (ii) gaseous fuels (for example, natural gas, liquefied petroleum gas [LPG], biogas), and (iii) electricity.

energy consumption[3] deriving from all renewable sources (bioenergy, aerothermal, geothermal, hydro, ocean, solar, wind). Further methodological details and directions for future improvement are provided below and described extensively in the main report.

In addition to measuring progress at the global level, the report sheds light on the starting point for regional and income groupings. It also identifies two important categories of countries: high-impact countries, whose efforts will be particularly critical to the achievement of the objectives globally; and fast-moving countries, which are already making rapid progress toward the SE4ALL goals and may have valuable policy and implementation lessons to share.

Scenarios based on the various existing global energy models—such as the World Energy Model of the International Energy Agency (IEA) and the Global Energy Assessment (GEA) of the International Institute for Applied Systems Analysis (IIASA)—clarify the scale of the challenge involved in meeting the SE4ALL objectives. In particular, they illustrate the combinations of technological change, policy frameworks, and financing flows that will be needed to reach the objectives. They also shed light on the relationship between the three objectives, as well as the differential contributions to global targets across world regions based on respective comparative advantage.

Development of the Global Tracking Framework has been made possible through a unique partnership of international agencies active in the energy knowledge space. The steering group for the framework is co-chaired by the World Bank and its Energy Sector Management Assistance Program (ESMAP, a multidonor technical assistance trust fund administered by the World Bank) and the IEA. Members of the group are the Global Alliance for Clean Cookstoves (the Alliance), IIASA, the International Partnership for Energy Efficiency Cooperation (IPEEC), the International Renewable Energy Agency (IRENA), Practical Action, the Renewable Energy Network for the 21st Century (REN21), the United Nations Development Programme, UN–Energy, the United Nations Environment Programme, the United Nations Foundation, the United Nations Industrial Development Organization (UNIDO), the World Energy Council (WEC), and the World Health Organization (WHO). Experts from all of these agencies have collaborated intensively in the development of this report.

The report also benefited from two rounds of public consultation. The first round, which took place in October 2012, focused on the proposed methodology for global tracking. It was launched by a special session of the World Energy Council's Executive Assembly in Monaco. The second round, in February 2013, focused on data analysis. It was preceded by a consultation workshop held in conjunction with the World Future Energy Summit in Abu Dhabi in January 2013. The consultation documents reached more than a hundred organizations drawn from a broad cross-section of stakeholders and covering a wide geographic area. This report benefited greatly from the contributions of those organizations.

Achieving universal access to modern energy services

By some measures, progress on access to modern energy services was impressive over the 20 years between 1990 and 2010. The number of people with access to electricity increased by 1.7 billion, while the number of those with access to non-solid fuels for household cooking increased by 1.6 billion. Yet this expansion was offset by global population growth of 1.6 billion over the same period. As a result, the global electrification rate increased only modestly, from 76 to 83 percent, while the rate of access to non-solid fuels rose from 47 to 59 percent (figure O.1). In both cases, this represents an increase in access of about one percentage point of global population annually.

[3] Though technically energy cannot be consumed, in this report the term energy consumption means "quantity of energy applied", following the definition in ISO 50001:2011 and the future standard ISO 13273-1 Energy efficiency and renewable energy sources - Common international terminology Part 1: Energy Efficiency.

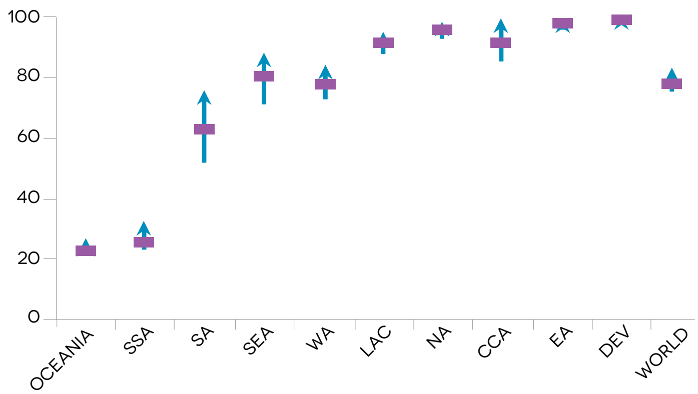

FIGURE O.1A **GLOBAL AND REGIONAL TRENDS IN ELECTRIFICATION 1990–2010, PERCENT**

FIGURE O.1B **GLOBAL AND REGIONAL TRENDS IN ACCESS TO NON-SOLID FUEL 1990–2010, PERCENT**

1990 2000 2010

SOURCE: WORLD BANK GLOBAL ELECTRIFICATION DATABASE, 2012. INDICATORS (WORLD BANK); WHO GLOBAL HOUSEHOLD ENERGY DATABASE, 2012.

NOTE: ACCESS NUMBERS IN MILLIONS OF PEOPLE. CCA = CAUCASUS AND CENTRAL ASIA; DEV = DEVELOPED COUNTRIES; EA = EASTERN ASIA; LAC = LATIN AMERICA AND CARIBBEAN; NA = NORTHERN AFRICA; SEA = SOUTH-EASTERN ASIA; SA = SOUTHERN ASIA; SSA = SUB-SAHARAN AFRICA; WA = WESTERN ASIA.

Starting point

The starting point for global electrification against which future progress will be measured is 83 percent in 2010. The SE4ALL global objective is 100 percent by 2030.

Electrification rates likely overestimate access to electricity. The reason is that some of those with access to an electricity connection receive a service of inadequate quantity, quality, or reliability of supply, which prevents them from reaping the full benefits of the service. A proxy for supply problems (albeit an imperfect one) is the average residential electricity consumption derived from the IEA World Energy Statistics and Balances (2012a). Globally, the average household electricity consumption was around 3,010 kilowatt-hours (kWh) per year in 2010. However, average household electricity consumption varies considerably ranging from over 6,000 kWh in developed countries to around 1,000 kWh in underserved regions of South Asia and Sub-Saharan Africa.

The starting point for access to non-solid fuels for household cooking against which future progress will be measured is 59 percent in 2010. The SE4ALL global objective is 100 percent by 2030.

Modern cooking solutions[4] are important because they curtail harmful indoor air pollution that leads to the loss of lives of 3.5 million people each year, mainly women and children; they also improve energy efficiency. Similar to electrification, rates of access to non-solid fuel do not fully capture access to modern cooking solutions. The reason for this is that an unknown and likely growing percentage of those without access to non-solid fuels may nonetheless be using acceptable cooking solutions based on processed biomass (such as fuel pellets) or other solid fuels paired with stoves exhibiting overall emissions rates at or near those of liquefied petroleum gas (LPG). At present, it is not possible to adequately measure the number of households in this situation. It is believed to be relatively small but is expected to grow over time as governments and donors place growing emphasis on more advanced biomass cookstoves as a relatively low-cost and accessible method of improving the safety and efficiency of cooking practices. These and other methodological challenges associated with the measurement of energy access are more fully described in box O.1.

[4] The term "modern cooking solutions" will be used throughout this document and includes solutions that involve electricity or gaseous fuels (including liquefied petroleum gas), or solid/liquid fuels paired with stoves exhibiting overall emissions rates at or near those of liquefied petroleum gas.

BOX O.1 Methodological challenges in defining and measuring energy access

There is no universally agreed-upon definition of energy access, and it can be a challenge to determine how best to capture issues such as the quantity, quality, and adequacy of service, as well as complementary issues such as informality and affordability. Because currently available global databases only support binary global tracking of energy access (that is, a household either has or does not have access, with no middle ground), this is the approach that will be used to determine the starting point for the SE4ALL Global Tracking Framework. Based on an exhaustive analysis of existing global household survey questionnaires, the following binary measures will be used:

- Electricity access is defined as availability of an electricity connection at home or the use of electricity as the primary source for lighting.
- Access to modern cooking solutions is defined as relying primarily on non-solid fuels for cooking.

An important limitation of these binary measures is that they do not capture improvements in cookstoves that burn solid fuels, nor are they able to register progress in electrification through off-grid lighting products. In the case of electricity, the binary measure fails to take into account whether the connection provides an adequate and reliable service, which it may often fail to do.

A variety of data sources—primarily household surveys (including national censuses) and in a few cases, utility data—contribute to the measurement of access. Two global databases—one on electricity and another on non-solid fuel—have been compiled: the World Bank's Global Electrification Database and WHO's Global Household Energy Database. IEA data on energy access were also reviewed in the preparation of these databases. Both databases encompass three datapoints for each country—around 1990, around 2000, around 2010. Given that surveys were carried out infrequently, statistical models have been developed to estimate missing datapoints.

While the binary approach serves the immediate needs of global tracking, there is a growing consensus that measurements of energy access should be able to reflect a continuum of improvement. A candidate multi-tier metric put forward in this report for medium-term development under the SE4ALL initiative addresses many of the limitations of the binary measures described above:

For electricity, the recommended new metric measures the degree of access to electricity supply along various dimensions. This is complemented by a parallel multi-tier framework that captures the use of key electricity services.

For cooking, the candidate proposal measures access to modern cooking solutions by measuring the technical performance of the primary cooking solution (including both the fuel and the cookstove) and assessing how this solution fits in with households' daily life.

For medium term country tracking, the further development of the multi-tier metric can be substantially strengthened by rigorous piloting of questionnaires, certification, and consensus building in SE4ALL opt-in countries. The metric is flexible and allows for country-specific targets to be set to adequately account for varying energy challenges. For medium-term global tracking, a condensed version of the new metric would support a three-tier access framework requiring only marginal improvements in existing global data collection instruments.

The SE4ALL universal access goal will be achieved only if every person on the planet has access to modern energy services provided through electricity, clean cooking fuels, clean heating fuels, and energy for productive use and community services. Although global tracking of energy sources for heating, community services, and productive uses will not be possible in the immediate future, it is recommended that an approach to track them at the country level be developed in the medium term.

With respect to electricity, the global access deficit amounts to 1.2 billion people. Close to 85 percent of those who live without electricity (the "nonelectrified population") live in rural areas, and 87 percent are geographically concentrated in Sub-Saharan Africa and South Asia (figure O.2). For cooking, the access deficit amounts to 2.8 billion people who primarily rely on solid fuels. About 78 percent of that population lives in rural areas, and 96 percent are geographically concentrated in Sub-Saharan Africa, Eastern Asia, Southern Asia, and South-Eastern Asia.

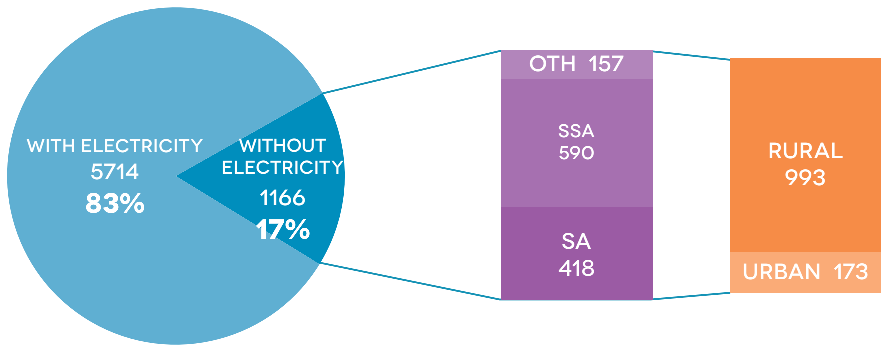

FIGURE O.2A **SOURCE OF ELECTRIFICATION ACCESS DEFICIT, 2010**

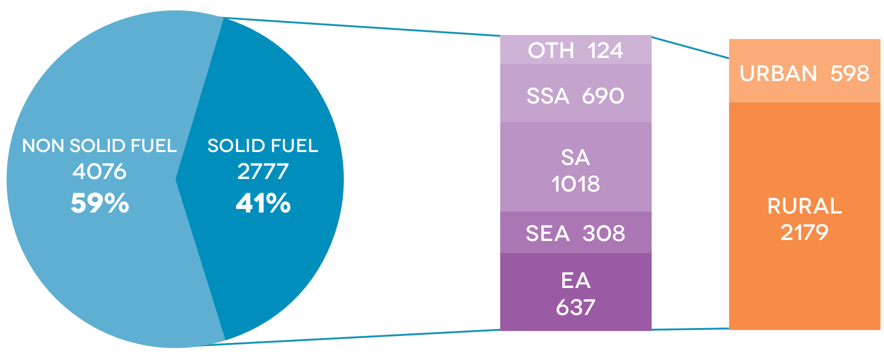

FIGURE O.2B **SOURCE OF NON-SOLID FUEL ACCESS DEFICIT, 2010**

SOURCE: WORLD BANK GLOBAL ELECTRIFICATION DATABASE, 2012; WHO GLOBAL HOUSEHOLD ENERGY DATABASE, 2012.
NOTE: ACCESS NUMBERS IN MILLIONS OF PEOPLE. EA = EASTERN ASIA; SEA = SOUTH-EASTERN ASIA; SA = SOUTHERN ASIA; SSA = SUB-SAHARAN AFRICA; OTH = OTHERS.

Most of the incremental electrification over the period 1990–2010 was in urban areas, where electrification increased by 1.7 percent of the population annually, about twice the rate in rural areas (0.8). However, even with this significant expansion, electrification only just kept pace with rapid urbanization in the same period, so that the overall urban electrification rate remained relatively stable, growing from 94 to 95 percent across the period. By contrast, more modest growth in rural populations allowed the electrification rate to increase more steeply, from 61 to 70 percent, despite a much lower level of electrification effort overall in the rural space. The rate of increase in access to non-solid fuel over the two decades was higher in urban areas, at around 1.7 percent of the population annually, with the overall urban access rate rising from 77 to 84 percent. Rural growth in non-solid fuel use was as low as 0.6 percent annually on average, while overall access in rural areas grew from 26 to 35 percent. Thus, most of the expansion in energy access between 1990 and 2010 was in urban areas, while most of the remaining deficit in 2010 was in rural areas (figure O.3).

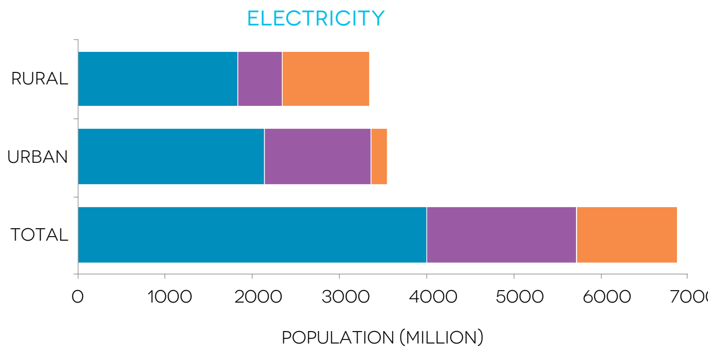

FIGURE O.3A **GLOBAL TRENDS IN ACCESS TO ELECTRICITY, 1990–2010, POPULATION MILLION**

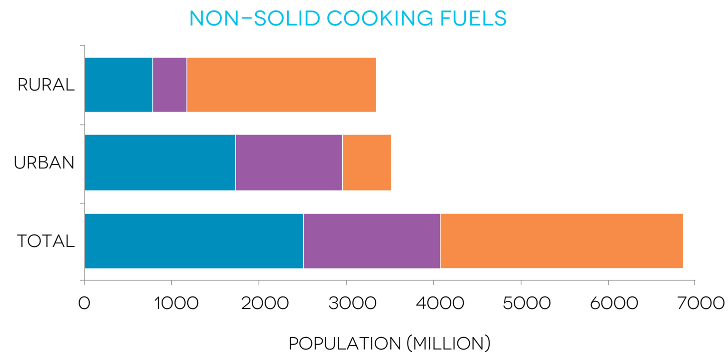

FIGURE O.3B **GLOBAL TRENDS IN ACCESS TO NON-SOLID FUEL, 1990–2010, POPULATION MILLION**

POPULATION WITH ACCESS IN 1990 INCREMENTAL ACCESS IN 1990–2010 POPULATION WITHOUT ACCESS IN 2010

SOURCE: WORLD BANK GLOBAL ELECTRIFICATION DATABASE, 2012; WHO GLOBAL HOUSEHOLD ENERGY DATABASE, 2012.

High-impact countries

The achievement of universal access to modern energy will depend critically on the efforts of 20 high-impact countries. Together, these countries account for more than two-thirds of the population presently living without electricity (0.9 billion people) and more than four-fifths of the global population without access to non-solid fuels (2.4 billion people). This group of 20 countries is split between Africa and Asia (figure O.4). For electricity, India has by far the largest access deficit, exceeding 300 million people, while for non-solid cooking fuel India and China each have access deficits that exceed 600 million people.

The access challenge is particularly significant in Sub-Saharan Africa, which is the only region where the rate of progress on energy access fell behind population growth in 1990–2010, both for electricity and for non-solid fuels. Among the 20 countries with the highest deficits in access, 12 are in Sub-Saharan African countries; of those, eight report an access rate below 20 percent. Similarly, among the 20 countries with the lowest rates of use of non-solid fuel for cooking, nine are Sub-Saharan African countries, of which five have rates of access to non-solid fuel below 10 percent.

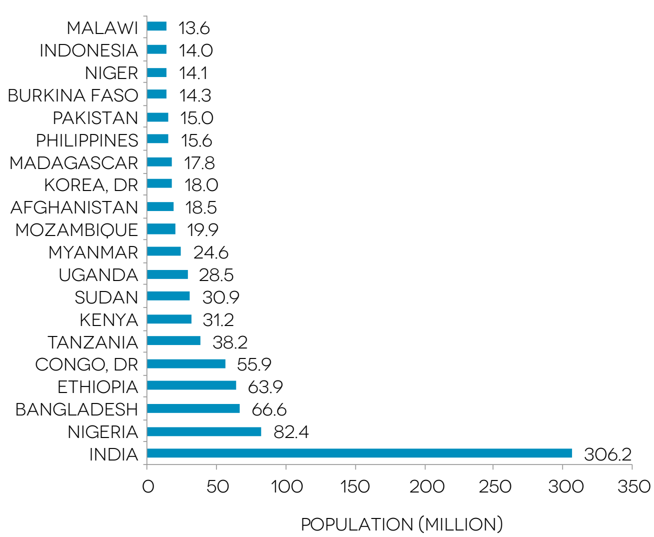

FIGURE O.4A **THE 20 COUNTRIES WITH THE HIGHEST DEFICIT IN ACCESS TO ELECTRICITY, 2010, POPULATION MILLION**

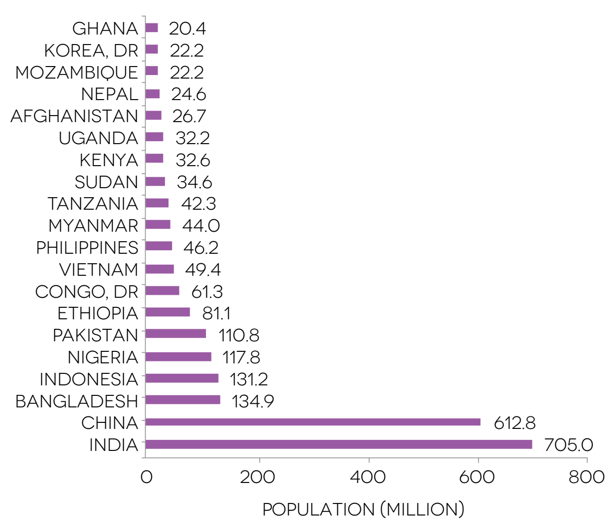

FIGURE O.4B **THE 20 COUNTRIES WITH THE HIGHEST DEFICIT IN ACCESS TO NON-SOLID FUEL, 2010, POPULATION MILLION**

SOURCE: WORLD BANK GLOBAL ELECTRIFICATION DATABASE, 2012; WHO GLOBAL HOUSEHOLD ENERGY DATABASE, 2012.
NOTE: DR = "DEMOCRATIC REPUBLIC OF."

Fast-moving countries

In charting a course to universal access, it will be important to learn from those countries that have successfully achieved universal energy access and those that have advanced the fastest toward this goal during the last two decades. The 20 countries that have made the most progress provided electricity to an additional 1.3 billion people in the past two decades. India has made particularly rapid progress, electrifying an average of 24 million annually since 1990, with an annual growth rate of 1.9 percent. Similarly, the 20 countries that have made the most progress on the cooking side—most of them in Asia—moved 1.2 billion people to non-solid fuel use. Whereas the global annual average increase in access was 1.2 percent for electrification and 1.1 percent for non-solid fuels, the countries making the most progress in scaling up energy access reached an additional 3–4 percent of their population each year (figures O.5 and O.6).

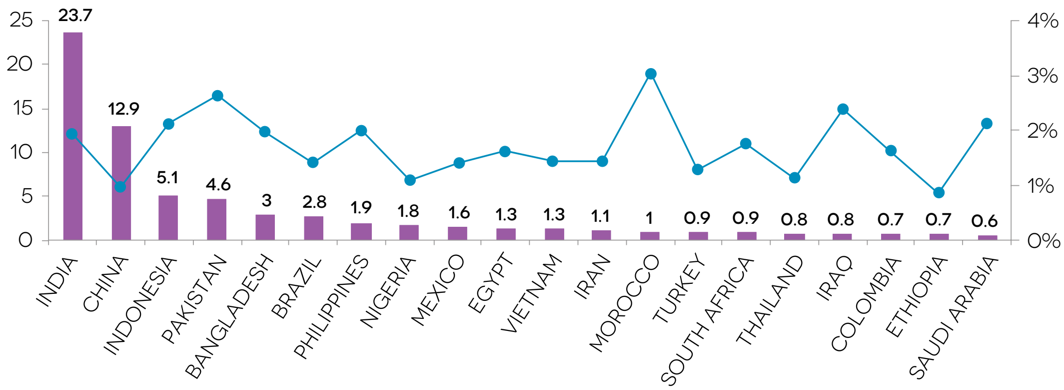

FIGURE O.5 **THE 20 COUNTRIES WITH THE GREATEST ANNUAL INCREASES IN ACCESS TO ELECTRICITY, 1990–2010**

ANNUAL INCREMENTAL ACCESS (MILLION PEOPLE) — ANNUAL GROWTH IN ACCESS (%)

SOURCE: WORLD BANK GLOBAL ELECTRIFICATION DATABASE, 2012.

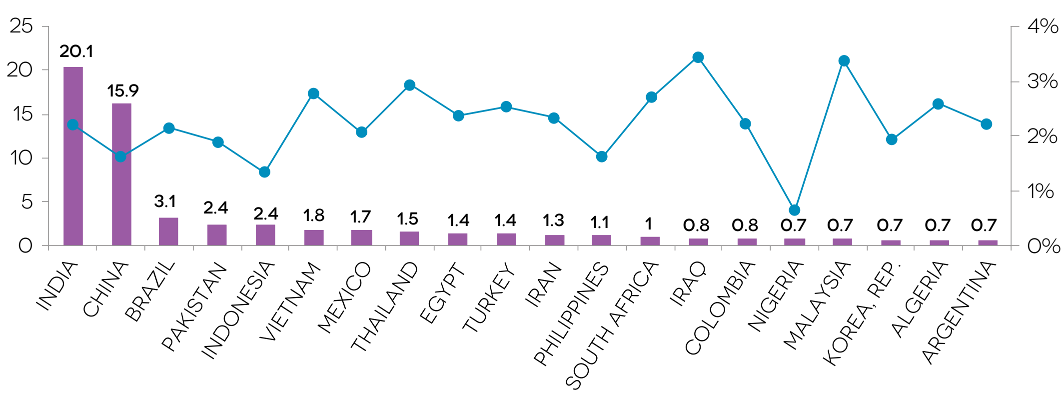

FIGURE O.6 **THE 20 COUNTRIES WITH THE GREATEST ANNUAL INCREASES IN ACCESS TO NON-SOLID FUELS, 1990–2010**

ANNUAL INCREMENTAL ACCESS (MILLION POEPLE) — ANNUAL GROWTH IN ACCESS (%)

SOURCE: WHO GLOBAL HOUSEHOLD ENERGY DATABASE, 2012.

Scale of the challenge

If the global trends observed during the last two decades were to continue, the SE4ALL objective of universal access would not be met. The IEA's World Energy Outlook for 2012 (IEA 2012b) projects that under a New Policies Scenario that reflects existing and announced policy commitments, access rates would climb to just 88 percent by 2030, still leaving almost a billion people without access to electricity (figure O.7). Access to electricity would improve for all regions except Sub-Saharan Africa, which is expected soon to overtake developing Asia as the region with the largest electrification deficit. By comparison, the GEA projects 84 percent access to electricity by 2030 under business-as-usual assumptions.

The IEA projects that under the New Policies Scenario access to non-solid fuel would climb to 70 percent in 2030, leaving the number of people without access to non-solid fuels largely unchanged at 2.6 billion by the end of the period (figure O.7b). By comparison, the GEA projects 64 percent access to non-solid fuels by 2030 under business-as-usual assumptions.

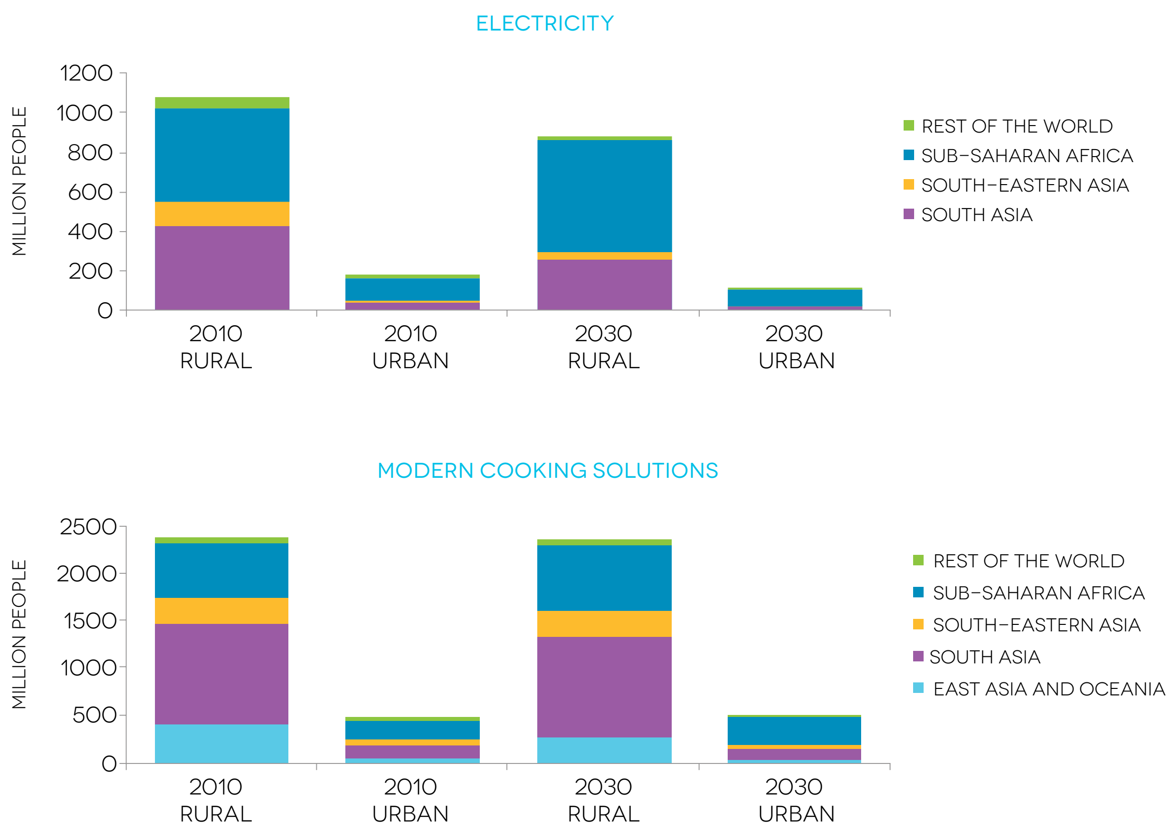

FIGURE O.7 **NUMBER OF PEOPLE WITHOUT ACCESS IN RURAL AND URBAN AREAS, BY REGION, 2010 AND 2030**

SOURCE: IEA 2012B.

Looking ahead, population growth over the next 20 years is expected to occur entirely in urban areas. Thus, while today's access deficit looks predominantly rural, considerable future electrification efforts in urban areas will be needed simply to keep electrification rates constant.

According to the IEA, achieving universal access to electricity by 2030 will require an average annual investment of $45 billion (compared to $9 billion estimated in 2009). More than 60 percent of the incremental investment required would have to be made in Sub-Saharan Africa and 36 percent in developing Asia. Universal access to modern cooking solutions by 2030 will require average annual investment of around $4.4 billion, a relatively small sum in global terms but a large increase compared with negligible current annual investments of about $0.1 billion.

IIASA's 2012 GEA provides estimates (based on different assumptions than those used by the IEA) of the cost of reaching universal access, which amount to $15 billion per year for electricity and $71 billion per year for modern cooking solutions. The higher estimate for modern cooking solutions is based on the assumption that providing universal access will not be feasible without fuel subsidies of around 50 percent for LPG, as well as microfinance (at an interest rate of 15 percent) to cover investments in improved cookstoves.

The IEA estimates that achievement of universal access for electricity and modern cooking solutions would add only about 1 percent to global primary energy demand over current trends. About half of that additional demand would likely be met by renewable energy and the other half by fossil fuels, including a switch to LPG for cooking. As a result, the impact of achieving universal access on global CO2 emissions is projected to be negligible, raising total emissions by around 0.6 percent in 2030.

Several barriers must be overcome to increase access to electrification and modern cooking solutions. A high level of commitment to the objective from the country's political leadership and the mainstreaming of a realistic energy access strategy into the nation's overall development and budget processes are important. So are capacity building for program implementation, a robust financial sector, a legal and regulatory framework that encourages investment, and active promotion of business opportunities to attract the private sector. In some cases, carefully designed and targeted subsidies may also be needed. Nonfinancial barriers to the expansion of access include poor monitoring systems and sociocultural prejudices.

Doubling the rate of improvement of energy efficiency

The energy intensity of the global economy (the ratio of the quantity of energy consumption per unit of economic output) fell substantially during the period 1990–2010, from 10.2 to 7.9 megajoules per U.S. dollar (2005 dollars at PPP).[5] This reduction in global energy intensity was driven by cumulative improvements in energy efficiency, offset by growth in activity, resulting in energy savings of 2,276 EJ over the 20-year period (figure O.8). Strong demographic and economic growth around the world caused global primary energy supply to continue to grow at a compound annual rate of 2 percent annually over the period, nonetheless improvements in energy intensity meant that global energy demand in 2010 was more than a third lower than it would otherwise have been.

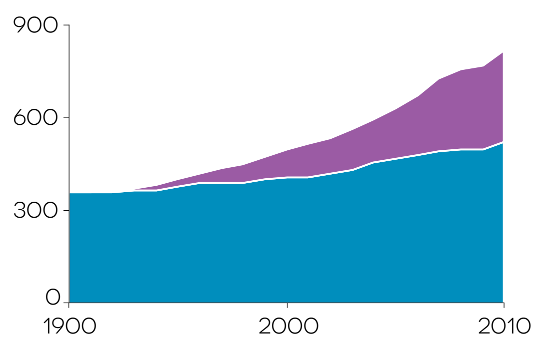

FIGURE O.8 **ENERGY SAVINGS OWING TO REALIZED IMPROVEMENTS IN ENERGY INTENSITY (EXAJOULES)**

PRIMARY ENERGY CONSUMPTION AVOIDED ENERGY CONSUMPTION

SOURCE: BASED ON WORLD DEVELOPMENT INDICATORS, WORLD BANK; IEA 2012A; UN ENERGY STATISTICS DATABASE.

[5] Countries with a high level of energy intensity use more energy to create a unit of GDP than countries with lower levels of energy intensity. Throughout the report, energy intensity is measured in primary energy terms and GDP at PPP unless otherwise specified. More details on the accounting methodology and the terminology used can be found in the energy efficiency chapter of the report.

Starting point

Globally, energy intensity decreased at a compound annual growth rate (CAGR) of –1.3 percent over the 20 years between 1990 and 2010. The rate of improvement slowed considerably during the period 2000–2010, however, to a CAGR of –1.0, compared to –1.6 per year for 1990–2000 (figure O.9a).

With the starting point for measuring future progress in global energy efficiency under the SE4ALL, set as –1.3 percent, the SE4ALL global objective is therefore a CAGR in energy intensity of –2.6 percent for the period 2010–2030.[6]

Energy intensity is an imperfect proxy for underlying energy efficiency (defined as the ratio between useful output and the associated energy input). Indeed, the global rate of improvement of global energy intensity may over- or understate the progress made in underlying energy efficiency. This is because energy intensity is affected by other factors, such as shifts in the structure of the economy over time, typically from less energy-intensive agriculture to higher energy-intensive industry and then back toward lower energy -intensive services. A review of the methodological issues in measuring energy efficiency is presented in box O.2.

Statistical techniques that allow for the confounding effects of factors other than energy efficiency to be partially stripped out reveal that the adjusted energy intensity trend with a CAGR of –1.6 could be significantly higher than the unadjusted CAGR of –1.3 (figure O.9b). The effect of this adjustment is particularly evident for the period 2000–2010, when globalization led to a major structural shift toward industrialization in emerging economies, partially eclipsing their parallel efforts to improve energy efficiency.

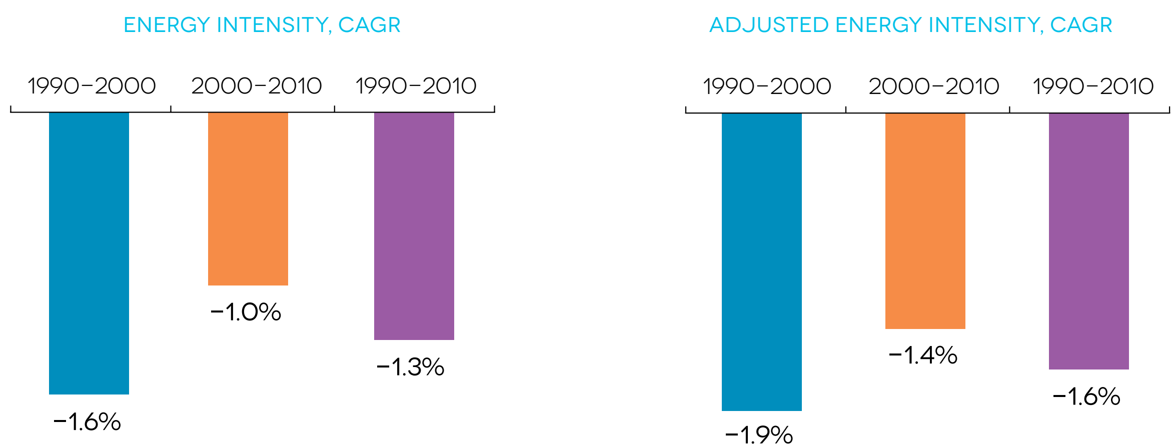

FIGURE O.9 **RATE OF IMPROVEMENT IN GLOBAL ENERGY INTENSITY, 1990–2010 (PPP TERMS)**

SOURCE: BASED ON WORLD DEVELOPMENT INDICATORS, WORLD BANK; IEA 2012A.
NOTE: PPP = PURCHASING POWER PARITY; CAGR = COMPOUND ANNUAL GROWTH RATE. "ADJUSTED ENERGY INTENSITY" IS A MEASURE DERIVED FROM THE DIVISIA DECOMPOSITION METHOD THAT CONTROLS FOR SHIFTS IN THE ACTIVITY LEVEL AND STRUCTURE OF THE ECONOMY.

[6] When measured in final energy terms, the compound annual growth rate is –1.5 percent for the period 1990–2010. Thus the goal is –3.0 percent on average for the next 20 years.

BOX O.2 Methodological challenges in defining and measuring energy efficiency

Energy efficiency is defined as the ratio between useful outputs and associated energy inputs. Rigorous measurement of this relationship is possible only at the level of individual technologies and processes, and the data needed for such measures are available only for a handful of countries. Even where data are available, they result in hundreds of indicators that cannot be readily used to summarize the situation at the national level.

For these reasons, energy intensity (typically measured as energy consumed per dollar of gross domestic product, GDP) has traditionally been used as a proxy for energy efficiency when making international comparisons. Energy intensity is an imperfect proxy for energy efficiency because it is affected not only by changes in the efficiency of underlying processes, but also by other factors such as changes in the volume and sectoral structure of GDP. These concerns can be partially addressed by statistical decomposition methods that allow confounding effects to be stripped out. Complementing national energy intensity indicators with sectoral ones also helps to provide a more nuanced picture of the energy efficiency situation.

Calculation of energy intensity metrics requires suitable measures for GDP and energy consumption. GDP can be expressed either in terms of market exchange rate or purchasing power parity (PPP). Market exchange rate measures may undervalue output in emerging economies because of the lower prevailing domestic price levels and thereby overstate the associated energy intensity. PPP measures are not as readily available as market exchange rate measures, because the associated correction factors are updated only every five years.

Energy consumption can be measured in either primary or final energy terms. While it may make sense to use primary energy for highly aggregated energy intensity measures (relative to GDP) because it captures intensity in both the production and use of energy, it is less meaningful to use it when measuring energy intensity at the sectoral or subsectoral level, where final energy consumption is more relevant.

Based on a careful analysis of these issues and of global data constraints, the SE4ALL Global Tracking Framework for energy efficiency will:

- Rely primarily on energy intensity indicators
- Use PPP measures for GDP and sectoral value-added
- Use primary energy supply for national indicators and final energy consumption for sectoral indicators
- Complement those indicators with energy intensity of supply and of the major demand sectors
- Provide a decomposition analysis to at least partially strip out confounding effects on energy intensity
- Use a five-year moving average for energy intensity trends to smooth out extraneous fluctuations

For the purposes of global tracking, data for the period 1990–2010 have been compiled from energy balances for 181 countries published by the International Energy Agency and the United Nations. These are complemented by data on national and sectoral value-added from the World Bank's World Development Indicators.

Looking ahead, significant international efforts are needed to improve the availability of energy input and output metrics across the main sectors of the economy to allow for more meaningful measures of energy efficiency.

Global final energy consumption can be broadly divided among the following major economic sectors: agriculture, industry, residential, transport, and services. For the purpose of initial global tracking, residential, transport, and services are aggregated into a single category of "other sectors" owing to data limitations. Industry is by far the most energy-intensive of these sectors, consuming around 6.8 megajoules per 2005 dollar in 2010, compared with 5.5 for "other sectors" (residential, transport, and services) and 2.1 for agriculture.[7] The most rapid progress in reducing energy intensity has come in the agricultural sector, which recorded a CAGR of –2.2 percent during 1990–2010 (figure O.10a). Although progress was significantly slower in the industry and other sectors, due to their much-higher levels of energy consumption they made far larger contributions to global energy savings than did agriculture during the same period (figure O.10b).

By contrast, the ratio of final to primary energy consumption, which provides a measure of the overall efficiency of conversion in the energy supply industry, actually deteriorated during the period 1990-2010, falling from 72 to 68 percent. This reflects relatively little improvement in the efficiency of the electricity supply industry over the same period. The efficiency of thermal generation (defined as the percentage of the energy content of fossil fuels that is converted to electricity during power generation) improved only slightly from 38 to 39 percent, while transmission and distribution losses remained almost stagnant at around 9 percent of energy produced. Gas supply losses fell a little more steeply, from 1.4 to 0.9 percent.

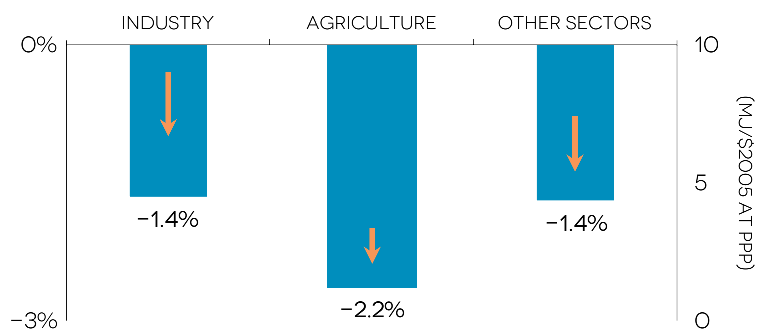

FIGURE O.10A **ENERGY INTENSITY TRENDS BY SECTOR (PPP TERMS)**

CAGR 1990–2010 (LEFT) | EI IN 1990 (RIGHT) | EI IN 2010 (RIGHT)

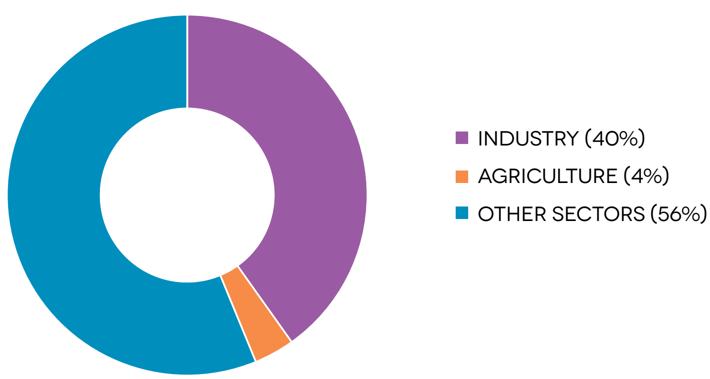

FIGURE O.10B **SHARE OF CUMULATIVE ENERGY SAVINGS BY SECTOR**

SOURCE: BASED ON WORLD DEVELOPMENT INDICATORS, WORLD BANK; IEA 2012A.
NOTE: "OTHER SECTORS" INCLUDE RESIDENTIAL, TRANSPORT, AND SERVICES. CAGR = COMPOUND ANNUAL GROWTH RATE; EI = ENERGY INTENSITY; PPP = PURCHASING POWER PARITY.

[7] Owing to data limitations, in this report the category "other sectors" includes transport, residential, services, and others. The medium- and long-term methodology considers them separately.

The rate of progress on energy intensity varied dramatically across world regions over the period 1990–2010. At one end of the spectrum, the Caucasus and Central Asia region achieved a CAGR of –3.2 percent while nonetheless remaining the region with the highest energy intensity (figure O.11a). At the other end, Western Asia (also known as the Middle East) was the only region to show a deteriorating trend in energy intensity, with a CAGR of +0.8 percent. Overall, 85 percent of the energy savings achieved between 1990 and 2010 were contributed by Eastern Asia and the developed countries (figure O.11b).

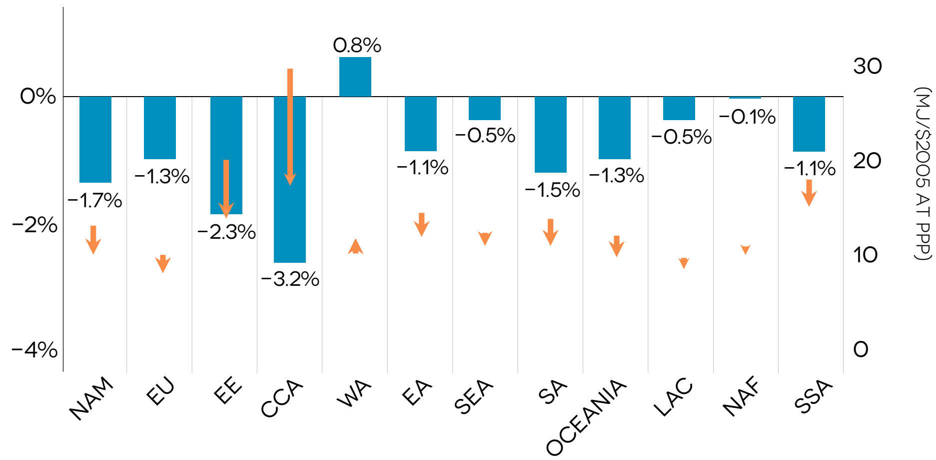

FIGURE O.11A **ENERGY INTENSITY TRENDS BY REGION (PPP TERMS)**

CAGR 1990–2010 (LEFT) | EI IN 1990 (RIGHT) | EI IN 2010 (RIGHT)

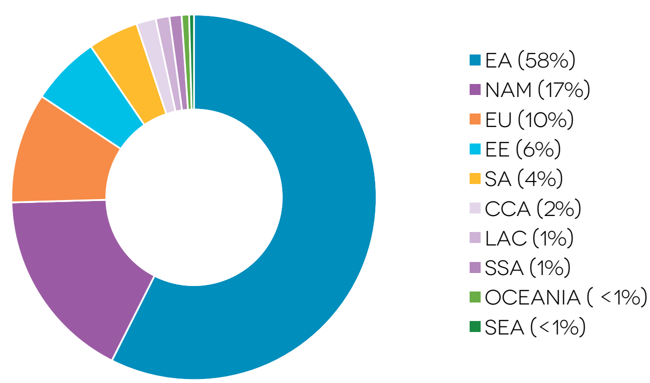

FIGURE O.11B **SHARE OF CUMULATIVE ENERGY SAVINGS BY REGION**

SOURCE: BASED ON WORLD DEVELOPMENT INDICATORS, WORLD BANK; IEA 2012A; UN ENERGY STATISTICS DATABASE.
NOTE: PPP = PURCHASING POWER PARITY; CAGR = COMPOUND ANNUAL GROWTH RATE; EI = ENERGY INTENSITY; NAM = NORTH AMERICA; EU = EUROPE; EE = EASTERN EUROPE; CCA = CAUCASUS AND CENTRAL ASIA; WA = WESTERN ASIA; EA = EASTERN ASIA; SEA = SOUTH-EASTERN ASIA; SA = SOUTHERN ASIA; LAC = LATIN AMERICA AND THE CARIBBEAN; NAF = NORTHERN AFRICA; SSA = SUB-SAHARAN AFRICA.

High-impact countries

Energy consumption is distributed unequally across countries, almost to the same degree as income. The 20 largest energy consumers account for 80 percent of primary energy consumption, with the two largest consumers (the United States and China) together accounting for 40 percent of the total (figure O.12). The achievement of the global objective of doubling the rate of improvement of energy efficiency will therefore depend critically on energy consumption patterns in these countries.

As of 2010, the high-income countries (with the exception of Saudi Arabia) show the lowest energy intensity relative to GDP. Nevertheless, energy consumption per capita varies hugely across this group, from 110 gigajoules per capita in Western Europe to 300 in North America. By contrast, the middle-income countries (with the exception of Russia and Kazakhstan) show much lower levels of per capita energy consumption but vary widely in their energy intensities. In particular, energy intensities in Latin America are comparable to those found in Western Europe, whereas in the Ukraine and Uzbekistan they are exceptionally high (figure O.13).

The gap between the world's most and least energy-intensive economies is wide—more than tenfold. At one extreme, the most energy-intensive countries—a heterogenous mix of the countries of the former Soviet Union and those of Sub-Saharan Africa—report intensities of 20–30 megajoules per 2005 PPP dollar (figure O.13). At the other extreme, the least energy-intensive countries—predominantly small island developing states with exceptionally high energy costs—report intensities of 2–4 megajoules per 2005 PPP dollar (figure O.14). Even among the 20 largest energy consuming countries, energy intensities range from more than 12 megajoules per 2005 PPP dollar in Ukraine, Russia, Saudi Arabia, South Africa, and China to less than 5 in the United Kingdom, Spain, Italy, Germany, and Japan.

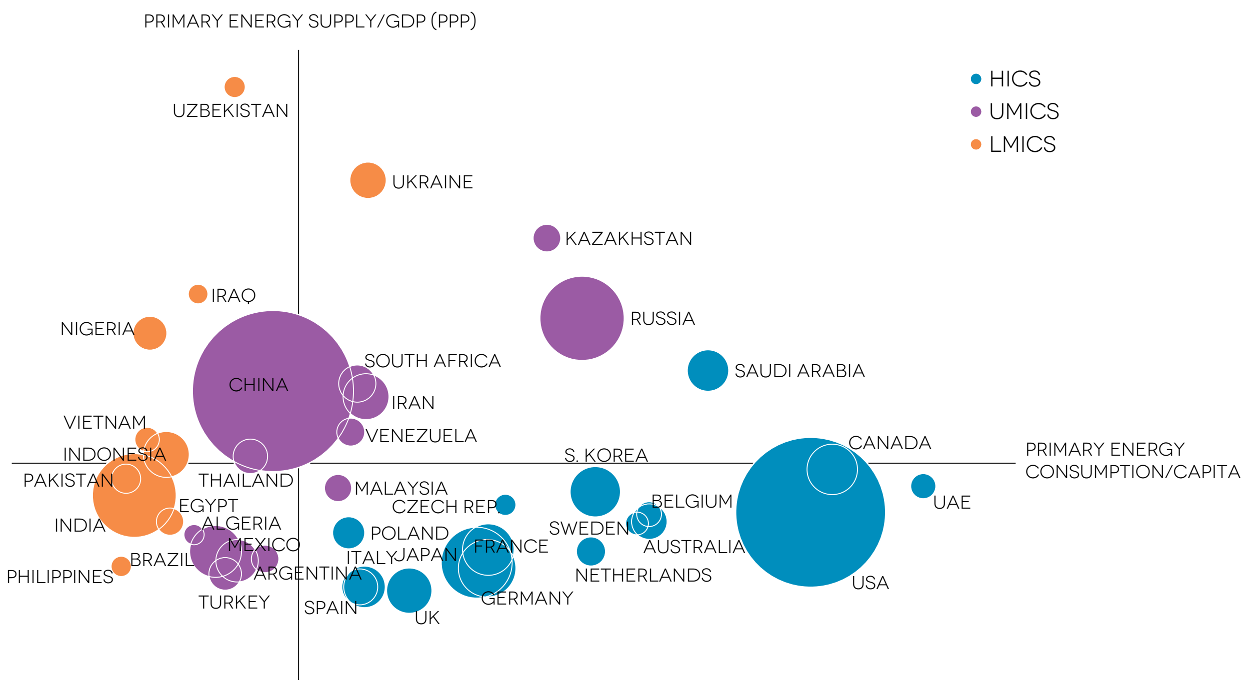

FIGURE O.12 **ENERGY INTENSITY (PPP) VS. ENERGY CONSUMPTION PER CAPITA IN 40 LARGEST ENERGY CONSUMERS, 2010**

SOURCE: BASED ON WORLD DEVELOPMENT INDICATORS, WORLD BANK; IEA 2012A.

NOTE: VALUES ARE NORMALIZED ALONG THE AVERAGE. BUBBLE SIZE REPRESENTS VOLUME OF PRIMARY ENERGY CONSUMPTION. PPP = PURCHASING POWER PARITY. GDP = GROSS DOMESTIC PRODUCT; PPP = PURCHASING POWER PARITY; HICS = HIGHER-INCOME COUNTRIES; UMICS = UPPER-MIDDLE-INCOME COUNTRIES; LMICS = LOWER-MIDDLE-INCOME COUNTRIES; UAE = UNITED ARAB EMIRATES.

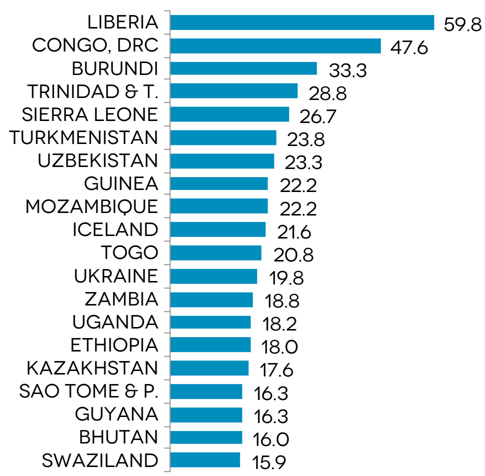

FIGURE O.13 **COUNTRIES WITH HIGHEST ENERGY INTENSITY LEVEL IN 2010 (MJ/$2005)**

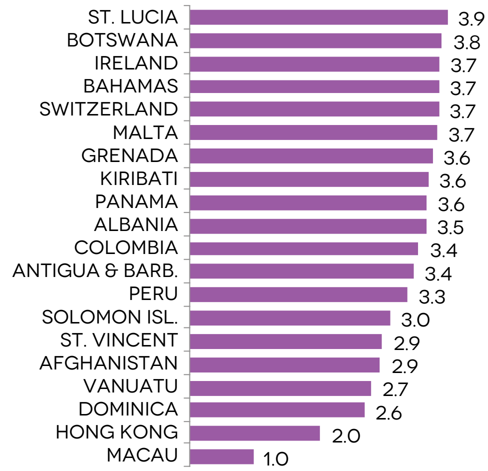

FIGURE O.14 **COUNTRIES WITH LOWEST ENERGY INTENSITY LEVEL IN 2010 (MJ/$2005)**

SOURCE: BASED ON WORLD DEVELOPMENT INDICATORS, WORLD BANK; IEA 2012A; UN ENERGY STATISTICS DATABASE.
NOTE: PPP = PURCHASING POWER PARITY; DR = "DEMOCRATIC REPUBLIC OF."

Fast-moving countries

In doubling the rate of energy efficiency improvement globally, it will be important to learn from those countries that made the most rapid progress toward this goal during the 20 years between 1990 and 2010. While the global CAGR of energy intensity was only –1.3 percent over the period 1990–2010, 20 countries achieved rates of –4.0 percent or greater (figure O.15). The countries making the most rapid progress on energy intensity often started out with particularly high levels of energy intensity—notably China, the countries of the former Soviet Union, and several countries in Sub-Saharan Africa (figure O.16). By far the largest absolute energy savings have been made by China, where energy efficiency efforts have yielded savings equivalent in magnitude to the energy used by the country over the same time frame. Savings in the United States, the European Union, and India have also been globally significant.

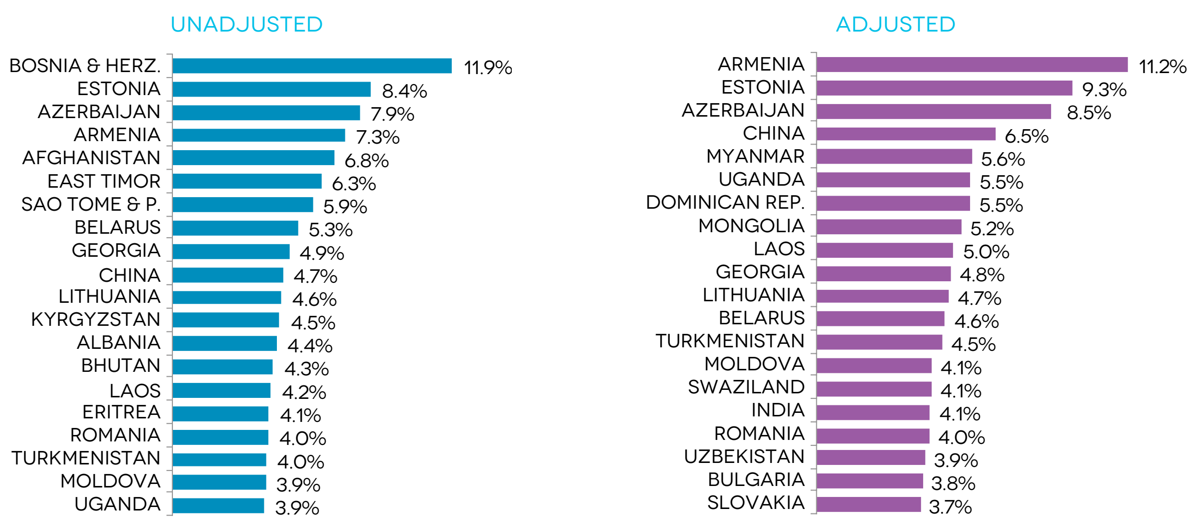

FIGURE O.15 **REDUCTIONS IN ENERGY INTENSITY OF 20 FASTEST-MOVING COUNTRIES, CAGR, 1990–2010 (PPP TERMS)**

SOURCE: BASED ON WORLD DEVELOPMENT INDICATORS, WORLD BANK; IEA 2012A; UN ENERGY STATISTICS DATABASE.
NOTE: CAGR = COMPOUND ANNUAL GROWTH RATE. "ADJUSTED ENERGY INTENSITY" IS A MEASURE DERIVED FROM THE DIVISIA DECOMPOSITION METHOD THAT CONTROLS FOR SHIFTS IN THE ACTIVITY LEVEL AND STRUCTURE OF THE ECONOMY.

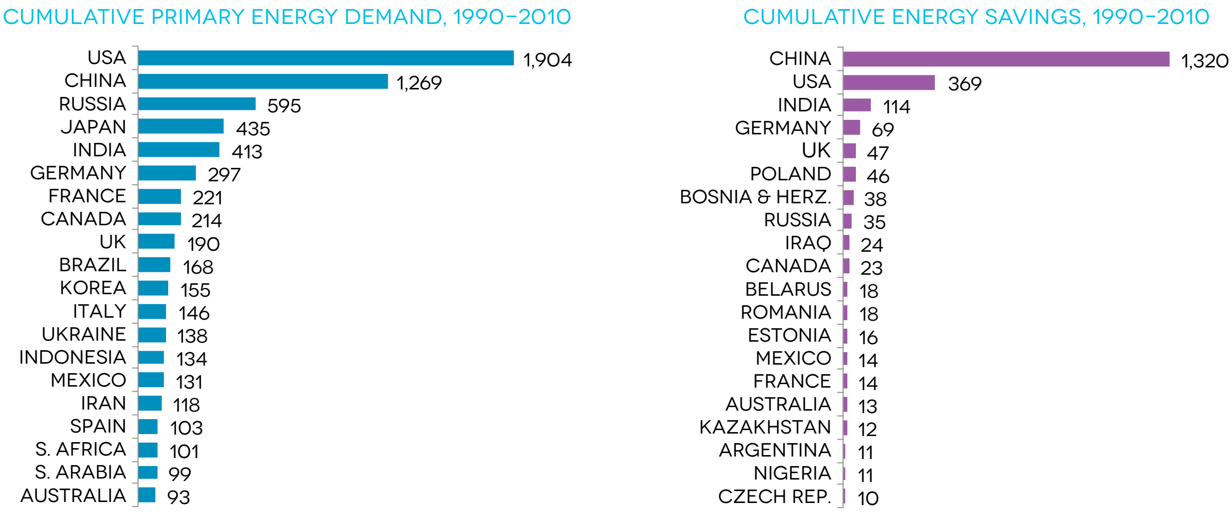

FIGURE O.16 **LARGEST CUMULATIVE CONSUMERS OF PRIMARY ENERGY, AND CUMULATIVE ENERGY SAVINGS AS A RESULT OF REDUCTIONS IN ENERGY INTENSITY, 1990–2010 (EXAJOULES)**

SOURCE: BASED ON WORLD DEVELOPMENT INDICATORS, WORLD BANK; IEA 2012A; UN ENERGY STATISTICS DATABASE.
NOTE: BOSNIA & = BOSNIA & HERZEGOVINA.

Scale of the challenge

Looking ahead, analysis from the IEA's World Energy Outlook 2012 indicates that energy efficiency policies currently in effect or planned around the world would take advantage of just a third of all economically viable energy efficiency measures. The current or planned uptake of available measures is highest in the industrial sector at 44 percent, followed by transport at 37 percent, power generation at 21 percent, and buildings at 18 percent.

Recent analysis shows that the existing potential for cost-effective improvements in energy efficiency goes far beyond what will be captured through current and planned policies (referred to as the New Policies Scenario in figure O.17; IEA 2012b). Under an Efficient World Scenario that exploits all cost-effective improvements, it would be possible to improve energy intensity by an average CAGR of –2.8 percent through 2030, more than double historic rates and even somewhat beyond the SE4ALL objective. About 80 percent of the energy savings that are achievable under this scenario would result from measures taken by energy consumers in end-use sectors, with much of the remaining 20 percent attributable to fuel switching and supply-side efficiency measures. By far the largest potential for energy efficiency improvements is to be found in developing Asia.

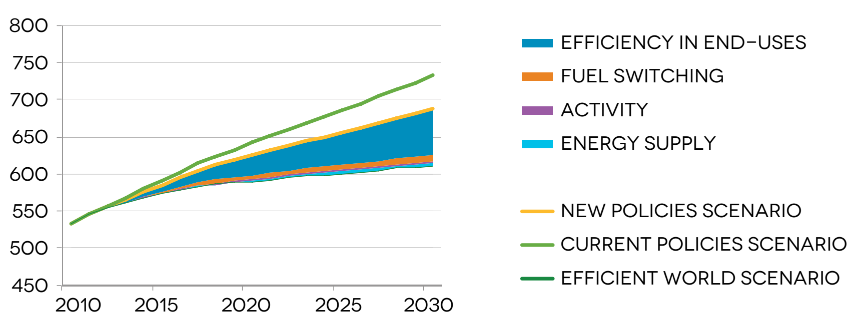

FIGURE O.17 **CHANGE IN GLOBAL PRIMARY ENERGY DEMAND BY MEASURE BETWEEN IEA EFFICIENT WORLD SCENARIO AND IEA NEW POLICIES SCENARIO, 2010–2030 (EXAJOULES)**

SOURCE: IEA 2012B.

The Efficient World Scenario would slow the CAGR of global energy demand to 0.6 percent through 2030, compared with an anticipated 1.3 percent under current and planned policies. It should be noted that even the Efficient World Scenario does not bring about an overall decline in global energy demand over the period 2010–2030.

Mobilizing these improvements would call for cumulative additional investments of close to $400 billion annually through 2030, more than triple historic levels. These investments—although high—would offer the prospect of rapid payback, giving a boost to the global economy of $11.4 trillion over the same period. As in the case of renewable energy, achieving change on this scale is contingent on the adoption of a strong set of energy policy measures, including the phasing out of fossil-fuel subsidies, the provision of price signals for carbon emissions, and the adoption of strict energy efficiency standards.

IIASA's GEA presents six scenarios that meet all three SE4ALL objectives while also meeting the requirement to limit global temperature increases to 2°C. All six of these scenarios require CAGRs for energy intensity on the order of –3.0 percent annually. Achieving the global objective would entail CAGRs for energy intensity in the range of –4.0 to –6.0 percent for Asia and the former Soviet Union (figure O.18).

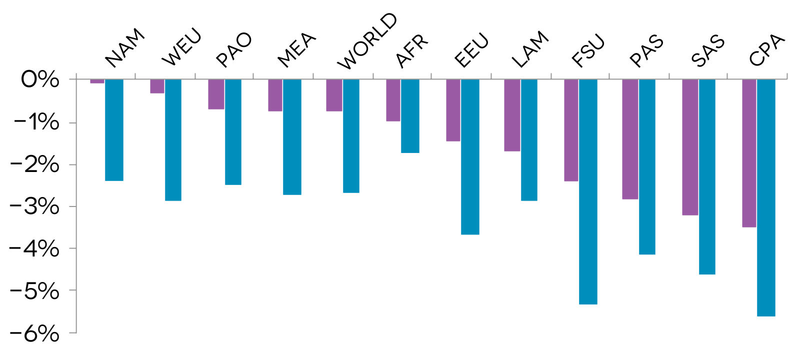

FIGURE O.18 **ANNUAL RATE OF IMPROVEMENT IN PRIMARY ENERGY INTENSITY: IIASA GLOBAL ENERGY ASSESSMENT BASELINE VS. SE4ALL SCENARIO, CAGR, 2010–2030**

■ BASELINE ■ SE4ALL

SOURCE: IIASA (2012).
NOTE: ON THE CHART ABOVE GDP IS MEASURED AT MARKET EXCHANGE RATE AND PRIMARY ENERGY IS MEASURED USING DIRECT EQUIVALENT METHOD AS OPPOSED TO THE PHYSICAL CONTENT METHOD USED ELSEWHERE. CAGR = COMPOUND ANNUAL GROWTH RATE. NAM = NORTH AMERICA; WEU = WESTERN EUROPE; PAO = PACIFIC OECD; MEA = MIDDLE EAST AND NORTH AFRICA; AFR = SUB-SAHARAN AFRICA; EEU = EASTERN EUROPE; LAM = LATIN AMERICA; FSU = FORMER SOVIET UNION; PAS = PACIFIC ASIA; SAS = SOUTH ASIA; CPA = CENTRALLY PLANNED ASIA.

Doubling the share of renewable energy in the global energy mix

The amount of energy provided from renewable sources for electricity, heating, and transportation has expanded rapidly since 1990, and particularly since 2000, with a compound annual growth rate (CAGR) of 1.5 percent during 1990–2000 and 2.4 percent during 2000–2010.[8] Global consumption of renewable energy grew from 40 exajoules (EJ) in 1990 to almost 60 EJ in 2010 (figure O.19). Yet as the consumption of energy from renewable sources rose, global TFEC grew at a comparable pace of 1.1 percent during 1990–2000 and 2.0 percent during 2000–2010. As a result, the share of renewable energy in the total final energy consumption remained relatively stable, growing from 16.6 percent in 1990 to 18.0 percent in 2010.

[8] Nuclear energy is not considered renewable.

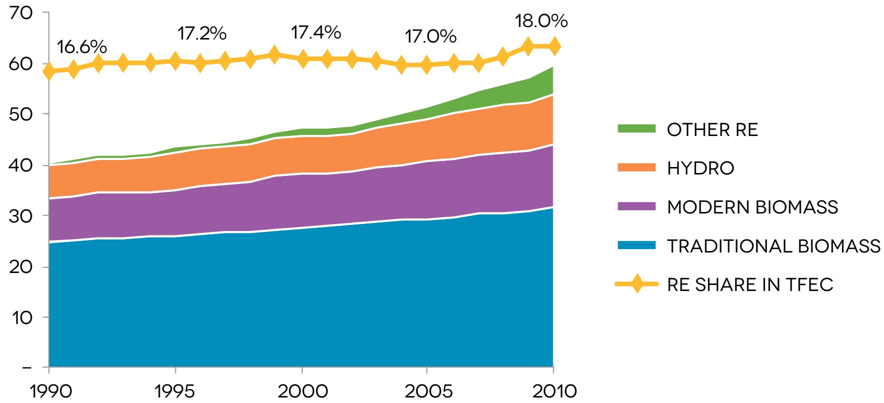

FIGURE O.19 **WORLD CONSUMPTION OF RENEWABLE ENERGY (EXAJOULES) AND SHARE OF RENEWABLE ENERGY IN TFEC (%)**

SOURCE: IEA 2012A.
NOTE: TFEC = TOTAL FINAL ENERGY CONSUMPTION; RE = RENEWABLE ENERGY.

Focusing specifically on electricity, power generation from renewable sources increased from 2,300 terawatt-hours (TWh) in 1990 to 4,160 TWh in 2010. The increase in electricity generation from renewable sources is equivalent to the combined electricity output of Russia and India in 2010. Global electricity generation almost doubled in the 20-year period, growing from 11,800 TWh in 1990 to 21,400 TWh in 2010, which is equivalent to the combined electricity generation of China, the United States, and India in 2010. As of 2011, renewable energy sources accounted for more than 20 percent of global power generated, 25 percent of global installed power generation capacity, and half of newly installed power generation capacity added that year. More than 80 percent of all renewable electricity generated globally was from hydropower.

The starting point

The starting point for the share of renewable energy in total final energy consumption against which future progress will be measured is estimated to be at most 18 percent of TFEC in 2010, reflecting uncertainties over whether some types of renewable energy usage (notably traditional biomass) meet sustainability criteria (figure O.20). The implied SE4ALL global objective is up to 36 percent by 2030.

It is estimated that traditional biomass accounts for about half of the renewable energy total, although data on these traditional usages are imprecise, and the sustainability of these sources cannot be reliably gauged.[9] A further quarter of the renewable energy total relates to modern forms of bioenergy, and most of the remainder is hydropower. Remaining forms of renewable energy—including wind, solar, geothermal, waste, and marine—together contribute barely 1 percent of global energy consumption, though they have been growing at an exponential rate. For example, wind power grew at a CAGR of 25.0 percent and solar at 11.4 percent, compared with a growth rate of slightly over 1 percent for traditional biomass (figure O.21).

An examination of the methodological issues of measuring the renewable energy share can be found in box O.3.

9 The UN Food and Agriculture Organization defines traditional biomass as "woodfuels, agricultural by-products, and dung burned for cooking and heating purposes." In developing countries, traditional biomass is still widely harvested and used in an unsustainable and unsafe way. It is mostly traded informally and non-commercially. So-called modern biomass, by contrast, is produced in a sustainable manner from solid wastes and residues from agriculture and forestry.

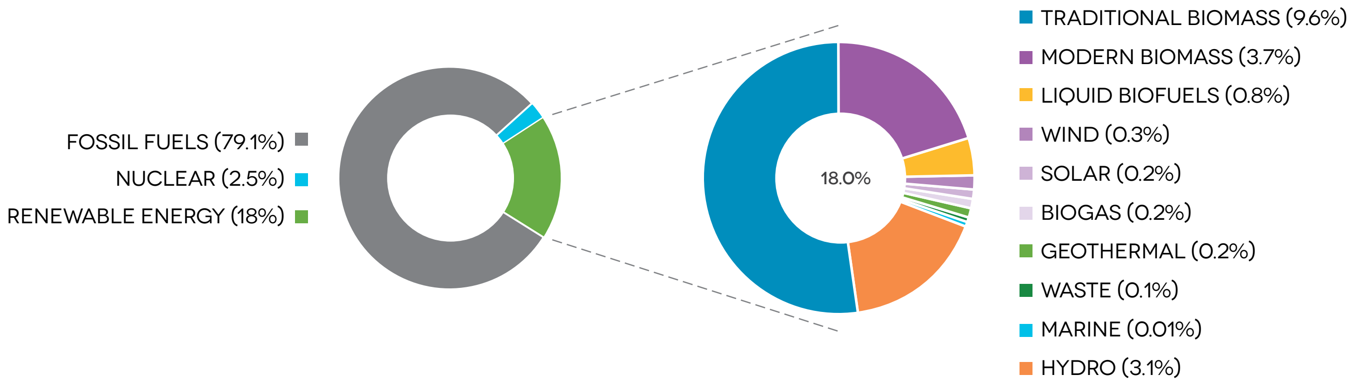

FIGURE O.20 **SHARE OF RENEWABLE ENERGY IN GLOBAL TFEC, 2010**

SOURCE: IEA 2012A.
NOTE: TFEC = TOTAL FINAL ENERGY CONSUMPTION;

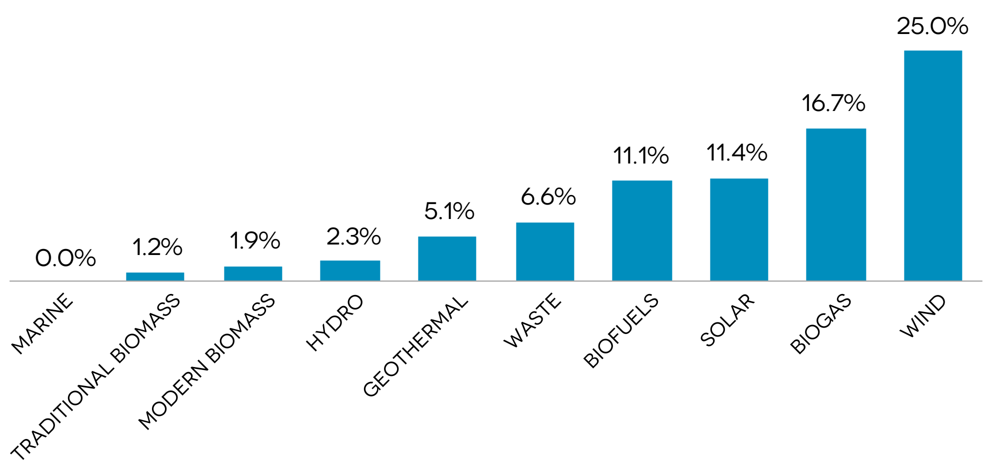

FIGURE O.21 **COMPOUND ANNUAL GROWTH RATES (CAGRS) BY RENEWABLE ENERGY SOURCE, 1990–2010**

SOURCE: IEA 2012A.

Box O.3 Methodological challenges in defining and measuring renewable energy

There are various definitional and methodological challenges in measuring and tracking the share of renewable energy in the global energy mix used for heating, electricity, and transportation.

First, while there is a broad consensus among international organizations and government agencies on what constitutes renewable energy, their legal and formal definitions vary slightly in the type of resources included and the sustainability considerations taken into account. For the purposes of the SE4ALL Global Tracking Framework, it is important that the definition of renewable energy should be specific about the range of sources to be included, should embrace the notion of natural replenishment, and should espouse sustainability. But the data and agreed-upon definitions needed to determine whether renewable energy—notably biomass—has been sustainably produced are not currently available. Therefore, it is proposed that, as an interim measure for immediate tracking purposes, renewable energy should be defined and tracked without the application of specific sustainability criteria. Accordingly, its broad definition is as follows:

"Renewable energy is energy from natural sources that are replenished at a faster rate than they are consumed, including hydro, bioenergy, geothermal, aerothermal, solar, wind, and ocean."

Second, an important methodological choice is whether tracking should be undertaken at the primary level of the energy balance or on the basis of final energy. Power generation from fossil fuels leads to substantial energy losses in conversion, leading to a discrepancy between primary energy, or fuel input, and final energy, or useful energy output. Since renewable energy sources do not have fuel inputs, they are only reported in final energy terms; expressing them in primary terms would require the use of somewhat arbitrary conversion factors.

Third, the high aggregation levels and data gaps in certain categories of available data repositories still limit the analysis. Data gaps have also been identified in the areas of distributed generation and off-grid electricity services. An additional challenge is related to measuring the heat output from certain renewable sources of energy such as heat pumps and solar water heaters. These missing components of renewable energy are relatively small in scale at present but are expected to grow significantly through 2030, making it increasingly important to develop methodologies and systems for capturing the associated data.

For the purposes of global tracking, data for the period 1990–2010 have been compiled from energy balances for 181 countries published by the International Energy Agency and the United Nations. Those data will be complemented by indicators on: (i) policy targets for renewable energy and adoption of relevant policy measures; (ii) technology costs for each of the renewable energy technologies; and (iii) total investment in renewable energy from the Renewable Energy Network 21, the International Renewable Energy Agency, and Bloomberg New Energy Finance, respectively.

Looking ahead, significant international efforts are needed to improve data collection methodologies and bridge identified data gaps. In particular, there is a need to develop internationally agreed-upon standards for sustainability for each of the main technologies, which can then be used to assess the degree to which deployment meets the highest sustainability standards. This is particularly critical in the case of biomass, where traditional harvesting practices can be associated with deforestation.

Looking across regions, it is striking that lower-income regions, such as Africa and Asia, have the highest shares of renewable energy, ranging from 20 to 60 percent. These shares declined significantly in 1990–2010, however, in part due to decreased reliance on traditional biomass for cooking and wider adoption of non-solid cooking fuels (figure O.22). By contrast, higher-income regions such as Europe and America present much lower shares of renewable energy (in the range of 10 to 15 percent), although those shares grew steadily over the two decades. Overall, Africa and Asia alone accounted for about two-thirds of global share of renewable energy in TFEC in 2010, while Europe and North America together contributed about 20 percent (figure O.23).

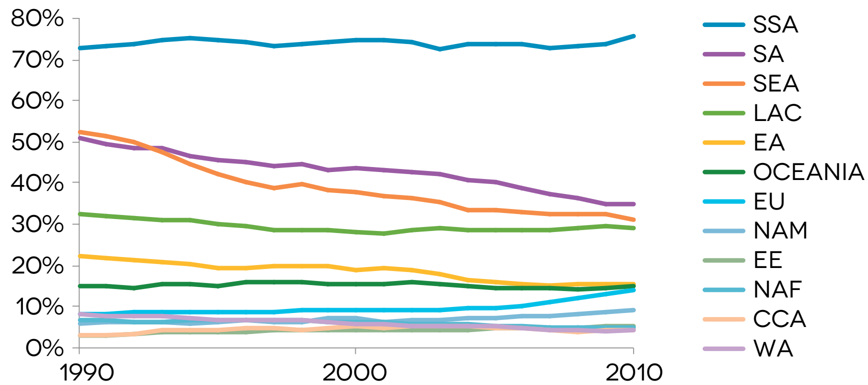

FIGURE O.22 **EVOLVING RENEWABLE ENERGY SHARE BY REGION, 1990–2010 (PERCENTAGE OF TOTAL FINAL ENERGY CONSUMPTION)**

SOURCE: IEA 2012A.
NOTE: TFEC = TOTAL FINAL ENERGY CONSUMPTION; RE = RENEWABLE ENERGY. CCA = CAUCASUS AND CENTRAL ASIA; EA = EASTERN ASIA; LAC = LATIN AMERICA AND CARIBBEAN; NAF = NORTHERN AFRICA; SEA = SOUTH-EASTERN ASIA; SA = SOUTHERN ASIA; SSA = SUB-SAHARAN AFRICA; WA = WESTERN ASIA; EU = EUROPE.

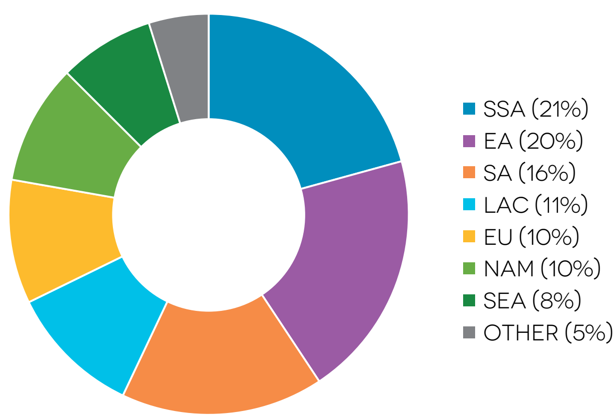

FIGURE O.23 **REGIONAL CONTRIBUTIONS TO GLOBAL RENEWABLE ENERGY 2010 (PERCENTAGE CONTRIBUTION TO THE GLOBAL SHARE OF RENEWABLE ENERGY IN TFEC)**

SOURCE: IEA 2012A.
NOTE: CCA = CAUCASUS AND CENTRAL ASIA; EA = EASTERN ASIA; LAC = LATIN AMERICA AND CARIBBEAN; NAF = NORTHERN AFRICA; SEA = SOUTH-EASTERN ASIA; SA = SOUTHERN ASIA; SSA = SUB-SAHARAN AFRICA; WA = WESTERN ASIA; EU = EUROPE; OTHER = ALL OTHER REGIONS.

If we confine attention to power generation only, the regional picture for the share of renewable energy in the electricity mix looks quite different. Latin America and Caribbean emerges as the region with by far the highest share of renewable energy in the electricity generation portfolio of 56 percent, which is more than twice the level in the next highest regions – Caucuses and Central Asia, Europe, Oceania and Sub-Saharan Africa – all of them above 20 percent. Globally, 80 percent of renewable electricity generation is found evenly spread across just four regions: East Asia, Europe, Latin America and Caribbean and North America.

High-impact opportunities

Substantial potential exists for further tapping of renewable energy sources. Studies have consistently found that the technical potential for renewable energy use around the globe is substantially higher than projected global energy demand in 2050. The technical potential for solar energy is the highest among the renewable energy sources, but there is also substantial untapped potential for biomass, geothermal, hydro, wind, and ocean energy. Available data suggest that most of this technical potential is located in the developing world. For instance, at least 75 percent of the world's unexploited hydropower potential is found in Africa, Asia, and South America, and about 65 percent of total geothermal potential is found in countries that are not members of the Organisation for Economic Co-operation and Development (OECD). The solar belt—that is, the tropical latitudes that have the highest solar irradiance across the globe—endows many developing countries with a high potential for solar-based power generation and heating.

Despite the major technical potential of renewable energy, large-scale adoption will ultimately depend on economic factors. The costs of renewable energy—particularly wind and solar—have been falling steeply and are expected to fall further as the scale of production increases. As a result, renewable energy sources—in particular hydropower, wind, and geothermal—are increasingly competitive in many environments, while solar energy is becoming competitive in some environments. Nevertheless, it is still challenging for renewable energy to compete financially with conventional fossil-fuel alternatives, particularly given that the local and global environmental impact of these conventional sources of energy is not fully reflected in costs. The further integration of renewable energy sources into the public electricity supply system also calls for more proactive expansion of both transmission grids and backup capacity for handling higher levels of variability in the production of wind and solar energy and this further adds to the associated cost. The relatively high capital costs of renewable energy, even when overall lifecycle costs may be lower, adds further to the financing challenge.

Fast-moving countries

Over the 20 years between 1990 and 2010, renewable energy technologies matured and became more widely adopted. Both developed and developing countries are increasingly motivated by the social benefits offered by renewable energy, including enhanced energy security, reduced greenhouse gas emissions and local environmental impacts, increased economic and industrial development, and more options for reliable and modern energy access. Today, about 120 countries—more than half of them developing countries—have a national target related to renewable energy. Moreover, 88 countries have introduced price- or quantity-based incentives for renewable energy. Just over half of those countries are in the developing world.

Almost 80 percent of renewable energy other than traditional biomass has been produced and consumed by high-income and emerging economies, most notably China, the United States, Brazil, Germany, India, Italy, and Spain (figure O.24). The technology of focus differs from case to case, with China focusing mainly on hydropower; the United States on liquid biofuels; Brazil, Germany, and India on modern biomass; and Spain on wind power. Those countries moving most rapidly, such as China and Germany, experienced average annual rates of growth of 8–12 percent in 1990–2010. As of 2010, the countries with the highest shares of renewable energy (excluding traditional biomass) were Norway, Sweden, and Tajikistan, where the shares were about 50 percent (figure O.25). Many other emerging countries—among them Argentina, Mexico, Turkey, Indonesia, Philippines, and a few African countries—are starting to show progress in adopting policies to scale up renewables.

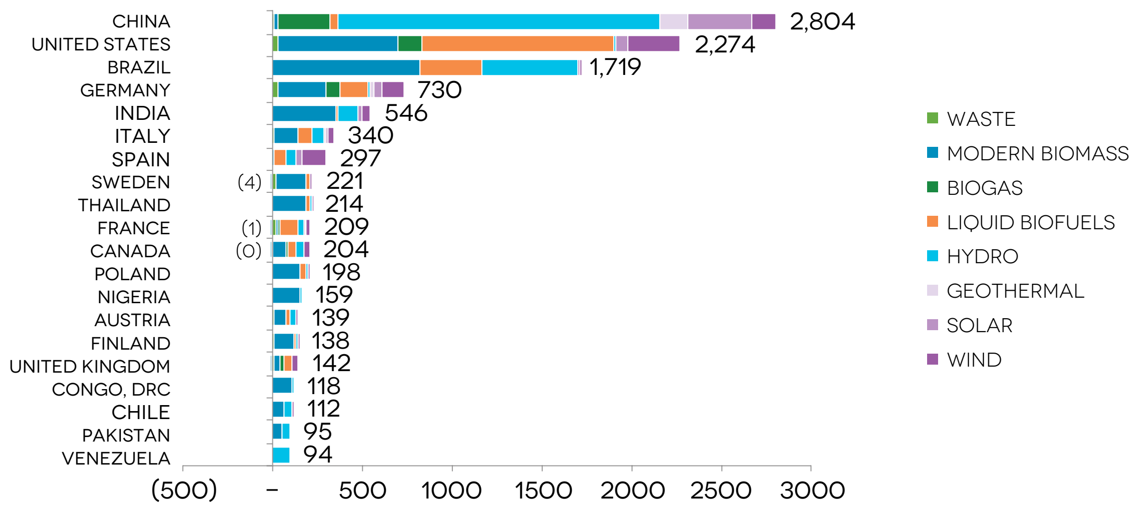

FIGURE O.24 **VOLUME OF INCREMENTAL CONSUMPTION OF RENEWABLE ENERGY (EXCLUDING TRADITIONAL BIOMASS), 1990–2010 (PETAJOULES)**

SOURCE: IEA 2012A.
NOTE: "INCREMENTAL CONSUMPTION" INDICATES ADDITIONAL CONSUMPTION OF RENEWABLE ENERGY OVER AND ABOVE THE LEVEL OF CONSUMPTION IN 1990. DRC = DEMOCRATIC REPUBLIC OF CONGO.

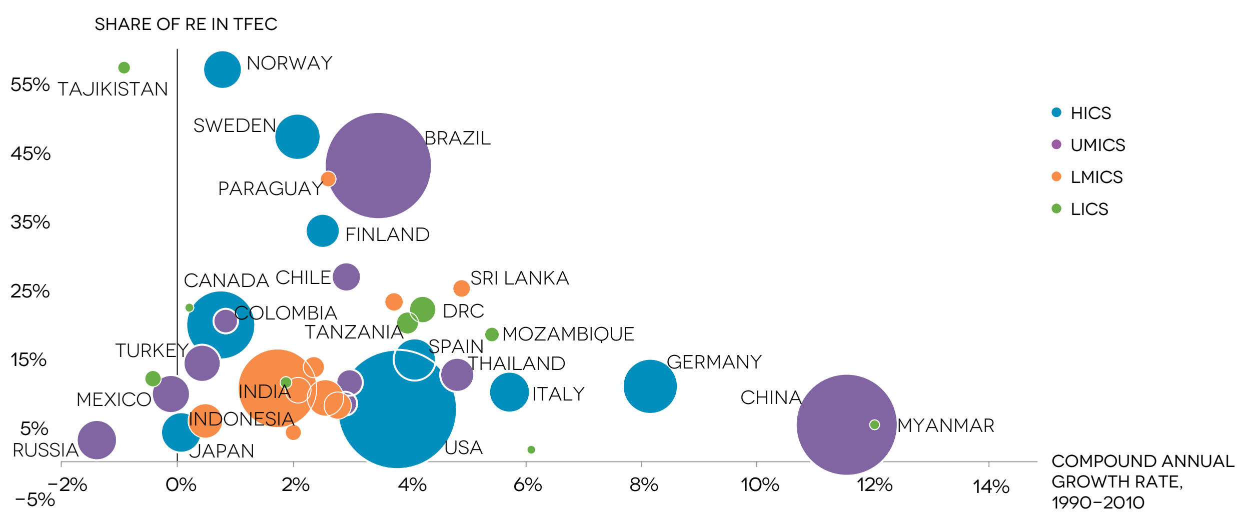

FIGURE O.25 **SHARE OF RENEWABLE ENERGY IN TOTAL FINAL ENERGY CONSUMPTION AND COMPOUND ANNUAL GROWTH RATE IN CONSUMPTION OF RENEWABLE ENERGY, 2000–10**

SOURCE: IEA 2012A.
NOTE: TFEC = TOTAL FINAL ENERGY CONSUMPTION; CAGR = COMPOUND ANNUAL GROWTH RATE; RE = RENEWABLE ENERGY. FIGURE EXCLUDES TRADITIONAL BIOMASS, BUT INCLUDES THE USE OF MODERN BIOMASS. CONGO AND TANZANIA APPEAR DUE TO THEIR HIGH USE OF MODERN BIOMASS IN THE INDUSTRIAL SECTOR. NEGATIVE CAGRS SHOWN DENOTE A REDUCTION IN THE USE OF NON-TRADITIONAL SOLID BIOMASS (MOST NOTABLY IN INDUSTRY) IN TURKEY, MEXICO, AND INDONESIA. UNLABELED BUBBLES REPRESENT COUNTRIES WITH A LOW SHARE OF RE IN TFEC AND A LOW CAGR.

Scale of the challenge

If current trends were to continue, the expansion of renewable energy would barely keep pace with the projected expansion of global energy demand. Consequently, the expected renewable energy share in 2030 would be no greater than 19.4 percent—barely one percentage point higher than it is today.

Furthermore, if current overall growth in energy demand continues, renewable energy consumption would have to triple, growing at an annual rate of 5.9 percent—or two and a half times the current growth rate—in order meet the target of doubling by 2030. Given that traditional biomass (representing about half of renewable energy use in 2010) is not expected to expand greatly, the annual growth rate for other forms of renewable energy would have to be in double digits.

By contrast, if overall energy demand were to stabilize (due to greater energy efficiency, for example), doubling the renewable energy contribution would require an annual growth rate of 3.5 percent, or a 50 percent increase over the levels observed in 1990–2010. This analysis highlights the critical linkage between the SE4ALL objectives for renewable energy and energy efficiency.

Several agencies and organizations have modeled scenarios of the evolution of renewable energy. These vary greatly in terms of their methodologies (that is, forecasting versus goal-seeking) as well as their assumptions about the prevailing policy environment. A review of energy modeling scenarios by the Intergovernmental Panel on Climate Change finds that more than half of 116 scenarios indicate a renewable energy share in total primary energy supply of less than 17 percent by 2030, with the highest cases projecting a renewable energy share of 43 percent (figure O.26). Those scenarios in which renewable energy shares rise above the 30 percent mark typically assume a strong package of policy measures, such as elimination of fossil -fuel subsidies, imposition of carbon pricing, aggressive pursuit of energy efficiency, sustained support for research and development of emerging renewable technologies, and the advent of advanced transport fuels and technologies.

Achieving the SE4ALL renewable energy objective within a supportive policy environment will call for sustained global investments in the range of $250 to $400 billion per year, depending on the pace of growth in energy demand. Financing for renewable energy rose exponentially in 2000–2010, reaching $277 billion in 2011. Only the last four years of this period, however, saw an investment exceeding the bottom of the required range; the total investment over the ten-year period amounted to an annual average of just $120 billion.

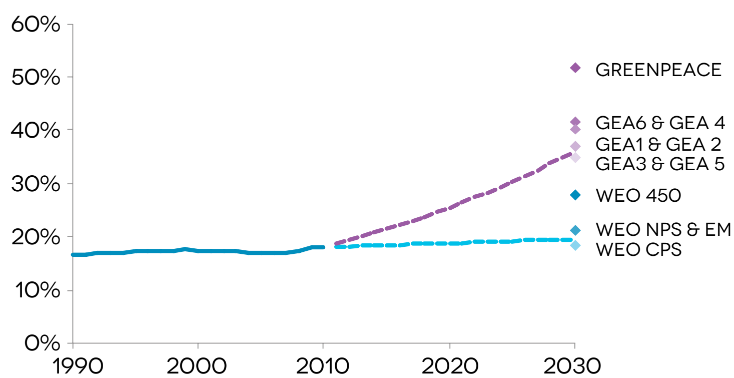

FIGURE O.26 **PROJECTIONS OF SHARE OF RENEWABLE ENERGY IN TFEC, 1990–2030**

% RE – HISTORICAL % RE – TRENDS CONTINUED % RE – SE4ALL TARGET GROWTH RATE

SOURCE: IEA (2012B): GREENPEACE INTERNATIONAL (2012); IIASA (2012); EXXONMOBIL (2012).
NOTE: TFEC = TOTAL FINAL ENERGY CONSUMPTION; RE = RENEWABLE ENERGY; WEO = WORLD ENERGY OUTLOOK; GEA = GLOBAL ENERGY ASSESSMENT; NPS = NEW POLICIES SCENARIO (IEA); CPS = CURRENT POLICIES SCENARIO (IEA); EM = EXXONMOBIL; SEFA = SUSTAINABLE ENERGY FOR ALL (SE4ALL).

The way forward

On the basis of the Global Tracking Framework, it is possible to establish the following starting points against which progress will be measured under the SE4ALL initiative: the rate of access to electricity and primary non-solid fuel will have to increase from 83 and 59 percent in 2010, respectively, to 100 percent by 2030; the rate of improvement of energy intensity will need to double from –1.3 percent in 1990–2010 to –2.6 percent in 2010–30; and the share of renewable energy in the global energy mix will need to double from an estimated 18 percent in 2010 to up to 36 percent by 2030 (table O.3).

	OBJECTIVE 1		OBJECTIVE 2	OBJECTIVE 3
	Universal access to modern energy services		Doubling global rate of improvement of energy efficiency	Doubling share of renewable energy in global energy mix
Proxy indicator	Percentage of population with electricity access	Percentage of population with primary reliance on non-solid fuels	Rate of improvement in energy intensity*	Renewable energy share in TFEC
Historic reference 1990	76	47	–1.3	16.6
Starting point 2010	83	59		18.0
Objective for 2030	100	100	–2.6	36.0

TABLE O.3 **SE4ALL HISTORIC REFERENCES, STARTING POINTS, AND GLOBAL OBJECTIVES (%)**

SOURCE: AUTHORS.
NOTE: TFEC = TOTAL FINAL ENERGY CONSUMPTION
*Measured in primary energy terms and GDP at purchasing power parity

While progress in all countries is important, achievement of the global SE4ALL objectives will depend critically on progress in the 20 high-impact countries that have a particularly large weight in aggregate global performance. Two overlapping groups of 20 high-impact countries in Asia and Africa account for about two-thirds of the global electrification deficit and four-fifths of the global deficit in access to non-solid fuels (figure O.27). Meeting the universal access objective globally will depend to a considerable extent on the progress that can be supported in these countries. A third group of 20 high-income and emerging economies accounts for four-fifths of global energy consumption. Therefore, the efforts of those high-impact countries to accelerate improvements in energy efficiency and develop renewable energy will ultimately determine the global achievement of the corresponding targets.

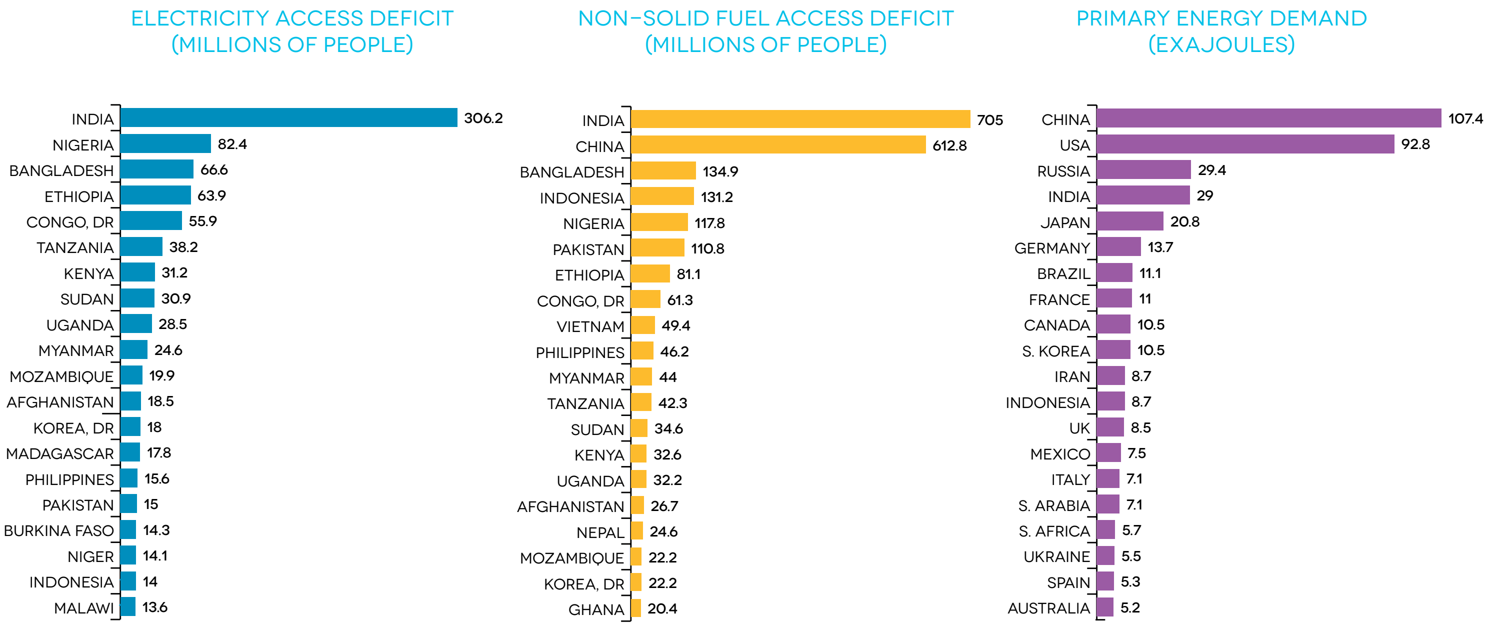

FIGURE O.27 **OVERVIEW OF HIGH-IMPACT COUNTRIES**

SOURCE: IEA, WB GLOBAL ELECTRIFICATION DATABASE, WHO GLOBAL HOUSEHOLD ENERGY DATABASE.
NOTE: DR = "DEMOCRATIC REPUBLIC OF."

In charting a course toward the achievement of the SE4ALL objectives, it will also be important to learn from the experience of the fast-moving countries that made the most progress during the 20 years between 1990 and 2010 (figure O.28). China and (to a lesser extent) India stand out as both high-impact and fast-moving countries on all three aspects of energy sector development.

In the case of electrification and cooking, even the most rapidly moving countries have not expanded access by more than 3–4 percentage points annually. In the case of energy efficiency, the countries with the most rapid improvements in energy intensity have seen CAGRs of minus 4–8 percent annually. In the case of renewable energy, the most rapidly moving countries experienced CAGRs of 10–20 percent (excluding traditional biomass).

AVERAGE ANNUAL RATE OF IMPROVEMENT (%)	GLOBAL AVERAGE	FAST MOVING COUNTRIES
Electrification	1.2	2.5 to 3.7
Non-solid fuel use	1.1	2.2 to 4.0
Energy intensity	1.3	3.9 to 11.9
Renewable energy [w/o trad. biomass]	3.0	7.0 to 18.2

TABLE O.4 **FAST MOVING COUNTRIES RELATIVE TO GLOBAL AVERAGE, AVERAGE ANNUAL RATE OF IMPROVEMENT (%)**

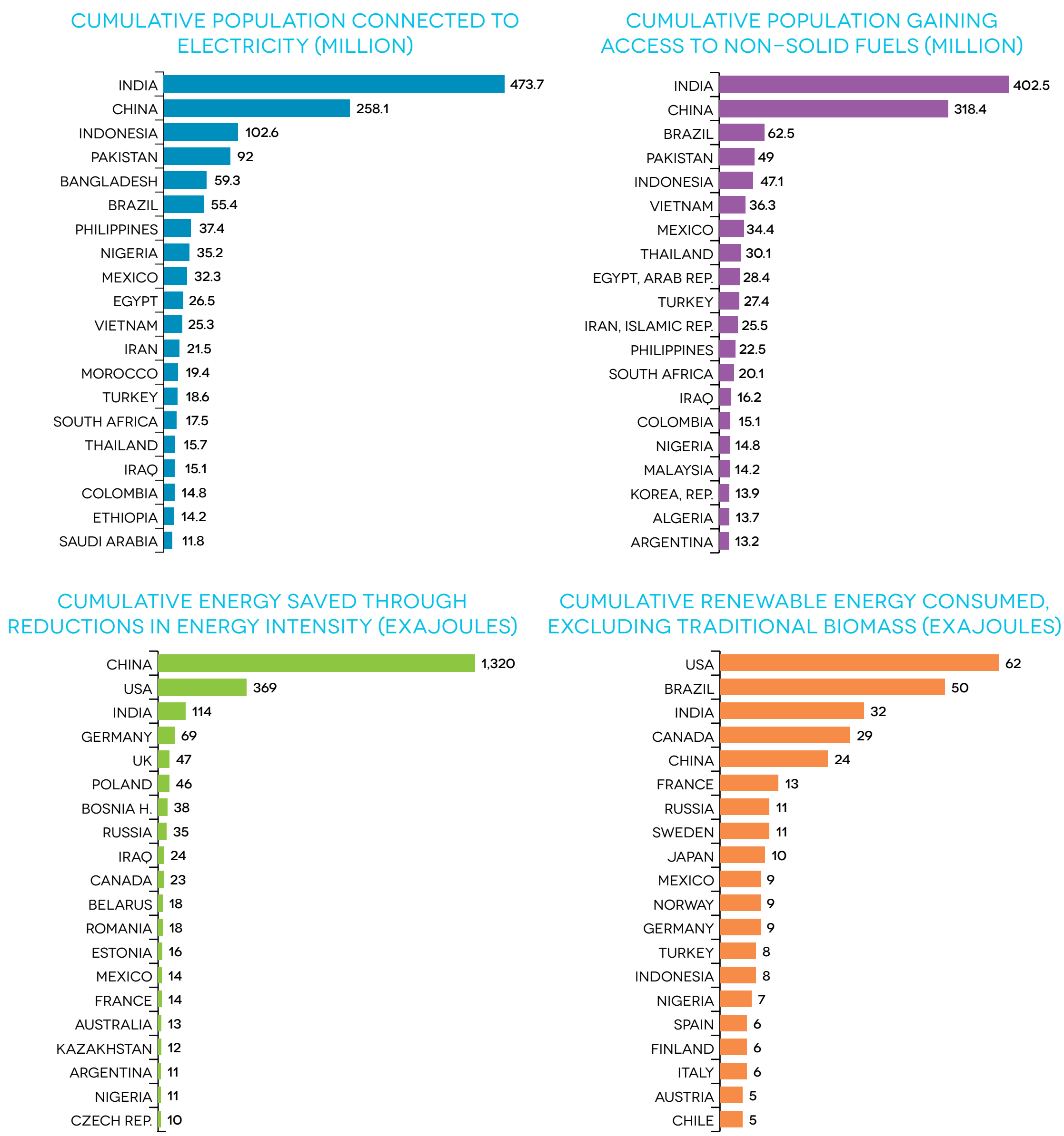

FIGURE O.28 **OVERVIEW OF FAST MOVING COUNTRIES (1990–2010)**

SOURCE: IEA, UN, WB GLOBAL ELECTRIFICATION DATABASE, WHO GLOBAL HOUSEHOLD ENERGY DATABASE.
NOTE: BOSNIA H. = BOSNIA AND HERZEGOVINA.

Global energy model scenarios enable us to gauge the scale of the global challenge of achieving the SE4ALL objectives. Based on these scenarios, it is clear that business as usual will not suffice (table O.4). With regard to universal access, business as usual would leave 12–16 percent and 31–36 percent of the world's population in 2030 without electricity and non-solid fuels, respectively. Implementing all currently available energy efficiency measures with reasonable payback periods would be enough to meet or even exceed the SE4ALL objective. However, numerous barriers prevent wider adoption of many of those measures, so that the current uptake ranges from around 20 percent for power generation and building construction to around 40 percent for manufacturing and transportation. Furthermore, few scenarios point to renewable energy shares above 30 percent by 2030.

Existing global investment in the areas covered by the three SE4ALL objectives was estimated at around $400 billion in 2010 (table O.5). The additional annual investments required to achieve the three objectives are tentatively estimated to be at least $600–800 billion—a doubling or tripling of current levels. The bulk of those investments is associated with the renewable energy and energy efficiency objectives, with access-related expenditures representing a relatively small share (10–20 percent) of the incremental costs.

The global energy models also help to clarify the kinds of policy measures that would be needed to reach the Secretary General's three sustainable energy objectives. The WEO and GEA coincide in highlighting the importance of phasing out fossil-fuel subsidies, adopting measures to provide price signals for carbon, embracing stringent technology standards for energy efficiency, and carefully designing and targeting subsidies to increase access.

In addition, global models help to clarify the likely pattern of efforts to achieve the SE4ALL objectives across geographical regions based on starting points, potential for improvement, and comparative advantage. On energy access, greatest efforts are needed in Sub-Saharan Africa and South Asia. For energy efficiency, the highest rates of improvement are projected at around –4 percent annually in Asia (particularly China) and the countries of the former Soviet Union. For renewable energy, Latin America and Sub-Saharan Africa (with its strong reliance on traditional biomass) emerge as the regions projected to reach the highest share of renewable energy in 2030—in excess of 50 percent, compared to the 20–40 percent range in much of the rest of the world (table O.6).

	OBJECTIVE 1		OBJECTIVE 2	OBJECTIVE 3
	Universal access to modern energy services		Doubling global rate of improvement of energy efficiency	Doubling share of renewable energy in global mix
Percentage in 2030	Population with electricity access	Population with primary reliance on non-solid fuels	Global rate of improvement in energy intensity*	Renewable energy share in total final energy consumption
IEA scenarios				
New policies	88	69	–2.3	20
Efficient world	88	69	–2.8	22
450	n.a.	n.a.	–2.9	27
GEA scenarios				
Baseline	84	64	–1.0	12
GEA Pathways	100	100	–3.0 to –3.2	34 to 41
2^0 Celsius	n.a.	n.a.	–1.8 to –3.2	23 to 41

TABLE O.5 **OVERVIEW OF PROJECTED OUTCOMES FOR 2030 FROM IEA WORLD ENERGY OUTLOOK AND IIASA GLOBAL ENERGY ASSESSMENT**

SOURCE: IEA (2012) AND IIASA (2012).
n.a. = NOT APPLICABLE.

* IEA scenarios are presented in primary energy terms while GEA scenarios in final energy terms (GDP at purchasing power parity in both cases)

	OBJECTIVE 1		OBJECTIVE 2	OBJECTIVE 3	
Average annual investment 2010–30 (US$ billion)	Universal access to modern energy services		Doubling global rate of improvement of energy efficiency	Doubling share of renewable energy in global mix	Total
	Electrification	Cooking	Energy efficiency	Renewable energy	
Actual for 2010	9.0	0.1	180	228	417.1
Additional from WEO	45.0	4.4	393	>>174	>>616.4*
Additional from GEA	15.0	71.0	259–365	259–406	604–858**

TABLE O.6 **OVERVIEW OF PROJECTED ANNUAL INVESTMENT NEEDS FOR 2010–2030 FROM WORLD ENERGY OUTLOOK AND GLOBAL ENERGY ASSESSMENT**

SOURCE: IEA (2012) AND IIASA (2012).

* WEO estimates are taken to be those closest to the corresponding SE4ALL objective: the Energy for All Scenario in the case of universal access, the Efficient World Scenario in the case of energy efficiency, and the 450 Scenario in the case of renewable energy. The 450 Scenario corresponds to a 27 percent renewable energy share, which is significantly below the SE4ALL objective. The Efficient World Scenario corresponds to a –2.8 percent CAGR for global energy intensity, which is significantly above the SE4ALL objective.

** GEA estimates that a further $716–910 billion would be needed annually for complementary infrastructure and broader energy sector investments not directly associated with the three objectives.

	Objective 1				Objective 2		Objective 3	
	Universal access to modern energy services				Doubling global rate of improvement of energy efficiency		Doubling share of renewable energy in global mix	
	Percentage of population with electricity access		Percentage of population with primary reliance on non-solid fuels		Rate of improvement in energy intensity*		Renewable energy share in total final energy consumption	
	2010	SE4ALL	2010	SE4ALL	1990–2010	SE4ALL	2010	SE4ALL
Sub-Saharan Africa	32	100	19	100	1.1	2.2–2.4	56	60–73
Centrally Planned Asia	98	100	54	100	5.2	3.6–3.9	17	27–31
Central and Eastern Europe	100	100	90	100	3.1	2.6–3.0	8	28–36
Former Soviet Union	100	100	95	100	2.4	3.7–4.3	6	27–48
Latin America and Caribbean	95	100	86	100	0.7	2.6–3.0	25	49–57
Middle East and North Africa	95	100	99	100	-0.9	1.8–2.1	3	13–17
North America	100	100	100	100	1.7	2.4–2.6	8	26–34
Pacific OECD	100	100	100	100	0.7	2.9–3.4	6	30–41
Other Pacific Asia	89	100	57	100	1.2	3.6–4.0	18	30–37
South Asia	74	100	38	100	2.9	2.7–2.9	47	25–32
Western Europe	100	100	100	100	1.1	3.2–3.5	11	27–43
World	83	100	59	100	1.5	3.0–3.2	17	34–41

TABLE O.7 **GLOBAL ENERGY ASSESSMENT: REGIONAL PROJECTIONS UNDER SE4ALL SCENARIOS**

SOURCE: IIASA (2012). ACCESS TO ELECTRICITY FOR 2010 IS FROM WB GLOBAL ELECTRIFICATION DATABASE, 2012. ACCESS TO NON-SOLID FUEL FOR 2010 IS FROM WHO GLOBAL HOUSEHOLD ENERGY DATABASE, 2012.

* Measured in final energy terms and GDP at purchasing power parity

Moreover, the global energy models clarify how the three SE4ALL objectives interact with one another and contribute to addressing global concerns, such as climate change. The IEA finds that energy efficiency and renewable energy are mutually reinforcing—neither one on its own is sufficient to contain global warming to 2°C. Furthermore, achieving universal access to modern energy would lead to a negligible increase—only 0.6 percent—of global carbon dioxide emissions. The GEA estimates that the probability of limiting global warming to 2°C increases to between 66 and 90 percent when the SE4ALL objectives for renewable energy and energy efficiency are simultaneously met, higher than if either objective was met individually (Rogelj and others 2013). The achievement of the universal access objective for modern cooking, which would increase reliance on typically fossil-fuel-based and non-solid fuels for cooking, would have a small offsetting effect, reducing the share of renewable energy in the global mix by some two percentage points, with a negligible impact on the probability of achieving the 2°C target.

In conclusion, the Global Tracking Framework has constructed a robust data platform capable of monitoring global progress toward the SE4ALL objectives on an immediate basis, subject to improvement over time. Looking ahead, the consortium of agencies that has produced this report recommends a biannual update on the status of the three SE4ALL objectives that will build on this framework.

While the methodology here developed provides an adequate basis for basic global tracking, there are a number of significant information improvements that would be desirable to implement in the medium term. To effectively monitor progress through 2030 incremental investments in energy data systems will be essential over the next five years, both at the global and national levels. These represent relatively cost-effective high-impact improvements, whose implementation would be contingent on the availability of financial resources. For energy access, the focus will be to go beyond binary measures to a multi-tier framework that better captures the quantity and quality of electricity supplied, as well as the efficiency, safety, and convenience of the cookstoves that are used for cooking, including those that make use of biomass. For energy efficiency, the main concern is to strengthen country capacity to produce more disaggregated data on sectoral and subsectoral energy consumption that are fully integrated with associated output measures from the key energy consuming sectors. In the case of renewable energy, the main priority will be to improve the ability to gauge the sustainability of different forms of renewable energy, and most particularly the use of traditional biomass. These are all required to ensure that high-performing policies are developed that effectively target tangible results. Developing the capability of countries to develop and respond to such improved indicators is in itself a significant task.

Finally, given the scale of the challenge inherent in meeting the three SE4ALL objectives for energy, it is clear that a combination of bold policy measures with a supportive regulatory and institutional environment is required to support the requisite ramp-up of delivery capacity and financial flows to the sector. A detailed analysis of the policy environment at the country level lies beyond the immediate scope of this Global Tracking Framework, which has focused on the monitoring of global progress toward outcomes. Such an analysis, however, would be an important focus for future work in support of the SE4ALL initiative.

	RECOMMENDED TARGETING OF EFFORT OVER NEXT FIVE YEARS
Energy access	Work to improve energy questionnaires for global networks of household surveys. Pilot country-level surveys to provide more precise and informative multi-tier measures of access to electricity and clean cooking Develop suitable access measures for heating.
Energy efficiency	Integrate data systems on energy use and associated output measures. Strengthen country capacity to collect data on sectoral (and ideally subsectoral process) intensities. Improve data on physical activity drivers (traffic volumes, number of households, floor space, etc.). Improve data on energy efficiency targets, policies, and investments.
Renewable energy	Improve data and definitions for bio-energy and sustainability. Capture renewable energy used in distributed generation. Capture renewable energy used off-grid and in micro-grids. Promote a more harmonized approach to target-setting.

TABLE O.8 **MEDIUM-TERM AGENDA FOR THE IMPROVEMENT OF GLOBAL ENERGY DATABASES**

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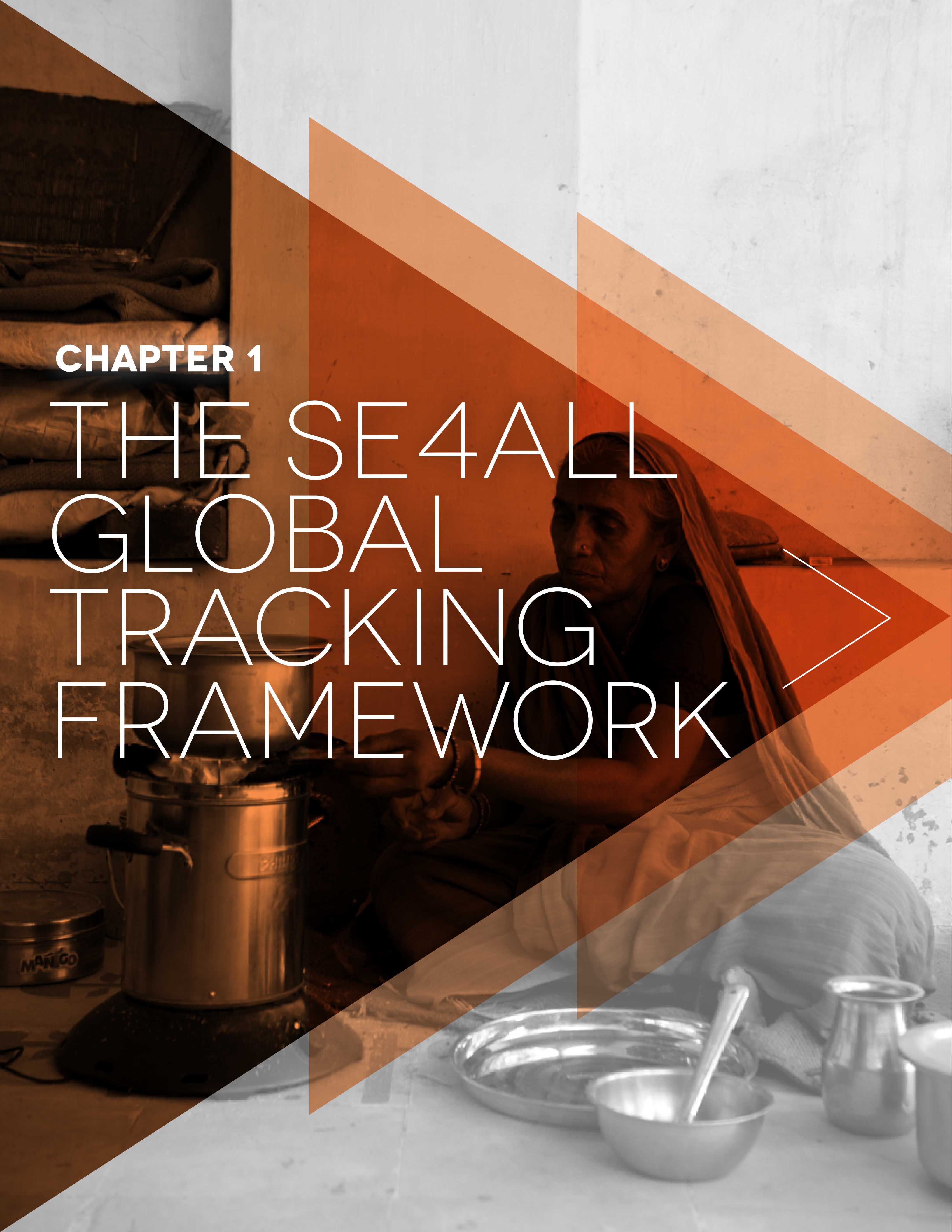


CHAPTER 1

THE SE4ALL GLOBAL TRACKING FRAMEWORK

CHAPTER 1: THE SE4ALL GLOBAL TRACKING FRAMEWORK

At the behest of the UN Secretary General, the UN General Assembly declared 2012 the International Year of Sustainable Energy for All. The Secretary General's Sustainable Energy for All (SE4ALL) initiative has three critical objectives to be achieved globally by 2030: (i) to ensure universal access to modern energy services; (ii) to double the global rate of improvement in energy efficiency; and (iii) to double the share of renewable energy in the global energy mix.

SE4ALL is rapidly establishing itself as a catalyst for public-private action toward the achievement of the Secretary General's three declared energy objectives. At the UN Conference on Sustainable Development in Rio de Janeiro (Rio+20) in June 2012, more than 60 countries opted into SE4ALL; that number has subsequently risen above 70. In addition, corporations and agencies have pledged tens of billions of dollars to the initiative. This combined effort will amount to an expansion of energy access to hundreds of millions of people worldwide. As 2012 drew to a close, the UN General Assembly announced that 2014–24 would be the Decade of Sustainable Energy for All.

The need for a global tracking framework

Given the need to sustain global attention on the SE4ALL objectives over the 20 years to 2030, it was soon recognized that a mechanism to track global progress from the starting point would be an important component of the initiative. The mechanism would also enable tracking of country-level information and therefore allow stakeholders to highlight successful experiences and identify areas where additional effort may be needed.

The resulting Global Tracking Framework complements the SE4ALL initiative's accountability framework, which provides transparent recognition and tracking of voluntary commitments to the initiative by specific institutions, thereby facilitating feedback, learning, and action. At the level of individual commitments, stakeholders are responsible for establishing milestones to record their progress for annual reporting.

The Global Tracking Framework was commissioned by the original SE4ALL High-Level Group, which has since been replaced by the SE4ALL Advisory Board. The objectives set for the Global Tracking Framework were three: (i) to build consensus among all relevant institutions about the best methodology for tracking progress toward the three SE4ALL objectives through 2030; (ii) to apply that methodology, with the year 2010 as the starting point for the three objectives; and (iii) to provide a road map for the gradual improvement of the Global Tracking Framework through 2030.

Responsibility for the development of the Global Tracking Framework was assigned to a Steering Group of international energy-knowledge institutions with a history of strong engagement in the SE4ALL initiative. The Steering Group is co-chaired by the World Bank/Energy Sector Management Assistance Program (ESMAP) and the International Energy Agency (IEA). Its members are:

- Global Alliance for Clean Cookstoves ("the Alliance")
- International Institute for Applied Systems Analysis (IIASA)
- International Partnership for Energy Efficiency Cooperation (IPEEC)
- International Renewable Energy Agency (IRENA)
- Practical Action
- Renewable Energy Network for the 21st Century (REN21)
- UN Energy
- UN Foundation
- United Nations Development Programme (UNDP)
- United Nations Environment Programme (UNEP)
- United Nations Industrial Development Organization (UNIDO)
- World Energy Council (WEC)
- World Health Organization (WHO)

Global versus country objectives

The three SE4ALL objectives are conceived of as global objectives, applying to both developed and developing countries, with individual nations setting their own domestic targets in a way that is consistent with the overall spirit of the initiative, depending on where they can make the greatest contribution to the global effort. Some countries may be able to set national targets that are more ambitious than the global ones, while the energy situation of others may restrict them to more modest targets.

For example, energy access remains a pressing concern in many low- and middle-income countries. In high-income countries, on the other hand, universal access to modern energy has largely been achieved, even if some challenges of energy poverty may remain.

In many cases, improving energy efficiency is the cheapest way to expand the energy supply. Once again, however, the potential to improve energy efficiency varies significantly across countries depending on the structure of their economies, the nature of their climate and, in particular, how aggressively they have pursued energy efficiency policies in the past.

For many developed and developing countries, renewable energy offers promise as a means of improving energy security, reducing the environmental impact of energy use, and promoting economic development. The availability of renewable energy resources around the globe varies greatly in extent and composition, however, affecting the degree to which individual countries may scale up the contribution of renewable energy to their overall energy mix.

Already, more than 70 countries have opted into the SE4ALL initiative. These countries are developing individual country action plans in which they will articulate their own national targets within the context of the global SE4ALL framework. Overall, if all countries make their best efforts in the areas in which they have the most to contribute the global targets may be attained.

The interconnected SE4ALL objectives

The three SE4ALL objectives—though distinct—were conceived as an integrated whole. The three objectives are mutually supportive. In other words, it is more feasible to achieve the three objectives together than it would be to pursue them individually.

To illustrate this idea, consider the links between energy access and energy efficiency. The achievement of universal energy access contributes to boosting energy efficiency and becomes more feasible as a result of advances in energy efficiency. For example, a significant share of global energy consumption is traceable to household cooking and heating, yet in many developing countries the traditional methods used to do so have thermal efficiencies as low as 10–20 percent. Providing universal access to modern cooking solutions can help to shift households away from cooking on open fires in favor of improved cooking stoves and non-solid fuels, which would significantly improve a given country's overall energy efficiency. At the same time, on the electricity side, improvements in energy efficiency enable existing power generation capacity to go further, thereby leaving more energy available to meet the need for basic electricity access. Finally, improved energy efficiency makes energy more affordable by reducing the implicit price of energy services, which helps to support the expansion of access.

Improving energy efficiency also has the potential to arrest the growth of global energy consumption, making it possible to meet the SE4ALL objective of doubling the contribution of renewable energy with a lower level of installed capacity.

Improvements in energy access and renewable energy are also fundamentally related. The rollout of renewable energy technologies, such as mini-grids and home systems, opens up new possibilities for providing electricity to the most remote and dispersed populations. Furthermore, as part of the transition to modern cooking solutions, some households will substitute unsustainable forms of traditional biomass (such as wood and charcoal) for more sustainable forms (such as wood pellets). Other households will eventually substitute solid fuels derived from renewable biomass for non-solid fuels (such as liquid petroleum gas) that are fossil-fuel based, however, with potentially offsetting effects on the share of renewable energy.

Toward a global tracking framework

Concepts, data, and methodology

While the three SE4ALL pillars—energy access, energy efficiency, and renewable energy—make sense intuitively, a formal Global Tracking Framework necessitates rigorous technical definitions of improvement in those areas that can be measured consistently across countries and over time. In the case of energy access, even coming up with a definition is conceptually challenging and subject to ongoing technical debate. In the case of energy efficiency, direct measurement is very demanding in data terms, and it may be necessary to rely on proxies such as energy intensity. In the case of renewable energy, on the other hand, deciding on a definition may be more straightforward, but choices still have to be made between alternative technical measures (with regard to sustainability, for example).

Providing rigorous technical definitions surely comes with significant challenges, but these are no greater in complexity than those faced in many other areas of development—such as poverty, human health, or water and sanitation—where the global community has already pushed ahead in tracking global progress.

The development of sound technical definitions must necessarily be informed by a thorough understanding of the different global databases that are currently available. However compelling a definition may be, it is of little use for global tracking if corresponding time series data are unavailable for the vast majority of the countries involved. In the case of energy efficiency, for example, very detailed indicators are available for a small group of countries, but these data are of limited value for global tracking. There is often a trade-off, therefore, between the precision of an indicator and the scope of country coverage. The development of a tractable definition requires an iterative process that shuttles between the underlying concepts of interest and the constraints of data availability. Accordingly, the next three chapters will map out the conceptual issues involved in the definition of indicators, review the availability of relevant global databases, and propose an accommodation of the two.

While the immediate basis for global tracking is constrained by what is already available, the quality and scope of global energy databases can be improved over time. To that end, this report also identifies incremental improvements to global energy databases that would significantly improve the resolution of the global tracking process and that could be implemented in a five-year, medium-term scenario. Each chapter distinguishes between the immediate tracking methodology and the proposed medium-term improvements (table 1.1). A detailed road map for ongoing improvements to global tracking will be presented in the closing chapter.

In some cases, the development of global energy databases with the ideal level of detail and disaggregation desired for tracking purposes may be beyond the realm of feasibility, even over a five-year period. Nevertheless, as mentioned above, SE4ALL is designing country action plans and programs for the countries that have opted into the initiative. It is highly desirable that these country action programs use a standardized tracking framework, one that is consistent with the Global Tracking Framework while still allowing for a more refined and detailed account of the countries' individual energy situation. Therefore, each chapter will also identify which indicators may best be captured at the country level.

	IMMEDIATE	MEDIUM-TERM
Global tracking	Indicators already available for global tracking, with all data needs (past, present, and future) already fully met	Indicators highly desirable for global tracking but that require a feasible incremental investment in global energy data systems over the next five years
Country-level tracking	Not applicable	Indicators ideal for country tracking but too ambitious for global tracking

TABLE 1.1 **FRAMEWORK FOR IDENTIFYING SUITABLE GLOBAL AND COUNTRY-LEVEL TRACKING INDICATORS**

While the main focus of the methodology will be on the development of a headline global tracking indicator, supporting indicators may also be helpful or necessary to interpret the headline indicator. For example, the headline indicator proposed to proxy for economy-wide energy efficiency will be complemented by measures of energy intensity in four key sectors of the economy. In other cases, tracking of complementary indicators can indicate that intermediate steps are being taken that should support more rapid progress over time. For example, in the case of renewable energy, it is important to track policy commitments and technology costs, which are key drivers of the scaling up of renewable energy.

Historic trends and a starting point

The year 2010 was chosen as a starting point for SE4ALL because it is the most recent year for which all necessary data were available at the time of writing the report. It also provides a round 20-year period (2010–30) over which progress on the SE4ALL initiative can be charted. Once the methodology for choosing indicators is defined and the appropriate data sources identified, it becomes possible to compute starting-point indicators for the year 2010, against which progress can be tracked. The chapters that follow will report the reference indicators for each of the initiative's three objectives—both globally and for large geographical and income groupings—to improve understanding of the variation around the current global average.

The starting-point indicators become much more meaningful when they are placed in the context of recent historical trends. Subsequent chapters will show trends for the 20 years leading up to 2010. Ultimately, an examination of progress over the past two decades will help to clarify what has been achieved and to permit comparisons with what needs to be achieved over the next 20 years if the SE4ALL objectives are to be met.

Country performance

The SE4ALL objectives are global, and progress toward them will be evaluated on a global basis. At the same time, global progress reflects the sum of efforts across the countries involved. Accelerating progress toward the achievement of the SE4ALL objectives requires targeting efforts where they are likely to have the greatest impact, as well as identifying countries that have made rapid progress in the past and that may have valuable experiences to share with others. Countries will need to understand their respective starting points to inform their individual target-setting processes. For these reasons, the report provides a data annex that lists starting point indicators for the more than 180 countries for which data are available. This is accompanied by an on-line database on the World Bank's World Development Indicators platform where all the global tracking indicators can be downloaded: http://data.worldbank.org/data-catalog.

In order to draw attention to high-impact countries, subsequent chapters will identify countries that have the greatest opportunity to make substantial progress on any of the SE4ALL objectives, particularly those whose efforts will have greatest impact on the achievement of the global targets. Ongoing international efforts must pay special attention to addressing the challenges faced by these high-impact countries and providing the support necessary for further progress; without success in these countries, the global targets are unlikely to be reached.

Many countries are already doing well and have been making rapid progress on one or more of the three energy objectives. These fast-moving countries can provide others with policy lessons and concrete experience on the ground. The global effort to achieve the three SE4ALL objectives will need to reflect a clear understanding of what has worked in these countries and why. Facilitation of knowledge exchanges between fast-moving and high-impact countries promises to be particularly valuable.

The good news is that some countries are both high-impact and fast-moving, which suggests that opportunities for progress are already being seized.

The scale of the challenge

How difficult will it be to reach the SE4ALL objectives? Comparing the road ahead with that already travelled provides some sense of the scale of the challenge. In addition, important insights can be gleaned by examining some of the major recent global energy modeling exercises that project future trends in energy access, energy efficiency, and renewable energy.

The outcomes of these modeling exercises ultimately depend on underlying assumptions about technological change, policy adoption, and finance. Some, such as the IEA's World Energy Outlook, focus on projecting trends from the underlying variables and gauging the resulting impact on energy-system outcomes. Others, such as the IIASA's Global Energy Assessment, focus more on setting specific targets for the global energy system and determining the technology, policy, and financing inputs that would make reaching those targets feasible. In both cases, the results are highly informative, even if direct comparisons between models may not be possible (box 1.1).

This report will draw on this important body of material to ascertain how challenging it will be to meet the SE4ALL targets. In particular, it will examine what combinations of technology, policy, and finance may be needed for success. The models can also inform understanding of the relationship between the three objectives and their potential for mutual reinforcement. Finally, they can help to clarify how the achievement of different objectives is likely to draw differentially on different regions of the world, based on their starting points and comparative advantages.

It was not possible within the time available to prepare the report to commission modeling exercises of scenarios designed specifically for the Global Tracking Framework. Instead, the report relies on preexisting scenarios, many of which are related to SE4ALL. As a result, however, the reporting of results is limited to what is already available in the literature and could not be standardized within this report.

BOX 1.1. Global energy projections as a tool for understanding the scale of the SE4ALL challenge

The IEA's World Energy Model

The World Energy Model (WEM) is a large-scale model designed to simulate energy markets. It is the principal tool used to generate detailed sector-by-sector and region-by-region projections for the World Energy Outlook (WEO) scenarios. Developed over many years, the model consists of four main modules: final energy consumption (covering residential services, agriculture, industry, transport, and nonenergy use); energy transformation, including power generation and heat, refinery/petrochemicals, and other transformation; biomass supply; and fossil-fuel supply. The model's outputs include energy flows by fuel, investment needs and costs, CO_2 emissions, and end-user pricing. It is a partial equilibrium model; major macroeconomic assumptions are exogenously determined.

The WEM is data intensive and covers the whole global energy system. Much of the data on energy supply, transformation and demand, and energy prices is obtained from the IEA's own databases of energy and economic statistics. Various external sources provide additional data.

The current version of WEM covers energy developments in 25 regions through 2035. Twelve large countries are individually modeled. The WEM is designed to analyze:

- *Global and regional energy prospects.* These include trends in demand, supply availability and constraints, international trade, and energy balances by sector and by fuel through 2035.

- *Environmental impact of energy use.* Estimates of CO_2 emissions from fuel combustion are derived from the projections of energy consumption. Greenhouse gases and local pollutants are also estimated in order to link WEM with other models.

- *Effects of policy actions and technological changes.* Alternative scenarios analyze the impact of policy actions and technological developments on energy demand, supply, trade, investments, and emissions.

- *Investment in the energy sector.* The model evaluates investment requirements in the fuel supply chain needed to satisfy projected energy demand through 2035. Alternative scenarios also evaluate demand-side investment requirements.

The WEM covers energy supply, energy transformation, and energy demand. The majority of the end-use sectors use stock models to characterize the energy infrastructure. In addition, energy-related CO_2 emissions and investment in energy developments are specified. Though the general model is built up as a simulation model, specific costs play an important role in determining the share of technologies in satisfying energy service demand. In some parts of the model, Logit and Weibull functions are used to determine the share of technologies based on their specific costs. This includes investment costs, operating and maintenance costs, fuel costs and, in some cases, the costs of emitting CO_2.

The main exogenous assumptions of the model concern economic growth, demographics, international fossil-fuel prices, and technological developments. Electricity consumption and electricity prices dynamically link the final energy demand and transformation sector. Demand for primary energy is an input for the supply modules. Complete energy balances are compiled at a regional level, and the CO_2 emissions of each region are then calculated using derived CO_2 factors. The time horizon of the model goes out to 2035, with annual time steps. Each year, the model is recalibrated to the latest available data point.

Main model outputs and data of the WEO scenarios can be downloaded from:
http://www.worldenergyoutlook.org/weomodel/.

The IIASA's Global Energy Assessment

IIASA's MESSAGE model was used for the development of the Global Energy Assessment (GEA) scenarios. MESSAGE is a systems engineering model for medium- to long-term energy-system planning, energy-policy analysis, and scenario development. The model represents the energy system in detail, from resource extraction, trade, conversion, transport, and distribution, to the provision of energy end-use services such as light, space conditioning, industrial production processes, and transportation. Specific features of the model include the explicit modeling of the vintaging of long-lived infrastructure, with assumptions regarding costs, penetration rates, and resource constraints based on literature surveys. In addition to the energy system, the model also includes generic representations of agriculture and the forestry sector, which allows incorporation of a full basket of greenhouse gas and air pollutant emissions (CO_2, CH_4, N_2O, NOx, PM2.5, CO, SO_2, BC, OC, SF6, volatile organic compounds, and various halocarbons).

The current version of MESSAGE operates on the level of 11 world regions and can be used for short- to medium-term energy planning to 2030 as well as for long-term scenario analysis to 2100. The modeling framework and the results provide core inputs for major international assessments and scenarios studies, such as the Intergovernmental Panel on Climate Change (IPCC), the World Energy Council (WEC), the European Commission, the German Advisory Council on Global Change (WBGU), and other multinational and national organizations. Principal applications of the model include the development of global and regional energy transformation pathways to address adverse social, environmental, and economic impacts of the energy systems. In the context of the GEA, the model was applied for the assessment of costs and benefits of the transformation in the following areas:

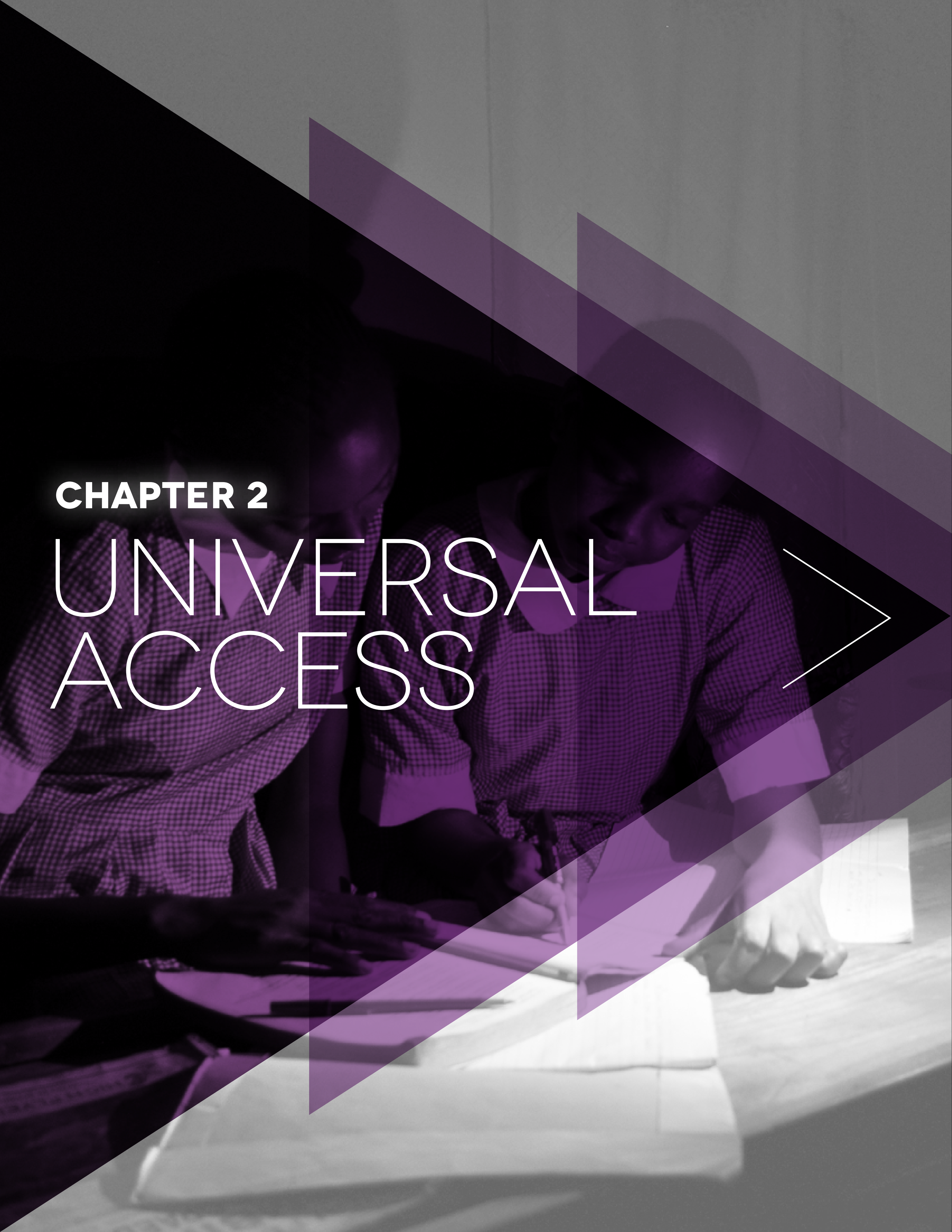
- Climate change
- Air pollution
- Energy access
- Energy security

MESSAGE is a technology-rich optimization model. It minimizes total discounted energy system costs and provides information on the utilization of domestic resources, energy imports and exports, trade-related monetary flows, investment requirements, the types of production or conversion technologies selected (technology substitution), pollutant emissions, and interfuel substitution processes, as well as temporal trajectories for primary, secondary, final, and useful energy. MESSAGE is coupled to the macroeconomic model MACRO for the assessment of macroeconomic feedbacks and internally consistent projections of energy demand and prices. Further linkages with IIASA's GLOBIOM (agricultural) model allow the assessment of land, forest, and water implications of energy systems. Finally, an explicit linkage to IIASA's GAINS air pollution framework allows the assessment of health impacts of energy systems.

Main model outputs and data of the GEA scenarios can be downloaded at the interactive GEA scenario database: http://www.iiasa.ac.at/web-apps/ene/geadb/.

The remainder of the report

The remainder of this report follows through on the framework laid down in this introductory chapter. Chapters 2-4 present a detailed discussion of energy access, energy efficiency, and renewable energy. Each chapter begins by addressing concepts, methodology, and sources of data and then goes on to present the starting point in 2010, to identify high-impact and fast-moving countries, and to sketch out the scale of the global challenge. Chapter 5 lays down a road map for future global tracking of progress toward the objectives through 2030—proposing a number of improvements that look to be feasible in the medium term—before synthesizing the main substantive conclusions of the report.



CHAPTER 2

UNIVERSAL ACCESS

CHAPTER 2: UNIVERSAL ACCESS TO MODERN ENERGY SERVICES

One of the three objectives of the Sustainable Energy for All (SE4ALL) initiative is to ensure universal access to modern energy services by 2030. The first section of this chapter examines the methodological challenges of measuring progress toward that goal and suggests approaches to address them. It also explains the methodology used to establish a starting point for the initiative. Succeeding sections describe global trends in access, opportunities to expand it, and the scale of the challenge ahead.

SECTION 1: METHODOLOGICAL CHALLENGES IN MEASURING ACCESS TO ENERGY

There are two initial challenges in measuring access to energy: (i) the absence of a universally accepted definition of "access" and (ii) the difficulty of measuring any definition in a precise manner. Access to electricity is usually equated with the availability of an electricity connection at home or the use of electricity for lighting. Similarly, access to energy for cooking is usually equated with the use of non-solid fuels[1] as the primary energy source for cooking. These binary metrics, however, fail to capture the multifaceted, multi-tier nature of energy access and do not go beyond a household focus to include productive and community applications of energy.

There is a growing consensus that access to energy should be measured not by binary metrics but along a continuum of improvement. Over the past decade, there have been several attempts to develop a more comprehensive measure—using single and multiple indicators, composite indicators, and multi-tier frameworks (annex 1). However, all these approaches have been underpinned by available databases, which are typically derived from household surveys, household connection data obtained from utilities, or residential consumption information at the country level.

Taking advantage of the unique opportunity for international collaboration that SE4ALL presents, the data needed to measure access can be improved over time, making it possible within five years to track access on the basis of multi-tier metrics supported by appropriate refinements in data-collection instruments. The rigorous piloting of questionnaires, technology certification, and consensus building in participating countries can substantially improve future measures of access.

The following subsection begins by identifying the databases currently available for measuring access and the main challenges of defining and measuring it. Proposals for multi-tier metrics of electrification and cooking solutions are laid out, and elements of those proposals are integrated into the proposed global and country-level tracking frameworks.

Compiling global databases to measure access at the starting point

A variety of data sources, including primarily household surveys and utility data, are used to measure access today. The most common indicators are (i) the rate of household connection to electricity, (ii) the proportion of households relying primarily on non-solid fuels for cooking, and (iii) average residential electricity consumption.[2] These indicators are assembled from the following databases.

[1] *Non-solid fuels* include (i) liquid fuels (for example, kerosene, ethanol, or other biofuels), (ii) gaseous fuels (such as natural gas, liquefied petroleum gas [LPG], and biogas), and (iii) electricity. *Solid fuels* include (i) traditional biomass (for example, wood, charcoal, agricultural residues, and dung), (ii) processed biomass (such as pellets, and briquettes); and (iii) other solid fuels (such as coal and lignite).

[2] Some household surveys also track certain electrical appliances (for example, radios, televisions, refrigerators), but data are not sufficient to build a global data base.

The World Bank's Global Electrification Database and the World Health Organization's Global Household Energy Database

To estimate access at the initiative's starting point, set as 2010, the partner agencies used two global databases: the World Bank's Global Electrification Database and the World Health Organization's (WHO's) Global Household Energy Database.[3] Various household data sources were leveraged in compiling these two databases to establish a historical series of data on electrification and primary fuel use between 1990 and 2010. Among the different sources, data from nationally representative household surveys (including national censuses) were given preference wherever possible[4], as these provide the most promising basis for future global tracking (table 2.1). Sources include the United States Agency for International Development's (USAID's) demographic and health surveys (DHS) and living standards measurement surveys (LSMS), the United Nations Children's Fund's (UNICEF's) multi-indicator cluster surveys (MICS), the WHO's World Health Survey, other nationally developed and implemented surveys, and various government agencies (for example, ministries of energy and utilities). While utility data are a valuable complement to household survey data, they provide a different perspective on access and cannot be expected to yield the same results. In particular, utility data may fail to capture (i) highly decentralized forms of electrification in rural areas and (ii) illegal access to electricity in urban areas.[5] Given the importance of these phenomena in the developing world, global tracking will be grounded in a household survey perspective.

The development of the two global databases used in the Global Tracking Framework followed an iterative process. As a first step, data on low- and middle-income countries were compiled from nationally representative household surveys. For electrification, this included 126 countries and encompassed 96 percent of the world's population; for cooking, the coverage was 142 countries and 97 percent of the world's population. Countries classified as developed countries according to the regional aggregation of the United Nations[6] are assumed to have achieved a 100 percent rate of access to electricity and non-solid fuel (that is, they are assumed to have made a complete transition to using primarily non-solid fuels or modern cooking devices with solid fuels) (Rehfuess, Mehta, and Prüss-Üstün 2006).[7]

Household surveys, though a consistent and standardized source of information, also present a number of challenges. Surveys such as the DHS or the LSMS/income-expenditure surveys are typically conducted every 3–4 years, while most censuses are held every 10 years. Thus, a number of countries have gaps in available data in any given year. Further, different surveys may provide different types of data because of differences in questions posed to respondents. For example, the question "Does your household have an electricity connection?" may elicit a different perspective on the household's electrification status than would another question, such as "What is the primary source of lighting?" This is especially the case for people who do not use electrical lighting despite having a connection—owing, for example, to a lack of supply during evening hours or the need to use what little electricity is available for other activities. Similarly, different results are observed when "expenditure on electricity" data are triangulated with "having an electricity connection." Further, most nationally representative surveys on household energy use fail to capture "fuel/cookstove stacking," or the parallel use of various kinds of stoves and fuels. Data collected are typically limited to primary cooking fuel. In some cases, inconsistencies may arise purely from sampling error or from the different sampling methodologies of the underlying surveys.

3 World Health Organization (WHO), http://www.who.int/indoorair/health_impacts/he_database/en/index.html.

4 For cooking solutions, only nationally-representative surveys are included in the WHO Global Household Energy Database and used to derive modeled estimates.

5 The distinction between household survey data and utility data is clearly highlighted in the case of Indonesia. The utility (PLN) reports an electrification rate of 74 percent, while the national statistical agency (BPS) puts forth a figure of 94 percent based on household surveys. http://www.pln.co.id/eng/?p=55 and http://sp2010.bps.go.id/index.php/site/tabel?tid=301&wid=0

6 High-income countries with a gross national income (GNI) of more than $12,276 per capita (World Bank, http://data.worldbank.org/about/country-classifications) and countries in the developed country group according to the UN aggregation (see table at front of this report).

7 The International Energy Agency (IEA) also publishes energy access databases, with broad country coverage (on electricity access and on the traditional use of bio mass for cooking) and collates these in its annual World Energy Outlook (WEO). The World Bank and IEA electricity access databases are consistent for most countries but, in some cases, differences in methodology mean that they rely on differing sources.

NAME	DESCRIPTION	COVERAGE (NO. OF COUNTRIES)	NUMBER OF SURVEYS (1990–2010)	QUESTION: ELECTRICITY	QUESTION: COOKING FUEL
Census	National statistical agencies	214	346	Is the household connected to an electricity supply or does the household have electricity?	What is the main source of cooking fuel in your household?
Demographic and health surveys (DHS)	MACRO International, supported by USAID	90	195	Does your household have electricity?	What type of fuel does your household mainly use for cooking?
Living standards measurement surveys (LSMS) or income expenditure (IE) surveys	National statistical agencies, supported by the World Bank	29 LSMS 116 IE	15 453	Is the house connected to an electricity supply? **or** What is your primary source of lighting?	Which is the main source of energy for cooking?
Multi-indicator cluster surveys (MICS)	UNICEF	65	144	Does your household have electricity?	What type of fuel does your household mainly use for cooking?
World Health Survey	WHO	71	71		What type of fuel does your household mainly use for cooking?

TABLE 2.1 **DESCRIPTION OF HOUSEHOLD SURVEYS**

SOURCE: AUTHORS.

As a second step to develop the historical evolution and starting point of electrification rates, a simple modeling approach was adopted to fill in the missing datapoints – around 1990, around 2000, and around 2010. Therefore, a country can have a continuum of zero to three datapoints. There are 42 countries with zero data point and the weighted regional average was used as an estimate for access to electricity in each of the data periods. 170 countries have between one and three data points and missing data are estimated by using a model with region, country, and time variables. The model keeps the original observation if data is available for any of the time periods. This modeling approach allowed the estimation of access rates for 212 countries over these three time periods.

For the WHO Global Household Energy Database a mixed model[8] was used to obtain a set of annual access rates to non-solid fuel for each country between 1990 and 2010 (see annex 2) (Bonjour and others 2012). This model derived solid fuel use estimates for 193 countries. Generating time-series curves for countries based on available actual data points has several advantages. It can derive point estimates for those countries for which there are no data by using regional trends. It also incorporates all the available data to derive point estimates and is not unduly influenced by large fluctuations in survey estimates from one year to the next.

Comparing the survey data from the latest available year and the modeled estimates suggests that differences are driven by inconsistent intervals between successive household surveys and by the absence of survey data for some countries at the starting point in 2010. Even so, the global and regional access rates from the modeled estimates and data on the latest survey year are remarkably aligned, at 83 percent (table 2.2). Oceania is the only region with a substantial divergence, but that region includes the largest group of countries with the least number of survey data points.

ACCESS RATE (% OF POPULATION)		
CCA	99	100
DEV	100	100
EA	100	98
LAC	95	95
NA	99	99
Oceania	18	25
SA	75	75
SEA	88	88
SSA	32	32
WA	90	91
WORLD	83	83

TABLE 2.2 **COMPARING SURVEY DATA AND MODELED ESTIMATES IN THE GLOBAL ELECTRIFICATION DATABASE**

SOURCE: AUTHORS.
NOTE: CCA = CAUCASUS AND CENTRAL ASIA; DEV = DEVELOPED COUNTRIES; EA = EASTERN ASIA; LAC = LATIN AMERICA AND CARIBBEAN; NA = NORTHERN AFRICA; SA = SOUTHERN ASIA; SEA = SOUTHEASTERN ASIA; SSA = SUB-SAHARAN AFRICA; WA = WESTERN ASIA.

IEA World Energy Statistics and Balances

The International Energy Agency's (IEA's) World Energy Statistics and Balances database includes time series information on total annual energy consumption in households at the aggregate level.[9] The database draws from a variety of sources—including meter readings made by utility companies and surveys of household energy consumption—and represents 132 countries (but none in Oceania and only 21 in Sub-Saharan Africa), covering 96 percent of the world's population. The global information on residential electricity consumption presented in this chapter is taken from this database. When plotted together, data on the electrification rate and average annual household electricity consumption can suggest a country's electricity access profile. However, as figure 2.1a shows, the correlation between the two variables is minimal. The spread of average consumption levels is extremely wide, not only among countries that achieved universal access but also among countries with lower electrification rates. The most dramatic increase in residential consumption between 2000 and 2010 occurred in Eastern Asia, where it rose by more than twice (figure 2.1b).

9 Statistics on energy consumption in households include those on gas, electricity, and stockable fuel consumption (IEA 2012).

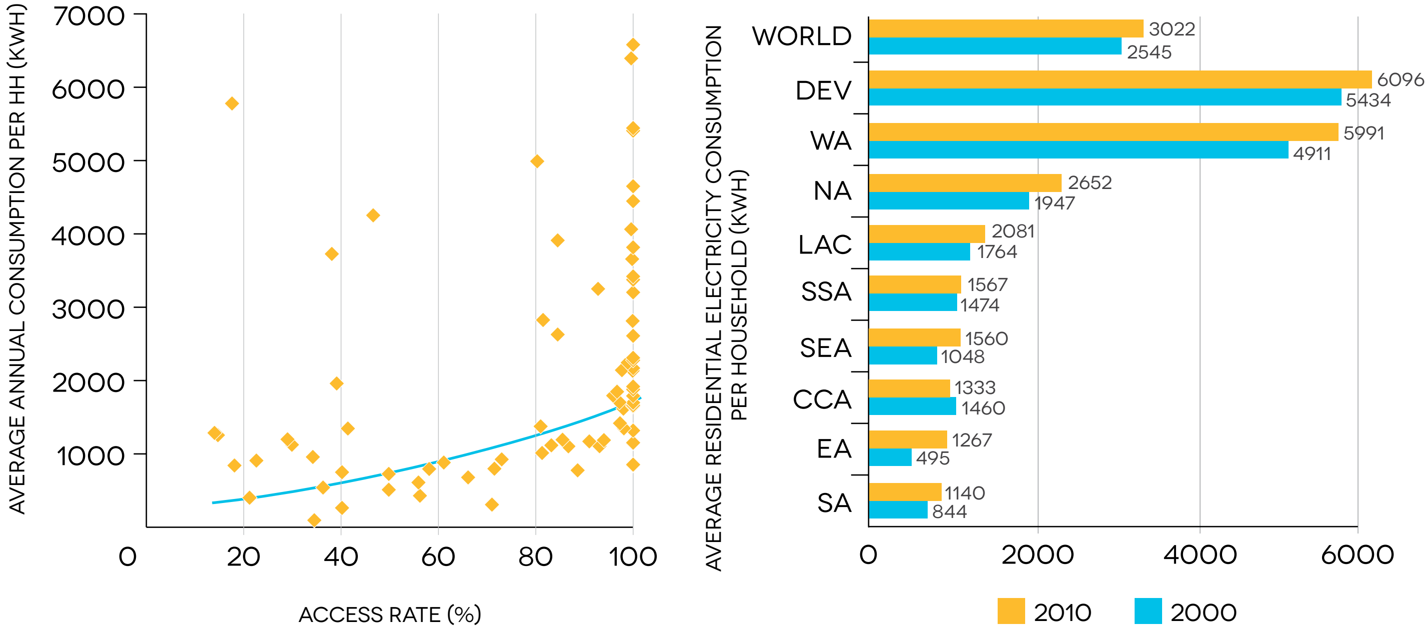


FIGURE 2.1 **AVERAGE ANNUAL HOUSEHOLD ELECTRICITY CONSUMPTION**

SOURCE: BASED ON THE WORLD BANK'S GLOBAL ELECTRIFICATION DATABASE AND IEA (2012).
NOTE: IEA = INTERNATIONAL ENERGY AGENCY.

Challenges to defining and measuring access at the starting point

Access to electricity

The existing definitions and measurements of access to electricity, although convenient, fail to capture several important aspects of the problem.

Multiple access solutions. Off-grid options (for example, solar lanterns or stand-alone home systems) and isolated mini-grids are required in many countries as transitional alternatives to grid-based electricity. In geographically remote areas, these options could potentially serve as long-term solutions as well.[10] Therefore, expansion of access through off-grid and mini-grid solutions needs to be tracked in addition to main grid connections, though it is important to recognize that such solutions may vary in the quantity and quality of electricity they can provide—and the measurement of electricity access should reflect those differences. Using current data and measures, access to electricity cannot be differentiated based on the supply characteristics of the electricity source.

Supply problems. In many developing countries, grid electricity, typically provided by utility companies, suffers from irregular supply, frequent breakdowns, and problems of quality (such as low or fluctuating voltage). Power is often supplied only at odd hours (such as midnight or midday), when the need for electricity is minimal. Low wattage also significantly reduces the usefulness of access under such conditions. Connection costs and electricity charges constrain energy use among households that cannot afford them. Illegal and secondary connections serve a significant proportion of the population in many countries, representing lost revenues for the utility and posing a safety hazard. None of these attributes of the availability, quality, affordability, and legality of supply are reflected in existing data on access.

Electricity supply and electricity services. Finally, electricity is useful only if it allows desired energy services to be run

[10] The International Energy Agency (IEA) has projected that about 60 percent of households not connected to the main grid at present are likely to obtain electricity through such systems by 2030 (IEA 2012).

adequately. Access to electricity supply is therefore different from use of electricity services, which implies the ownership of the appropriate electrical appliance and the actual use of electricity.[11] It is nonetheless important to measure both of these in order to inform policies and project design. Meanwhile, measuring access to electricity services through consumption of kilowatt-hours (kWh) fails to capture several important factors. First, such a measure does not reflect which energy services are actually operated within the household. Second, it tends to emphasize higher consumption, clashing with energy-efficiency goals. Poor households often have no choice other than to operate old and inefficient applications to meet their needs, despite high unit costs. Finally, electricity consumption depends on several external factors, such as household income, household size, household spending priorities, and so on. Therefore, ownership of appliances rather than electricity consumption provides a preferable measure of access to electricity services.

Access to cooking solutions

Current measures of access to modern cooking solutions are confined to fuels and therefore omit the role of the cookstove. Understanding the cooking solutions of households entails knowing not only the fuels but also the type of cookstoves used. It is the combination of the two that will determine levels of efficiency, pollution, and safety outcomes. Meanwhile, individual behaviors, cooking practices, and housing characteristics also affect the actual performance of a household's cooking solutions.

Technical standards and certification systems related to cookstoves. Ongoing development of improved or advanced cookstoves shows that high performance in terms of efficiency, pollution, and safety can be achieved even with solid fuels. This is important, since it is projected that a large part of the developing world will continue to rely on solid fuels (biomass and coal) for cooking despite increasing use of non-solid fuels (IEA 2012). Therefore, advanced biomass cookstoves that offer significant improvements over traditional self-made cookstoves may serve as a transitional alternative to the most modern cooking solutions. Nonetheless, it is not possible to evaluate the technical performance of a cookstove through simple observation. A certification system is therefore needed, whereby cookstoves carry a stamp that indicates their performance level.[12] This presents an additional challenge to reach universal consensus on the technical standards used for certification.

Convenience of cooking solutions. For the poorest households cooking often involves lengthy and exhausting fuel collection, particularly for women.[13] Several studies analyze the impacts of this burden on women's health, income-generating opportunities, and time for other tasks, not to mention leisure and repose (Clancy, Skutsch, and Batchelor 2003). Time and effort invested in cookstove preparation and cleaning, as well as in cooking itself, are also important dimensions to consider. It is therefore important to measure the "convenience factor" along with the technical performance of a cooking solution to obtain a comprehensive measure of access.

The variability of performance outcomes. The performance of cooking solutions, as evaluated under standard testing conditions, may not be achieved in practice owing to individual behavior, cooking practices, and site conditions. Maintenance requirements may have been disregarded and accessories such as chimneys, hoods, or pot skirts not used, deteriorating the performance of the cookstove.

Fuel stacking. Any measure of access solely based on the primary cooking solution will fail to capture the complex phenomenon of fuel stacking, which refers to the parallel use of multiple fuels and cookstoves (box 2.1). The transition to more modern energy solutions in the home is a dynamic process, and many factors contribute to the choice of fuels and cookstoves.[14] Even households that have adopted a modern fuel or an advanced cookstove may continue to use—in parallel—secondary and tertiary fuels and cookstoves on a regular basis. The underlying causes of this practice need to be identified to inform policy and project design.

[11] Measurement of access to electricity supply reflects the performance of utilities, markets, and policies in ensuring that electricity supply is fully usable, while measurement of access to electricity services reflects the combination of electricity supply and consumer behavior. Greater use of modern energy affects socioeconomic development.

[12] A stamp or label could indicate the stove's performance as measured during laboratory tests and field-tests where available.

[13] Gender roles and inequalities impose differential burdens on family members with regard to cooking energy systems. Women and children bear the main negative impacts of fuel collection and transport, indoor air pollution, and time-consuming and unsafe cooking technologies.

[14] Modern cooking solutions include those that involve electricity or liquid/gaseous fuels (including liquefied petroleum gas), or the use of solid/liquid fuels paired with stoves that have overall emissions rates at or near those of LPG.

BOX 2.1 Capturing home energy needs: Fuel stacking and multiple end uses

Regular use of multiple fuels and cookstoves, also called "fuel stacking," is a common practice throughout the developing world. Households in both urban and rural areas routinely use two or more fuels for cooking alone. Different studies in Latin America find that even households that have switched to liquefied petroleum gas (LPG) as a primary cooking fuel still rely on simpler, less-efficient cookstoves or open fires to prepare some types of foods (for example, tortillas—a daily staple), or to meet their space or water heating needs (Masera, Díaz, and Berrueta 2005; Davis 1998). Similar patterns of multiple fuel use have been documented in Vietnam, Brazil, Nepal, Ghana, India, and South Africa (Heltberg 2004). Fuel and cookstove stacking have been attributed to a combination of factors, including household income, multiple end uses (cooking, re-heating, boiling, etc.), cooking practices (types of food prepared, cooking time, taste, etc.), fuel availability and fuel consumption, as well as available infrastructure (access to electricity and gas pipelines) (Heltberg 2005; Davis 1998; Link, Axinn, and Ghimire 2012).

Access to heating

Heating is a major energy requirement in many countries, and its measurement presents several challenges. Heating needs can be met through a range of solutions: heat from a cookstove, fuel-based heating devices, a district heating system provided by a public utility based on combined generation of heat and power, or electric heating. Heating needs depend not only on the geographical location and weather patterns of a country, but also on the housing situation (poor insulation can substantially increase heating needs). As yet, there are no available data on energy for heating that would allow the compilation of a global database. In the medium term, SE4ALL envisions development of a framework to adequately measure access to heating.

Community and productive uses of energy

A household-based definition of access to energy excludes access to energy for community services and productive uses.[15]

Energy is crucial for enterprises. It drives economic and social development by increasing productivity, incomes, and employment[16]; reducing workloads and freeing up time for other activities; and facilitating the availability of higher-quality or lower-priced products through local production. In addition, providing energy to businesses secures the higher economic sustainability of electrification projects, as productive activities often translate into higher energy demand density and more reliable capacity to pay (EUEI 2011).

Energy for community services (e.g., health and education) is fundamental for socioeconomic development, because it can lead to the substantial improvement of human capital. Healthier, more-educated people with access to basic community infrastructure (such as clean water, street lighting, and so on) have better chances of escaping the poverty trap (Cabraal, Barnes, and Agarwal 2005). Models that deliver energy and energy services to poor households in a financially sustainable manner by leveraging productive and community energy users as anchor loads have been demonstrated across many countries—albeit still on a small scale.

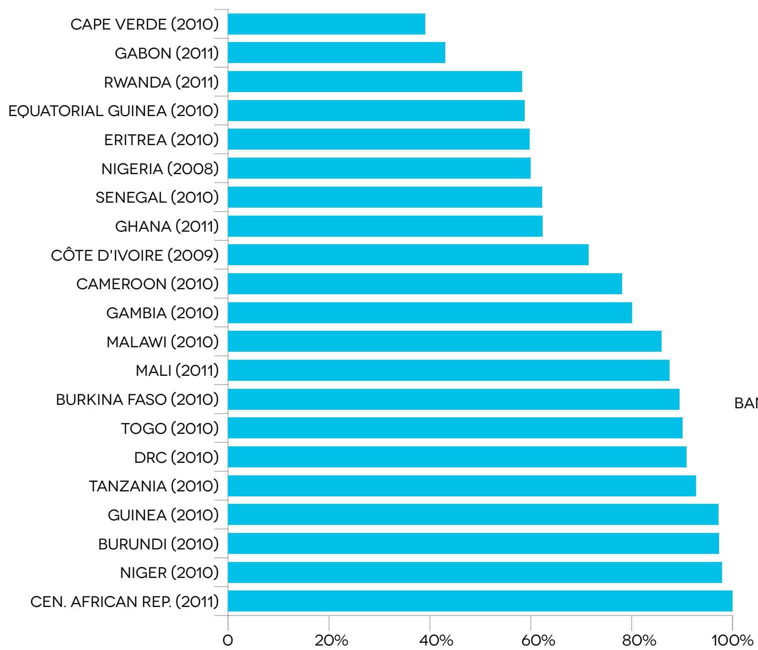
Data paucity is again a major constraint in measuring access to energy for community services and productive uses. Only recently, the IEA attempted to measure access to energy for public services and productive uses (IEA 2012). Similarly, the nongovernmental organization (NGO) Practical Action has identified households, community institutions, and productive enterprises as three dimensions of energy access (PPEO 2012; 2013). In the health sector, a recent joint WHO and USAID collaboration to harmonize indicators for health-facility assessments resulted in a

15 Productive uses of energy are defined as those that increase income or productivity and refer to the activities that add value, which could be taxable if part of the formal economy (EUEI 2011).

16 It is understood that energy access is a necessary but rarely sufficient condition for driving economic growth. Access to finance, markets, raw materials, technology, and a qualified workforce are also determinant factors.

comprehensive and cross-cutting facility-assessment tool called the Service Availability and Readiness Assessment (SARA), which includes an energy component. Created to fill critical gaps in measuring and tracking progress in the strengthening of health systems based on minimum service standards, SARA provides a consistent methodology for annual country-led monitoring of health service delivery in the country, including energy access (that is, the availability, source, and reliability of electricity). Currently, additional efforts by the WHO are under way to develop an energy module for health-care facilities that can be used as a stand-alone assessment tool or in conjunction with SARA. In the education sector, the United Nations Educational, Scientific, and Cultural Organization (UNESCO) has been tracking access to electricity, teaching aids, and computers in schools as a part of its survey of school infrastructure quality. These available data, based on connection rates, indicate that many schools and health clinics are not electrified (figure 2.2).

Relying on such efforts and methodologies, the SE4ALL initiative will begin to develop comprehensive frameworks for measuring energy access across community services and productive uses. Those frameworks will be implemented over the medium term.



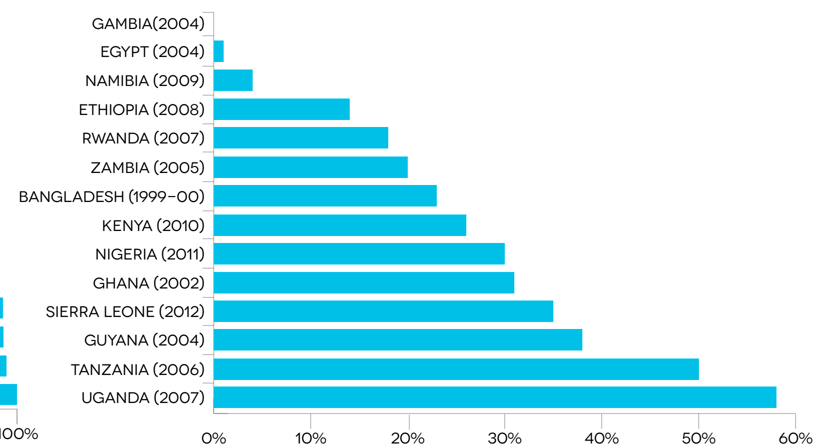


FIGURE 2.2A **PUBLIC PRIMARY SCHOOLS WITHOUT ELECTRICITY**

SOURCE: : UNESCO INSTITUTE OF STATISTICS (UIS) DATABASE.

FIGURE 2.2B **HEALTH CLINICS WITHOUT ELECTRICITY**

SOURCE: : SOURCE: WHO ENERGY IN HEALTH CARE FACILITIES DATABASE

A candidate proposal for tracking access

The multi-tier metric described below may be considered as a candidate proposal to address the challenges in current definition and measurement techniques, drawing on numerous recent efforts. The metric is flexible and allows for country-specific targets to be set. Because the challenge of energy access varies across and within countries, setting minimum standards of energy access without due regard to the stage of evolution of energy systems would understate the challenges faced around the world. A bar set too high (for example, universal access to uninterrupted grid-based electricity or to gaseous fuels for cooking by 2030) would be unachievable for many countries. A bar set too low (for example, universal access to lighting) risks making the SE4ALL initiative less relevant for countries with high rates of grid electrification but suffering from poor supply. A multi-tier approach would embrace the appropriate interventions to adequately track progress toward universal energy access across countries.

Access to electricity

The candidate proposal consists of a multi-tier measurement encompassing the following considerations (figure 2.3).

Electricity supply and electricity services. The multi-tier proposal consists of two distinct yet intertwined electricity measurements that can be compiled into two indices. On the one hand, it measures access to electricity supply[17] using multiple tiers, defined by increasing levels of supply attributes, including quantity (peak available capacity), duration, evening supply, affordability, legality, and quality, whereby more and more electricity services become feasible (annex 3). Different energy services (such as lighting, television, air circulation, refrigeration, ironing, and food processing) require different levels of electricity supply in terms of quantity, time of day, supply duration, quality, and affordability.[18] On the other hand, it measures use of electricity services using multiple tiers, based on ownership of appliances categorized by tier, each corresponding to the equivalent tier of electricity supply needed for their adequate operation. For instance, in tier 1, access to basic applications such as task lighting, radio, and phone charging is possible. From tier 2 onwards, access becomes increasingly advanced, allowing a higher number of electricity applications to be used.

Diversity of supply options. The structure of this proposal is technology-neutral and encompasses off-grid, mini-grid, and grid solutions, while reflecting the large spectrum of electricity access levels. Each technology is evaluated based on its capacity to provide for a certain tier of electricity supply, which subsequently affects the provision of energy services.

Incidence and intensity of access. The proposed approach evaluates both the extent of access (how many households have access) and the intensity of that access (the level of access that households have). This structure allows for an aggregated analysis of access to electricity supply as well as use of electricity services using two separate indices that can be calculated for any geographical area.[19] It is possible that the same household would not reach the same tier across the two measurements. Indeed, a higher level of electricity supply does not automatically result in additional electricity services. Electricity services typically lag behind improvements in supply, as consumers gradually acquire electrical appliances. Increased use of electricity is also constrained by limited household income and telescopic electricity tariffs.[20] Some households may also benefit from higher tiers of electricity services despite having poor electricity supply because they can afford stand-alone solutions (for example, diesel generators and inverters) as backups. Thus, gaps between access to electricity supply and access to electricity services are to be expected, revealing important information on the types of interventions needed to improve access.

Data collected in the course of calculating the two indices can also be used to conduct a disaggregated analysis of the incidence of various aspects of supply constraint,[21] by type of supply technology or by level of access to electricity services.

[17] Access to electricity supply can be achieved through a combination of central grid, mini-grid, and stand-alone solutions.

[18] For example, a grid-based electricity connection where supply is not available during the evening hours is not suitable even for basic lighting.

[19] A village, a district, a province, a country, a continent, or the whole world.

[20] The unit price of electricity increases at higher consumption levels.

[21] Share of households receiving less than four hours of electricity per day, share of households facing affordability issues or poor quality of supply, and so on.

ACCESS TO ELECTRICITY SUPPLY

ATTRIBUTES	TIER 0	TIER 1	TIER 2	TIER 3	TIER 4	TIER 5
Peak available capacity (W)	-	>1	>500	>200	>2,000	>2,000
Duration (hours)	-	≥4	≥4	≥8	≥16	≥22
Evening supply (hrs)	-	≥2	≥2	≥2	≥4	≥4
Affordability	-	-	√	√	√	√
Legality	-	-	-	√	√	√
Quality (voltage)	-	-	-	√	√	√

- Five-tier framework.
- Based on six attributes of electricity supply.
- As electricity supply improves, an increasing number of electricity services become possible.

Index of access to electricity supply $= \sum(P_T \times T)$

with P_T = Proportion of households at tier T

T = tier number {0,1,2,3,4,5}

USE OF ELECTRICITY SERVICES

TIER 0	TIER 1	TIER 2	TIER 3	TIER 4	TIER 5
–	Task lighting AND phone charging (OR radio)	General lighting AND television AND fan (if needed)	Tier 2 AND any low-power appliances	Tier 3 AND any medium-power appliances	Tier 4 AND any high-power appliances

- Five-tier framework.
- Based on of appliances.

Index of access to electricity supply $= \sum(P_T \times T)$

with P_T = Proportion of households at tier T

T = tier number {0,1,2,3,4,5}

FIGURE 2.3 **CANDIDATE FRAMEWORK FOR MULTI-TIER MEASUREMENT OF HOUSEHOLD ELECTRICITY ACCESS**

SOURCE: AUTHORS

Cooking

The candidate proposal measures access to cooking by evaluating, on the one hand, the technical performance of the primary[22] cooking solution (including the fuel and the cookstove), and, on the other hand, assessing how those solutions meet the needs of households. The combination of the two metrics offers a comprehensive measurement of access to cooking. Similar to electricity, the methodology is based on multiple tiers and is fuel-neutral (figure 2.4).

[22] The primary cookstove is defined as the one that is the most used for cooking meals.

STEP 1: TECHNICAL PERFORMANCE

- Multi-tier technical measurement of the primary cooking solution in two steps:
    1. Three-level measurement based on the direct observation of the cookstove and fuel.
    2. Manufactured non-BLEN cookstoves (medium grade) are further categorized into four grades based on technical attributes. This grade categorization would only be possible for cookstoves that have undergone third-party testing. Non-BLEN manufactured cookstoves that have not been tested are assumed to be Grade D.

LOW GRADE	MEDIUM GRADE	HIGH GRADE
Self-made[1] cookstove	Manufactured[2] non-BLEN cookstove	BLEN[3] cookstove

	LOW GRADE	MEDIUM GRADE			HIGH GRADE
Attributes	Grade-E	Grade-D	Grade-C	Grade-B	Grade-A
Efficiency Indoor pollution Overall pollution Safety	Self-made cookstoves or equivalent	Uncertified Non-BLEN manufactured cookstoves	Certified Non-BLEN manufactured Cookstoves		BLEN cookstoves or equivalentt

1 A self-made cookstove refers to a three-stone fire or equivalent, typically made by an untrained person without the use of premanufactured parts.

2 A manufactured cookstove refers to any cookstove available in the market (including cookstoves from artisans and small local producers trained under a cookstove program)

3 BLEN cookstove refers to stove-independent fuels (such as biogas, LPG, electricity, natural gas). BLEN equivalence of more fuels (such as ethanol) would be examined going forward. Non-BLEN cookstoves include most solid and liquid fuels for which performance is stove dependent.

STEP 2: ACTUAL USE

- Measurement of additional aspects of access beyond technical performance.
- Three types of attributes, as listed below:

Conformity	• Chimney/hood/pot skirt used (as required). • Stove regularly cleaned and maintained (as required).
Convenience	• Household spends less than 12 hrs/week on fuel collection/preparation. • Household spends less than 15 min/meal for stove preparation. • Ease of cooking is satisfactory.
Adequacy	• Primary stove fulfills most cooking needs of the household, and it is not constrained by availability or affordability of fuel, cultural fit, or number of burners. • If multiple cooking solutions are used (stacking), other stoves are not of a lower technical grade.

- Multi-tier measurement is based on technical performance adjusted for the above attributes.

	LEVEL 0	LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
Grade-A					w/o CCA	w/ CCA
Grade-B				w/o CCA	w/ CCA	
Grade-C			w/o CCA	w/ CCA		
Grade-D		w/o CCA	w/ CCA			
Grade-E	w/o CCA	w/ CCA				

FIGURE 2.4 **CANDIDATE FRAMEWORK FOR MULTI–TIER MEASUREMENT OF HOUSEHOLD COOKING SOLUTIONS***

SOURCE: AUTHORS.

$$\text{Index of access to electricity supply} = \sum(P_T \times T)$$

$$\text{with} \quad P_T = \text{Proportion of households at tier T}$$

$$T = \text{tier number } \{0,1,2,3,4,5\}$$

SOURCE: WORLD BANK /ESMAP.

NOTE: BLEN = BIOGAS–LPG–ELECTRICITY–NATURAL GAS; CCA = CONFORMITY, CONVENIENCE, AND ADEQUACY.

* The proposed multi-tier framework (above) is complementary to the multi-tiered technical standards for cookstove performance proposed by the Alliance led International Workshop Agreement (IWA). The IWA multi-tier standards provide the basis for measurement of cookstove performance on the four technical attributes—efficiency, indoor pollution, overall pollution, and safety (annex 4). Laboratory measurements based on the IWA standards would be used by the multi-tier framework (above) to determine the overall technical performance of the primary cookstove in step-1. The objective of the multi-tier framework (above) is to measure the level of household access to cooking solutions. It builds upon the technical performance of each of the multiple cooking solutions being used in the household (including the use of non-solid fuels), while also taking into account CCA attributes.

The technical performance of the primary cooking solution is evaluated in two steps. First, the cooking solution is categorized as low, medium, or high grade, based on direct observation of stove and fuel type, and on whether it is (i) a self-made cookstove,[23] (ii) a biogas-LPG-electricity–natural gas (BLEN) cookstove,[24] or (iii) a manufactured non-BLEN cookstove (including kerosene cookstoves— see box 2.2).[25] A self-made cookstove is assigned a Grade E, while the BLEN cookstove is assigned a Grade A. Second, the manufactured non-BLEN cookstove is assessed based on whether it has been tested or not. If it is not tested, its performance is unknown and it is assigned a Grade D. If results are available from third-party testing that meet the requirements of the International Standards Organization's (ISO's) International Workshop Agreement (IWA),[26] the technical grades can be refined further.

Non-BLEN manufactured cookstoves are differentiated across Grades A, B, C, D, and E based on their performance across four technical attributes that correspond to the four performance indicators in the IWA: (i) fuel efficiency, (ii) overall emissions, (iii) indoor emissions, and (iv) safety. The IWA tiers of performance have been directly mapped to Grades A to E for this measurement system. The cookstove performance on these attributes may be measured using the IWA developed by the Global Alliance for Clean Cookstoves (hereafter, the Alliance)[27] (annex 4).

Results from the third-party testing of cookstoves should be reported publicly through the Stove Performance Inventory, which is maintained by the Alliance. Certified cookstoves may also carry an easily identifiable stamp or label (or brand name) that provides easy indication of their technical performance based on laboratory testing, through a certification system developed at the country level. A network of designated certification agencies and laboratories could be established for this purpose, possibly assisted by the Alliance and WHO.[28]

It is acknowledged that the evaluation of tested or certified cookstoves adds complexity to the framework. Yet it is desirable to base the evaluation of technical performance on empirical data and capture the efforts of the Alliance, testing centers, donors, and manufacturers in promoting advanced cookstoves. The five-grade technical measurement is therefore essential for capturing the wide spectrum of manufactured cookstoves, and for incentivizing testing and certification.[29]

[23] Including open fires and all types of self-made cooking arrangements.

[24] BLEN fuels are stove independent, that is, their technical performance does not depend on the type of stove used.

[25] Including locally made or imported traditional stoves, clay stoves, improved stoves, advanced stoves, or any type of stove on the market. It is assumed for practical reasons that manufactured cookstoves perform better than self-made cookstoves, although this may not always be true.

[26] The standards have been developed in collaboration with the WHO and International Standards Organization (ISO), and the latest version was agreed on at the International Workshop Agreement (IWA) meeting in February 2012. Protocols are under development for additional types of cookstoves (for example, plancha and charcoal) and multiple end-use stoves and will be incorporated into the IWA framework.

[27] The Global Alliance is a public-private partnership aiming to achieve universal access to modern cooking by promoting a global market for clean and efficient household cooking solutions.

[28] The Global Alliance has started the process of establishing regional testing sites and aims to encompass a wide range of cookstoves and fuels.

[29] A manufactured cookstove without certification is automatically categorized into the lowest level of manufactured stoves (Grade D), since its performance is unknown.

Beyond the technical performance of the cooking solution, the framework attempts to evaluate its impact on the daily lives of users. First, it determines whether the household uses the cooking solution in conformity with instructions (that is, a chimney, hood, or pot skirt is used if required and regular cleaning and maintenance are performed). It also evaluates convenience, by considering how long it takes the household to collect the fuel and how long it takes to prepare the cookstove. Finally, it examines the issue of fuel stacking by considering whether the household regularly uses a secondary cooking solution and for what reason (for example, the primary fuel is too expensive or is not always available; or the solution does not satisfy cultural preferences or does not have the desired number of burners). If the use of the primary cooking solution is constrained by such factors, it is inadequate.

Conformity, convenience, and adequacy (CCA) are the three attributes considered, in addition to technical performance, to obtain an integral measurement of access to a modern cooking solution. The methodology proposes to adjust the technical grade of a cooking solution to account for these attributes to obtain the household tier (level) of access. If all three attributes are satisfied, the technical grade is raised to a higher tier (level). If the household's solution does not comply with all three attributes, the technical grade remains unchanged at the lower tier (level).

BOX 2.2 Kerosene use in the home for cooking, heating, and lighting

Kerosene makes a significant contribution to the basket of fuels that households use to meet their energy needs. In several Sub-Saharan countries, national surveys show that more than 80 percent of households rely on kerosene as their primary energy source for lighting. Similarly in some Middle Eastern and Sub-Saharan countries, national surveys indicate that more than 25 percent of households rely mainly on kerosene to meet their space-heating needs.

The results of national surveys from 122 low- and middle-income countries show that, on average, approximately 4 percent of households use kerosene as their primary cooking fuel. These households are concentrated in two regions, Sub-Saharan Africa and South Asia, with some countries exhibiting much higher levels of reliance on kerosene for cooking—such as Nigeria and Eritrea at about 20 percent, and Maldives and Indonesia closer to 40 percent of households.

Kerosene: A risk for health

In the past, kerosene stoves and lamps were considered a cleaner-burning alternative to traditional solid fuel for cooking, heating and lighting. But recent scientific studies have shown that, depending on the design of the device (cookstove, lamp), household use of kerosene can emit troubling amounts of health-damaging pollutants (particulate matter, carbon monoxide, and formaldehyde) that have been shown to impair lung function, increase infectious illnesses (for example, tuberculosis), and cancer risk (Lam and others 2012). Kerosene use also poses a number of health and safety risks in and around the home, including poisoning and burns (Mills 2012).

Accordingly, use of kerosene lamps for lighting is classified as tier 0 in the multi-tier framework for access to electricity supply. For the purpose of tracking access to modern cooking solutions, kerosene is classified as a non-BLEN fuel (see figure 2.4). Because emissions from kerosene-based cooking depend on the design of the cookstove (whether wick-type or pressurized-type), technical performance can vary substantially.

SOURCE: WHO GLOBAL HOUSEHOLD ENERGY DATABASE.

Global and country tracking of access

SE4ALL's goal of universal access to modern energy services by 2030 will be achieved only if every person has access to modern cooking and heating solutions, as well as productive uses and community services (SE4ALL 2012). This report proposes tracking arrangements for access to electricity and modern cooking solutions. It is expected that similar frameworks for heating, productive uses, and community services will be developed and implemented over the medium term.

Given that access to modern energy is a continuum of improvement and will be measured using the proposed multi-tier methodology, countries are encouraged to set their own targets (choosing any tier above tier 0). Such targets will depend on the current access situation in the country, the evolution of the energy needs of users, the availability of energy supply for income-generating activities, and the affordability of different energy solutions in the country. For example, countries in which most people are without electricity in any meaningful form might set a target of achieving universal access to electric lighting. Other countries may choose to set the target of universal grid connectivity. Countries that have recently achieved near-universal electricity connections but face problems of adequacy, quality, and reliability of supply may choose to set a target that emphasizes improved supply. Similarly, for household cooking solutions, countries with very low penetration of modern fuels or electricity may choose to set a target of certified advanced biomass cookstoves. Other countries may aim to achieve universal access to BLEN fuels. Countries have the flexibility of choosing whether they will improve access tier by tier or jump across tiers. Large countries may set different targets for different provinces or subregions.

To address limitations in data availability, a phased (immediate versus medium term) and differentiated (global versus country-level) approach is proposed (table 2.3).

	IMMEDIATE	MEDIUM TERM
Global tracking	Binary measurement of access to electricity and cooking solutions.	• Modification of global omnibus surveys to obtain information for simplified three-tier measurement. • Simplified three-tier measurement of access to electricity and cooking solutions. • Piloting and possible regular implementation of customized energy surveys to obtain five-tier access information globally.
Country-level tracking		• Piloting of multi-tier framework for electricity and cooking solutions in select countries. • Development and piloting of approaches to track access to energy for heating, community, and productive uses. • Regular multi-tier measurement of access to electricity and cooking solutions through

TABLE 2.3 **IMMEDIATE AND MEDIUM-TERM TRACKING ACROSS GLOBAL AND COUNTRY LEVELS**

SOURCE: AUTHORS.

Tracking access to energy in the immediate term

In the immediate term, the nature of existing databases constrains measurement possibilities. The World Bank's Global Electrification Database and the WHO's Global Household Energy Database will continue to support the tracking process. For estimating the starting point of electricity access and tracking in the immediate future, household connection to electricity constitutes the threshold, regardless of the type of supply or services. Similarly, for cooking, the use of non-solid fuel as the primary cooking fuel is deemed to constitute access. In the absence of data on cookstove type, the primary use of solid fuels is treated as lack of access. Apart from the World Bank and WHO databases, the IEA's energy access databases are a valuable additional source of information to support the tracking process.

Tracking access to energy in the medium term

The adoption of a multi-tier metric, either in its entirety or in part, would require enhancements to existing data-collection instruments, moving away from a binary definition and measurement of access.

Household surveys remain the instruments best suited to obtaining the data required, but additional energy-focused questions should be designed. For electricity, surveys could facilitate the reporting of households served by off-grid technologies (for example, solar lanterns or stand-alone home systems), as well as households connected to decentralized mini-grids. Such technologies are most likely to reach underserved peri-urban and rural populations—where substantial progress is likely to be made in coming decades. Household surveys are also able to capture the level of electricity supply (in terms of duration, quality, affordability, and so on) availed by end-users and to identify the electricity applications used within the household. On the cooking side, in the absence of any centralized utility, household surveys are the only sources of data available to comprehensively capture all the fuels and types of cookstoves used by households and to assess questions of convenience and fuel stacking.

Country-level tracking. Countries that opt into a program to expand access to energy under the SE4ALL initiative will likely be able to implement a more elaborate system of monitoring access. A multi-tiered, comprehensive measurement of access, as in the candidate proposal, is possible only if a country's government has developed the requisite methodologies, extensively revised household surveys, established testing laboratories, and carried out detailed consultations with the parties involved. Such efforts need to ensure that high-quality data are consistently generated.

Global tracking. It is acknowledged that a major effort to improve data is a long and intensive process and that not all countries will be able to collect all the new data required. A simplified three-level measurement system that condenses the six tiers of the multi-tier candidate proposal would require only marginal improvement in data collection (figure 2.5). The few additional questions needed to capture this information could be added to the household survey instruments of the various international survey networks (such as DHS, LSMS, and MICs).

TRACKING ACCESS TO ELECTRICITY	GLOBAL TRACKING	NO ACCESS	NO ACCESS	ADVANCED ACCESS			
		NO ELECTRICITY	SOLAR LANTERN OR RECHARGEABLE BATTERY LANTERN	HOME SYSTEM OR GRID CONNECTION			
	COUNTRY-LEVEL TRACKING	TIER-0	TIER-1	TIER-2	TIER-3	TIER-4	TIER-5
TRACKING ACCESS TO COOKING	GLOBAL TRACKING	NO ACCESS	BASIC ACCESS			ADVANCED ACCESS	
		SELF-MADE COOKSTOVE	MANUFACTURED NON-BLEN COOKSTOVE			BLEN COOKSTOVE	
	COUNTRY-LEVEL TRACKING	TIER-0	TIER-1	TIER-2	TIER-3	TIER-4	TIER-5

FIGURE 2.5 **TRACKING ACCESS IN THE MEDIUM TERM**

SOURCE: AUTHORS.
NOTE: BLEN = BIOGAS-LPG-ELECTRICITY-NATURAL GAS.

For electricity, access is graded as "no access," "basic access," and "advanced access." No access is aligned with tier 0 of the multi-tier measurement, reflecting a complete lack of electricity. Basic access, aligned with tier 1, corresponds to the level of supply and the level of electricity services that a solar lantern can provide. Advanced access corresponds to tiers 2 and above, which are likely obtained by off-grid and grid solutions. Using this simplified measurement system, advances under programs such as Lighting Africa and Lighting Asia would be counted as basic access. Stand-alone off-grid and mini-grid solutions would be counted as advanced access. To facilitate the data-collection process, this simplified version is technology-based. It does not capture the nuances of advanced access or the different attributes of electricity supply.

For cooking, access is graded as for electricity. No access is aligned with tier 0 of the multi-tier measurement, and corresponds mainly to self-made cookstoves. Basic access, aligned with tiers 1–3, reflects the use of manufactured non-BLEN cookstoves. Advanced access, aligned with tiers 4 and 5, corresponds to BLEN cookstoves or the equivalent. Under this simplified measurement system, the use of manufactured non-BLEN cookstoves is captured as basic access, while the use of BLEN fuels would be considered advanced access. To facilitate the data-collection process, this measurement system is based on the simple observation of fuels and cookstoves. It does not capture the technical grade of the cooking solution or additional details about the convenience or adequacy of the cooking solution.

Such a simplified three-level measurement system follows the same methodology of weighted aggregation as the full multi-tier system. It is therefore possible to construct an index to capture both the incidence of access (how many households have access) and its intensity (the level of access the households have—basic or advanced).

To sum up this section, binary metrics that rely on available data have been used to set the starting point for the SE4ALL initiative and will continue to be used for global and country-level tracking in the immediate future. Meanwhile, multi-tier approaches that address many of the shortcomings of the binary metric will be refined and piloted in select participating countries in order to validate them for wider application. The feasibility of rolling out global customized energy surveys will also be explored. Methodologies for measuring access to energy for productive and commercial uses, as well as for heating applications, will also be developed. For country tracking in the medium term, the refined version of the multi-tier metric for electricity and modern cooking solutions will be implemented across all participating countries. Selected implementation of measurements of heating, productive, and community uses will also be carried out over this period. For global tracking in the medium term, a simplified version of the multi-tier metric comprising two thresholds will be adopted. Nationally representative household surveys will need to be modified to capture the necessary household information for an effective implementation of this tiered metric (table 2.4).

CHALLENGE	PROPOSED APPROACH TO GLOBAL TRACKING	PROPOSED APPROACH TO COUNTRY TRACKING
Off-grid, mini-grid, and grid solutions	Two-threshold measurement to reflect access to electricity for lighting and for more advanced applications on a technology-neutral basis.	Technology-neutral multi-tier measurement based on attributes of supply and covering grid and off-grid solutions.
Quality of supply	Not reflected. Quality of supply cannot be measured without detailed household surveys or reliable utility data.	Quality of supply aspects are reflected through detailed household surveys using the multi-tier framework.
Access to electricity supply versus electricity services	Electricity supply and services overlap across the two-threshold measurement.	Both electricity services and electricity supply are measured through separate multi-tier frameworks.
Productive and community uses	New methodologies to be developed.	New methodologies to be developed.
Heating	New methodologies to be developed.	New methodologies to be developed.
Improved solid fuel cookstoves	Two-threshold measurement to reflect the use of manufactured non-BLEN cookstoves and BLEN cookstoves (based on direct observation).	Technology-neutral multi-tier framework reflects the wide range of technical performance of non-BLEN cookstoves, along with the associated CCA attributes.
Stacking of stoves and fuels	Only the primary cooking solution is reflected.	Multi-tier framework reflects fuel stacking through the adequacy attribute.
Convenience and conformity	Not reflected. BLEN cookstoves may be assumed to be convenient and conforming.	Multi-tier framework reflects all actual use attributes.

TABLE 2.4 **ADDRESSING METHODOLOGICAL CHALLENGES THROUGH THE MEDIUM TERM**

SOURCE: AUTHORS.
NOTE: BLEN = BIOGAS–LPG–ELECTRICITY–NATURAL GAS; CCA = CONFORMITY, CONVENIENCE, AND ADEQUACY.

SECTION 2. ACCESS TO ELECTRICITY

This section presents a global and regional snapshot of electricity access in 2010 and access trends since 1990. It delves into country trends, identifying high-impact and fast-moving countries. The analysis makes use of binary access metrics and rests on modeled estimates from the World Bank's Global Electrification Database, as elaborated in section 1.

Global snapshot in 2010

The starting point for global electrification, against which future improvement will be measured, is established as 83 percent in 2010, with the SE4ALL global objective being 100 percent by 2030. Due to the lim itations of the binary metric in capturing inadequate service quality, this can be considered an upper bound for electrification.

1.2 BILLION
PEOPLE LIVED
WITHOUT ELECTRICITY IN 2010

The electricity access deficit affects 17 percent of the global population, or 1.2 billion people, about 85 percent of whom live in rural areas and 87 percent in Sub-Saharan Africa and Southern Asia. The rest of the unelectrified are scattered around the world, with a sizeable number in Southeastern Asia (figure 2.6). The primary sources of energy for the unelectrified population are kerosene, candles, and batteries. Ensuring sustainable delivery of modern energy services to this unserved population is vital to global prosperity and development.

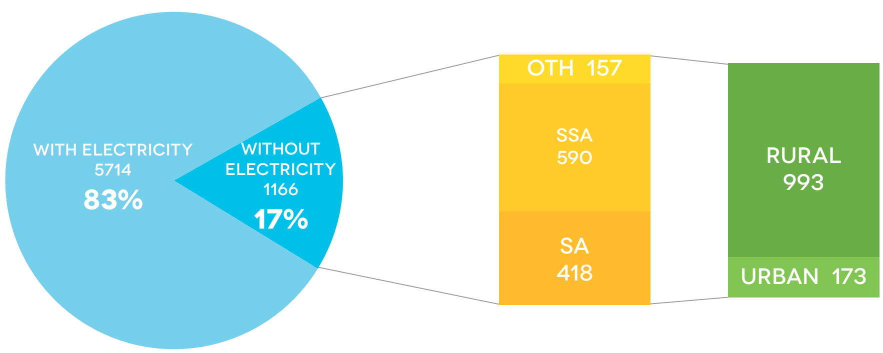


FIGURE 2.6 **THE ELECTRICITY ACCESS DEFICIT IN 2010**
(% AND ABSOLUTE NUMBER OF UNELECTRIFIED PEOPLE IN MILLIONS)

SOURCE: WORLD BANK'S GLOBAL ELECTRIFICATION DATABASE 2012.
NOTE: AUSTRALIA AND NEW ZEALAND ARE INCLUDED IN THE DEVELOPED COUNTRIES GROUP (AND NOT IN OCEANIA). CCA = CAUCASUS AND CENTRAL ASIA; DEV = DEVELOPED COUNTRIES; EA = EASTERN ASIA; LAC = LATIN AMERICA AND THE CARIBBEAN; NA = NORTHERN AFRICA; SEA = SOUTHEASTERN ASIA; SA = SOUTHERN ASIA; SSA = SUB-SAHARAN AFRICA; WA = WESTERN ASIA; OTH = OTHERS.

The regional electrification rate varies from 25 percent in Oceania to 32 percent in Sub-Saharan Africa to near-universal access (greater than 95 percent) in the Caucasus and Central Asia, Eastern Asia, Northern Africa, and the developed countries. More-urbanized and higher-income regions typically exhibit higher electrification rates. Northern Africa, Eastern Asia, Southeastern Asia, and the Caucasus and Central Asia are clustered together and demonstrate a distinctly higher electrification rate than the other developing regions. Western Asia and Latin America are to some extent outliers which report by far the highest income and urbanization rate, yet report lower electrification rates than Eastern Asia and Northern Africa (figure 2.7). Southern Asia also stands out as having an electrification rate of around double that observed in Sub-Saharan Africa and Oceania both with comparable income levels and rates of urbanization.

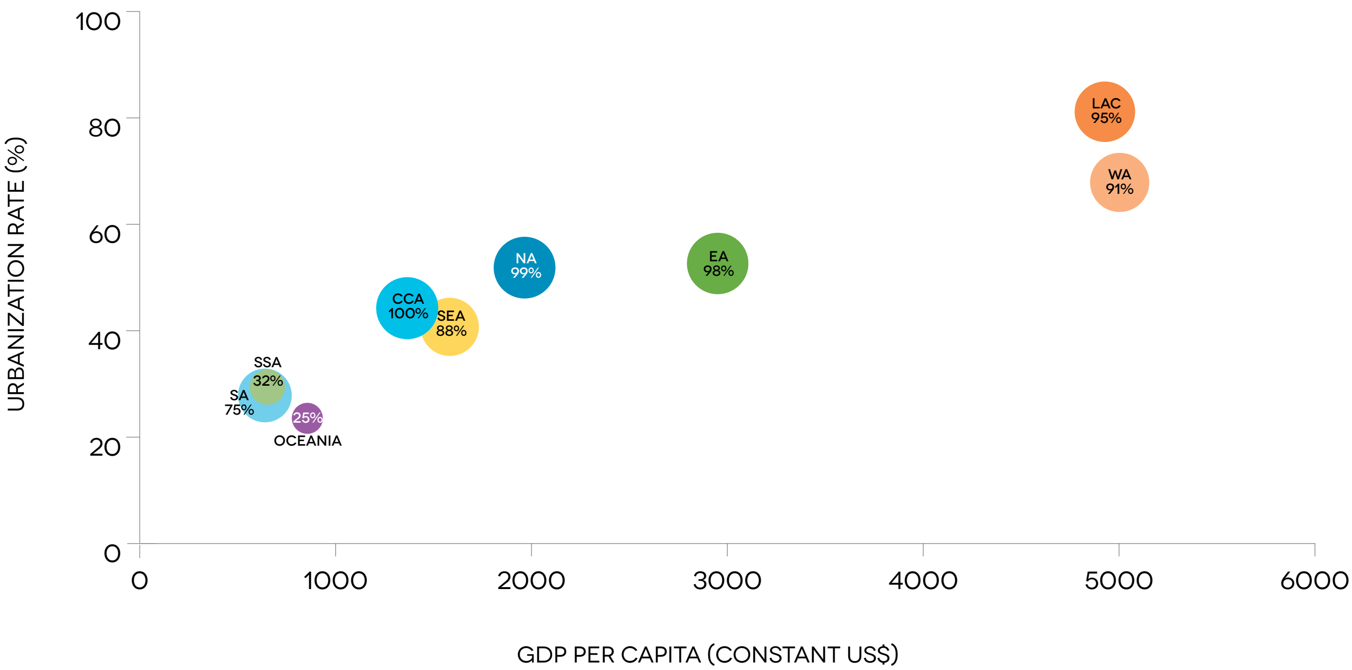


FIGURE 2.7 **REGIONAL ELECTRIFICATION RATE IN 2010, BY LEVEL OF URBANIZATION AND INCOME**

SOURCE: WORLD BANK'S GLOBAL ELECTRIFICATION DATABASE 2012.
NOTE: SIZE OF BUBBLE INDICATES ELECTRIFICATION RATE BY REGION. CCA = CAUCASUS AND CENTRAL ASIA; EA = EASTERN ASIA; LAC = LATIN AMERICA AND CARIBBEAN; NA = NORTHERN AFRICA; SEA = SOUTHEASTERN ASIA; SA = SOUTHERN ASIA; SSA = SUB-SAHARAN AFRICA; WA = WESTERN ASIA.

Sub-Saharan Africa and Oceania are the only regions where the majority of the population remains unelectrified. In fact, Sub-Saharan Africa accounts for 48 percent of the unelectrified rural population in the world. Rural areas have achieved more than 63 percent electrification in every region except Sub-Saharan Africa and Oceania (where only 14 percent of the rural population is electrified in bot region). Similarly, urban areas have achieved more than a 90 percent electrification rate in every region except Sub-Saharan Africa (63 percent of urban population) and Oceania (65 percent of urban population). It is evident that rural areas the world over remain far from universal access, while in urban areas the challenge is largely concentrated in Sub-Saharan Africa and Oceania (figure 2.8).

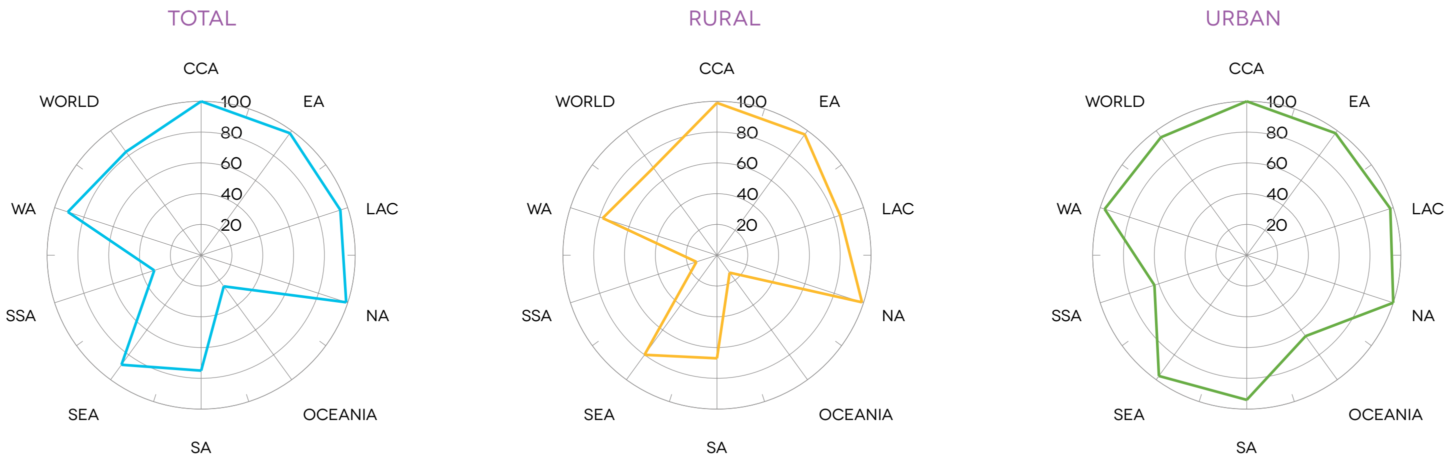


FIGURE 2.8 **REGIONAL ELECTRIFICATION RATES IN 2010: BY REGION**

SOURCE: WORLD BANK'S GLOBAL ELECTRIFICATION DATABASE 2012.
NOTE: CCA = CAUCASUS AND CENTRAL ASIA; EA = EASTERN ASIA; LAC = LATIN AMERICA AND CARIBBEAN; NA = NORTHERN AFRICA; SEA = SOUTHEASTERN ASIA; SA = SOUTHERN ASIA; SSA = SUB-SAHARAN AFRICA; WA = WESTERN ASIA.

Global trends

In the 1990s and 2000s, the global electrification rate rose from 76 percent to 83 percent within 20 years, driven by expansion in rural areas, where the access rate grew from 61 percent to 70 percent. The urban electrification rate remained relatively stable, growing from 94 to 95 percent across the period. Southeastern Asia and Southern Asia witnessed dramatic progress, both displaying a 24 and 17 percentage point increase respectively. Sub-Saharan Africa followed far behind, with gains of 9 percentage points and Oceania with 4 percentage increased in 20 years. Eastern Asia, Northern Africa, Latin America and the Caribbean, and the Caucasus and Central Asia had already accomplished near-universal access by 2000. The remaining regions registered modest or negligible changes in the two decades and remained in the 80–95 percent electrification range (figure 2.9).

70%
OF THOSE GAINING ACCES
TO ELECTRICITY BETWEEN 1990 AND 2010 WERE FROM URBAN AREAS

Between 1990 and 2010, the global population expanded by around 1.6 billion, while the global electrified population rose by around 1.7 billion people. Globally, therefore, access to electricity outpaced population growth by about 128 million people during the period. While growth in the electrified population in Southern Asia, Eastern Asia, Southeastern Asia, Latin America and the Caribbean, Northern Africa, the Caucasus and Central Asia, and Asia Oceania kept pace with growth in population, the growth in the electrified population of Sub-Saharan Africa fell behind growth in population.

1.7 BILLION
PEOPLE GAINED ACCESS TO ELECTRICITY;
JUST SLIGHTLY AHEAD OF GLOBAL POPULATION GROWTH

The increment in electrification was comparable across both decades, but the geographical growth centers varied. Southeastern Asia, Western Asia, and Northern Africa added an almost equivalent number of people in both decades. Southern Asia and Sub-Saharan Africa added a comparatively higher number of people in the second half of the period (figure 2.10).

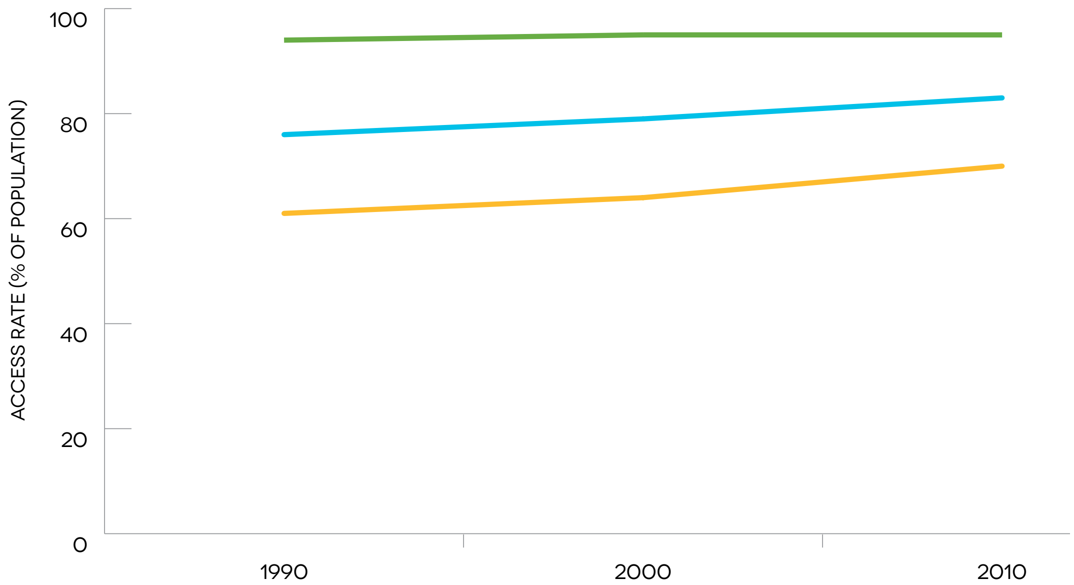


FIGURE 2.9A **GLOBAL TRENDS IN THE ELECTRIFICATION RATE, 1990–2010**

TOTAL RURAL URBAN

SOURCE: WORLD BANK'S GLOBAL ELECTRIFICATION DATABASE 2012.

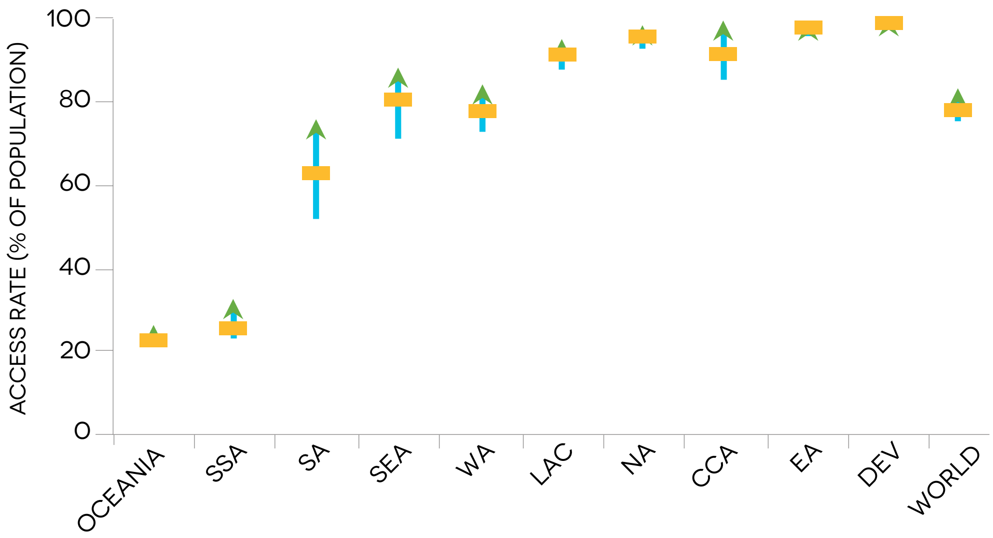


FIGURE 2.9B **REGIONAL TRENDS IN THE ELECTRIFICATION RATE, 1990–2010**

1990 2000 2010

SOURCE: WORLD BANK'S GLOBAL ELECTRIFICATION DATABASE 2012.
NOTE: CCA = CAUCASUS AND CENTRAL ASIA; DEV = DEVELOPED COUNTRIES; EA = EASTERN ASIA; LAC = LATIN AMERICA AND CARIBBEAN; NA = NORTHERN AFRICA; SA = SOUTHERN ASIA; SEA = SOUTHEASTERN ASIA; SSA = SUB-SAHARAN AFRICA; WA = WESTERN ASIA.

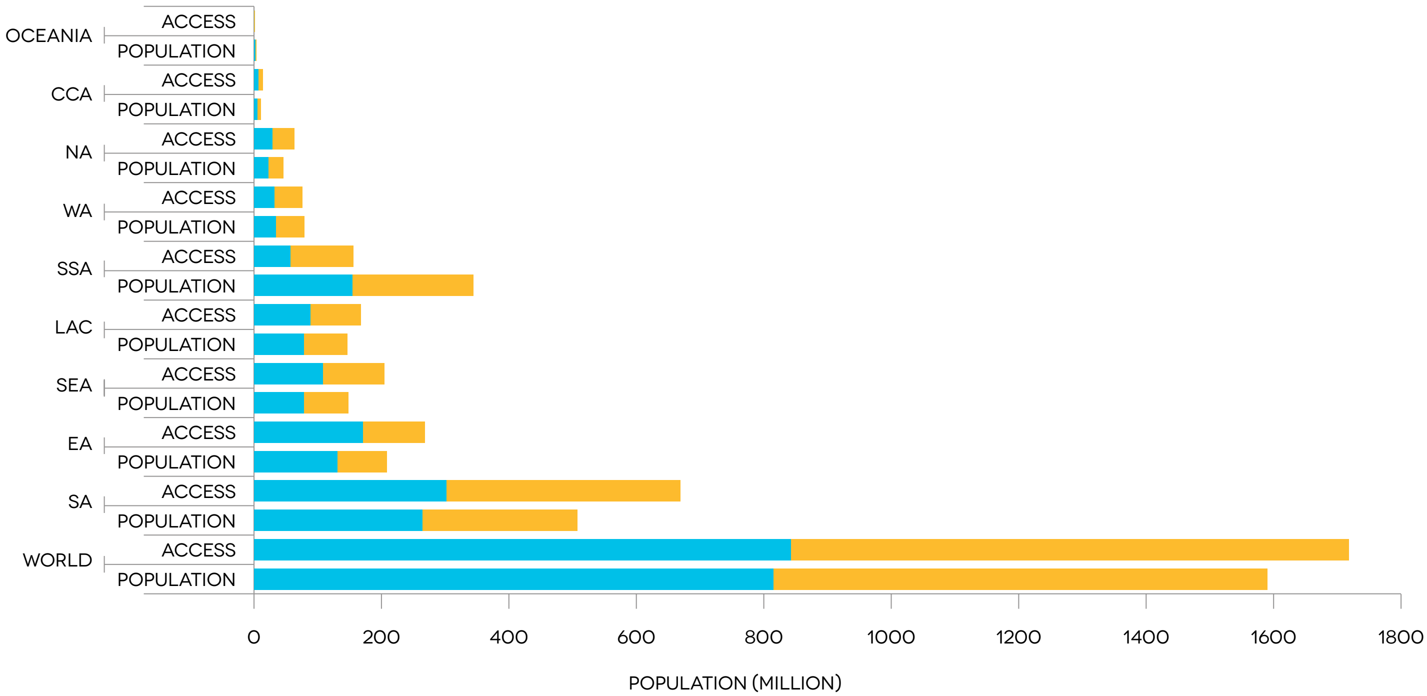


FIGURE 2.10 **POPULATION GROWTH AND PROGRESS IN ACCESS TO ELECTRICITY, 1990–2010**

1990–2000 | 2001–2010

SOURCE: WORLD BANK GLOBAL ELECTRIFICATION DATABASE 2012.
NOTE: CCA = CAUCASUS AND CENTRAL ASIA; EA = EASTERN ASIA; LAC = LATIN AMERICA AND CARIBBEAN; NA = NORTHERN AFRICA; SA = SOUTHERN ASIA; SEA = SOUTHEASTERN ASIA; SSA = SUB-SAHARAN AFRICA; WA = WESTERN ASIA.

Dramatic urbanization has altered the profile of electrification during 1990–2010. Population growth in urban areas was explosive (about 1.3 billion people, compared to 315 million in rural areas). As a result, the global population is now roughly equally divided between urban and rural areas. The evolution of electrification, meanwhile, differed in its pattern. Starting in 1990, the electrified population was 2.1 billion in urban areas and 1.8 billion in rural areas, respectively (figure 2.11). Expansion of electrification in urban areas, at 1.7 percent annually, far outstripped the 0.8 percent growth rate found in rural areas. However, due to more rapid demographic growth in cities, electrification in urban areas falls behind population growth by 56 million people. On the other hand, the relatively modest population growth in rural populations made it possible for rural electrification to outstrip population growth by 195 million. Consequently, rural electrification rates jumped by 9 percentage points in 1990–2010.

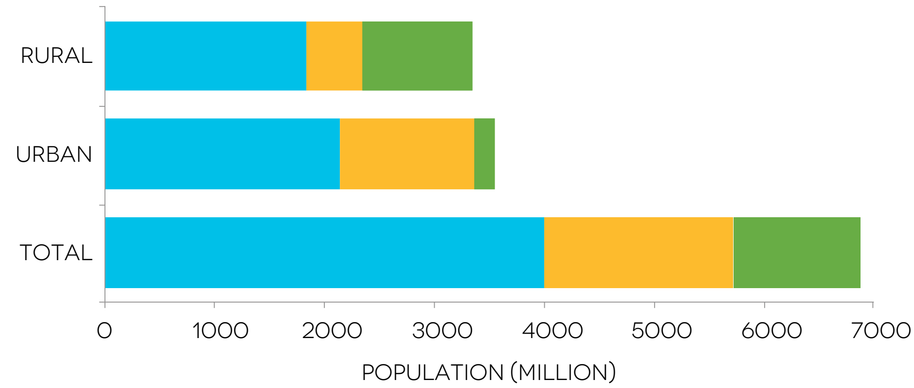


FIGURE 2.11A **GLOBAL PROGRESS IN ACCESS, BY URBANIZATION STATUS, 1990–2010**

POPULATION WITH ACCESS IN 1990 INCREMENTAL ACCESS IN 1990–2010 POPULATION WITHOUT ACCESS IN 2010

SOURCE: WORLD BANK'S GLOBAL ELECTRIFICATION DATABASE 2012.

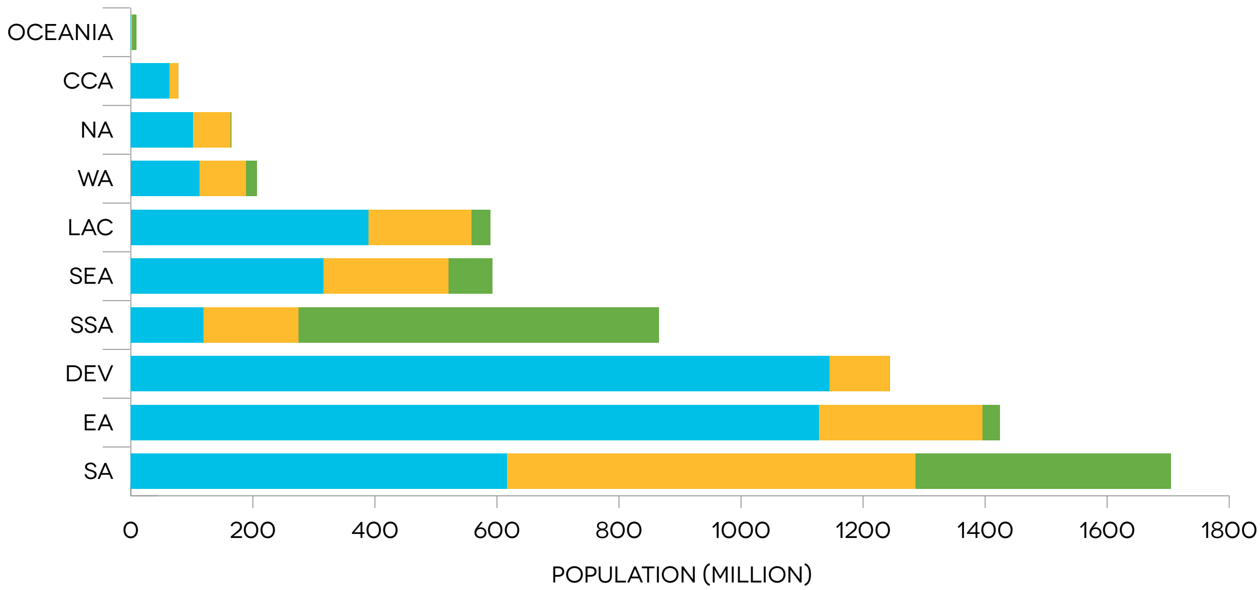


FIGURE 2.11B **GLOBAL PROGRESS IN ACCESS, BY REGION, 1990–2010**

POPULATION WITH ACCESS IN 1990 INCREMENTAL ACCESS IN 1990–2010 POPULATION WITHOUT ACCESS IN 2010

SOURCE: WORLD BANK'S GLOBAL ELECTRIFICATION DATABASE 2012.
NOTE: CCA = CAUCASUS AND CENTRAL ASIA; DEV = DEVELOPED COUNTRIES; EA = EASTERN ASIA; LAC = LATIN AMERICA AND CARIBBEAN; NA = NORTHERN AFRICA; SA = SOUTHERN ASIA; SEA = SOUTHEASTERN ASIA; SSA = SUB-SAHARAN AFRICA; WA = WESTERN ASIA.

The most-remarkable urban growth stories occurred in the Asian regions and in particular in Eastern Asia, Southeastern Asia, Western Asia and Southern Asia. The four regions displayed close to a 2.5 percent annual urban growth rate and together managed to move 788 million people—39 million a year—into electricity use. The rural increment was highest in Southern Asia and Southeastern Asia, where 534 million, or 27 million people annually, were added to the rolls of rural electricity users.

In every region in the world, urban electrification expanded by around 1 percent a year. Rural electrification, on the other hand, witnessed minimal growth rates in Sub-Saharan Africa and Oceania and a negative growth rate in Eastern Asia and the developed countries. The growth performance of Southeastern Asia and in Southern Asia was impressive in both rural and urban areas.

Though the access deficit in 2010 is geographically concentrated in Sub-Saharan Africa and Southern Asia, the electrification trends in these two regions have moved in opposite directions. Sub-Saharan Africa is the only region where the unelectrified population increased in both urban and rural areas, owing to an inability to keep pace with a growing population. Southern Asia recorded the most remarkable progress in electrification, adding 669 million new users of electricity (about 33 million each year and 161 million more than population growth for the period). In Sub-Saharan Africa, by contrast, only 156 million people gained access to electricity in 1990–2010, trailing population growth by 189 million people. Rural electrification was particularly slow in Sub-Saharan Africa, where the electrified population grew only by 0.4 percent (figure 2.12). Eastern Asia experienced a decrease in rural population of about 163 million people over the two decades, with a consequent annual decline of 1 percent in the electrified rural population.

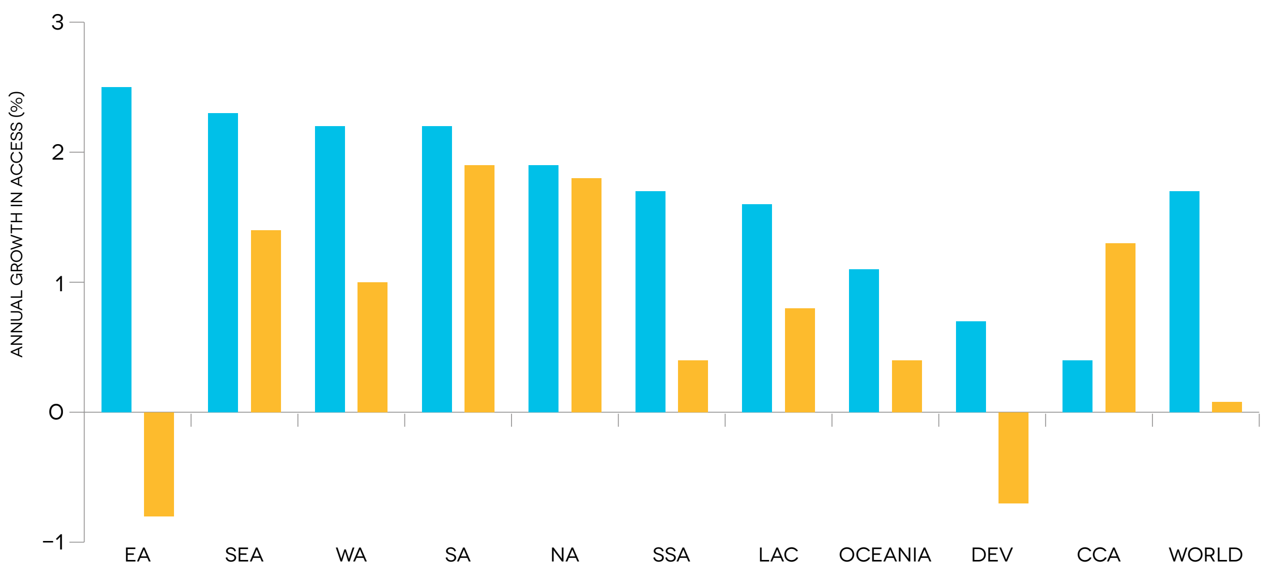


FIGURE 2.12 **ANNUAL GROWTH IN POPULATION WITH ACCESS: URBAN AND RURAL AREAS, 1990–2010**

RURAL URBAN

SOURCE: WORLD BANK'S GLOBAL ELECTRIFICATION DATABASE 2012.
NOTE: CCA = CAUCASUS AND CENTRAL ASIA; DEV = DEVELOPED COUNTRIES; EA = EASTERN ASIA; LAC = LATIN AMERICA AND CARIBBEAN; NA = NORTHERN AFRICA; SA = SOUTHERN ASIA; SEA = SOUTHEASTERN ASIA; SSA = SUB-SAHARAN AFRICA; WA = WESTERN ASIA.

Country snapshots in 2010

The electrification rate spans a wide range: from just 1.5 percent in South Sudan to near-universal access in 39 developing countries. (When the developed countries are added, the number of countries with near-universal access rises to 95.) Even within regions, there is heterogeneity in the electrification rate. For example, in Sub-Saharan Africa, Mauritius is the only country with access rates above 95 percent. In Southern Asia, the outliers are Bhutan and the Islamic Republic of Iran where access rates exceed 95 percent.

The world can be arbitrarily divided into three blocks of countries based on the electrification rate—those at the lower end (<30 percent), those in the middle (30–95 percent), and those at the high end (>95 percent). At the lower end are 32 countries—28 in Sub-Saharan Africa, 3 in Oceania, and 1 in Eastern Asia. Seven of these lower-end countries, all in Sub-Saharan Africa, have an access rate lower than 10 percent. At the higher end are 95 countries, only one of them in Sub-Saharan Africa (Mauritius). The Caucasus and Central Asia, Northern Africa, and the developed countries have homogenous universal access rates. In all other regions, the countries are spread across the three blocks, though in Sub-Saharan Africa countries at the lower end of the electrification rate outnumber the countries at the higher end (figure 2.13).

The heterogeneity stems primarily from disparities in rural areas. Four countries, all located in Sub-Saharan Africa, still have less than 1 percent of their rural population in the electrified category. The median rural access rate is at 9 percent in Sub-Saharan Africa, compared to a global median of 89 percent. The electrification rate is relatively uniform in urban areas, with 123 countries reporting near-universal access. In urban areas, the median is higher than 99.6 percent in all regions, except in Sub-Saharan Africa, where it is 53 percent.

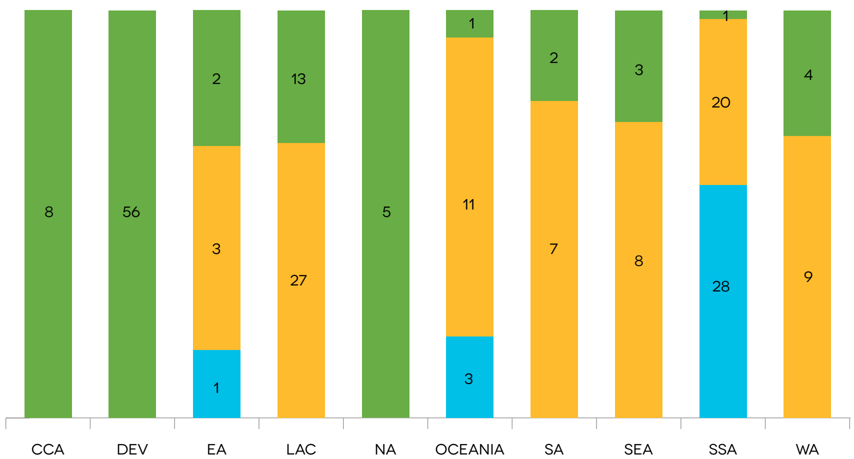


FIGURE 2.13 **DISTRIBUTION OF RATES OF ACCESS TO ELECTRICITY, BY NUMBER OF COUNTRIES PER REGION**

<30 30<>95 >95

SOURCE: WORLD BANK'S GLOBAL ELECTRIFICATION DATABASE 2012.
NOTE: CCA = CAUCASUS AND CENTRAL ASIA; DEV = DEVELOPED COUNTRIES; EA = EASTERN ASIA; LAC = LATIN AMERICA AND CARIBBEAN; NA = NORTHERN AFRICA; SA = SOUTHERN ASIA; SEA = SOUTHEASTERN ASIA; SSA = SUB-SAHARAN AFRICA; WA = WESTERN ASIA.

High-impact countries

The 20 countries with the highest access deficits and the 20 with the lowest electrification rates—dubbed "high-impact countries" for purposes of achieving the SE4ALL target of universal access by 2030—illustrate the magnitude of the access challenge. The 20 countries with the greatest access deficits measured in absolute terms are home to 889 million people who lack access to electricity—more than two-thirds of the global total. Eight are in Asia and 12 in Africa. India's share is the largest—India's unelectrified population is equivalent to the total population of the United States. 19 of the top 20 countries with the lowest electrification rates are in Sub-Saharan Africa. All 20 countries together represent about 287 million unelectrified people, one-fourth of the global total (figure 2.14). The development impact of electrification in these countries is immense, even though their contribution to the SE4ALL universal access objective is projected to be substantially smaller than that of the group of countries with the largest access deficits.

19/20
COUNTRIES
WITH THE LOWEST ENERGY ACCESS RATES GLOBALLY ARE IN SUB-SAHARAN AFRICA

74%
OF THE GLOBAL ACCESS DEFICIT
FOR ELECTRICITY IS CONCENTRATED IN JUST 20 COUNTRIES

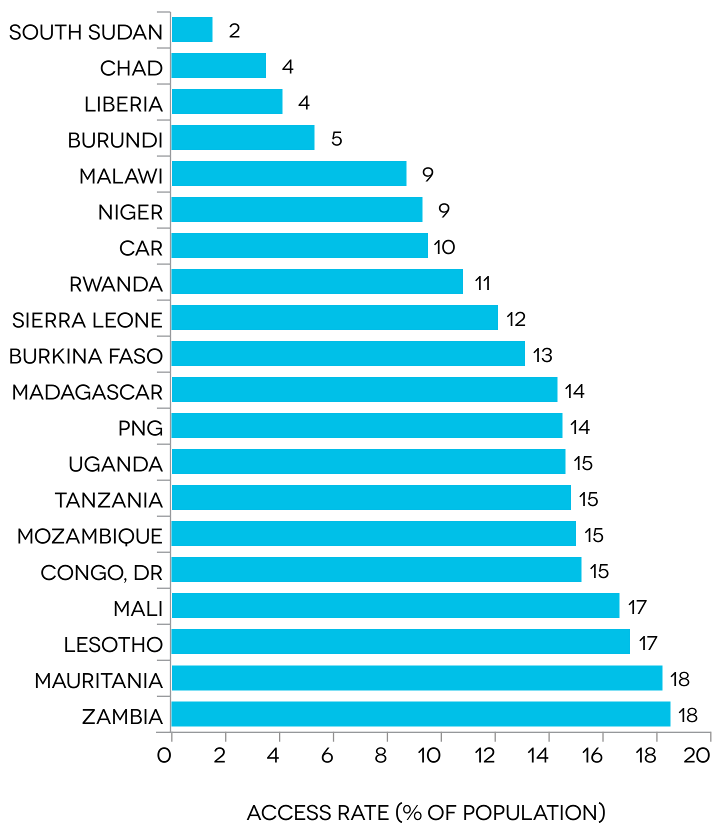


FIGURE 2.14A **TOP 20 COUNTRIES WITH LOWEST ACCESS RATES**

SOURCE: WORLD BANK'S GLOBAL ELECTRIFICATION DATABASE 2012.
NOTE: CAR=CENTRAL AFRICAN REPUBLIC; PNG=PAPUA NEW GUINEA; DR =DEMOCRATIC REPUBLIC.

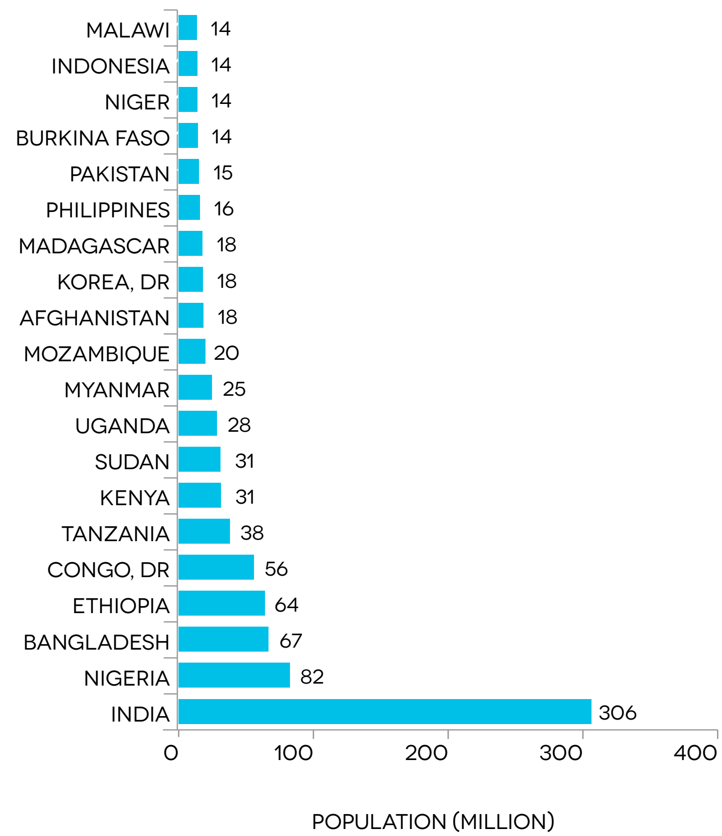


FIGURE 2.14B **TOP 20 COUNTRIES WITH LARGEST ACCESS DEFICITS**

SOURCE: WORLD BANK'S GLOBAL ELECTRIFICATION DATABASE 2012.
NOTE: DR = DEMOCRATIC REPUBLIC.

Fast-moving countries

Of the 20 countries with the largest number of people that have been electrified during the last 20 years, 12 are in Asia. Their experience could hold valuable policy lessons for other countries aiming to accelerate electrification. They introduced 1.3 billion people to electricity (of the 1.7 billion electrified globally between 1990 and 2010), 283 million more than their population increase. The most impressive expansion of electrification occurred in India, China, Indonesia, Pakistan and Bangladesh. The advances in these populous countries are of enormous significance for achievement of the global universal access target. In particular, India charted a remarkable trajectory, electrifying 474 million people over two decades, or 24 million people annually (figure 2.15), with an annual growth rate of around 1.9 percent.

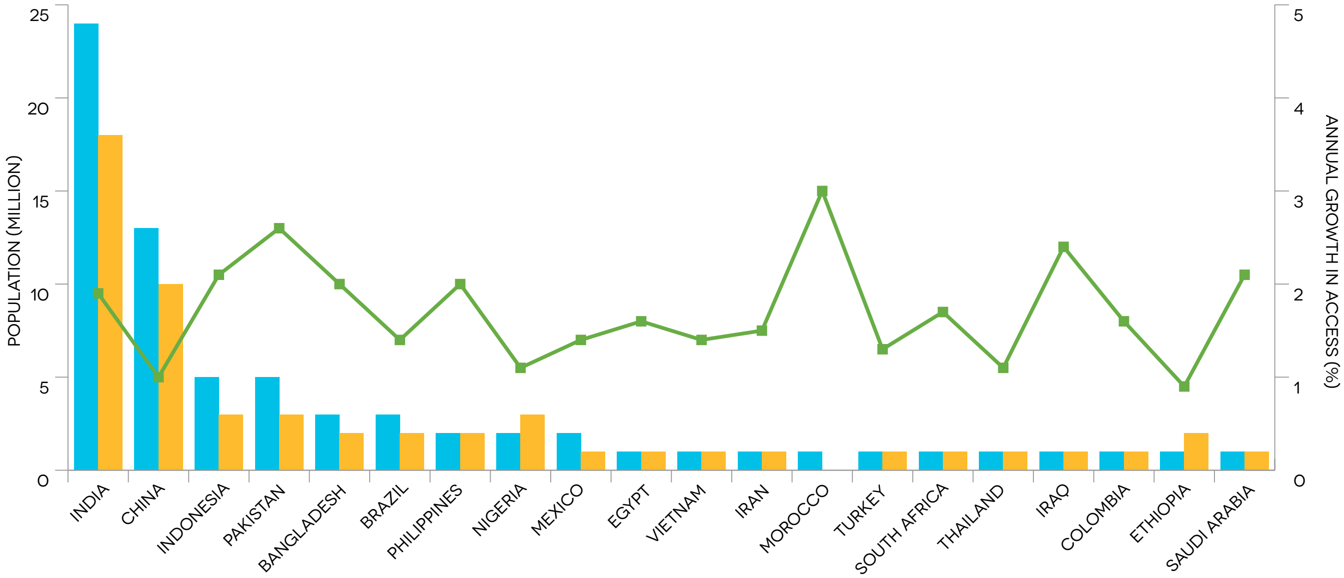


FIGURE 2.15 **TOP 20 DEVELOPING COUNTRIES WITH GREATEST ANNUAL PROGRESS IN ACCESS TO ELECTRICITY, 1990–2010**

INCREMENTAL ACCESS (MILLION) INCREMENTAL TOTAL POPULATION (MILLION) ANNUAL GROWTH IN ACCESS (%)

SOURCE: WORLD BANK'S GLOBAL ELECTRIFICATION DATABASE 2012.

Focusing on absolute increments in the electrified population tends to highlight the experience of populous countries. Another measure identifies a different group of 20 countries whose electrified population grew the fastest relative to the size of their overall population. The analysis shows that these countries provided new electricity service to at least 2 percent of their populations annually. Only two country—United Arab Emirates and Qatar—raised its pace of electrification beyond 3.5 percent of the population annually (figure 2.16). Interestingly, Iraq , Indonesia, Bangladesh and Pakistan belong to both groups showing substantial progress in electrification both in absolute terms and relative to the size of their respective populations.

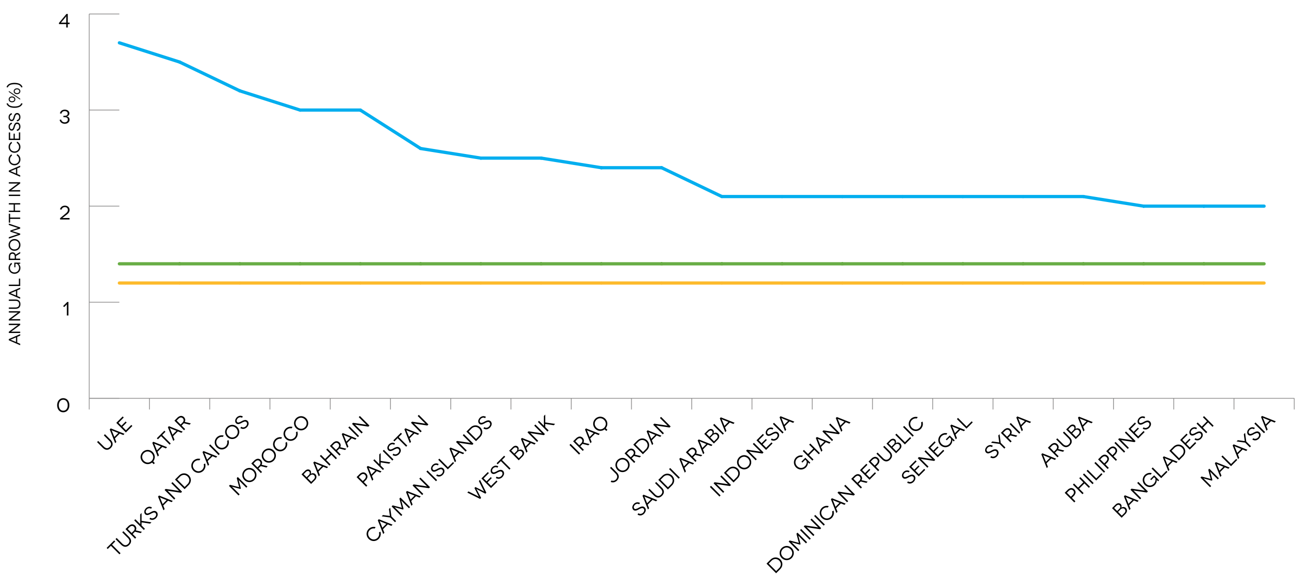


FIGURE 2.16 **TOP 20 FASTEST-GROWING COUNTRIES**

GLOBAL ANNUAL GROWTH IN ACCESS= 1.2% ANNUAL GROWTH IN ACCESS (%) DEVELOPING COUNTRIES ANNUAL GROWTH IN ACCESS= 1.4%

SOURCE: WORLD BANK'S GLOBAL ELECTRIFICATION DATABASE 2012.
NOTE: UAE = UNITED ARAB EMIRATES.

Mapping multi-tier measurements with existing databases

The World Bank's Global Electrification Database and the IEA's World Energy Statistics and Balances can be used with the multi-tier methodology for measuring electricity access by combining the country's electrification rate with average residential electricity consumption. But it is important to recognize that the approximation of the tier (T), based on average consumption at the country level, does not provide the distribution of households across all five tiers of access for the country. Moreover, an indicator based on kilowatt hours consumed cannot accurately reflect the diversity of appliances used or appropriately account for energy efficiency. Implementation of the household-level multi-tier framework using survey data is critical to capture progress in electricity access in its entirety.

This adaptation of the multi-tier methodology to available databases employs two variables to assign a tier to a country and create an "index of access." First, each tier is transformed into annual consumption ranges by assuming indicative use (in hours) of a minimum package of electricity services (in wattage) (annex 5). Tier 0 represents a category of households that do not receive electricity by any means and is associated with an annual household consumption range of less than 3 kWh per year. From tier-tier 1 onwards, households have access to electricity at different levels of service and quality. Each tier corresponds, among other attributes, to the use of several appliances, which determine the definition of the range of kilowatt-hours per household per year equivalent to each tier. The associated annual household consumption range increases accordingly, with tier 5 corresponding to consumption in excess of 2,121 kWh per year.

Residential electricity consumption data available from the IEA,[31] together with the electrification rate, make it possible to place a country's households either in tier 0 for those who lack access or in the tier corresponding to the average residential electricity consumption of the population with access. In Zambia, for example, 81.5 percent of households are categorized as tier 0 (no access) and 18.5 percent as tier 5 based on the average annual electricity residential consumption of 5,779 Kwh per household per year. The index of access for Zambia is therefore a population-weighted average of these two tiers, which comes to 0.9.

	TIER 0	TIER 1	TIER 2	TIER 3	TIER 4	TIER 5
Indicative electricity services	-	Task lighting + Phone charging or Radio	General lighting + Air circulation + Television	Tier 2 + Light appliances	Tier 3 + Medium or continuous appliances	Tier 4 + Heavy or continuous appliances
Consumption (kWh) per household per year	<3	3–66	67–321	322–1,318	1,319–2,121	>2,121

Index of access to electricity supply = $\sum(P_T \times T)$

with P_T = Proportion of households at tier T

T = tier number {0,1,2,3,4,5}

FIGURE 2.17 **MAPPING OF TIERS OF ELECTRICITY CONSUMPTION TO INDICATIVE ELECTRICITY SERVICES**

SOURCE: AUTHORS.
NOTE: KWH = KILOWATT-HOUR.

[31] The residential annual consumption per household varies in developing countries from 255 kWh in Sub-Saharan Africa to 20,000 kWh in Western Asia, with a median consumption of 1,696 kWh.

The access index can range from 0 to 5. In 2000 the global average of the simplified energy access index based on average consumption was 3.6, and by 2010 it had increased to 3.9.[32] In 2010, 103 countries (78 percent) reported a value of 3 or above; the remaining 29 countries scored between 0.6 and 2.6 (19 of them in Sub-Saharan Africa). At the regional level, all regions had an index above 3, except Sub-Saharan Africa and Southern Asia, which reported an average index of 1.4 and 2.8, respectively (figure 2.18). All regions have shown progress in their indices over time, recording both higher electrification rates and increased average consumption.[33] The strongest improvements in performance were in Southeastern Asia and Eastern Asia. Sub-Saharan Africa reported weak improvement in both electrification and average consumption.

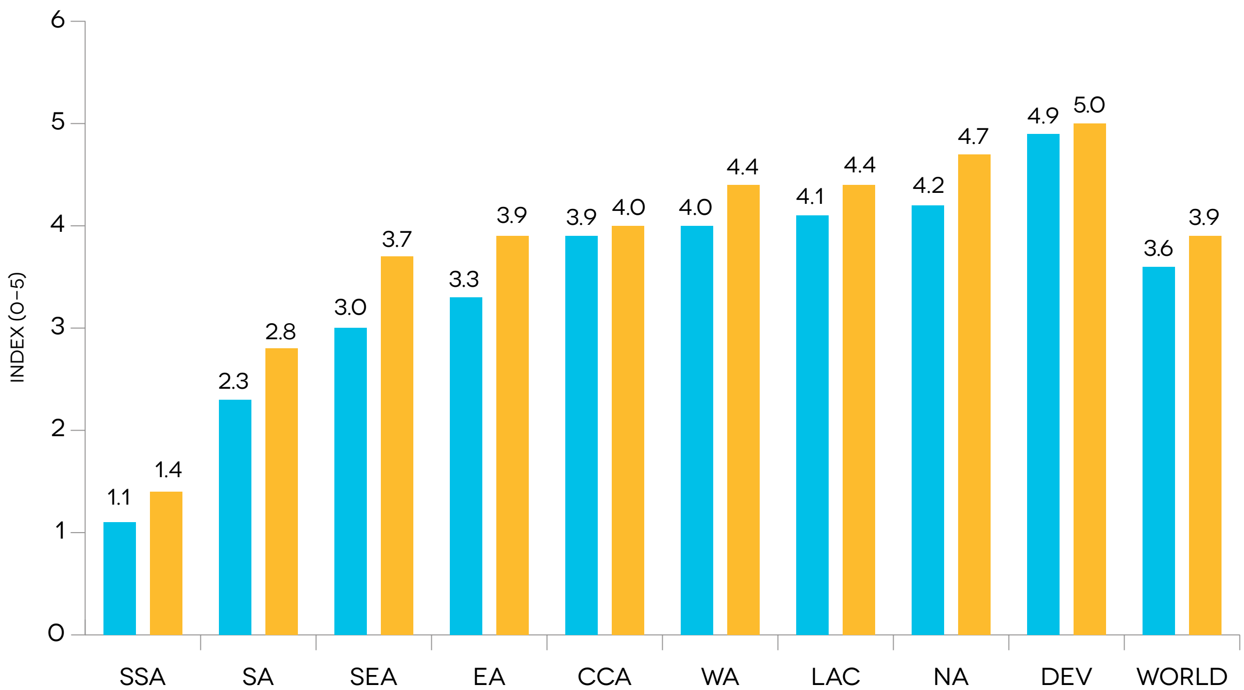


FIGURE 2.18 **APPROXIMATION TO MULTI-TIER INDEX OF ELECTRICITY ACCESS BASED ON NATIONAL DATA, 2000 AND 2010**

SOURCE: BASED ON THE WORLD BANK'S GLOBAL ELECTRIFICATION DATABASE AND IEA (2012).
NOTE: CCA = CAUCASUS AND CENTRAL ASIA; DEV = DEVELOPED COUNTRIES; EA = EASTERN ASIA; LAC = LATIN AMERICA AND CARIBBEAN; NA = NORTHERN AFRICA; SEA = SOUTHEASTERN ASIA; SA = SOUTHERN ASIA; SSA = SUB-SAHARAN AFRICA; WA = WESTERN ASIA.

[32] The IEA's World Energy Statistics and Balances database reports average consumption data by country for 132 countries out of the 212 countries included in the World Bank's Global Electrification Database, leaving out 4 percent of the global population (295 million people in 2010). The lack of data is particularly acute in Sub-Saharan Africa, where 28 countries out of 49 do not report consumption data, accounting for 207 million people in 2010 (or 24 percent of Sub-Saharan Africa's population). There are relatively large countries among them—one-third of the missing countries have populations in excess of 10 million people, and one country (Uganda) has a population of more than 30 million.

[33] The only exception is the Caucasus and Central Asia region, which recorded a slight decrease in the average consumption.

SECTION 3. ACCESS TO NON-SOLID FUELS

This section presents a global and regional snapshot of access to non-solid fuels in 2010, as well as global trends since 1990. Current global data capture only primary fuel use. Given this constraint, in estimating the starting point for access to modern cooking solutions, access is defined in terms of the primary non-solid fuel used by households for cooking. The access deficit is represented by households still dependent on solid fuels.[34] The country snapshots provided in this section focus on high-impact and fast-moving nations that are introducing large numbers of new households to non-solid fuel. The analysis rests on modeled estimates from the WHO's Global Household Energy Database and explained in section 1.

Global snapshot in 2010

The starting point for global access to non-solid fuel, against which future improvement will be measured, is established as 59 percent in 2010, with the SE4ALL global objective being 100 percent access by 2030. Owing to the limitations of the binary metric in capturing usage of improved biomass cookstoves, this can be considered a slight lower bound for access to modern cooking solutions.

2.8 BILLION PEOPLE RELIED PRIMARILY
ON SOLID FUELS FOR COOKING IN 2010

If the share of the global population that used primarily non-solid fuels in 2010 was 59 percent, that means that 41 percent of the global population, or 2.8 billion people, relied mainly on solid fuels for cooking. About 78 percent of that population lived in rural areas, and 96 percent was geographically concentrated in Sub-Saharan Africa, Eastern Asia, Southern Asia, and Southeastern Asia (figure 2.19). Ensuring sustainable delivery of non-solid fuel to these households is vital to global prosperity and development (box 2.3).

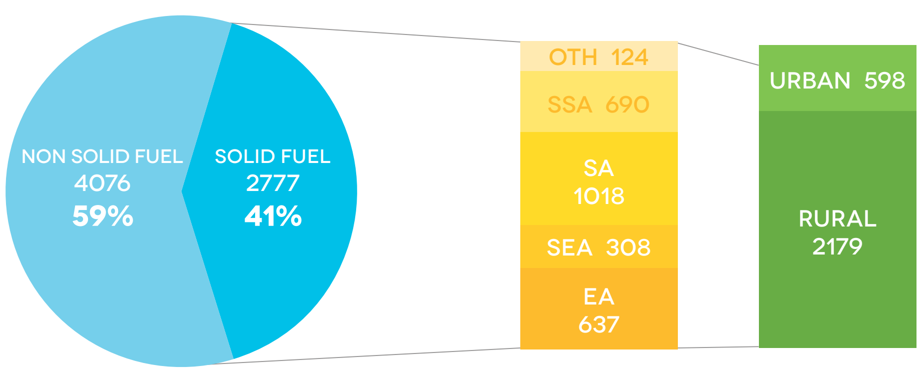


FIGURE 2.19 **DEFICIT IN ACCESS TO NON-SOLID FUEL, 2010**
(% AND ABSOLUTE NUMBER OF PEOPLE, IN MILLIONS, USING SOLID FUELS)

SOURCE: WHO'S GLOBAL HOUSEHOLD ENERGY DATABASE 2012.
NOTE: EA = EASTERN ASIA; SA = SOUTHERN ASIA; SEA = SOUTHEASTERN ASIA; SSA = SUB-SAHARAN AFRICA; OTH=OTHERS.

3.5 MILLION PEOPLE DIE EACH YEAR
– MAINLY WOMEN AND CHILDREN – DUE TO HARMFUL INDOOR AIR POLLUTION CAUSED BY UNSAFE COOKING PRACTICES

[34] Non-solid fuels include (i) liquid fuels (for example, kerosene, ethanol, or other biofuels), (ii) gaseous fuels (such as natural gas, liquefied petroleum gas [LPG], and biogas), and (iii) electricity. Solid fuels include (i) traditional biomass (for example, wood, charcoal, agricultural residues, and dung), (ii) processed biomass (such as pellets, and briquettes); and (iii) other solid fuels (such as coal and lignite).

BOX 2.3 Health and safety risks of the inefficient use of household fuels

The inefficient use of energy in the home for cooking, heating, and lighting is a major health risk across the developing world. Gender roles and inequalities impose differential costs on family members, with women bearing most of the negative effects of fuel collection and transport, household air pollution, and time-consuming and unsafe cooking technologies (Clancy, Skutsch, and Batchelor 2005). The smoke resulting from the incomplete combustion of fuels (for example, wood, coal, kerosene) is a major source of household air pollution (HAP), which contains fine particles (for example, black carbon), carcinogens, and other health-damaging pollutants (for example, carbon monoxide). Exposure to HAP has been shown to increase the risk of communicable diseases (pneumonia, tuberculosis) and noncommunicable diseases (heart disease, cancer, cataracts) and is responsible for a large fraction (3–5 percent) of the total global disease burden (WHO 2006b; Lim and others 2012). WHO estimated in 2004 that close to 2 million deaths, mostly of women and children, were attributed to exposure to HAP alone, the highest among the environmental risk factors (figure A). The toll includes more than half a million deaths from childhood pneumonia, almost a million deaths from chronic obstructive pulmonary disease, and around 36,000 from lung cancer traceable to coal use (WHO 2009). Another recent global disease burden assessment, which accounts for cardiovascular disease in addition to other health outcomes, estimates that in 2010 HAP was directly responsible for around 3.5 million deaths, and another half a million deaths from the ambient air pollution produced by HAP leaking outdoors (Lim and others 2012).

Inefficient energy use in the home also poses substantial risks to safety and is the cause of a large number of burns and injuries across the developing world. More than 95 percent of the 200,000 deaths from fire-related burns occur in developing countries; many can be attributed to the use of kerosene, open fires, and simple stoves in the home (Mills 2012). Fuel collection, typically done by women and children, puts people at risk of injury (for example, from land mines, snake, or insect bites) and violence (for example, rape, harassment) (WHO 2006b; Popalzai 2012). The ingestion of kerosene, often from unsafe storage containers (for example, soft drink and water bottles), is a major cause of child poisonings worldwide and can lead to death, chemical pneumotitis, and impairments to the central nervous system (Mills 2012).

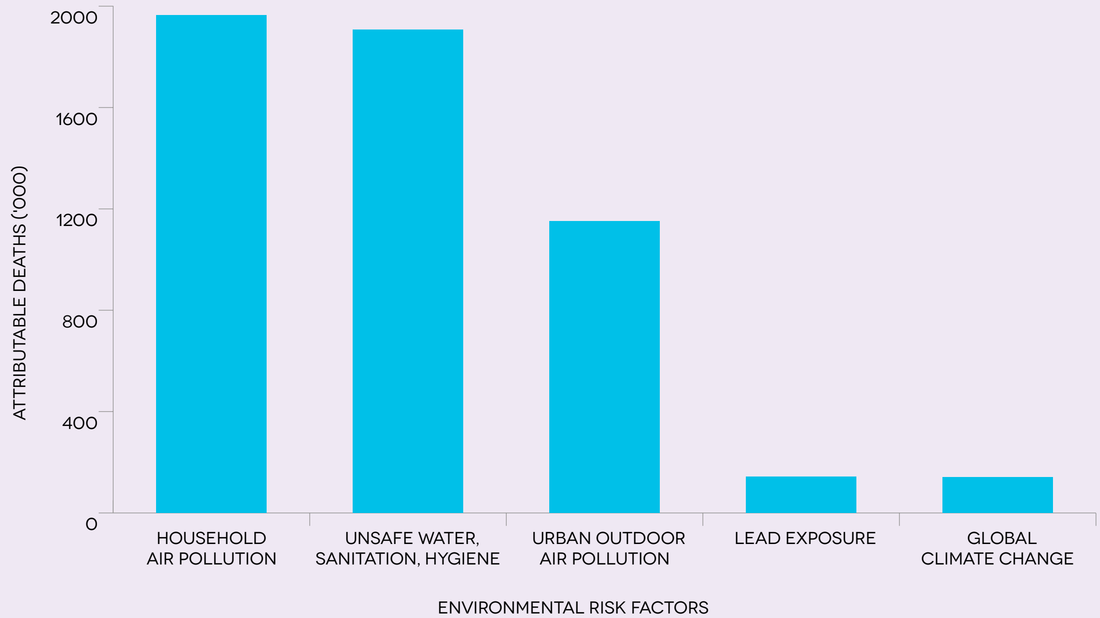


FIGURE A. **DEATHS ATTRIBUTABLE TO ENVIRONMENTAL RISK FACTORS**

SOURCE: WHO 2009.

Within the developing world, the rate of access to non-solid fuel varies from 19 percent in Sub-Saharan Africa to about 95 percent in Western Asia and 100 percent in Northern Africa. Except in Western Asia, the Caucasus and Central Asia, and Northern Africa, more than two-thirds of the rural population of the developing world depends on solid fuels. The situation is particularly dire in Sub-Saharan Africa (94 percent), Oceania (79 percent), Southeastern Asia (77 percent), and Southern Asia (73 percent). These four regions together account for three-quarters of the total rural use of solid fuel in the world. In urban areas, more than 70 percent of the population has access to non-solid fuel, except in Sub-Saharan Africa (42 percent) (figure 2.20).

More-urbanized and higher-income regions typically exhibit higher reliance on non-solid fuel. Western Asia, the wealthiest and most urbanized developing region, has close to universal access to non-solid fuel. At the lower end of the income and urbanization profile are Southern Asia, Sub-Saharan Africa, and Oceania, which also report the lowest access rates. But Southeastern Asia and Eastern Asia, with incomes and urbanization rates similar to those of Northern Africa, show markedly lower access rates (as indicated by the size of the bubbles in figure 2.21).

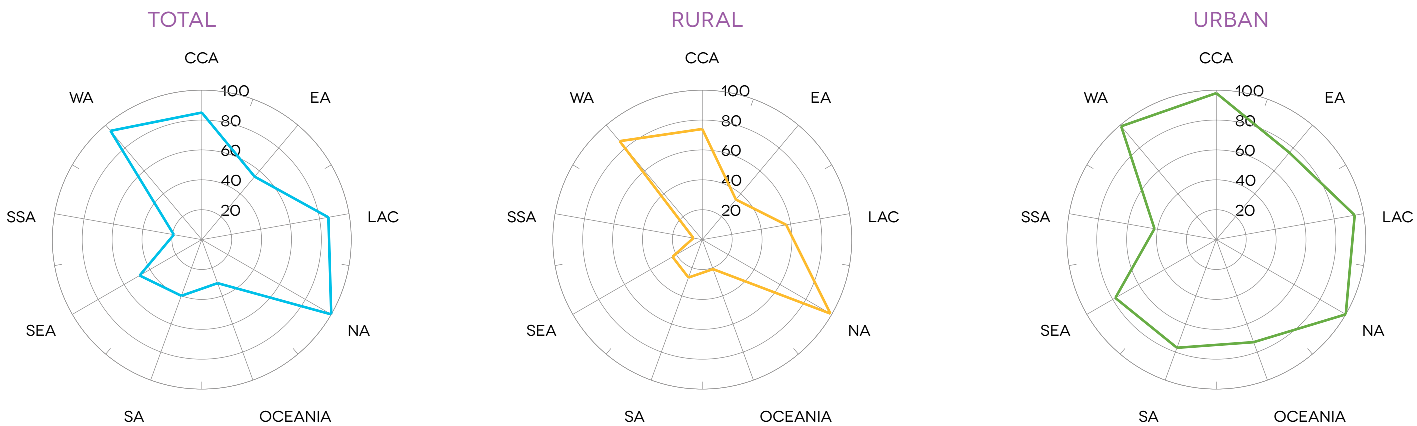


FIGURE 2.20 **RATES OF ACCESS TO NON-SOLID FUEL IN 2010, BY REGION**

SOURCE: WHO'S GLOBAL HOUSEHOLD ENERGY DATABASE 2012.
NOTE: CCA = CAUCASUS AND CENTRAL ASIA; EA = EASTERN ASIA; LAC = LATIN AMERICA AND CARIBBEAN; NA = NORTHERN AFRICA; SA = SOUTHERN ASIA; SEA = SOUTHEASTERN ASIA; SSA = SUB-SAHARAN AFRICA; WA = WESTERN ASIA.

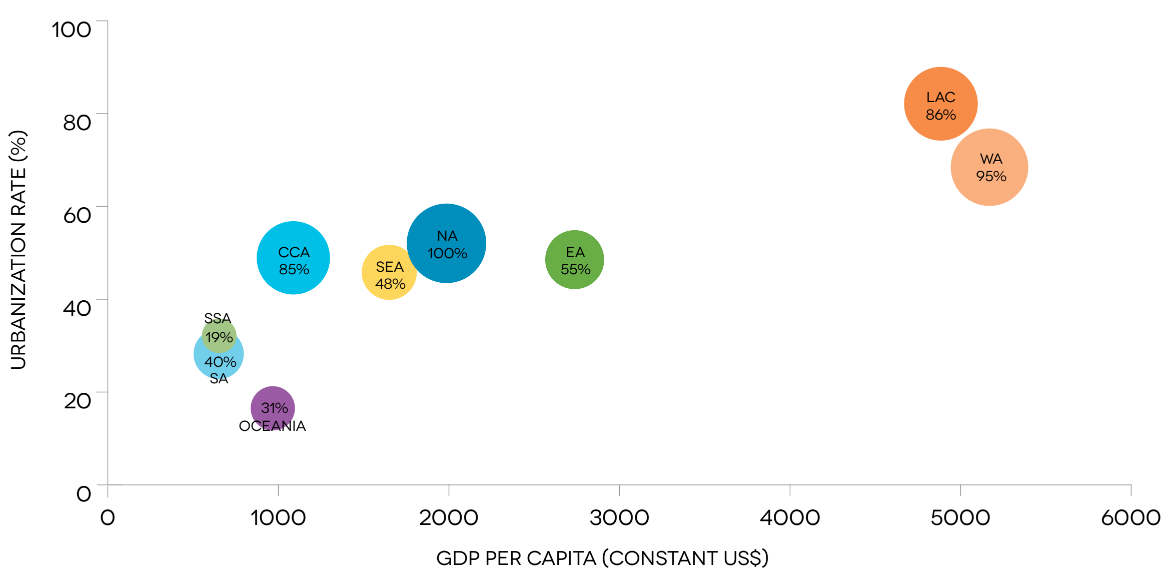


FIGURE 2.21 **RATES OF ACCESS TO NON-SOLID FUEL IN 2010, BY LEVEL OF URBANIZATION AND INCOME**

SOURCE: BONJOUR AND OTHERS 2012.
NOTE: SIZE OF BUBBLE INDICATES ACCESS RATE BY REGION. CCA = CAUCASUS AND CENTRAL ASIA; EA = EASTERN ASIA; GDP = GROSS DOMESTIC PRODUCT; LAC = LATIN AMERICA AND CARIBBEAN; NA = NORTHERN AFRICA; SA = SOUTHERN ASIA; SEA = SOUTHEASTERN ASIA; SSA = SUB-SAHARAN AFRICA; WA = WESTERN ASIA.

Global trends

The share of the global population with access to non-solid fuel rose from 47 percent (2.5 billion people) in 1990 to approximately 59 percent (4.1 billion people) in 2010 (figure 2.22). The access rate in rural areas increased over the same period from 26 percent to 35 percent; in urban areas, from 77 percent to 84 percent. The Caucasus and Central Asia and Southern Asia all witnessed dramatic progress, registering increases of 27 and 24 percentage points, respectively, over the two decades. On average, Eastern Asia, Latin America, Northern Africa, Oceania, Southeastern Asia, and Western Asia exhibited an increase in non-solid fuel use of 15 percentage points. Sub-Saharan Africa followed far behind, with an increase from 14 to 19 percent during the same period. Eastern Europe and Western Asia had accomplished near-universal access by 2010.

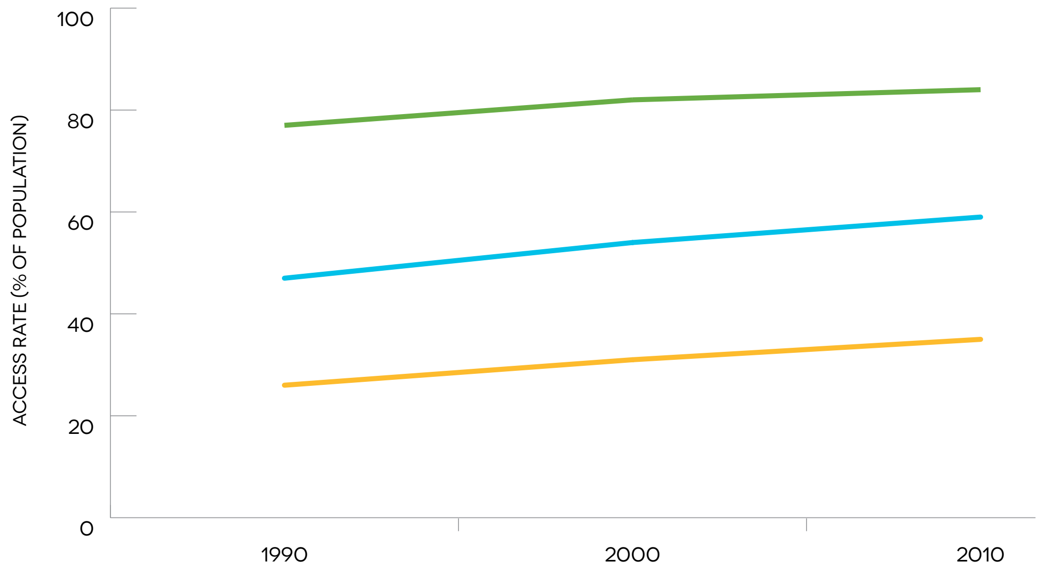


FIGURE 2.22A **GLOBAL TRENDS IN RATES OF ACCESS TO NON-SOLID FUEL, 1990–2010**

TOTAL RURAL URBAN

SOURCE: WHO'S GLOBAL HOUSEHOLD ENERGY DATABASE 2012.

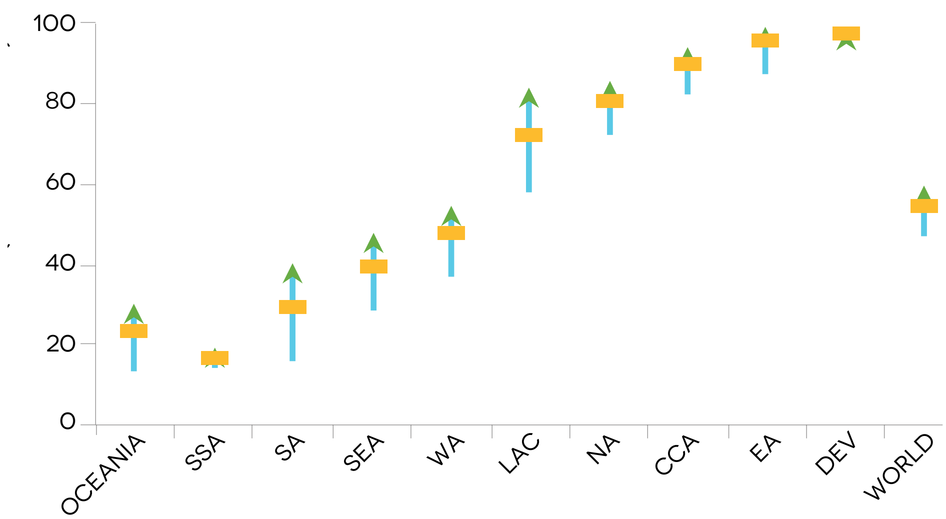


FIGURE 2.22B **REGIONAL TRENDS IN RATES OF ACCESS TO NON-SOLID FUEL, 1990–2010**

SOURCE: WHO'S GLOBAL HOUSEHOLD ENERGY DATABASE 2012.
NOTE: CCA = CAUCASUS AND CENTRAL ASIA; DEV = DEVELOPED COUNTRIES; EA = EASTERN ASIA; LAC = LATIN AMERICA AND CARIBBEAN; NA = NORTHERN AFRICA; SA = SOUTHERN ASIA; SEA = SOUTHEASTERN ASIA; SSA = SUB-SAHARAN AFRICA; WA = WESTERN ASIA.

The global population grew by 1.6 billion in the two decades between 1990 and 2010, and non-solid fuel use almost kept pace (figure 2.23). Globally the increment in non-solid fuel access was comparable across both decades, but with some variation geographically. Growth in access kept up with population growth in Central Asia, Northern Africa, Southeastern Asia, Latin America and Oceania in both decades. In Eastern Asia, access grew much faster than the population, especially in the 2000s.

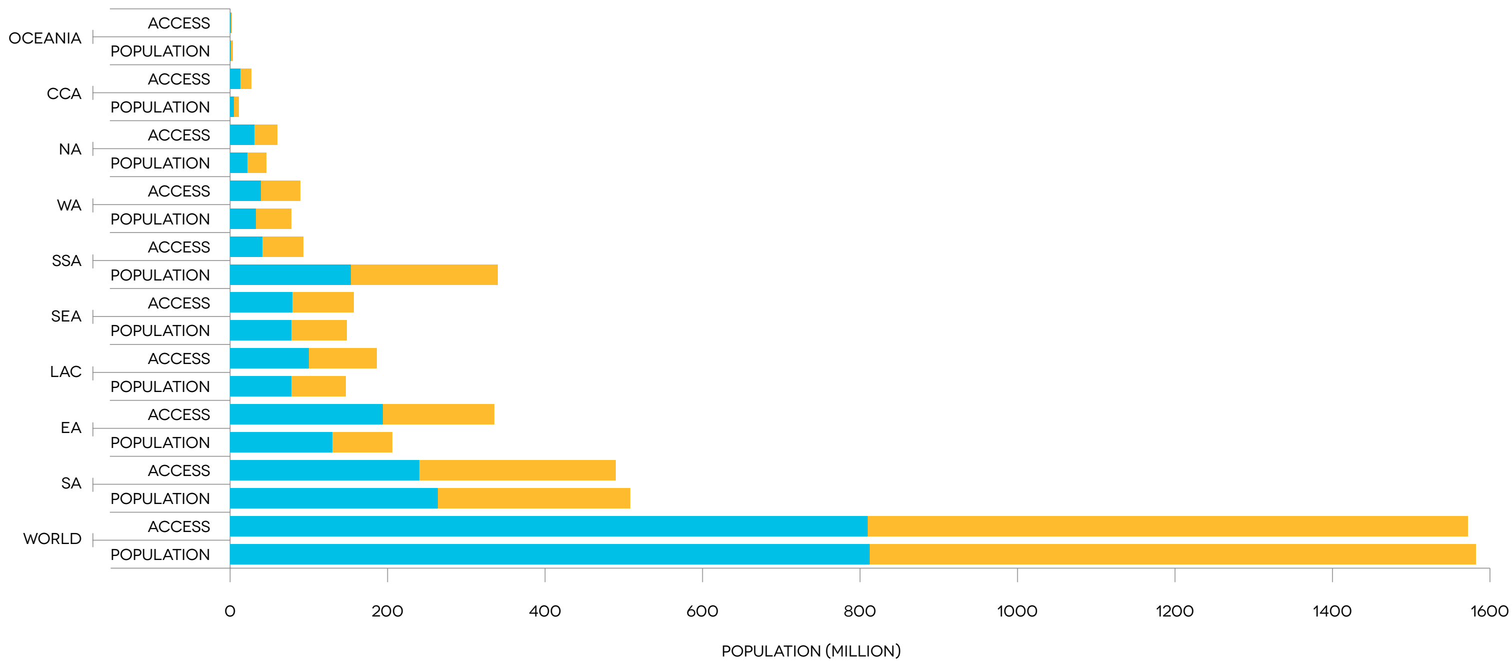


FIGURE 2.23 **GROWTH IN POPULATION AND IN ACCESS TO NON-SOLID FUEL, 1990–2010**

1990–2000 2001–2010

SOURCE: WHO'S GLOBAL HOUSEHOLD ENERGY DATABASE, 2012.
NOTE: CCA = CAUCASUS AND CENTRAL ASIA; EA = EASTERN ASIA; LAC = LATIN AMERICA AND CARIBBEAN; NA = NORTHERN AFRICA; SA = SOUTHERN ASIA; SEA = SOUTHEASTERN ASIA; SSA = SUB-SAHARAN AFRICA; WA = WESTERN ASIA.

The access deficit—or the use of solid fuel—in 2010 was geographically concentrated in Sub-Saharan Africa and Southern Asia. From 1990, both regions experienced an expansion of reliance on solid fuels in both urban and rural areas. In Southern Asia, an additional 490 million people gained access to non-solid fuel as their primary cooking fuel, but even that impressive figure trailed population growth—by 18 million people in the same time period. Sub-Saharan Africa increased non-solid fuel use by only 92 million people, falling behind population growth by 248 million people (figure 2.24).

1.6 BILLION
PEOPLE GAINED ACCESS
TO NON-SOLID FUELS BETWEEN BETWEEN 1990 AND 2010

[17] Further details are provided in IEA 2012b.

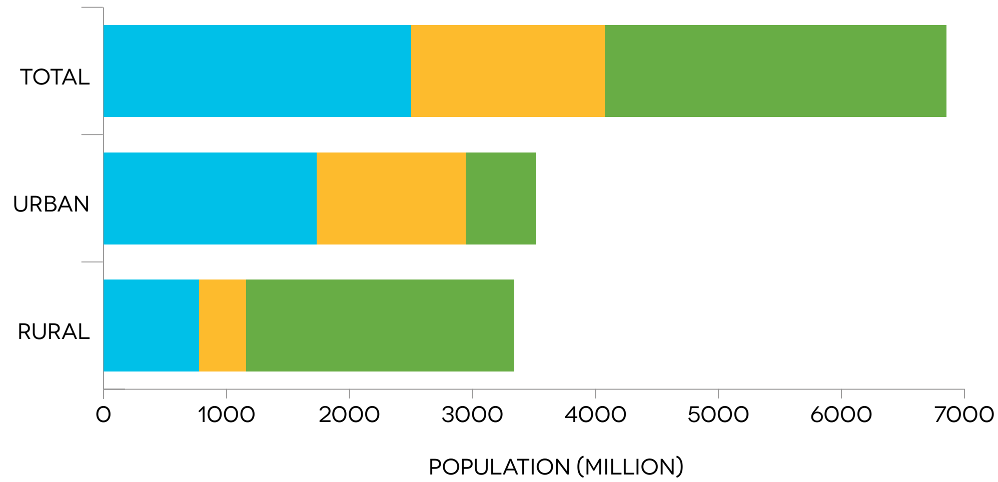


FIGURE 2.24A **GLOBAL PROGRESS IN ACCESS TO NON-SOLID FUEL, BY URBANIZATION STATUS, 1990–2010**

POPULATION WITH ACCESS IN 1990 INCREMENTAL ACCESS IN 1990–2010 POPULATION WITHOUT ACCESS IN 2010

SOURCE: WHO'S GLOBAL HOUSEHOLD ENERGY DATABASE 2012.

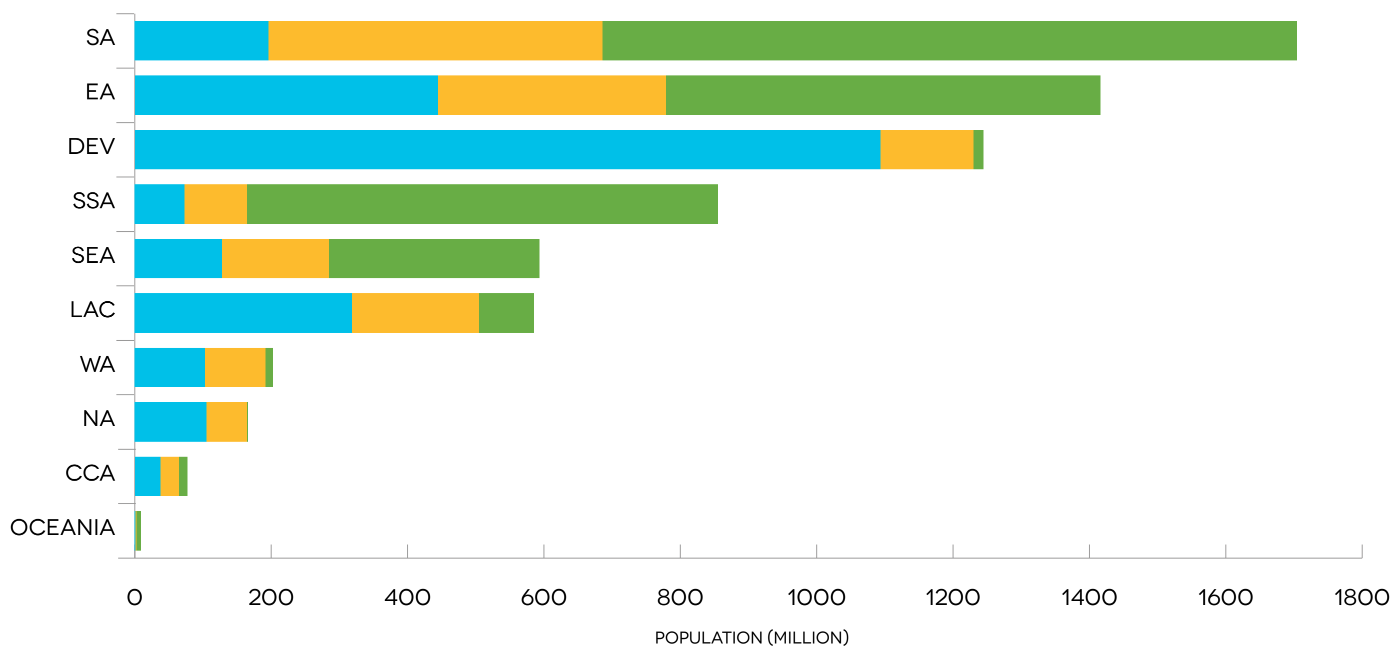


FIGURE 2.24B **GLOBAL PROGRESS IN ACCESS TO NON-SOLID FUEL, BY REGION, 1990–2010**

POPULATION WITH ACCESS IN 1990 INCREMENTAL ACCESS IN 1990–2010 POPULATION WITHOUT ACCESS IN 2010

NOTE: CCA = CAUCASUS AND CENTRAL ASIA; DEV = DEVELOPED COUNTRIES; EA = EASTERN ASIA; LAC = LATIN AMERICA AND CARIBBEAN; NA = NORTHERN AFRICA; SA = SOUTHERN ASIA; SEA = SOUTHEASTERN ASIA; SSA = SUB-SAHARAN AFRICA; WA = WESTERN ASIA.

Between 1990 and 2010 the rapid rate of urbanization added 1.2 billion people to urban populations; populations living in rural areas increased by only 0.4 billion over the same period. The growth rate of access to non-solid fuel in urban areas, at 1.7 percent, far outpaced the rural growth rate of 0.6 percent (figure 2.25). Nevertheless, the rapid pace of urban population growth over this period made it difficult for non-solid fuel access in urban areas to keep up, with the expansion of access falling short of population growth by 51 million people over the two decades. In rural areas, by contrast, access grew faster than the population by 67 million people. The remarkable urban growth story has occurred for the most part in the Asian regions (Eastern Asia, Western Asia, Southern Asia, and Southeastern Asia), which together managed to provide 760 million people—or 38 million people annually—with access to non-solid fuel. The rural increment was highest in Western Asia, Southern Asia, and the Caucasus and Central Asia, where 334 million people—or 17 million annually—began to use primarily non-solid fuel for cooking.

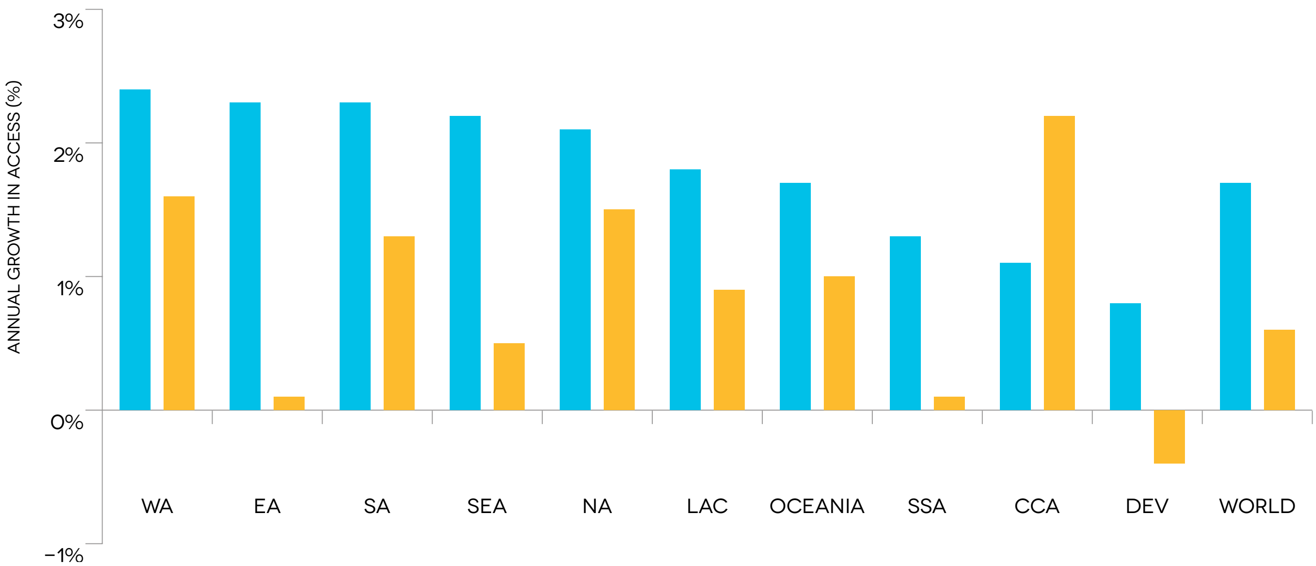


FIGURE 2.25 **ANNUAL INCREMENTS IN GROWTH OF ACCESS TO NON-SOLID FUELS IN URBAN AND RURAL AREAS, 1990–2010**

SOURCE: WHO'S GLOBAL HOUSEHOLD ENERGY DATABASE 2012.
NOTE: CCA = CAUCASUS AND CENTRAL ASIA; DEV = DEVELOPED COUNTRIES; EA = EASTERN ASIA; LAC = LATIN AMERICA AND CARIBBEAN; NA = NORTHERN AFRICA; SA = SOUTHERN ASIA; SEA = SOUTHEASTERN ASIA; SSA = SUB-SAHARAN AFRICA; WA = WESTERN ASIA.

Country snapshots in 2010

The rate of access to non-solid fuel spans a wide range: from 2 percent in many Sub-Saharan African countries to near-universal access (greater than 95 percent access) in 73 countries of the world (37 of which are developing countries). Even within a given region, access rates are heterogeneous.

The world can be arbitrarily divided into three country blocks based on the degree of access to non-solid fuel: those at the lower end (<30 percent), those in the middle (30–95 percent), and those at the higher end (>95 percent). At the low end are 47 countries, 33 of which are in Sub-Saharan Africa. Among them, 21 show less than 10 percent access to non-solid fuel. Mauritius and Seychelles are the outliers in Sub-Saharan Africa, with access rates above 95 percent; South Africa can also be considered an outlier, as its rate of access to non-solid fuel is 85 percent. Northern Africa and Western Asia are the only regions with an almost homogenous universal access rate (figure 2.26).

The heterogeneity stems primarily from rural areas, where 68 countries still have less than 30 percent non-solid fuel access. The median rural access rate is at 5 percent in Sub-Saharan Africa, compared to a global median of 63 percent. Non-solid fuel access is relatively uniform in urban areas; 92 countries report near-universal urban access. In urban areas, the median is 100 percent in all regions except Sub-Saharan Africa, where it stands at 28 percent.

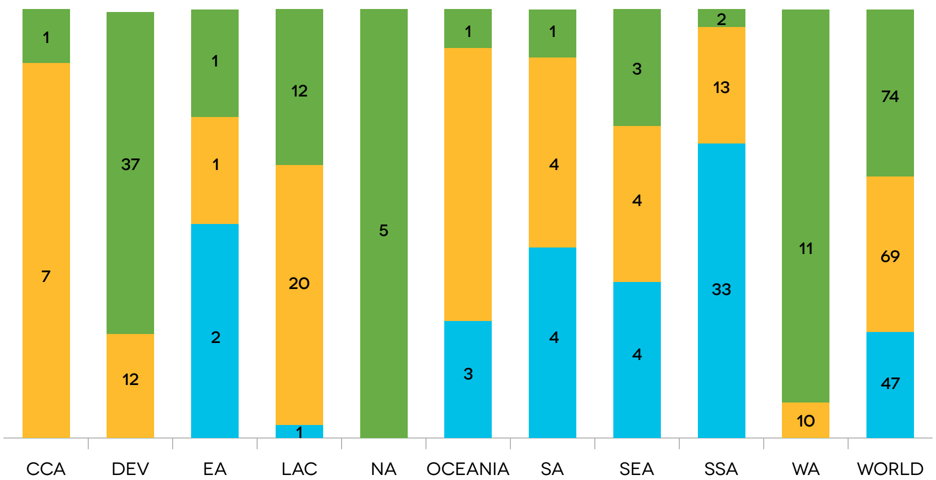


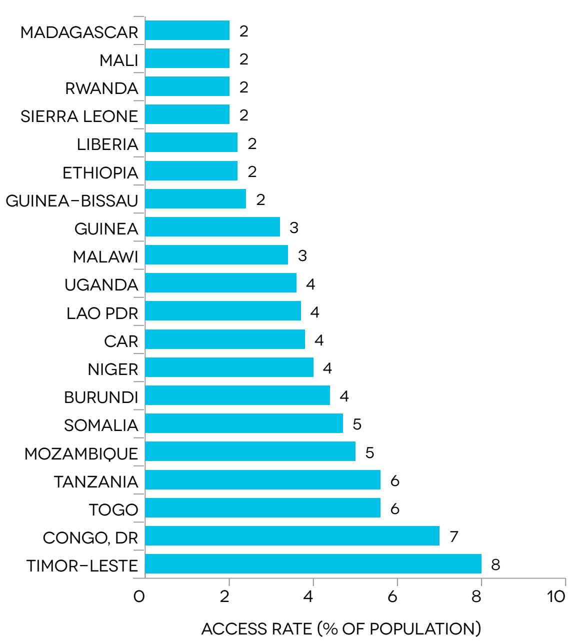
FIGURE 2.26 **DISTRIBUTION OF RATES OF ACCESS TO NON-SOLID FUEL, BY NUMBER OF COUNTRIES PER REGION**

SOURCE: WHO'S GLOBAL HOUSEHOLD ENERGY DATABASE, 2012.
NOTE: CCA = CAUCASUS AND CENTRAL ASIA; DEV = DEVELOPED COUNTRIES; EA = EASTERN ASIA; LAC = LATIN AMERICA AND CARIBBEAN; NA = NORTHERN AFRICA; SA = SOUTHERN ASIA; SEA = SOUTHEASTERN ASIA; SSA = SUB-SAHARAN AFRICA; WA = WESTERN ASIA.

High-impact countries

Among the 20 countries with the lowest rates of access to non-solid fuel (figure 2.27a), 18 are in Sub-Saharan Africa. Solid-fuel users make up 369 million. Another 20 "high impact" countries account for 85 percent (2.4 billion people) of the absolute global deficit in access to non-solid fuel (figure 2.27b). Eleven of the 20 are in Asia and nine in Sub-Saharan Africa. India and China together account for 1.3 billion solid-fuel users.

A. LOWEST ACCESS RATES, 2010: 369 MILLION SOLID-FUEL USERS



B. LARGEST ACCESS DEFICITS, 2010: 2.4 BILLION SOLID-FUEL USERS

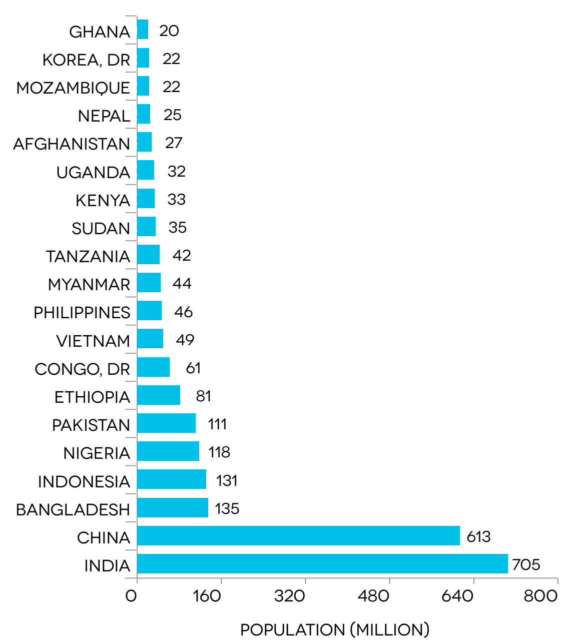


FIGURE 2.27 **TOP 20 COUNTRIES: THE LOWEST ACCESS RATES AND LARGEST DEFICITS IN ACCESS TO NON-SOLID FUEL**

SOURCE: WHO'S GLOBAL HOUSEHOLD ENERGY DATABASE 2012.
NOTE: CAR = CENTRAL AFRICAN REPUBLIC; DR = DEMOCRATIC REPUBLIC OF.

SOURCE: WHO'S GLOBAL HOUSEHOLD ENERGY DATABASE 2012.
NOTE: DR = DEMOCRATIC REPUBLIC OF.

Fast-moving countries

Of the 20 countries that have shown the largest numbers of people transitioning to primary use of non-solid fuels, most are in Asia (figure 2.28). The 20 countries moved an additional 1.2 billion people to non-solid fuel in 1990–2010, but that figure was 200 million behind their overall population increase. The greatest growth was in India, China, and Brazil, where a total of 783 million people secured access to non-solid fuel as their primary cooking fuel during this period. India charted a remarkable trajectory, providing access to non-solid fuel to 402 million over two decades, or 20 million people annually.

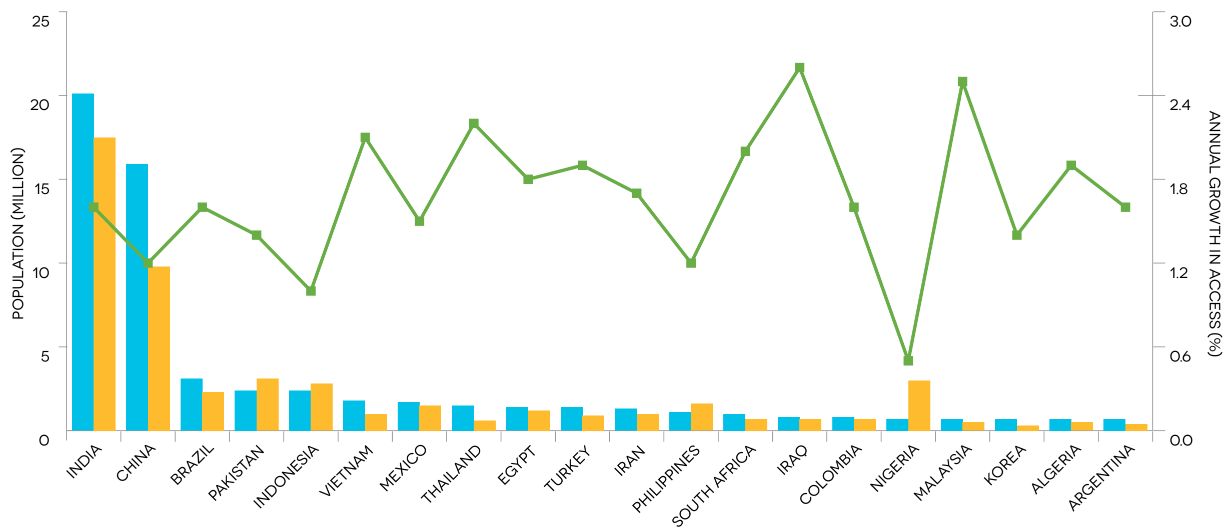


FIGURE 2.28 **TOP 20 COUNTRIES WITH HIGHEST ANNUAL INCREMENTAL GROWTH IN ACCESS TO NON-SOLID FUEL, 1990–2010**

SOURCE: WHO'S GLOBAL HOUSEHOLD ENERGY DATABASE 2012.

Focusing on absolute increments in non-solid fuel access tends to highlight the experiences of large countries. Twenty fast-moving small countries—many of them island nations—also showed substantial growth in access as a percentage of their population over the two decades from 1990 to 2010 (figure 2.29). Fourteen countries transitioned at least 2.5 percent of their population annually to primary use of non-solid fuel. But only the United Arab Emirates (UAE) and Qatar increased access to non-solid fuel at an annual rate greater than 3.5 percent of the population. Their performance is the upper bound of what any country has been able to achieve in the past two decades.

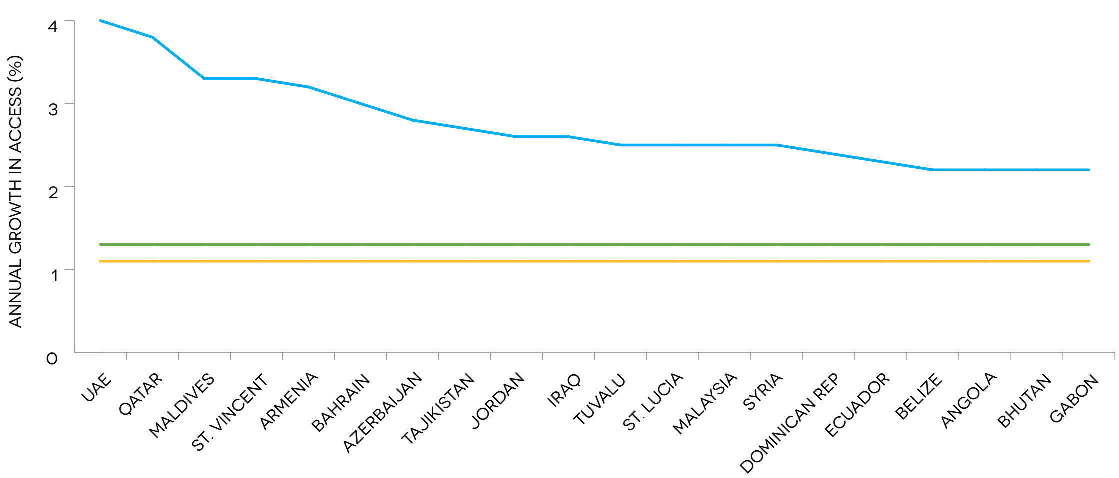


FIGURE 2.29 **TOP 20 FASTEST-GROWING COUNTRIES IN NON-SOLID FUEL USE, 1990–2010**

SOURCE: WHO'S GLOBAL HOUSEHOLD ENERGY DATABASE 2012. **NOTE:** UAE = UNITED ARAB EMIRATES.

SECTION 4. SCALE OF THE CHALLENGE

Building on the foregoing analysis, this section looks to the future, mapping out today's energy access trajectory and quantifying the scale of the challenges that must be overcome to achieve the SE4ALL goal of universal access to modern energy services by 2030. Drawing on the World Energy Outlook (IEA 2012), it presents global and regional projections for modern energy access under a so-called New Policies Scenario (NPS) that estimates the likely impact of existing and announced policy commitments. The projections provide a basis from which to analyze what needs to be done to achieve universal access by 2030. Variables include how many more people will need to obtain access to modern energy services by region, the levels of investment and types of technologies required, the barriers to achieving the goal, and the benefits and broader implications of achieving it (such as the impact on energy demand and energy-related carbon dioxide [CO2] emissions).

Methodology for projecting energy access developments to 2030

This section draws heavily on data, projections, and analysis from the IEA's *World Energy Outlook*[35] (box 2.4). The energy access projections under the NPS reflect the impact that existing and announced policy commitments (assuming cautious implementation) are expected to have by 2030.

For this analysis, the following definitions and methodology have been adopted.[36] Access to electricity is indicated by a household's first connection to electricity and by consumption of a specified minimum level of electricity, with the amount varying depending on whether the household is in a rural or an urban area. The initial threshold level of electricity consumption for rural households is defined as 250 kilowatt-hours (kWh) per year; for urban households, 500 kWh. The higher consumption in urban areas reflects urban consumption patterns. Both levels are calculated based on an assumption of five people per household. In rural areas, the minimum level of consumption could, for example, provide for the use of a floor fan, a mobile telephone, and two compact fluorescent light bulbs for about five hours per day. In urban areas, consumption might also include an efficient refrigerator, a second mobile telephone per household, and another appliance (such as a small television or computer).

Different levels of electricity consumption are adopted in other published analyses. Sanchez (2010), for example, bases access on consumption of 120 kWh per person (600 kWh per household, assuming five people per household). As a point of reference, the observed average electricity consumption in India in 2009 was 96 kWh per person in rural areas and 288 kWh in urban areas, for all people connected to electricity, with those connected more recently consuming lower amounts (Government of India 2011).

In the spirit of the multi-tier candidate proposal presented in section 1, the projections for electricity access that follow go beyond a simple binary definition and make some allowance for different tiers of access, as reflected in differentiated levels of electricity consumption. Once an initial connection to electricity is made, the level of consumption is assumed to rise gradually over time, moving toward a regional average level of consumption after several years. The initial period of growing consumption is a deliberate attempt to reflect the fact that eradication of energy poverty is a long-term endeavor. In the analysis, the average level of electricity consumption per capita across all households newly connected over the period is assumed to rise to about 750 kWh by 2030.

Access to modern cooking solutions focuses on the provision of an appropriate stove and refers primarily to biogas systems, LPG stoves, and advanced biomass cookstoves that have considerably lower emissions and higher efficiencies than traditional three-stone fires for cooking. We assume that LPG stoves and advanced biomass cookstoves require replacement every five years, while a biogas digester is assumed to last 20 years.

[35] This section of the report uses the IEA's World Energy Outlook databases on electricity access and on the traditional use of biomass for cooking. On many counts, the IEA's electricity access database, which reports 1.3 billion people without access, is consistent with the World Bank's Global Electrification Database, which reports 1.2 billion people lacking access. The major share of the discrepancy between the two global estimates can be ascribed to differences in a relatively small number of countries, including Pakistan, Indonesia, South Africa, Thailand, and Gabon, where the IEA uses government data (which typically report more people without access) while the World Bank uses estimates derived from various types of surveys.

[36] For more about the IEA's energy access data and modeling methodologies, see http://www.worldenergyoutlook.org/resources/energydevelopment.

To arrive at estimates of the investments needed to achieve the SE4ALL goal of universal access to electricity, an assessment was conducted of the required combination of on-grid, mini-grid, and isolated off-grid solutions in each region. This assessment accounts for regional costs and consumer density to determine a regional cost per megawatt-hour (MWh). When delivered through an established grid, the cost per MWh is cheaper than other solutions, but extending the grid to sparsely populated, remote, or mountainous areas can be very expensive, and long-distance transmission systems can have high technical losses. Grid extension is the most suitable option for urban areas and for about 30 percent of rural areas, but not for more remote rural areas. The remaining rural areas are connected either with mini-grids (65 percent of this share) or small, stand-alone off-grid solutions (the remaining 35 percent) that have no transmission and distribution costs.

Investment needs for modern cooking solutions are based on the expectation that a combination of different technical solutions will be provided. These include advanced biomass cookstoves, LPG stoves, and biogas systems. Advanced biomass cookstoves and biogas systems are relatively more common solutions in rural areas, while LPG stoves play a more significant role in urban areas. Related infrastructure, distribution, and fuel costs are not included in the estimate of investment costs.

Projections are shown at the regional level because the available data do not permit a more disaggregated analysis over the time frame. The regional aggregations used in this section differ slightly from those in the first three sections of this report, reflecting the usages of the IEA's World Energy Model.[37] As examples of the differences in country classification, the IEA's World Energy Outlook groups Iran in the Middle East region, rather than in Southern Asia. The IEA excludes Bhutan and the Maldives from Southern Asia; both are part of Eastern Asia and Oceania in the figures shown in this section. Furthermore, Timor-Leste is part of Eastern Asia and Oceania, not Southeastern Asia, in the data presented here. Finally, the Republic of Korea is not included in Eastern Asia or any other region here, whereas it is included in the UN region of Eastern Asia.

BOX 2.4 IEA's energy access model

The energy access projections presented in this section of the report come from the IEA's World Energy Model, which integrates trends in demography, economy, technology, and policy. This kind of integrated analysis offers valuable insights into the globe's energy trajectory and what will have to be done to attain the SE4ALL goal of universal access to modern energy services by 2030. The projections for access to electricity and to modern cooking solutions are based on separate econometric panel models that regress the electrification rates and rates of reliance on biomass for different countries over many variables to test their level of significance. In the case of electrification, the variables that were determined to be statistically significant and thus included in the equations are per capita income, demographic growth, urbanization level, fuel prices, level of subsidies for electricity consumption, technological advances, electricity consumption, and electrification programs. In the case of cooking solutions, variables that were determined statistically significant and consequently included in the equations are per capita income, demographic growth, urbanization level, level of prices of alternative modern fuels, level of subsidies to alternative modern fuel consumption, technological advances, and government programs to promote modern cooking.

The models are run under the following economy and population assumptions: world gross domestic product (in purchasing power parity terms) grows by an average of 3.6 percent per year over the period 2010–2030, with the rate of growth slowing gradually over time as the emerging economies mature. The assumed rate varies by region. The rates of population growth assumed for each region are based on UN projections (UNDP 2011). World population is projected to grow from an estimated 6.8 billion in 2010 to 8.3 billion in 2030. In line with the long-term historical trend, population growth slows over the projection period. Almost all of the increase in global population is expected to occur in countries outside the Organisation for Economic Co-operation and Development (OECD), mainly in Asia and Africa.

SOURCE: AUTHORS.

Access to electricity in 2030 under the New Policies Scenario

Under the assumptions of the NPS the number of people lacking access to electricity around the world will decline to just over 990 million in 2030, around 12 percent of the global population at that time (figure 2.30). About 1.7 billion people will gain access to electricity by 2030, but that achievement will be counteracted, to a large extent, by global population growth. Those gaining access to electricity will reach a range of consumption levels, and therefore a range of tiers in the electricity access framework, by 2030—ranging from the defined minimum consumption levels in urban and rural areas to consumption levels above the regional average at that time. Access to electricity will improve in relative terms for all regions except Sub-Saharan Africa, where the current trend will worsen over time.

12%
OF THE WORLD'S POPULATION
WILL STILL LACK ACCESS TO ELECTRICITY IN 2030 UNDER BUSINESS AS USUAL

The NPS projects the largest populations without access in 2030 to be found in developing Asia (mainly Southern Asia) and Sub-Saharan Africa. Sub-Saharan Africa is projected to overtake developing Asia in a few years as the region with the largest population without access to electricity.

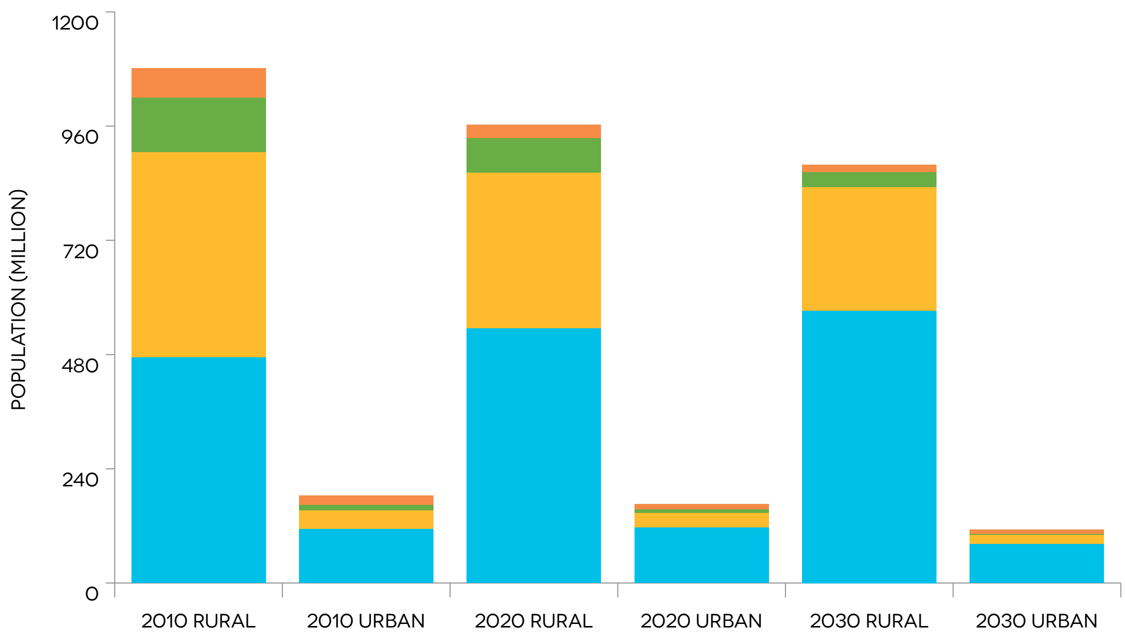


FIGURE 2.30 **NUMBER OF PEOPLE WITHOUT ACCESS TO ELECTRICITY IN RURAL AND URBAN AREAS, BY REGION, 2010–2030**

SUB-SAHARAN AFRICA · SOUTH ASIA · SOUTH-EASTERN ASIA · REST OF THE WORLD

SOURCE: BASED ON DATA/ANALYSIS FROM IEA (2012).

In developing Asia the number of people without electricity access under the NPS scenario is projected to be halved by 2030, reaching around 335 million. That will extend an already positive trend, with China (which today reports more than 99 percent access) expected to reach universal access by the middle of the current decade. The remainder of Eastern Asia and Southeastern Asia will have much smaller numbers without access in 2030; Southern Asia is also expected to see significant improvement. Even so, a population larger than that of the United States today is still expected to be without access to electricity in developing Asia in 2030, with India expected to have the largest single no-access population, at around 150 million. Nine out of 10 people without access to electricity in developing Asia in 2030 are expected to live in rural areas.

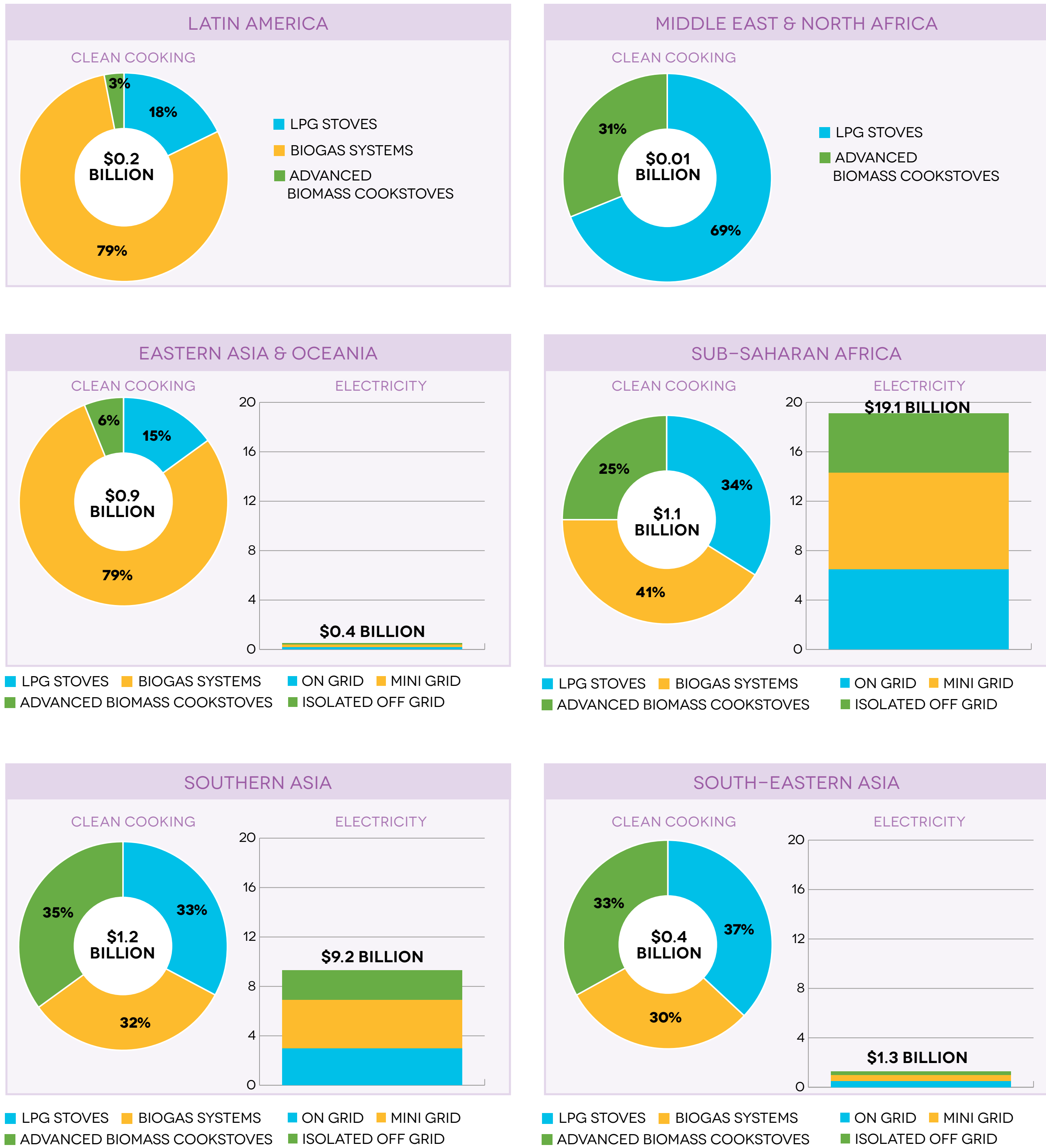
In Sub-Saharan Africa, the number of people without access to electricity is projected to increase under the NPS by around 11 percent, to 655 million in 2030. Projections suggest that the worsening trend will extend to around 2025 and that the prospect of improvement from that date is fragile, remaining vulnerable to upset by a change in economic fortunes, higher energy prices, or a failure to implement policy. Over the projection period, those lacking electricity access in Sub-Saharan Africa will be increasingly concentrated in rural areas, which will account for more than 85 percent of the regional deficit in 2030. Owing to projected improvements elsewhere, Sub-Saharan Africa will account for an increasing share of the global population without electricity access, going from less than half to around two-thirds by 2030.

The regions projected to reach universal access to electricity before 2030 are Latin America and the Caribbean, the Middle East, and Northern Africa. That success is not guaranteed but relies on the continuation of trends in economic growth, investment, and policies to improve electricity access.

Access to electricity in 2030: Achieving universal access

To achieve universal access to electricity by 2030, some 50 million more people will have to gain access to electricity each year than under the NPS. About 40 percent of the additional electricity supply needed for universal access in 2030 would come from grid solutions (of which almost two-thirds would be fossil-fuel based) and the remainder from mini-grid and stand-alone off-grid solutions (of which around 80 percent would be based on renewables).

It is estimated that universal access to electricity by 2030 will require investment of around $890 billion over the period (2010 dollars), of which around $288 billion is projected to be forthcoming under the NPS, meaning that an additional $602 billion would be required to provide universal access to electricity by 2030—an average of $30 billion per year (2011–2030). The annual level of investment would increase over time, reflecting the escalating number of connections being made. More than 60 percent of the additional investment required would come in Sub-Saharan Africa, because the region would need the equivalent of an extra $19 billion per year to achieve universal electricity access by 2030 (figure 2.31). Achieving universal access in Sub-Saharan Africa would depend more heavily than elsewhere on mini-grid and isolated off-grid solutions, particularly in countries such as Ethiopia, Nigeria, and Tanzania, where a relatively high proportion of those lacking electricity live in rural areas. Developing Asia accounts for 36 percent of the additional investment required to achieve universal electricity access, with Southern Asia accounting for the largest share.



WORLD ACCESS TO CLEAN COOKING FACILITIES: **$3.8 BILLION** & WORLD ACCESS TO ELECTRICITY: **$30.1 BILLION**

FIGURE 2.31 **ADDITIONAL AVERAGE ANNUAL INVESTMENT NEEDED TO ACHIEVE UNIVERSAL ACCESS TO MODERN ENERGY SERVICES BY 2030, BY REGION AND TECHNICAL SOLUTION**

SOURCE: BASED ON DATA/ANALYSIS FROM IEA (2012).

As a high-quality and highly flexible form of energy, electricity can enable a whole range of social and economic benefits, empowering the leap from poverty to a better future. Electric light extends the day, providing extra hours for studying and work. Access to radio and television can help keep communities up to date on events both local and global. Street lighting has been reported to increase social mobility, especially of women. Electricity in schools can improve education by enabling access to lighting, heating, water, and sanitation. In health facilities, it can also bring benefits by powering medical and communications equipment. Refrigeration allows health facilities to keep needed medicines on hand and for households to keep food fresh. Access to electricity also provides the means to generate income and improve productivity, which in turn creates wealth and new markets. In agriculture, electricity can support various forms of modernization, enabling people to pump water for household use and irrigation and to use mobile phones to access new markets for their crops. Expanding access to modern energy services can yield significant social and economic returns, especially when integrated with efforts to promote the efficient use of limited energy resources and the harnessing of locally available renewable energy sources.

Access to modern cooking solutions in 2030 under the New Policies Scenario

Under the NPS, the number of people lacking access to modern cooking solutions is projected to remain, because of population growth, almost unchanged at around 2.6 billion in 2030—more than 30 percent of the projected global population in that year (figure 2.32).

30%
OF THE WORLD'S POPULATION
WILL STILL DEPEND ON SOLID FUELS IN 2030 UNDER BUSINESS AS USUAL

FIGURE 2.32 **NUMBER OF PEOPLE WITHOUT ACCESS TO MODERN COOKING SOLUTIONS IN RURAL AND URBAN AREAS BY REGION, 2010–2030**

SUB-SAHARAN AFRICA · SOUTH ASIA · EAST ASIA AND OCEANIA · SOUTH-EASTERN ASIA · REST OF THE WORLD

SOURCE: BASED ON DATA/ANALYSIS FROM IEA (2012).

In developing Asia, China is projected to show the single biggest improvement, with almost 150 million fewer people lacking access to modern cooking solutions by 2030. That improvement will come from economic growth, urbanization, and deliberate policy interventions, such as actions to expand natural gas networks. India will see a small improvement but is still expected to account for the largest single population going without modern cooking solutions—nearly 30 percent of the world's total in 2030. The rest of developing Asia is also projected to see only a marginal improvement by 2030, with half of its population still lacking access to modern cooking solutions at that time.

In Sub-Saharan Africa, NPS projections reveal a worsening situation over time, with the number of people without modern cooking solutions increasing by more than a quarter, reaching around 880 million in 2030. While more than 310 million people will achieve access to modern cooking solutions by 2030, their number will not keep pace with the population growth expected over the period. As in all regions, the lack of access will continue to be concentrated in rural areas.

Latin America and the Middle East have much smaller populations lacking modern cooking solutions. There, NPS projections show a slight improvement over time, focused on urban areas. In rural areas, the size of the population without access to modern cooking solutions will remain essentially unchanged, as population growth offsets positive efforts. In Latin America, 11 percent of the population is projected still to be without access to modern cooking solutions in 2030, while the figure is less than 3 percent in the Middle East.

Access to modern cooking solutions in 2030: Achieving universal access

To achieve universal access, modern cooking solutions will need to be provided to an additional 135 million people per year, on average, over and above those gaining access under the NPS. This could occur through a combination of various technical solutions, including advanced biomass cookstoves, LPG stoves, and biogas systems.[38] In rural areas, advanced biomass cookstoves and biogas systems are relatively more common solutions, whereas in urban areas LPG stoves play a more significant role. While the target population is much larger than for access to electricity and the operational challenge no less significant, it is striking how much less investment is needed is to provide universal access to modern cooking solutions than to electricity.

It is estimated that universal access to modern cooking solutions by 2030 would require investment of about $89 billion over the period (in 2010 dollars), of which about $13 billion is projected to be forthcoming under the NPS, meaning that an additional $76 billion ($3.8 billion per year, 2011–2030) would be required to provide universal access to modern cooking solutions by 2030. Figure 2.31 breaks down the additional investment required by region, as well as technical solutions to achieve universal access to modern cooking solutions by 2030. For comparison, the Global Energy Assessment of the International Institute for Applied Systems Analysis, IIASA, also estimates the investment required to achieve universal energy access in 2030, but based on different assumptions (box 2.5).

The benefits of universal access to clean cookstoves are clear. A huge proportion of the world's population still uses polluting, inefficient cookstoves that emit toxic smoke. Indoor air pollution is the fifth-largest health risk in the developing world. Millions of people are estimated to die prematurely each year from exposure to cookstove smoke many of which are children (WHO, 2009). Moving away from biomass for cooking and heating would also free women and children from spending hours each week collecting wood, allowing this time to be used more productively. It would also reduce or remove the personal security risks that women face when searching for fuel. Finally, use of clean fuels and cookstoves, many of which do not consume wood fuel, could help reduce the risks of local deforestation and other forms of damage to natural resources (see boxes 2.2 and 2.3).

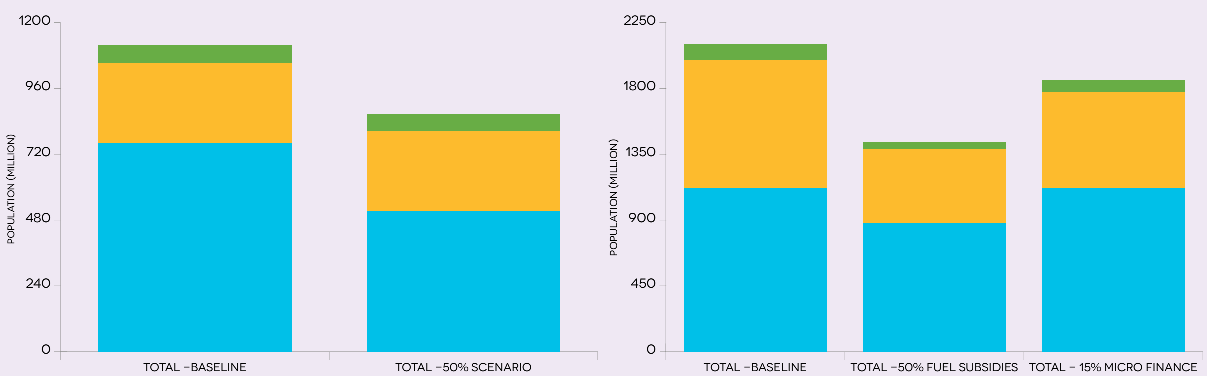
[38] Section 3 of this chapter presented global and country snapshots of household access to non-solid fuels. But the projections presented here are based on access to improved cooking appliances, which are captured in various tiers of the multi-tier framework in figure 2.3.

BOX 2.5 GEA investment cost projections to reach universal access

The Global Energy Assessment (GEA) of the International Institute for Applied Systems Analysis, which models 41 energy "pathways" (or scenarios designed to meet certain prespecified objectives) has estimated the investment costs associated with reaching near-universal access to electricity and modern cooking solutions by 2030. Six of these pathways are consistent with meeting all three global SE4ALL goals, in addition to achieving emissions reductions consistent with the 2°C climate target, limiting health-damaging air pollution, and improving energy security.

The analysis estimates the global cost of reaching universal access with a specific focus on Sub-Saharan Africa, Southern Asia, and Pacific Asia, which are home to the bulk of the populations without access today. For modern cooking solutions, the model puts forth critical policy measures—assuming a final transition to LPG (as a proxy for modern cooking solutions) for those who have access to it and can afford it as well as microfinance options to enable households to finance new cookstoves. In the scenarios that meet SE4ALL objectives, the model assumes 50 percent fuel subsidies for LPG (70 percent for Sub-Saharan Africa) and microfinancing to purchase cookstoves at a 15 percent interest rate. This model internalizes the demographic and income changes associated with growth in these regions. For electrification, the GEA pathways assume achievement of near-universal power supply through grid-based options. Mini-grid and off-grid options are not included in the model. The SE4ALL scenario assumes a 100 percent electrification rate in all regions and consumption of 420 kWh/household/year arising from the use of 115 watts for 10 hours a day (for television, lighting, refrigeration, and other small appliances).

The GEA model estimates an annual investment requirement of $71.3 billion for modern cooking facilities and $15.2 billion for rural electrification to reach universal access by 2030. These figures are the same across all the six energy pathways. This total of more than $85 billion annual spending is several times higher than the $9.6 billion currently spent annually to expand access.



SOURCE: RIAHI AND OTHERS 2012.
NOTE: SSA = SUB–SAHARAN AFRICA; SAR = SOUTH ASIA; EAP = EAST ASIA AND PACIFIC.

$49 BILLION WILL NEED TO BE INVESTED

EVERY YEAR TO REACH UNIVERSAL ACCESS TO ENERGY BY 2030

Broader implications of universal access, and key barriers

If universal access to modern energy services were achieved, global primary energy demand would be around 167 million tons of oil equivalent (Mtoe) higher in 2030 than under the NPS, an increase of around 1 percent (figure 2.33). Less than half of the additional energy demand would be for fossil fuels, with the remainder coming from renewables. For cooking, an additional 0.85 million barrels per day (mb/d) of LPG would be required in 2030.

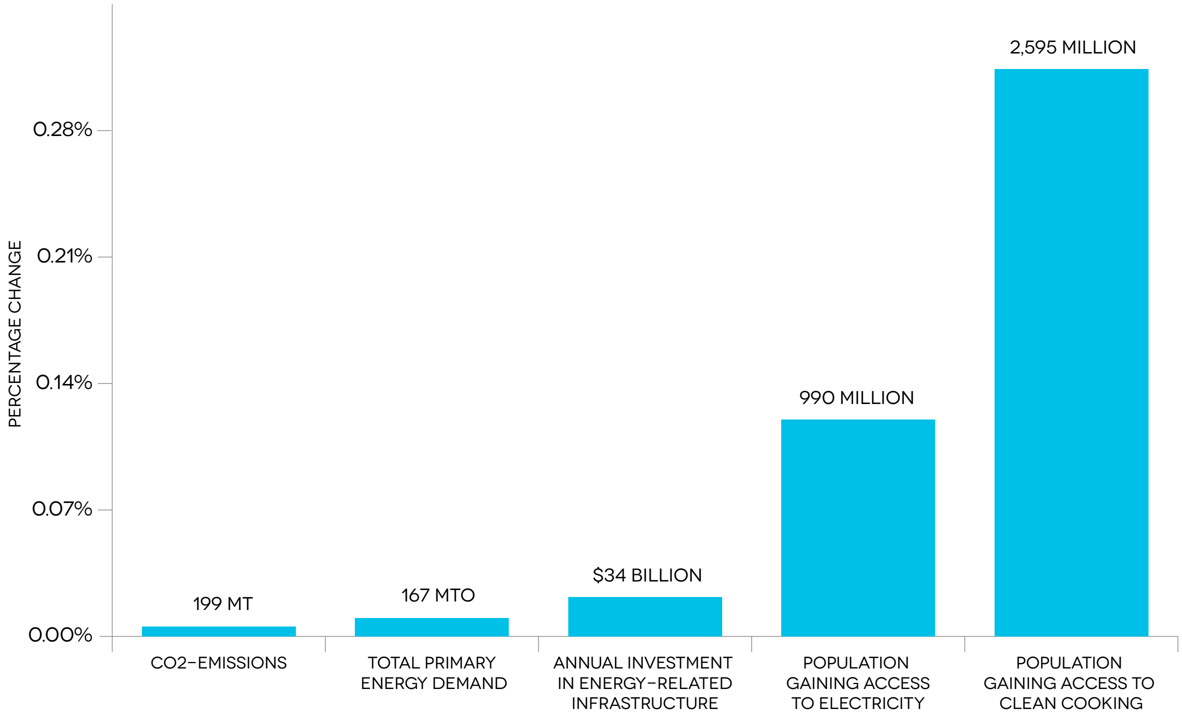


FIGURE 2.33 **ADDITIONAL GLOBAL IMPACT OF UNIVERSAL ACCESS TO MODERN ENERGY SERVICES OVER THE NEW POLICIES SCENARIO, 2030**

SOURCE: IEA 2012.
NOTE: PERCENTAGES ARE A SHARE OF GLOBAL ENERGY-RELATED CARBON DIOXIDE (CO2) EMISSIONS (2030), GLOBAL PRIMARY ENERGY DEMAND (2030), GLOBAL ENERGY RELATED INFRASTRUCTURE INVESTMENT (ANNUAL AVERAGE, BASED ON THE NEW POLICIES SCENARIO, IN 2010 DOLLARS), AND GLOBAL POPULATION (2030). MT = MILLION TONS; MTOE = MILLION TONS OF OIL EQUIVALENT.

The significant role of renewables in delivering universal access to electricity means that the impact of increased access on global CO2 emissions is projected to be relatively small, increasing the total by around 0.6 percent (199 Mt) by 2030. Even with such as increase, emissions per capita in those countries achieving universal access would still be less than one-fifth of the OECD average in 2030. The small size of this increase in emissions is attributable to the low level of energy per capita consumed by the people newly provided with modern energy access and to the significant proportion of renewable solutions adopted, particularly in rural and peri-urban households. The diversity of factors involved in these projections means that the estimate of the total impact on greenhouse gas emissions of achieving universal access to modern cooking facilities must be treated with caution. It is, however, widely accepted that advanced stoves and greater conversion efficiency would reduce emissions and thus reduce this projection.

Several barriers must be overcome if universal access to energy is to be achieved. As highlighted by SE4ALL (2012), a set of common elements will have to be put in place to overcome those barriers:

- High-level commitments on the part of each country's political leadership to achieving universal energy access.
- A realistic energy-access strategy and clear implementation plans linked to overall national development and budget processes.
- Strong communication campaigns to inform stakeholders of planned changes and related benefits.
- Sufficient funding to support the delivery of energy services from appropriate sources and at affordable rates. An increase in financing from all sources and in various forms is required, from large projects down to the micro level.
- A robust financial sector, willing to lend to the energy sector and to provide end-user financing.
- A legal and regulatory framework that encourages investment.
- The active promotion of project and business opportunities and a consistent flow of deals or transactions to attract a critical mass of private sector players (such as banks).
- Processes to match actors around specific projects and proposals, particularly in public-private partnerships.
- Energy access for community institutions (for example, rural multifunctional platforms, typically driven by diesel that powers pumps, grain mills, generators etc.).
- The means to support successful small-scale projects and solutions to reach a larger scale.
- Robust and effective public utilities.
- Strong internal capacity, potentially supported by external technical assistance.
- A deliberate effort to improve the availability of accurate and timely information.
- Reconciliation of regional and national interests in energy projects.

While some of these solutions are context-specific and need to be supported by efforts to build the capacity of local institutions, most address generic problems found in all or most countries seeking to deliver access to modern energy. They involve financial, planning, and regulatory measures needed to strengthen the operating environment of private developers and service providers. The barriers are not insurmountable, but they will require the collective strengths of national governments, the private sector, and civil society. The SE4ALL initiative provides a platform for addressing these barriers in a comprehensive manner, offering countries a menu of options based on global good practices.

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ANNEX 1: Approaches to defining and measuring access to energy

METHODOLOGY	NAME	DESCRIPTION	OBJECTIVE
Single indicator	Energy Poverty Line (Barnes, Khandker, and Samad 2011)	Demand-based approach to define an energy poverty line at the threshold point at which households consume a bare minimum level of energy needed to sustain life.	Define a threshold point at which households consume a bare minimum level of energy.
Dashboard of indicators	Energy Indicators for Sustainable Development (IAEA 2005)	Set of 30 indicators of sustain-able development aiming to measure the current and future effects of energy use on human health, human society, air, soil, and water to determine whether current energy use is sustainable and if not how to change it.	Measure the social, economic, and environmental impact of energy.
	Energy access situation in developing countries (UNDP/WHO 2009)	Measures percentage of popula-tion in developing countries with access (or lack of) to three key areas of energy supply; electrici-ty, modern household fuels, and mechanical power (data limited to 3 countries); plus measures access to improved cookstoves and analyses overall fuel use.	Estimate the penetration rate of modern energy.
	Ecosystem Health Indicator (PPEO 2012)	Set of 17 indicators across three elements of an energy access ecosystem—financing, policy, and capacity.	Evaluate the health of ener-gy-access ecosystems.
Composite index	Energy Development Index (IEA 2004—amended 2010 and 2012)	Tracks progress in a country's transition to the use of modern fuels.	Estimate the penetration rate of modern energy and levels of energy consumption across households and community indicators, compiling a coun-try-level index.
	Multidimensional Energy Poverty Index (Nussbaumer and others 2011)	Measure of deprivation of access to a range of modern energy services affecting individuals.	Measure lack of access to energy services by ownership of appliances.
	Total Energy Access (PPEO 2010)	Categorizes five essential energy access services with quantitative minimum standards.	Set minimum access stan-dards for five energy services.

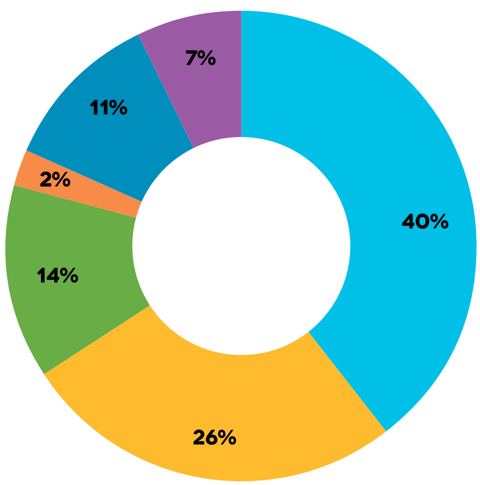
METHODOLOGY	NAME	DESCRIPTION	OBJECTIVE
Multi-tier	Energy Supply Index (PPEO 2010)	Categorizes three key areas of energy supply with qualitative levels of supply.	Create a multidimensional measure of the quality of energy supply.
	Incremental levels of access to energy services (AGECC 2010)	Multilevel access to energy services: (i) basic human needs, (ii) productive uses, and (iii) modern society needs.	Estimate level of access to energy services through energy usage (kWh/per capita).
	Minimum levels and priorities of access to energy services (EnDev 2011)	Defines minimum levels for three key energy services—(i) lighting (ii) cooking, and (iii) communication and information, based on quantitative and qualitative indicators.	Measure minimum access to basic energy needs in terms of quantity, quality, and affordability.
	Multi-tier standards for cookstoves (GACC/PCIA 2012)	Multi-tier standards for household cookstoves (levels not finalized).	Establish standards for cookstoves in terms of efficiency, safety, and emissions.

SOURCE: AUTHORS' COMPILATION.

ANNEX 2: Compilation of World Bank's Global Electrification Database and World Health Organization's Household Energy Database

An intensive data compilation effort underpins the establishment of the starting point and the analysis of historical evolution presented in this report. Those efforts took form in the World Bank's Global Electrification Database and World Health Organization's (WHO's) Household Energy Database. As a first step in the creation of the two databases, data on electrification and use of primary fuels for cooking were collected from nationally representative household surveys, including the United States Agency for International Development's (USAID's) demographic and health surveys (DHS) and living standards measurement surveys (LSMS), the Nations Children's Fund's (UNICEF's) multiple indicator cluster surveys (MICS), the WHO's World Health Survey, and other nationally developed and implemented surveys, and from various government agencies (for example, ministries of energy, utilities).

This data-gathering effort resulted in 126 data points for electrification and 142 countries for household energy around the starting point in 2010 (latest year available) (figure A2.1). For electrification the major sources are the DHS and LSMS. For cooking solutions, data are primarily from the DHS, national census or national household surveys, and MICS.



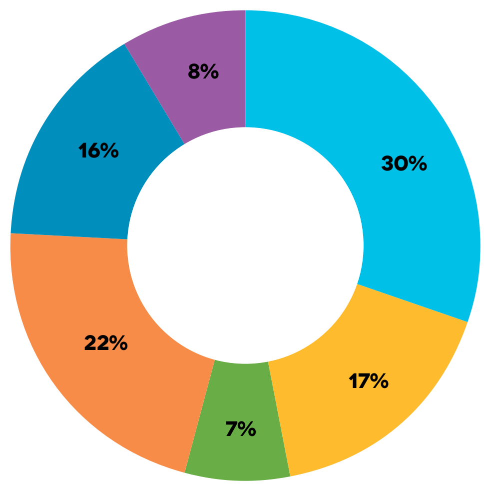


FIGURE A2.1 **DISTRIBUTION OF SURVEY SOURCES FOR ORIGINAL DATA—LATEST YEAR AVAILABLE**

DHS LSMS/IE CENSUS MICS OTHER SURVEYS NON SURVEY

DHS LSMS/IE CENSUS MICS OTHER SURVEYS WHS

SOURCE: AUTHORS
NOTE: HH = HOUSEHOLD; DHS = DEMOGRAPHIC AND HEALTH SURVEY; IES = INTEGRATED EXPENDITURE SURVEY; LSMS = LIVING STANDARD MEASUREMENT SURVEY; MICS = MULTIPLE INDICATOR CLUSTER SURVEY; WHS = WORLD HEALTH SURVEY

To develop the historical evolution and starting point of electrification rates, a simple modeling approach was adopted to fill in the missing datapoints – around 1990, around 2000, and around 2010. Therefore, a country can have a continuum of zero to three datapoints. For 42 countries there are no observed rates in all the time series and 170 countries have between one and three datapoints. For the latter group of countries, a model with region, country, and time variables was used to estimate the missing observations. The model keeps the original observation if data is available for any of the time periods. For the former group of countries, the weighted regional average was used as an estimate for electrification in each of the data periods (see annex 2). This modeling approach allowed the estimation of electrification rates for 212 countries over these three time periods.

First over, the sample of countries for which there was at least one observation the following model was estimated:

$$y = \alpha * R + \beta * C + \delta * time + u$$

Where R denotes region dummies, t denotes time dummies; y denotes percentage with access, C denotes a vector of dummy variables reflecting the country. The α; β and δ are unknown parameters and u is an error term.

For the sake of constructing the series, the model then uses the latest access rates available from the above household surveys. For those countries with at least one observation but missing values the study then uses the estimates of β ; α and δ to make predictions of the missing values.

For predicting access for countries with no observed values for any time period the study estimates the model over the following model over the sample which is available.

$$y = \alpha_1 * R + \delta_1 * time + u_1$$

where R denotes region dummies, t denotes time dummies; and y denotes percentage with access. The α_1 and δ_1 are unknown parameters and u_1 is an error term. For those countries with no observations the study then uses the estimates of α_1 and δ_1 to make predictions.

In the case of WHO Global Household Energy Database, a mixed model was used to derive solid fuel use estimates for 193 countries. Generating time-series curves for countries based on available actual data points has several advantages. It can derive point estimates for those countries for which there are no data by using regional trends. It also incorporates all the available data to derive point estimates and is not unduly influenced by large fluctuations in survey estimates from one year to the next. For example, in the case of household cooking solutions in Namibia, household survey data for use of solid fuels are available for 1991, 2000, 2001, 2003, and 2006, but not for 2010. Using the mixed model, an estimate of 55 percent was obtained for Namibia in 2010. For Nepal an even greater number of surveys are available (n = 8), some of which report substantially different estimates. Looking at the Nepal graph (figure A2.3), it is evident that the mixed model derives estimates that lie at or near the median of various survey estimates and derives a reasonable estimate of 82 percent for 2010.

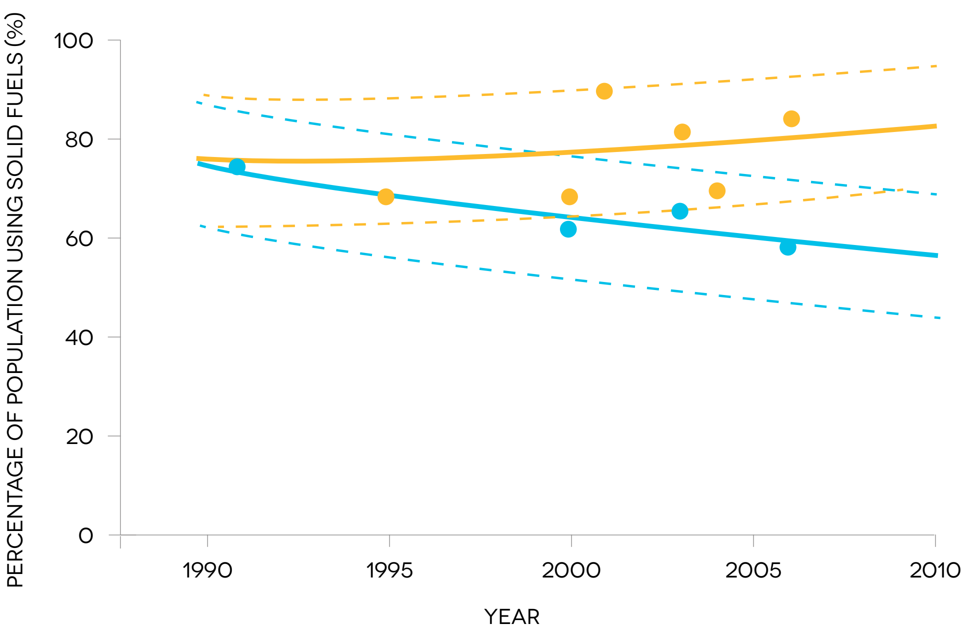


FIGURE A2.3 **EXAMPLE OF MODEL ESTIMATES IN SELECTED COUNTRIES**

NAMIBIA	SURVEY DATA	MODEL ESTIMATE	95% CONFIDENCE INTERVAL
NEPAL	SURVEY DATA	MODEL ESTIMATE	95% CONFIDENCE INTERVAL

SOURCE: WHO.

Finally, the World Bank Global Electrification Database encompasses 212 countries and WHO Household Energy Database includes 193 countries, both representing near universal coverage of global population (table A2.1).

	COUNTRY COVERAGE	% OF POPULATION
Electricity		
Household survey data available	126 *	96 *
Data from model estimates	212	100
Household cooking fuel		
Household survey data available	142 *	97 *
Data from model estimates	193	99.6

* REFERS ONLY TO LOW- AND MIDDLE-INCOME COUNTRIES.

ANNEX 3: Matrix for measuring household access to electricity supply and electricity services

Supply tiers

ATTRIBUTES

	TIER 0	TIER 1	TIER 2	TIER 3	TIER 4	TIER 5
Quantity (peak available capacity)	—	>1W	>50W	>200W	>2,000 W	>2,000 W
Duration of supply (hours)	—	>4	>4	>8	>16	>22
Evening supply	—	>2	>2	>2	4	4
Affordability (of a standard consumption package)	—	—	Affordable	Affordable	Affordable	Affordable
Legality	—	—	—	Legal	Legal	Legal
Quality (voltage)	—	—	—	Adequate	Adequate	Adequate

	TIER 0		TIER 1	Watts	TIER 2	Watts	TIER 3	Watts	TIER 4	Watts	TIER 5	Watts
Likely feasible applications (May not be actually used) (Wattage is indicative)			Radio Task lighting Phone charging	1 1 1	Radio Task lighting Phone charging General lighting Air circulation Television Computing Printing Etc.	 18 15 20 70 45	Radio Task lighting Phone charging General lighting Air circulation Television Computing Printing Air cooling Food processing Rice cooking Washing machine Etc.	 240 200 400 500	Radio Task lighting Phone charging General lighting Air circulation Television Computing Printing Air Cooling Food processing Rice cooking Washing machine Water pump Refrigeration Ironing Microwave Water heating Etc.	 500 300 1,100 1,100 1,500	Radio Task lighting Phone charging General lighting Air circulation Television Computing Printing Air Cooling Food processing Rice cooking Washing machine Water pump Refrigeration Ironing Microwave Water heating Air conditioning Space heating Electric cooking Etc.	 1,100 1,500 1,100
Possible electricity supply technologies	Dry cell Solar lantern Rechargeable batteries Home system Mini-grid/grid		— Solar lantern Rechargeable batteries Home system Mini-grid/grid		— — Rechargeable batteries Home system Mini-grid/grid		— — — Home system Mini-grid/grid		— — — Home system Mini-grid/grid		— — — Home system Mini-grid/grid	

NOTE: — = NOT APPLICABLE

Service tiers

	TIER 0	TIER 1	TIER 2	TIER 3	TIER 4	TIER 5
Actual use of indicative electricity services	—	Task lighting AND phone charging OR electric radio	General lighting AND television AND air circulation	Tier 2 package AND light and discontinuous application (thermal or mechanical)	Tier 3 package AND medium and/or continuous application (thermal or mechanical)	Tier 4 package AND heavy and/or continuous application (thermal or mechanical)

SOURCE: AUTHORS' COMPILATION.
NOTE: — = NOT APPLICABLE

ANNEX 4: Technical performance standards for cookstoves

In February 2012, the Global Alliance for Clean Cookstoves (the Alliance) in collaboration with the World Health Organization (WHO) and International Standards Organization (ISO) achieved an International Workshop Agreement (IWA) on multi-tier standards for measuring technical performance of cookstoves. The IWA acknowledges the emerging scientific consensus that not all reductions in emissions are of equal value to human health and to climate change. The IWA multi-tier guidelines provide the basis for measurement of cookstove performance on the four technical attributes—efficiency, indoor pollution, overall pollution, and safety.

TECHNICAL ATTRIBUTES		TIER 0	TIER 1	TIER 2	TIER 3	TIER 4
Efficiency	HPTEa (%)	>15	<15	>25	>35	>45
	LPSCb (MJ/min/L)	>0.05	<0.05	<0.039	<0.028	<0.017
Indoor pollution	CO (g/min)	>0.97	<097	<0.62	<0.49	<0.42
	PM (g/min)	>40	<40	<17	<8	<2
Overall pollution	HPCOc (g/MLd)	>16	<16	<11	<9	<8
	LPCOd (g/min/L)	>0.2	<0.2	<0.13	<0.1	<0.09
	HPPMe (mg/MJd)	>979	<979	<386	<168	<41
	LPPMf (mg/min/L)	>8	<8	<4	<2	<1
Safety	Iowa protocol	<45	<45	>75	>88	>95

SOURCE: AUTHORS' COMPILATION.
NOTE: — = NOT APPLICABLE

The above guidelines could potentially form the basis for determining the overall technical performance of the primary and secondary cookstoves as the first step in the multi-tier measurement of household access to cooking solutions. In addition to technical performance of primary and secondary cookstoves (including the use of non-solid fuels), measurement of household access to cooking solutions takes into account the conformity, convenience, and adequacy attributes for the household as a whole, as indicated in figure 2.4 of this document.

It should be noted that the IWA standards have been developed separately for each technical parameter and are not designed to be aggregated to obtain an overall rating for the cookstove. The different technical parameters have been kept separate in the IWA to allow programs, donors, investors, and consumers the ability to distinguish and prioritize between different parameters.

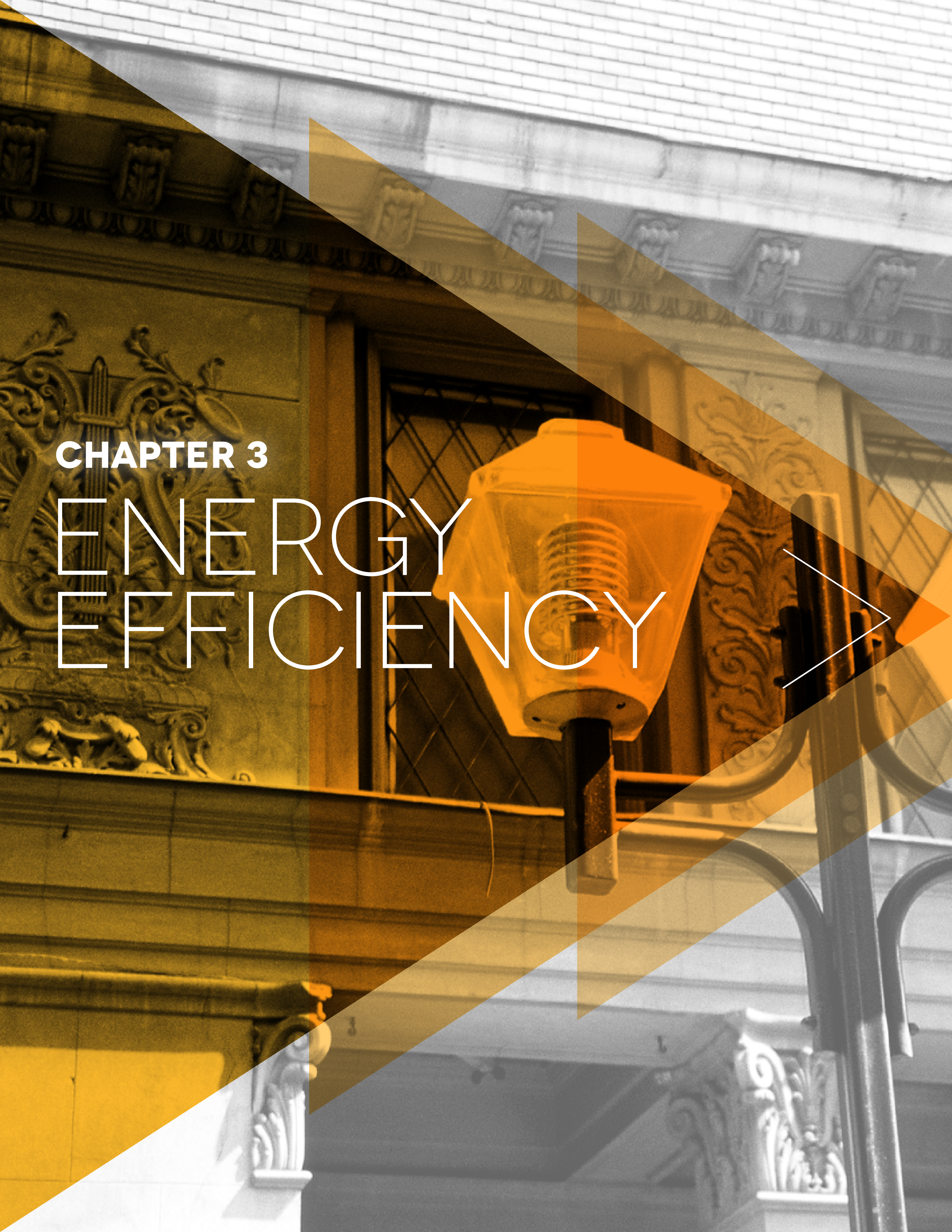
ANNEX 5: Mapping of consumption ranges to proposed multi-tier measurement of access

APPLIANCES	$WATT_{EQ}$ PER UNIT	HOURS/ DAY	TOTAL (KWH/ YEAR)	BASIC ACCESS	ADDITIONAL ACCESS			
				TIER 1	TIER 2	TIER 3	TIER 4	TIER 5
Radio	1	2	0.7	**0.7**	0.7	0.7	0.7	0.7
Task lighting	1	4	1.5	**1.5**	1.5	1.5	1.5	1.5
Phone charger	1	2	0.7	**0.7**	0.7	0.7	0.7	0.7
General lighting	18	4	26.3		26.3	26.3	26.3	26.3
Air circulator (fan)	15	4	21.9		21.9	21.9	21.9	21.9
Television	20	2	14.6		14.6	14.6	14.6	14.6
Food processors	200	1	73.0			73.0	73.0	73.0
Washing machine	500	1	182.5			182.5	182.5	182.5
Refrigerator	300	8	876.0				876.0	876.0
Iron	1,100	0.3	120.5				120.5	120.5
Air conditioner	1,100	2	803.0					803.0
				3	66	321	1,318	2,121

SOURCE: AUTHORS' COMPILATION.
NOTE: $WATT_{EQ}$ = WATT EQUIVALENT; KWH = KILOWATT–HOUR.

CHAPTER 3

ENERGY EFFICIENCY



CHAPTER 3: ENERGY EFFICIENCY

This chapter proposes a framework for understanding energy efficiency trends, integrating the current approaches to energy efficiency of various international agencies and national institutions, and establishing a methodology to determine the starting point against which future improvements in energy efficiency can be measured at the global and national levels. The chapter begins by identifying the methodological challenges of defining and measuring energy efficiency. After mapping a conceptual framework to address these issues, it goes on to review available global databases and to examine the extent to which those databases can be used to address the methodological issues raised.

Households and industries use energy sources such as electricity to provide goods and so-called end-use services that result in higher levels of economic productivity. Energy efficiency is measured as the ratio between the useful output of the end-use service and the associated energy input. In other words, it is the relationship between how much energy is needed to power a technology (for example, a light bulb, boiler, or motor) and the end-use service (for example, lighting, space heating, or motor power) that the technology provides.

Improving energy efficiency is a means to an end; it is not an end in itself. The value of energy efficiency policies can be measured by the social, economic, and environmental benefits that they bring. Improved efficiency is an important means of addressing the cost, availability constraints, and environmental impacts of energy use and production. Yet the real benefits often come from improved service outcomes: faster journeys, better health from warmer homes, and higher industrial productivity and product performance.

In places where the energy needs of consumers are already met, efficiency improvements primarily translate into reduced demand for energy and reduced costs, which can improve competitiveness. On the other hand, many developing countries cannot meet the energy demands of consumers; in places like these, improvements in energy efficiency are critical to providing more-reliable service and increasing productivity. Both aspects of efficiency—reduced energy demand and improved service value—are essential for wealth creation and social development.

SECTION 1: METHODOLOGICAL CHALLENGES IN DEALING WITH ENERGY EFFICIENCY

Measuring and tracking the rate of improvement of energy efficiency in the global energy mix poses various definitional and methodological challenges—chief among them:

- Finding a single headline measure of energy efficiency despite its multidimensional nature
- Dealing with the fact that headline measures of energy intensity are, at best, imperfect proxies for underlying energy efficiency
- Deciding whether to measure economic output in terms of market exchange rate or purchasing power parity
- Deciding whether to measure energy input in terms of primary or final energy.

Those challenges are considered individually in the four subsections that follow.

Multidimensionality

Energy efficiency is most accurately expressed in terms of the relationship between energy inputs and end-use outputs at the level of individual technologies and processes (as represented by the base of the pyramid in figure 3.1). An example of an indicator of such "process efficiencies" would be units of energy input per ton of steel produced in a particular type of steel mill using a particular quality or type of input material and industrial process.

Operationally, however, such precise indicators present problems as benchmarks for energy efficiency, particularly for comparative analyses across countries. First, few countries, if any, consistently track detailed information across the full spectrum of energy use in their economies, and, even when they do, it is often not possible within a plant to define exactly how much energy is flowing into different processes. (Issues relating to industrial confidentiality pose additional challenges when trying to collect disaggregated data.) Second, even if such data were available, they would comprise a huge number of process-level indicators with different metrics that could not ultimately be aggregated, or, if they could be aggregated, would not be very informative in evaluating a country's overall progress on energy efficiency. In fact, owing to the interactions between energy processes and the different metrics used to measure efficiency, the overall energy efficiency of a country will not necessarily equal the average efficiency of the component processes.

To address this problem, aggregate indicators and methodologies have been developed (represented by the higher tiers of the pyramid shown in figure 3.1). Subsectoral indicators trace the relationship between energy input and physical or service output in an industry or subsector. This is done for energy-intensive products (for example, steel, cement, pulp and paper) regardless of the differences in the process used among factories. For the residential sector, indicators typically track energy used per household and per unit of floor space as well as for each end-use (for example, space heating and cooking). For transport, indicators include energy per traffic unit (such as passenger kilometers and ton kilometers). At an even higher level of aggregation, sectoral indicators measure the relationship between energy input and associated output in one broad sector of the economy, such as industry or agriculture. Finally, the highest level of aggregation measures the relationship between energy input and the output of the economy as a whole.

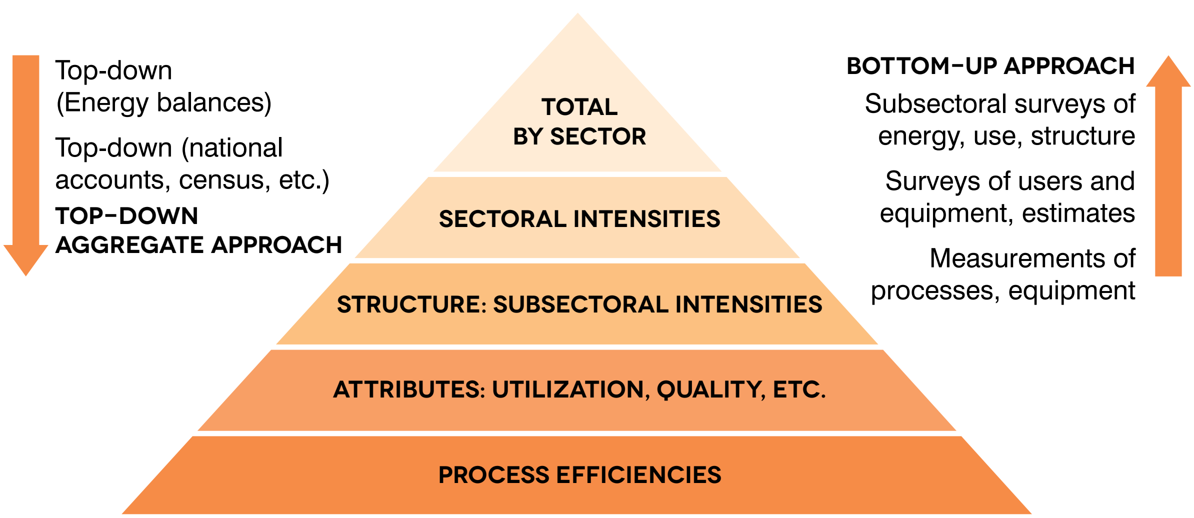


FIGURE 3.1 PYRAMID OF ENERGY EFFICIENCY INDICATORS

SOURCE: MARTIN AND OTHERS 1995; IEA 1997; PHYLIPSEN 2010.

Intensity versus efficiency

As one moves up the pyramid in figure 3.1, the higher degree of aggregation across economic activities makes it increasingly difficult to measure output in physical terms (for example, tons of steel or units of floor space). Instead, output is typically measured in monetary units as the value added of a specific economic sector.

Such value-based measures are typically measured in terms of megajoules (MJ) per U.S. dollar of value added and are technically measures of energy intensity rather than energy efficiency. Energy intensity is at best an imperfect proxy for energy efficiency. This is because energy intensity is affected not only by changes in energy demand but also by shifts in the components that comprise the denominator of that ratio, which may have little to do with energy efficiency. For example, a country that moves rapidly from subsistence agriculture to industrialization would experience a change in the structure of the economy toward more energy-intensive activities rather than a shift in energy efficiency per se.

Energy intensity may also be affected by other factors, such as demographic changes, weather variation, fuel-use shifts, and the overall level of activity in the economy. For example, as national income increases, so does car ownership and car usage,[1] a structural change that has a significant effect on energy intensity even if the fuel consumption of individual automobiles is no higher than before (and may even have improved). Several decomposition methods can help to capture changes in the drivers of energy demand and thus to isolate the changes in energy efficiency (Ang and Choi 1997; Baksi and Green 2007) (box 3.1).

Despite its limitations, energy intensity has traditionally been used as a proxy for energy efficiency when making international comparisons owing to the limited availability of disaggregated data and the multidimensional nature of energy efficiency.

Energy intensity measures are ratios; trends represent the rates of change of those ratios. Therefore, small changes in either the numerator or denominator of energy intensity measures can result in significant shifts in year-to-year trends. The volatility of data trends from one year to the next can make tracking the evolution of energy intensity difficult.

BOX 3.1 Understanding what drives change in aggregate variables

Changes in energy demand in an economy or sector are influenced by multiple driving forces, including changes in:

- Activity or output. Demand for energy rises with increases in industrial output, the number of people needing housing, or the volume of passengers and distances travelled in the transportation sector.
- Structure. Larger houses and sparser occupancies increase household energy intensity independent of changes in population; decreases in steel production or increases in financial services lower the energy intensity of the economy as a whole; shifts in transport modes (for example, from public or nonmotorized transport to private cars, or from trains to trucks) alter transport energy consumption.
- Fuel type. A shift from wood to electricity, for example, alters energy demand.
- External/explanatory factors. Cold weather affects the quantity of energy used for residential space heating; changes in income and lifestyle affect consumer preferences, travel, and the use of appliances.
- Technical efficiency. Managerial or technological changes—such as better insulation, process improvements in industry, or innovations in automotive technology—affect the demand for energy.

[1] There appears to be an upper limit to car ownership and usage. Policy matters, but it does not cancel out the effect of increased car ownership and usage as incomes increase.

A decomposition analysis is typically used to break down the change in an aggregate variable, like energy demand, into its driving factors. Several methodologies can be used for such an analysis, including the Divisia-based and Laspeyres-based methods. Since decomposition is a series expansion truncated at first order, a residual usually remains that captures higher-order terms. Most of the methods based on the Divisia index have the advantage of being "residual free," which comes at the expense of an arbitrary attribution of interaction terms. For the purposes of global tracking, the logarithmic mean Divisia index I (LMDI I) method will be used both because it is practical and because it is already widely used to assess energy efficiency progress.

The Divisia index was devised by François Divisia and first published in the *Revue d'économie politique* in 1925 (Divisia 1925). Divisia initially used the index to determine the variable in the equation of exchange. Its application to energy analysis was pioneered by Boyd, Hanson, and Sterner (1988).

SOURCE: AUTHORS.

Market exchange rate versus purchasing power parity

Another difficulty associated with international comparisons of value-based measures of energy efficiency is that of determining a suitable value measure of output. In particular, value added can be expressed either in terms of market exchange rate (MER) or purchasing power parity (PPP). MER measures simply convert the value of output to a common monetary metric based on standard exchange rates. The drawback to this approach is that price levels vary significantly across countries, and prices of locally produced goods tend to be systematically higher in higher-income countries. As a result, MER measures may undervalue output from lower-income countries and therefore overstate energy intensity. But PPP measures are not as readily available as MER measures because the associated correction factors are updated only every five years (box 3.2).

BOX 3.2 Purchasing power parity

Purchasing power parity (PPP) adjustments are calculated by the International Comparison Program at the World Bank using data from surveys undertaken every five years. A total of 180 countries participate in the surveys.

PPP estimates are developed by interpolation for countries that do not participate in the surveys and for years during which surveys are not conducted. For nonparticipating countries, the PPPs are estimated using a price level index adjustment that computes the relative size of the economies in terms of gross domestic product (GDP), imports, and exports in U.S. dollars. PPP series are updated in years between surveys using the most recent nominal GDP and relative GDP deflators (accounting for the rate of inflation) between the country and the United States since the last PPP value was calculated. The current PPP series in use is from the 2005 survey, and the next update will be released in 2013, based on the survey done in 2011.

In terms of projections, the International Monetary Fund forecasts country-level annual real GDP through 2017 in the *World Economic Outlook*. That report (IMF 2012) uses PPP adjusted values and weights for country comparisons and regional aggregations.

SOURCE: WORLD BANK INTERNATIONAL COMPARISON PROGRAM; IMF 2012; UN 2012.

Primary versus final energy

Just as energy intensity measures are affected by the monetary unit used to capture the value added of output, they are also affected by the way that energy consumption[2] is measured. Specifically, energy consumption can be measured either in terms of primary or final energy.[3] The use of primary energy as a measure requires selecting a method of accounting for nuclear, hydro, and other renewable sources of energy for which there is no distinct process of converting final energy (outputs) to primary energy inputs.[4]

When energy intensity is tracked at the primary energy level, efficiency improvement trends and potential can be analyzed on both the supply side and the demand side. On the supply side, the conversion from primary energy (such as coal) to final energy (such as electricity) can be captured. On the demand side, the conversion from final energy (such as electricity used by appliances) to useful energy (such as light and heat) can be captured. If only final energy is tracked, the analysis will miss the potential for improvements on the supply side, which could be significant for developing countries. Furthermore, analysis at the primary energy level can also capture much of the traditional (that is, noncommercial) energy that accounts for a significant share of energy demand in lower-income countries.

While it may make sense to use primary energy for highly aggregated measures of energy intensity, it is less useful for measuring energy intensity at the sectoral or subsectoral level. For example, it would be difficult to interpret the results of an analysis that uses primary energy measures to gauge the energy intensity of the residential sector, because this would confound the efficiency of energy conversion and transformation in the electricity and heating supply sector (which supplies energy to residential buildings) with the efficiency of energy used within the buildings for end-use services (such as space heating, cooling, and lighting).

2 Though technically energy cannot be consumed, in this report the term *energy consumption* means “quantity of energy applied”, following the definition in ISO 50001:2011 and the future standard ISO 13273-1 Energy efficiency and renewable energy sources - Common international terminology Part 1: Energy Efficiency.

3 Final energy can also be expressed in primary terms through the use of dynamic and country-specific conversion factors. This approach is proposed in the ISO standard “Energy Efficiency and Savings Calculation for Countries, Regions and Cities,” currently under development (ISO/TC257). Given the objectives of the UN SE4ALL Global Tracking Framework, data availability issues, and the arguments presented in this section, final energy in primary terms is not used in this report to calculate sectoral intensities. For further discussion on the use of primary or final energy accounting, see the section on methodological issues in chapter 4.

4 As explained further in this chapter, primary energy supply data from the International Energy Agency, which employs the physical energy content method, will be used.

Suggested methodology for defining and measuring energy efficiency

While it is not possible to fully resolve all of the challenges outlined in the preceding section, SE4ALL's preferred methodological approach is outlined in table 3.1.

CHALLENGE	PROPOSED APPROACH
The multidimensionality of energy efficiency	Track global performance on energy intensity while also tracking the energy intensity of major economic sectors and the efficiency of the energy industry. Move toward better tracking of targets, policies, institutions, and investments.
Intensity versus efficiency	Track energy intensity for countries and major regions and blocks. Where feasible, complement that tracking with decomposition of changes in energy demand to strip out structural effects.
Market exchange rate versus purchasing power parity	Track energy intensity using the purchasing power parity measure to capture the value-added of economic output.
Primary versus final energy	Track global energy intensity in terms of total primary energy supply and sectoral energy intensity in terms of final energy consumption.
Volatility of efficiency measures	Track a five-year moving average trend.

TABLE 3.1 **ADDRESSING METHODOLOGICAL CHALLENGES IN THE GLOBAL TRACKING OF ENERGY EFFICIENCY**

SOURCE: AUTHORS.

The headline indicator proposed here as a proxy for energy efficiency in global tracking is the compound annual growth rate of energy intensity at the national level. Energy intensity is measured as the ratio of total primary energy supply[5] to the value-added of the economy measured in terms of purchasing power parity to ensure a fairer comparison of energy intensity across developed and developing countries.

To address concerns about the year-to-year volatility of energy efficiency measures, energy intensity is calculated as the compound annual average growth rate for the 20 years between 1990 and 2010, which is the longest time series of data available for this purpose. Going forward, five-year moving averages will be tracked.

To get as close as possible to measuring the underlying changes in energy demand, the headline indicator is accompanied by a decomposition exercise of changes in final energy consumption that distinguishes between activity, structure, and underlying efficiency effects.[6] The proposed methodology uses the logarithmic mean Divisia decomposition (LMDI I) method for each country.

5 Total primary energy supply is defined as "indigenous production + imports – exports – international marine and aviation bunkers +/- stock changes. It is equivalent to total primary energy demand, and represents inland demand only and, except for world energy demand, excludes international marine and aviation bunkers" (IEA). As discussed later, energy statistics used to calculate indicators in this chapter come primarily from the International Energy Agency. Hence, IEA terminology and definitions are generally used for these variables. When referring to final energy consumption, the equivalent IEA indicator is total final consumption (TFC).

6 Decomposition analysis can also isolate fuel-switching effects, mainly electrification. This was not done in the analysis presented here, however, owing to data constraints.

7 Owing to data limitations, this report groups transport, residential, services, and others into "other sectors." The medium- and long-term methodology will consider these sectors separately.

8 For this analysis, transformation losses in oil production are considered negligible and will not be tracked.

9 These include iron and steel, cement, chemicals and petrochemicals, aluminum, pulp and paper, and fertilizers (provided there are sufficient data for tracking).

To give a more nuanced picture of energy efficiency trends, the headline indicators are complemented with indicators of the energy intensity of three end-use sectors (agriculture, industry, and "other sectors"[7]) and two energy supply sectors (electricity and gas[8]) along with the specific energy consumption of select energy-intensive products.[9] In addition, the suggested methodology tracks national targets, policies, institutions, and investments in energy efficiency.

For demand-side sectors, the methodology uses energy intensity measures based on the ratio between final energy consumption (expressed in joules) and a measure of the scale of the sector. Finding a suitable measure for the scale of the sector can be challenging. But its economic value can be captured through global statistics on sectoral value added.

Value added is clearly defined only for industry and agriculture. For "other sectors," a category that includes transport, some activities related to the residential sector, services, and other residuals, value added is less clearly defined. Indeed, grouping transport, which has a high energy intensity, with services, which has a low energy intensity, may not be very meaningful and may complicate the interpretation of results for this category, but the decomposition analysis can at least give some insight into structural changes occurring in better-defined sectors.

Ideally, it would be desirable to report separately on the energy intensity of the residential and transport sectors. In the case of the residential sector, energy consumption would ideally be normalized against the number of households or the size of residential housing units in square meters. Similarly, energy consumption in the transport sector would ideally be normalized against freight and passenger traffic volumes. Unfortunately, because none of these variables is widely available, it is not possible at present to report separate energy intensity measures for the residential and transport sectors.

Overall energy efficiency in the supply sector is captured by the ratio of final energy consumption to total primary energy supply. This is a practical indicator, and the data are typically available in country energy balances. While this indicator can be useful for tracking progress in supply-side energy efficiency within a country, caution is required in a global or regional comparison because the indicator is distorted by resource-endowment factors. In a country with a significant hydroelectric sector, for example, primary energy and delivered energy are more directly related, while a country rich in geothermal energy will have a lower ratio owing to the low thermodynamic quality of the primary resource.

It is very difficult to determine how much primary energy is needed per unit of final energy or end-use output. The electricity system is dynamic, with changing dispatch, outages, and utilization factors. It is not practical to process real-time generator data for indicators, and the use of transformation efficiency assumptions obscures the real changes that occur. Efficiency indicators that focus on the supply system itself are therefore more informative for supply-side decision makers. It is thus more effective to treat the supply side as separate from the demand side for indicator analysis.

Supply-side energy efficiency indicators measure the efficiency of thermal plants in converting primary energy sources—such as coal, gas, and oil—into electricity. They are calculated by dividing gross electricity production from electricity and cogeneration plants by total inputs of fuels into those plants. Whether market-based or privately owned, self-generating plants that do not export their power should be included in the index assessment. In the case of cogeneration plants, fuel inputs are allocated between electricity and heat production in proportion to their shares of the annual output.

Transmission and distribution (T&D) losses measure power lost in the transmission of (high-voltage) electricity from power generators to distributors and in the distribution of (medium- and low-voltage) electricity from distributors to end-users. T&D losses are represented as a percentage of gross electricity production. They include both technical and nontechnical (or commercial) losses. Included in the latter are unmetered, unbilled, and unpaid electricity, including theft, which could be significant in developing countries. Aggregate T&D system indicators may be dominated by factors other than losses. The location of primary energy resources (such as hydro lakes and coal seams) and large loads (cities and industries) may be more significant factors in T&D efficiency indicators than the losses or efficiency of the transmission system itself. Properly

[10] This makes the definition of sectors consistent both in the numerator and the denominator of the intensity calculation. The World Bank's World Development Indicators (WDI) database considers all of the items classified under the International Standard Industrial Classification (ISIC) 3, including the value of energy for own use, as value added in industry. Therefore, own use of energy by industry (as reported by IEA) was added to the sector's consumption. This excludes nonenergy uses (such as feedstocks and methanol production). Similarly, energy use in the WDI sector labeled "services" is calculated by adding the consumption of the EIA sectors listed as "services," "residential," "transportation," and "other nonspecified."

separating true losses (and hence the efficiency potential of transmission systems) from exogenous location and scale factors and nontechnical losses would require detailed studies of system-dynamic interactions and real operating requirements that are not practical for global tracking purposes.

For gas supply, the efficiency indicator is based on the ratio of losses to primary energy supply using data available from national energy balances.

Global databases for setting the tracking framework

A number of agencies have historically collected disaggregated data on sectoral—and sometimes subsectoral—measures of energy intensity and energy efficiency, although these focus primarily on the developed countries of the Organisation for Economic Co-operation and Development (OECD) (box 3.3).

At present, disaggregated data are available for few developed countries. Therefore, when constructing energy intensity indicators for a wide set of countries, it is necessary to analyze base sectoral and end-use energy and activity data.

Table 3.2 summarizes the available databases that are consistent across countries and time, three of which are in the public domain (IEA; the World Bank's World Development Indicators; and UN Energy Statistics). The table also includes ODYSSEE, which, although limited in country coverage, exemplifies the extent to which energy efficiency indicators can be constructed provided that there are sufficient data.

BOX 3.3 Overview of existing data sources for energy efficiency indicators

A number of different agencies are doing important work on developing energy efficiency indicators. In general, these efforts either cover a relatively small number of countries in great depth (e.g. ODYSSEE-MURE) or a large number of countries at a much higher level of aggregation (WEC). While all these sources are relevant and useful for global tracking, none of them are directly suited in their existing form.

The International Energy Agency's (IEA's) energy efficiency indicators start from the top of the energy efficiency indicator pyramid (recall figure 3.1) and cover as many aggregation levels as possible. The IEA makes efforts to deepen the coverage of energy efficiency indicators to lower levels of disaggregation in OECD-IEA member countries. At lower aggregation levels, data availability limits the number of countries for which detailed indicators can be developed to ever-smaller subsets of IEA member countries. The exception is a special effort undertaken for the 2012 World Energy Outlook (WEO), which includes energy efficiency analysis for 25 large countries and global subregions.

The ODYSSEE-MURE Project, under the Intelligent Energy Europe Programme of the European Commission, is one of the most ambitious attempts to produce subsectoral and process-level indicators on energy efficiency. It focuses on the 27 EU member states plus Norway and Croatia.

Through bilateral support—such as the assistance that ADEME (the French Agency for Environment and Energy Management) has provided to several developing countries, and the efforts of individual countries (for example, China, India, Mexico, South Africa, Turkey, and Vietnam)—Enerdata provides relatively good coverage of sectoral-level energy intensity indicators for 184 countries worldwide, but these are proprietary.

The World Energy Council (WEC), with technical support from ADEME/Enerdata, maintains a database of global energy efficiency indicators focusing on a small set of aggregated indicators. The WEC effort covers the entire world at a regional level but provides only relatively aggregated efficiency indicators; this level of aggregation is indicative of what can currently be achieved for most developing countries without substantial additional effort and local involvement. It is important to note that efforts are under way to expand the countries included in the WEC's database.

The Asia Pacific Economic Cooperation, through capacity building activities on energy efficiency indicators organized by its Energy Working Group, has been forging collaboration and information sharing among its member economies.

Additionally, information is collected by various other agencies, including the World Bank, the U.S. Department of Energy's Energy Information Administration (EIA), the UN Industrial Development Organization (UNIDO), and other UN agencies. National energy agencies also collect data as part of their routine work, but these are limited in scope by coverage (either by country or sector) and often are based on differing methodologies. As a result, care must be taken when using these inputs as part of a tracking framework.

ENERGY DEMAND						OTHER VARIABLES		
Source	Primary or secondary	Period covered	Number of countries covered	Sectoral: Sectors (# of countries)	Subsectoral: Subsectors (# of countries)	Sector value added	Transport activities (# of countries)	Household data (# of countries)
International Energy Agency (IEA)	Primary	1971–2010	138	Industry, agriculture, services, residential, transport, fishing, and forestry (138)	13 industry subsectors, 6 transport subsectors for (138)	—	—	Building characteristics (29)
UN Energy Statistics	Primary	1950–2009	Over 200	Industry, agriculture, services, residential, transport (over 200)	3 industry subsectors, 5 transport subsectors (over 200)	—	—	—
World Bank, World Development Indicators (WDI)	Primary	1980–2011	—	—	—	3 sectors (agriculture, industry, services)	Air transport, freight in million ton-km (169); Air transport, passengers carried (169); railways, goods transported in million ton-km (88)	Household final consumption (172)
Enerdata	Secondary	1970–2010	184	Industry (181), agriculture (135), services (167), residential (184), transport (184)	13 industry subsectors (16–61) 4 transport subsectors (87–184)	3 sectors (industry, agriculture, services)	—	Private consumption (134)
ODYSSEE	Primary	1990–2010	29	Industry, agriculture, services, residential, transport (29)	16 industrial subsectors, 9 transportation modes, 4 household end-uses, 5 appliances, 6 branches services, 1 agriculture sector (29)	3 sectors (agriculture, industry, services)	Traffic, annual distance travelled, and stock of vehicles by mode of transportation: road (cars, two-wheelers, buses, light vehicles, trucks), rail, water, air (29)	Stock of dwellings, new dwellings, floor area of dwelling, stock of appliances, equipment rate (29)

TABLE 3.2 **COVERAGE OF THE FEW AVAILABLE DATABASES THAT ARE CONSISTENT ACROSS COUNTRIES AND TIME**

SOURCE: AUTHORS.
— = DATA NOT AVAILABLE.

Global and country-level tracking frameworks

Immediate and short term

The immediate approach for global tracking will make use of the most widely available historical data to construct national and sectoral indicators of energy intensity. This will be done by combining two sets of public domain data: (i) data on total primary energy supply and final energy consumption at the national and sectoral levels from the IEA's national energy balances, complemented with UN data on countries for which IEA lacks information; and (ii) data on national and sectoral value added in PPP terms from the World Bank and International Monetary Fund. Indicators will be tracked on a country level and aggregated globally and regionally for reporting by SE4ALL.

The specific energy consumption of selected energy-intensive products will be tracked using a wide range of available studies and databases, including those produced by the IEA, Enerdata, UNIDO, and other relevant stakeholders. In this process, care should be taken to address issues of comparability between different methodologies. Tracking should include national (and regional when applicable) energy efficiency policies, targets, institutional frameworks, and investments. Sources of information for the former include databases and compendiums available from the IEA, the World Energy Council (WEC), the World Bank, the Asia Pacific Energy Research Centre (APERC), and the European Union (EU), as well as country consultations.

At present there is no established methodology or periodic data collection on a global scale for tracking investments in energy efficiency. IEA's recent work for the World Energy Outlook (WEO) 2012 could lay the foundation for this purpose. Data sources include the World Bank and other multilateral development organizations. As mentioned previously, energy intensity indicators should be calculated as five-year moving averages. For monitoring and evaluation, especially in EU countries, the European Commission Directive on energy efficiency and the national energy efficiency action plans may be used.

The question of the entity that should be responsible for tracking, monitoring, and evaluating progress on energy efficiency is still under discussion. Well-established institutions that already collect and analyze the base data, as well as special-purpose entities created under the SE4ALL initiative, are being considered.

Medium term

The development of energy efficiency indicators in many developing countries is limited by the availability and quality of data and by a lack of dedicated resources and expertise to collect, track, and analyze those data. Substantial capacity-building efforts and resources—both human and financial—are needed to strengthen existing programs and institutions. Several countries have already established tracking systems and are collecting data and conducting analysis. In other countries, energy data are limited to supply and demand at the national and sector levels, which makes it difficult both to assess energy efficiency and to target policy interventions.

Efforts to improve data collection are best directed at increasing the availability of sectoral activity indices that can be used to convert into energy intensities detailed data on sectoral energy consumption already available from the national energy balances. In particular, the focus should be on the residential and transport sectors, for which scaling variables are not readily available at present. In the case of the residential sector, data series on floor space, occupancy and the number of households in each country are needed to calculate more meaningful measures of residential energy intensity than are possible today. The same is true for data series on freight and passenger traffic volumes in the transport sector. Improved floor space data could also help to provide more meaningful measures of efficiency in the services sector.

Since SE4ALL envisions the establishment of national tracking systems, there will be opportunities to invest in country-level capacity to collect critical complementary data that can cover the spectrum of economic activity. In addition, at the country level, it may be possible to contemplate more refined and disaggregated data on energy efficiency at the level of subsectors and technology processes.

Annex 1 illustrates the proposed indicators and their limitations. For a country to understand key sector-level factors driving energy efficiency, a bottom-up data collection framework needs to be established. Figure 3.2 illustrates the levels of data needed to monitor energy efficiency and intensity.

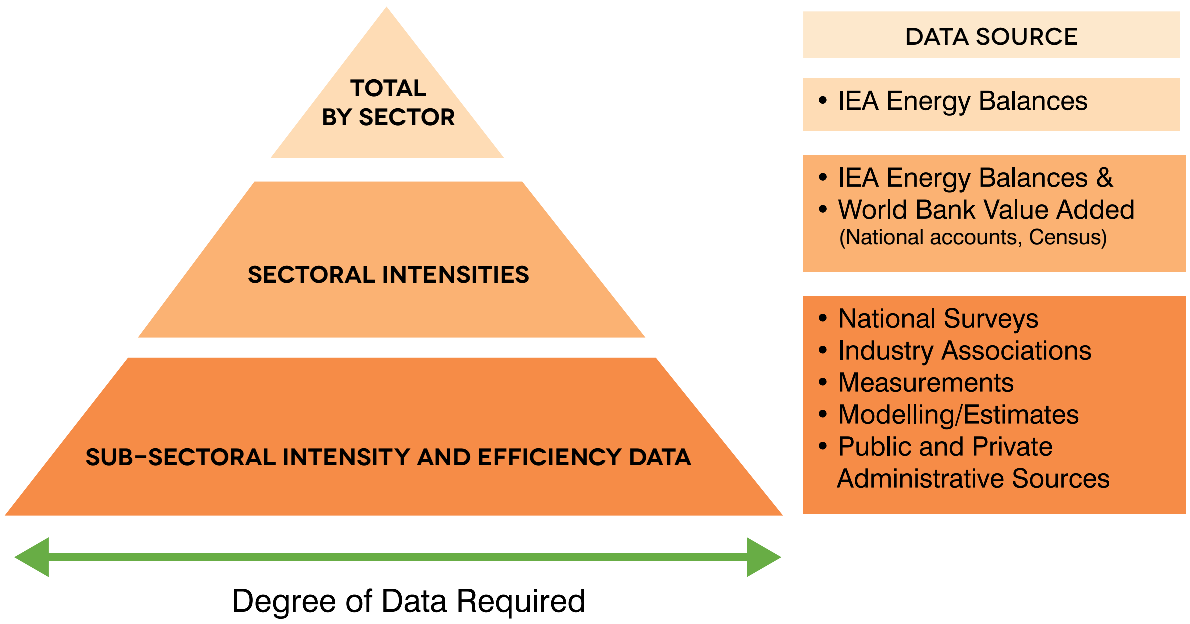


FIGURE 3.2 **ENERGY INDICATORS PYRAMID**

SOURCE: AUTHORS.
NOTE: IEA = INTERNATIONAL ENERGY AGENCY.

There is no single best approach to collecting country-level data; a country could choose from a number of ways to compile bottom-up energy demand data. Data collection could focus on sectors of interest and could include a combination of national surveying, metering, modeling, and collection of administrative data from existing public and private sources. Figure 3.3 illustrates a data collection framework that could be used for each sector based on several different sources. The final—and most important—step of the data collection framework is the bottom-up process of reconciliation and validation with energy balances. This is the step in which analysts ensure that energy and activity data are aligned with activity classification definitions. In addition, energy end-use data (such as for space heating and cooling), or derived data (obtained, for example, by estimating average fuel consumption of vehicles on roads by relating energy data to vehicle registration dates) are produced from the collated data.

Deciding which organization collects, consolidates, and analyzes data can be as important as determining how those data should be handled. This decision can be driven by existing national administrative laws. Some countries task statistical departments to undertake national surveys and carry out analysis; in other countries, final energy end-use analysis and estimates are carried out by ministries responsible for energy and natural resources. Often, different ministries are asked to work together. For example, statistics ministries and ministries tasked with overseeing energy resources and economic output are asked to coordinate to produce a final output together with one national organization taking the lead.

More data are not necessarily better. A country must commit to maintaining ongoing data collection and assessment of efficiency improvements. In order to establish timely and effective analysis of energy efficiency improvements, steps should be taken to ensure that sector-level monitoring of energy use is renewed on an annual basis. Resources should be allocated to monitor sectors that constitute a significant share of the country's absolute energy demand.

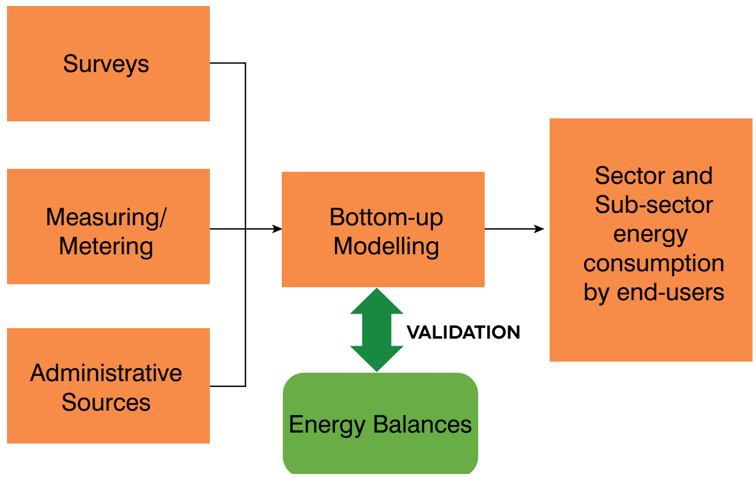


FIGURE 3.3 **DATA COLLECTION FRAMEWORK**

SOURCE: AUTHORS.

IEA's forthcoming *Manual on Statistics for Energy Efficiency Indicators* will be an essential guide for all countries that wish to establish a national framework. It will provide a list of key data elements needed to build energy efficiency indicators and describe how countries collect such data. The manual will feature examples of international practices, such as surveying, metering, modeling, and collecting of administrative sources. Other international guides are also being prepared, including the *Energy Statistics Compilers Manual* by the United Nations Statistics Division, and the *Manual for Statistics on Energy Consumption in Households* by Eurostat.

Figure 3.4 summarizes the proposed framework for the immediate and medium term, both globally and at the country level.

	IMMEDIATE	MEDIUM TERM
Global tracking	National and sectoral energy intensity measures for end-use sectors (industry, agriculture, and other sectors, the latter comprising services, residential and transport) plus an efficiency measure for electricity and gas supply. Apply Divisia decomposition method to track the underlying energy efficiency component of energy intensity.	Improve integration of data systems on energy use and associated output measures (for example, residential floor space and traffic units for transportation). Improve data on specific energy consumption of energy-intensive products.
Country-level Tracking	None	Strengthen country-level information systems and capability to collect data on sectoral intensities (and, ideally, subsectoral process efficiency measures). Improve data on physical activity drivers (traffic volumes—passenger and freight, number of households, floor space, and so on). Improve data on energy efficiency targets, policies, investments and institutional frameworks.

FIGURE 3.4 **IMMEDIATE AND MEDIUM–TERM TRACKING ACROSS GLOBAL AND COUNTRY LEVELS**

SOURCE: AUTHORS.

SECTION 2. GLOBAL, REGIONAL, AND SECTORAL TRENDS IN ENERGY INTENSITY

This section establishes the starting point for improvement in energy intensity using the approach outlined in the previous section. It reviews energy intensity trends over the two decades from 1990 to 2010 at the global, sectoral, and regional levels.

Defining the starting point for improvement

As described earlier, energy intensity measures the amount of energy used to produce a unit of economic activity (GDP). The 20 years between 1990 and 2010 witnessed an unprecedented growth in both GDP and energy demand across the globe. World primary energy supply grew from 367 exajoules (EJ) in 1990 to 534 EJ in 2010, an annual growth rate of 1.9 percent. Global GDP grew at an even higher rate of 3.2 percent per year (from $36 trillion in 1990 to almost $68 trillion in 2010) in PPP terms (constant 2005 U.S. dollars).

Thus, the starting point for the rate of energy efficiency improvement against which future progress will be measured under the SE4ALL initiative is a compound annual growth rate (CAGR) for global energy intensity of –1.3 percent (in PPP terms) for the period 1990–2010. The SE4ALL global objective is a CAGR of –2.6 percent for the period 2010–2030.[12] *For immediate tracking purposes, energy intensity is adopted as an imperfect proxy for energy efficiency that may be subject to improvement over time.*

As figure 3.5 illustrates, improvements in energy intensity were not even across the two decades. Energy intensity decreased more rapidly in the 1990s (–1.6 percent per year) than in the 2000s (–1.0 percent per year). This slowdown is mainly attributable to an increasing share of global economic activity during the 2000s in developing Asian countries, which have energy-intensive industries and coal-fired power generation, and thus relatively high energy intensities.

–1.0%
IS THE COMPOUND ANNUAL REDUCTION
IN GLOBAL ENERGY INTENSITY DURING THE DECADE 2000–2010; SIGNIFICANTLY LOWER THAN THE EQUIVALENT FIGURE OF –1.6% FOR THE DECADE 1990–2000

The magnitude of the deceleration during the decade 2000–2010 differs markedly across the MER and PPP measures. The rate of improvement of energy intensity slowed to only –0.1 percent annually in MER terms, compared to –1.0 percent in PPP terms. This divergence between MER and PPP measures can be attributed to globalization during the 2000s, which led to a large shift in the share of global GDP that was produced in non-OECD countries, where prices tend to be relatively low. As a result, the valuation of global output in PPP terms (to correct for these lower prices) rose steeply relative to MER terms. The rate of improvement in energy intensity thus looks much higher when the true value of increased output is taken into account.

[11] 1 exajoule (EJ) = 10^{18} J; 1 terajoule (TJ) = 10^{12} J; 1 megajoule (MJ) = 10^{6} J.

[12] When measured in final energy terms, the compound annual growth rate is –1.5 percent for the period 1990–2010. Thus the goal is –3.0 percent on average for the next 20 years.

FIGURE 3.5 **RATE OF IMPROVEMENT IN GLOBAL ENERGY INTENSITY (COMPOUND ANNUAL GROWTH RATE)**

SOURCE: BASED ON WORLD BANK WORLD DEVELOPMENT INDICATORS; IEA 2012A.
NOTE: GDP = GROSS DOMESTIC PRODUCT; MER = MARKET EXCHANGE RATE; OECD = ORGANISATION FOR ECONOMIC CO–OPERATION AND DEVELOPMENT; PPP = PURCHASING POWER PARITY.

In absolute terms, global energy intensity fell from 10.2 MJ/$ in 1990 to 7.9 MJ/$ in 2010 when measured in PPP terms (figure 3.6a). The role of major global economic shocks is evident when examining year-to-year rates of improvement. The impact of steeply rising energy prices is observable in the charts as triggering larger improvements in energy intensity in the 1990s. With the recession of the early 2000s and the global financial crisis of the late 2000s, improvements in energy intensity slowed.

7.9 MJ/US$ IS THE GLOBAL AVERAGE ENERGY
INTENSITY IN 2010; COMPARED WITH 10.2 MEGAJOULES PER US$ IN 1990

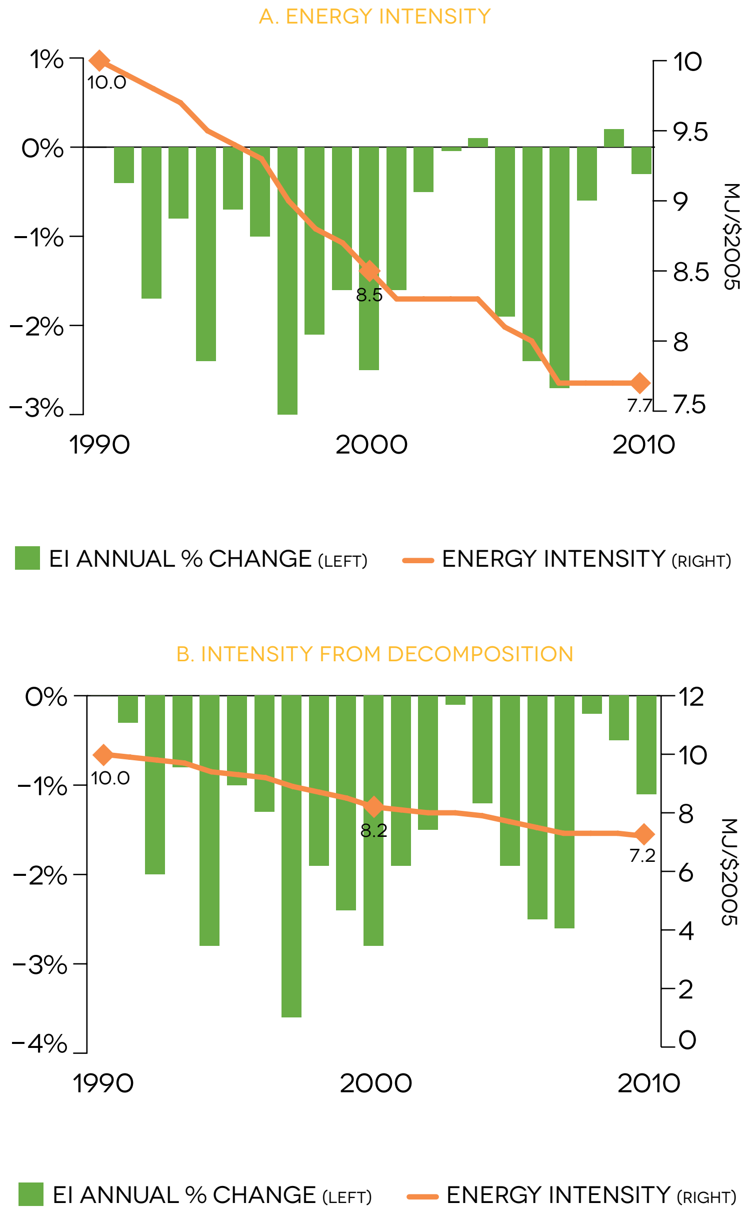


FIGURE 3.6 **EVOLUTION OF GLOBAL ENERGY INTENSITY TRENDS AT PPP**

SOURCE: BASED ON WORLD BANK WORLD DEVELOPMENT INDICATORS; IEA 2012A.
NOTE: EI = ENERGY INTENSITY; PPP = PURCHASING POWER PARITY.

As noted in the previous section, the decomposition of energy demand trends expressed in final energy consumption by sector makes it possible to distinguish among changes attributable to an expansion in economic activity (the activity effect), changes attributable to a shift in the structure of the economy (the structure effect), and changes attributable to improvements in energy intensity (intensity effect). The latter provides a first-order approximation of underlying energy efficiency (see figure 3.6b). The figure shows that improvements in the decomposed intensity were consistently higher than those in the unadjusted intensity, particularly in the last decade of the period analyzed.

Figure 3.7a shows more clearly the changes in the global energy intensity component of energy consumption for the 20 years since 1990. For the period 1990–2010, the CAGR of energy intensity with the activity and structure effects factored out is –1.6 percent—higher than the CAGR of energy intensity of –1.3 percent for the same time period, illustrating that energy intensity trends underestimate the rate of progress in underlying energy efficiency.[13]

The reason for this difference can be seen in figure 3.7b, which illustrates the variations in each component of energy demand from the base year. As the years progressed, the increase in economic activity in each sector was offset by the increased efficiency in each of the sectors used in the decomposition. The change in the structure component is insignificant at the global level because structural shifts in one country are to some extent offset by those in another, while the level of sector disaggregation is in any case quite coarse.

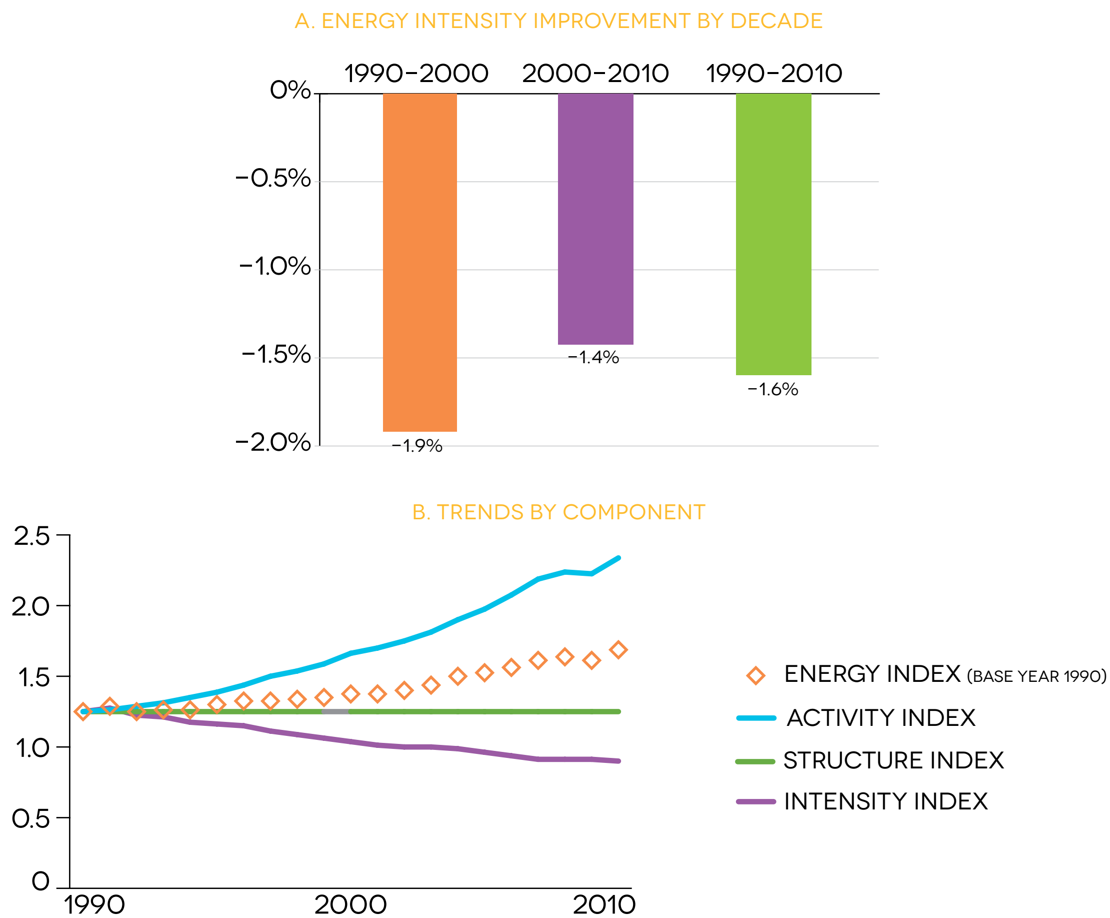


FIGURE 3.7 **GLOBAL RATE OF ENERGY INTENSITY IMPROVEMENT (DECOMPOSITION ANALYSIS)**

SOURCE: BASED ON WORLD BANK WORLD DEVELOPMENT INDICATORS; IEA 2012A.

[13] The –1.6 percent rate is also a larger improvement than the global compound annual growth rate measured in terms of final energy consumption terms with no decomposition. If taken as a baseline, it would imply average annual growth of –3.2 percent over the next 20 years.

Energy intensity improvements over the two decades 1990–2010 had a dramatic impact on the reduction of primary energy demand[14] globally. As figure 3.8 illustrates, if global energy intensity measured in PPP terms had remained at its 1990 level, world energy demand in 2010 would have been nearly 300 EJ higher. The energy intensity improvement that took place over the past 20 years allowed savings of nearly 2,300 EJ, equivalent to almost one-quarter of cumulative global primary energy demand—or the cumulative primary energy demand of China, Russia, and India combined over the same period.

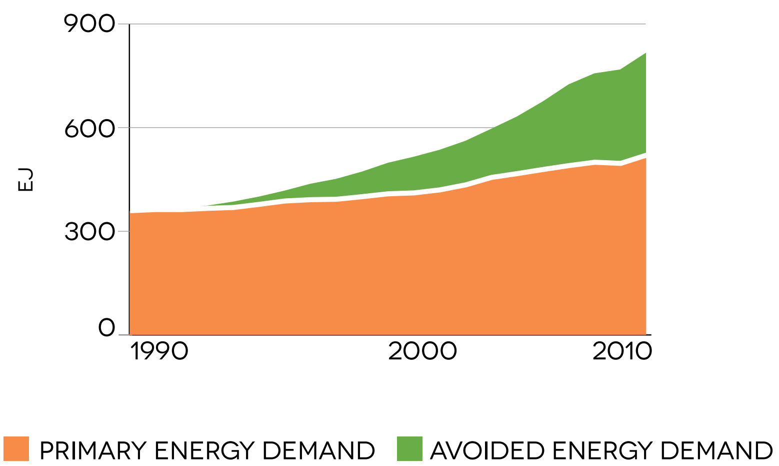


FIGURE 3.8 **ENERGY SAVINGS FROM REALIZED INTENSITY IMPROVEMENTS (EJ)**

SOURCE: BASED ON WORLD BANK WORLD DEVELOPMENT INDICATORS; IEA 2012A.

Global trends by sector

Further insights can be obtained by examining energy intensity trends at the level of major economic sectors—namely, agriculture, industry and other sectors (including transportation, residential, and services) (figure 3.9). The industrial sector is by far the most energy intensive, despite having improved at a relatively fast rate of –1.4 percent annually in PPP terms. The agricultural sector, which accounts for slightly over 2 percent of global final energy consumption, showed the fastest rate of improvement, at –2.2 percent per annum. Improvement in the other sectors is similar to that in industry, although this is difficult to interpret given the very different activities included under this category, which have markedly different drivers and intensity levels (see box 3.4 for an estimate of the contribution of the transport sector to improvements in energy intensity).

Although the rate of energy intensity improvement in industry and agriculture slowed down in 2000–2010 compared to 1990–2000, the opposite was true in the other sectors; once again, however, this result must be considered cautiously.

2,300 EJ
IS THE CUMULATIVE ENERGY SAVINGS
DUE TO DECREASES IN GLOBAL ENERGY INTENSITY FROM 1990 TO 2010; EQUIVALENT TO THE COMBINED CUMULATIVE PRIMARY ENERGY DEMAND OF CHINA, INDIA AND RUSSIA OVER THE SAME PERIOD

13 The –1.6 percent rate is also a larger improvement than the global compound annual growth rate measured in terms of final energy consumption terms with no decomposition. If taken as a baseline, it would imply average annual growth of –3.2 percent over the next 20 years.

14 As indicated previously, primary energy demand is equivalent to primary energy supply.

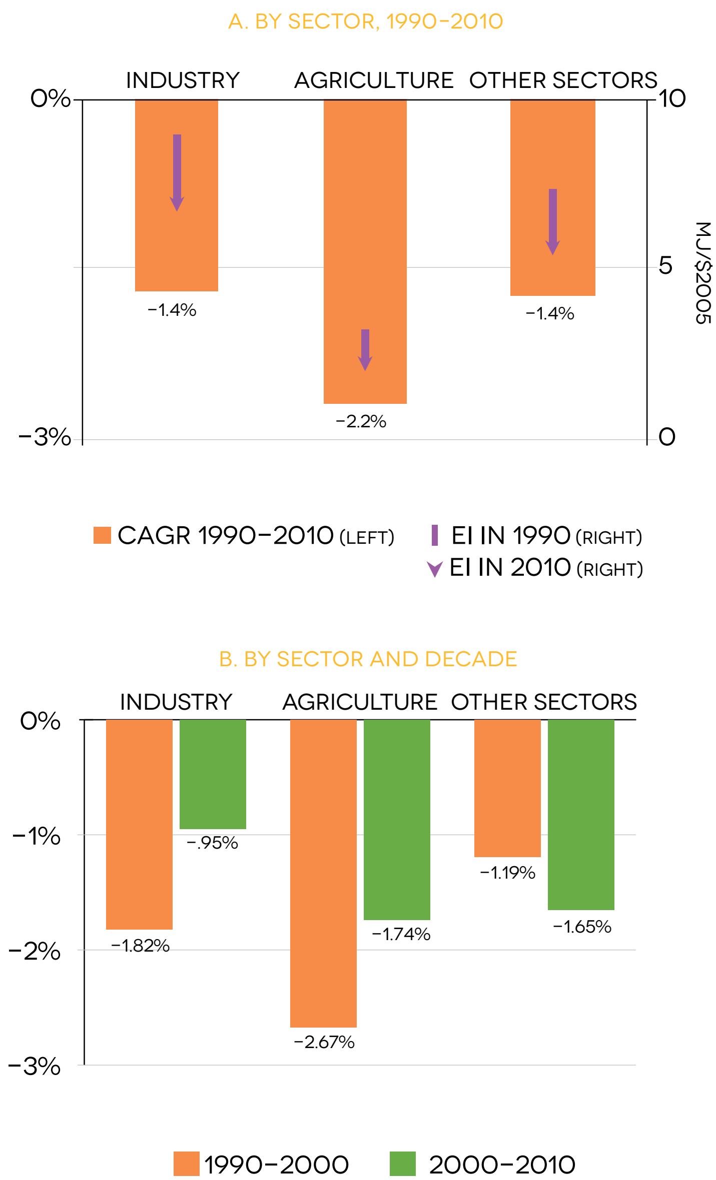


FIGURE 3.9 **SECTORAL ENERGY INTENSITY TRENDS AT PPP**

SOURCE: BASED ON WORLD BANK WORLD DEVELOPMENT INDICATORS; IEA 2012A.
NOTE: OTHER SECTORS INCLUDE THE TRANSPORTATION, RESIDENTIAL, AND SERVICE SECTORS. CAGR = COMPOUND ANNUAL GROWTH RATE; EI = ENERGY INTENSITY; PPP = PURCHASING POWER PARITY.

When looking at energy savings (that is, the difference between estimated cumulative final energy consumption if energy intensity levels had remained constant at 1990 levels and actual cumulative consumption through 2010), the percentage contribution of each sector (figures 3.10b and 3.10c) matches closely their share of final energy consumption (figure 3.10a).

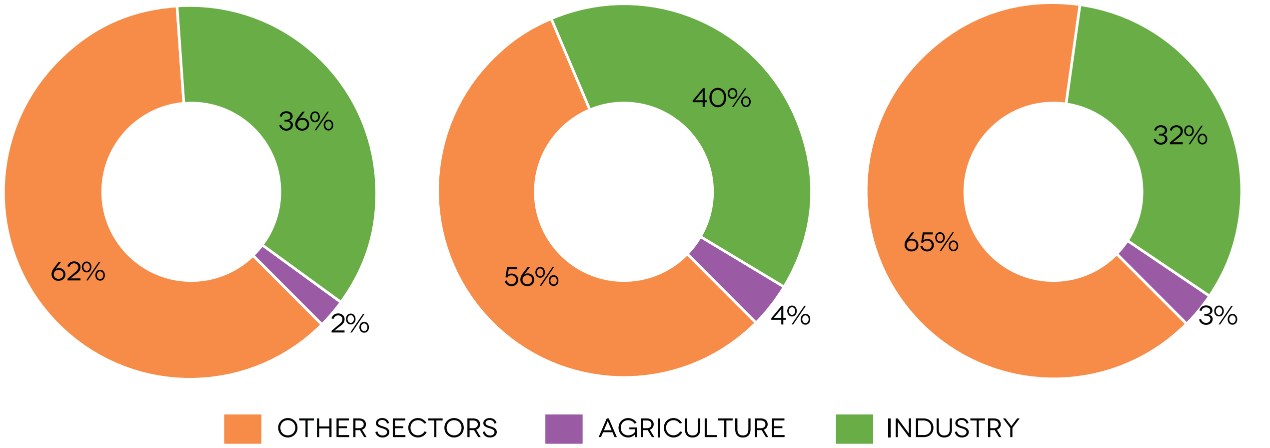


FIGURE 3.10A **FINAL ENERGY CONSUMPTION BY SECTOR, 1990–2010**

FIGURE 3.10B **ENERGY SAVINGS BY SECTOR, 1990–2010**

FIGURE 3.10C **ENERGY SAVINGS BY SECTOR, 1990–2010 (BASED ON INTENSITY FROM DECOMPOSITION)**

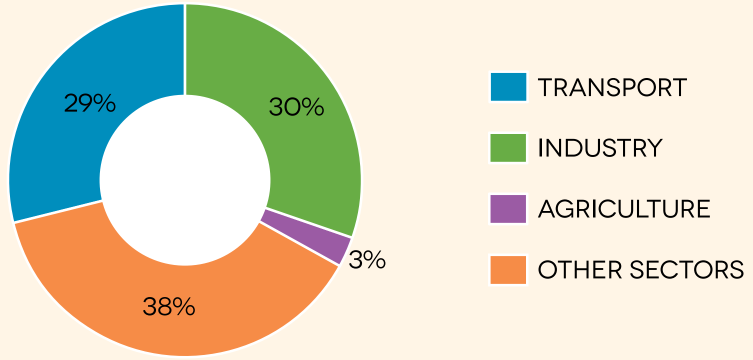
SOURCE: BASED ON WORLD BANK WORLD DEVELOPMENT INDICATORS; IEA 2012A.
NOTE: OTHER SECTORS INCLUDE THE TRANSPORTATION, RESIDENTIAL, AND SERVICE SECTORS.

BOX 3.4 Estimating the contribution of the transport sector to energy intensity improvements

Due to limitations in the availability of data on sectoral value added in the World Development Indicators, the main analysis here treats "other sectors" as a residual after industrial and agricultural output have been subtracted from GDP. As a consequence of this method, a number of disparate subsectors—including transport, residential, and services—are lumped together.

More disaggregated data on value added in the transport sector are available from the United Nations Statistics Division's National Accounts database, though that database covers 100 countries instead of 116 and only for 2000–10. Despite limitations in data, it is still of interest to explore trends in the transport sector as a supplement to the main analysis. The analysis shows a CAGR of –1.3 percent for the energy intensity of the transport sector in 2000–10. Overall, the transport sector contributed 29 percent of total global energy savings—almost as much as the other service sectors (38 percent) (figure A).

FIGURE A. **ECONOMYWIDE EXTENDED DECOMPOSITION: THE CONTRIBUTION OF SECTORAL ENERGY EFFICIENCY IMPROVEMENTS TO ENERGY SAVINGS, 2000–2010**



SOURCE: BASED ON WORLD BANK WORLD DEVELOPMENT INDICATORS; IEA 2012A; UN ENERGY STATISTICS DATABASE.
NOTE: OTHER SECTORS INCLUDE THE RESIDENTIAL, AND SERVICE SECTORS.

While the sectoral indicators reported above give a good sense of demand-side energy intensity, it is also important to consider the efficiency of conversion and transformation from primary to final energy. Figure 3.11a shows a gradual loss of global total primary energy to final energy transformation efficiency. This ratio decreased from 72 percent in 1990 to 68 percent in 2010. The driving forces behind this include the growth in coal use for electricity generation, and coal, oil, and gas consumption for heat provision relative to other primary resources.

Figure 3.11b shows the impact of improvements made in reducing losses in primary gas extraction and processing. Contributing factors include reduced gas flaring, reduced leakage, and improved efficiency of pipeline pressurization.

Figure 3.11c highlights the inertia in global electricity generation efficiencies, locked in at about 38 percent over many years. New coal-fired power stations dominate recent load growth, keeping overall efficiency relatively low despite the availability of higher-efficiency plants, such as combined-cycle gas generators.

Figure 3.11d highlights that again there is inertia in the dynamics of power transmission and distribution systems. The underlying drivers include the ongoing economic application of transmission efficiency improvements being countered by increasing network length as new generators are added farther from load centers.

The above indicators highlight that it is important to understand the underlying system inertia and dynamics and that disaggregation is key to explaining the status and opportunities of energy systems.

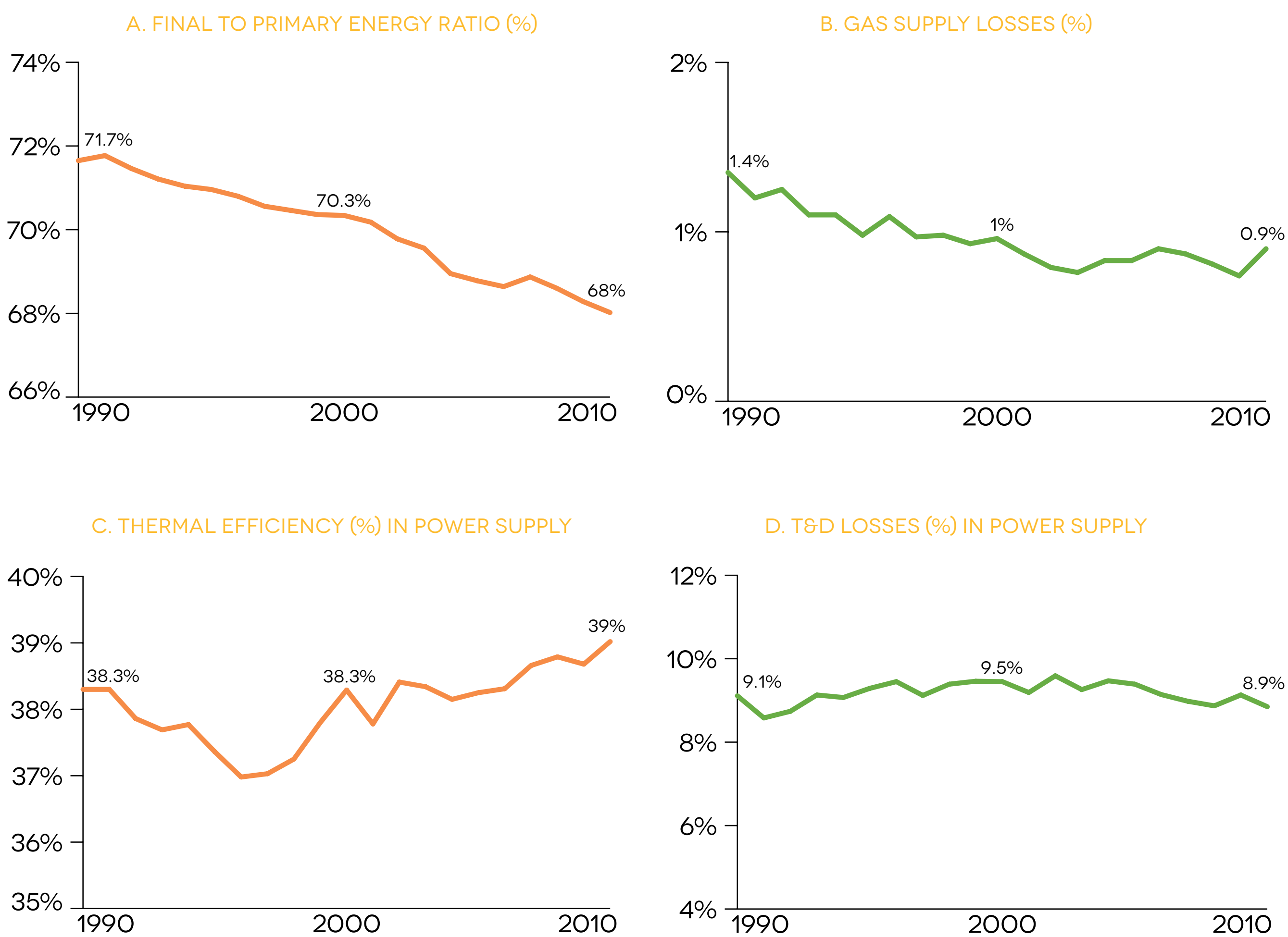


FIGURE 3.11 **SUPPLY-SIDE ENERGY EFFICIENCY INDICATORS**

SOURCE: BASED ON IEA 2012A.
NOTE: T&D = TRANSMISSION AND DISTRIBUTION.

Global trends by region

On a regional level, Eastern Europe and the Caucasus and Central Asia regions exhibited the fastest rate of energy intensity improvement over the past 20 years (figure 3.12). Despite this remarkable improvement, however, Eastern Europe and the Caucasus and Central Asia regions remain among the most energy intensive in the world, alongside Sub-Saharan Africa. Western Asia (which includes countries from the Middle East) is the only region to show a substantial deterioration in energy intensity, particularly in the past decade. Although Latin America and the Caribbean and Northern Africa are among the slowest-performing regions in terms of the rate of energy intensity improvement, they rank second and third, respectively, in terms of the lowest achieved level of energy intensity in 2010. Countries in Europe and North America also steadily improved their energy intensities. Southern and Southeastern Asia achieved similar levels of energy intensity, although the latter showed slower progress, having started from a relatively lower level.

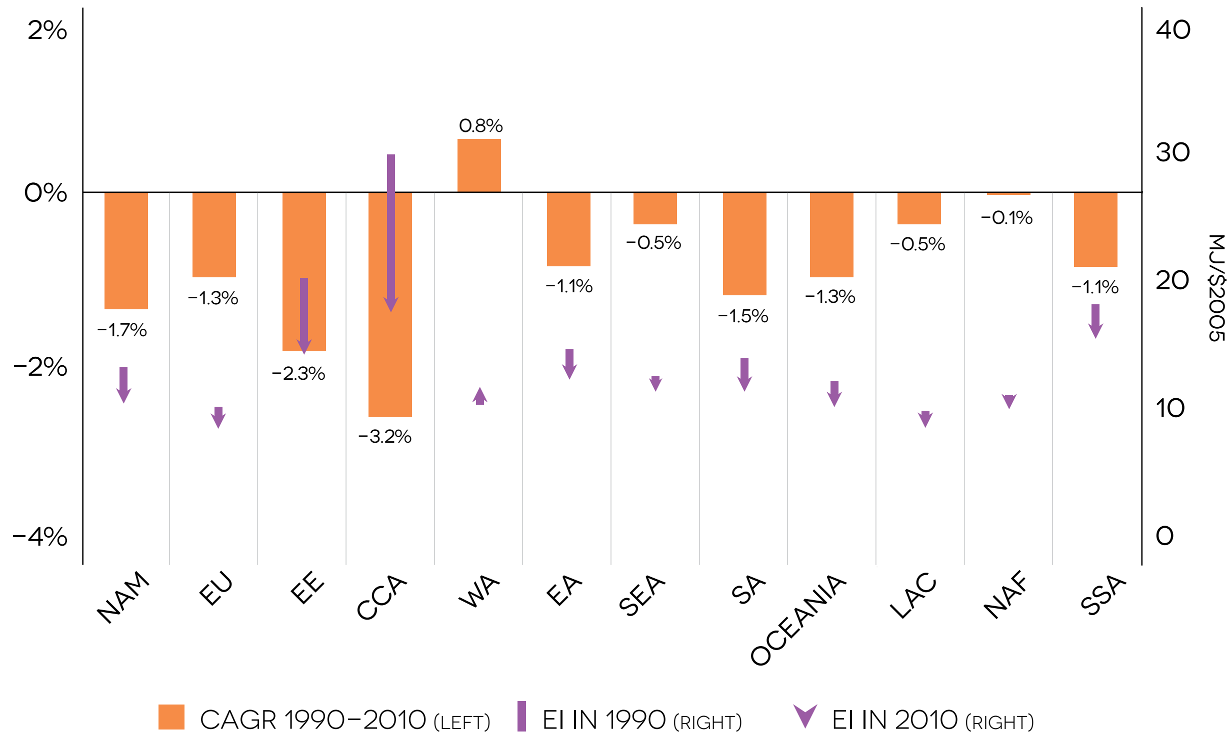


FIGURE 3.12A **RATE OF IMPROVEMENT IN ENERGY INTENSITY AT PPP VS. ENERGY INTENSITY LEVELS IN 1990 AND 2010, BY REGION**

NOTE: NAM = NORTH AMERICA; EU = EUROPE; EE = EASTERN EUROPE; CCA = CAUCASUS AND CENTRAL ASIA; WA = WESTERN ASIA; EA = EASTERN ASIA; SEA = SOUTHEASTERN ASIA; SA = SOUTHERN ASIA; LAC = LATIN AMERICA AND CARIBBEAN; NAF = NORTHERN AFRICA; SSA = SUB-SAHARAN AFRICA; CAGR = COMPOUND ANNUAL GROWTH RATE; EI = ENERGY INTENSITY; PPP = PURCHASING POWER PARITY.

Eastern Asia, North America, and Europe contributed most to global energy savings over the 20 years between 1990 and 2010 (figure 3.13).[15] Eastern Europe, Southern Asia, and other regions accounted for only 16 percent of energy savings while consuming about 35 percent of global energy. Western Asia and Northern Africa contributed a 0.6 percent decrease in energy savings owing to deterioration or slow progress in energy intensity improvement.

15 Savings are calculated comparing actual primary energy supply with what it would have been if countries in each region had maintained 1990 energy intensity levels.

FIGURE 3.12B **RATE OF IMPROVEMENT IN ENERGY INTENSITY AT PPP BY REGION AND DECADE**

SOURCE: BASED ON WORLD BANK WORLD DEVELOPMENT INDICATORS; IEA 2012A; UN ENERGY STATISTICS DATABASE.
NOTE: NAM = NORTH AMERICA; EU = EUROPE; EE = EASTERN EUROPE; CCA = CAUCASUS AND CENTRAL ASIA; WA = WESTERN ASIA; EA = EASTERN ASIA; SEA = SOUTHEASTERN ASIA; SA = SOUTHERN ASIA; LAC = LATIN AMERICA AND CARIBBEAN; NAF = NORTHERN AFRICA; SSA = SUB-SAHARAN AFRICA; CAGR = COMPOUND ANNUAL GROWTH RATE; EI = ENERGY INTENSITY; PPP = PURCHASING POWER PARITY.

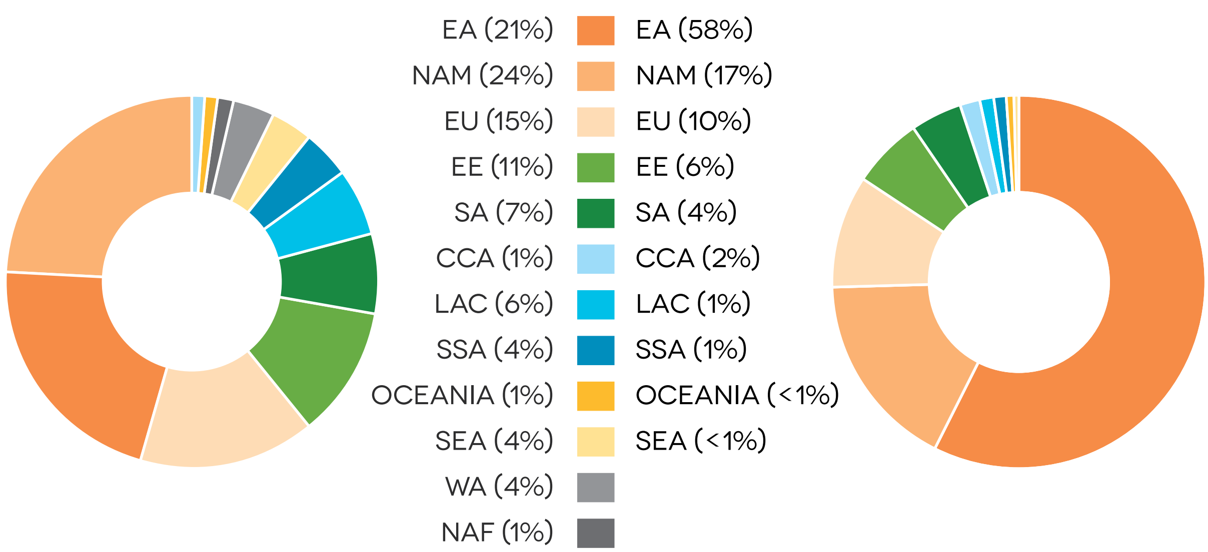


FIGURE 3.13A **PRIMARY ENERGY SUPPLY BY REGION, 1990–2010**

FIGURE 3.13B **ENERGY SAVINGS BY REGION, 1990–2010**

SOURCE: BASED ON WORLD BANK WORLD DEVELOPMENT INDICATORS; IEA 2012A; UN ENERGY STATISTICS DATABASE.
NOTE: NAM = NORTH AMERICA; EU = EUROPE; EE = EASTERN EUROPE; CCA = CAUCASUS AND CENTRAL ASIA; WA = WESTERN ASIA; EA = EASTERN ASIA; SEA = SOUTHEASTERN ASIA; SA = SOUTHERN ASIA; LAC = LATIN AMERICA AND CARIBBEAN; NAF = NORTHERN AFRICA; SSA = SUB-SAHARAN AFRICA.

Global trends by income level

Lower-middle-income countries started from the same level of energy intensity as the upper-middle-income countries in 1990 and made the most rapid progress in energy intensity improvement through 2010 (figure 3.14). Even though high-income countries improved their energy intensity at the slowest pace, their absolute level of energy intensity remains the lowest in the world; indeed, even their starting level of energy intensity in 1990 has not yet been matched by countries of other income levels as of 2010. Despite showing solid progress, low-income countries remain by far the most energy-intensive income group. Interestingly, apart from upper-middle-income countries, all income groups—particularly low- and lower-middle-income countries—accelerated their rates of energy intensity improvement in the decade between 2000 and 2010. The deceleration in the global rate of energy intensity improvement in this decade can therefore be attributed to the upper-middle -income countries.

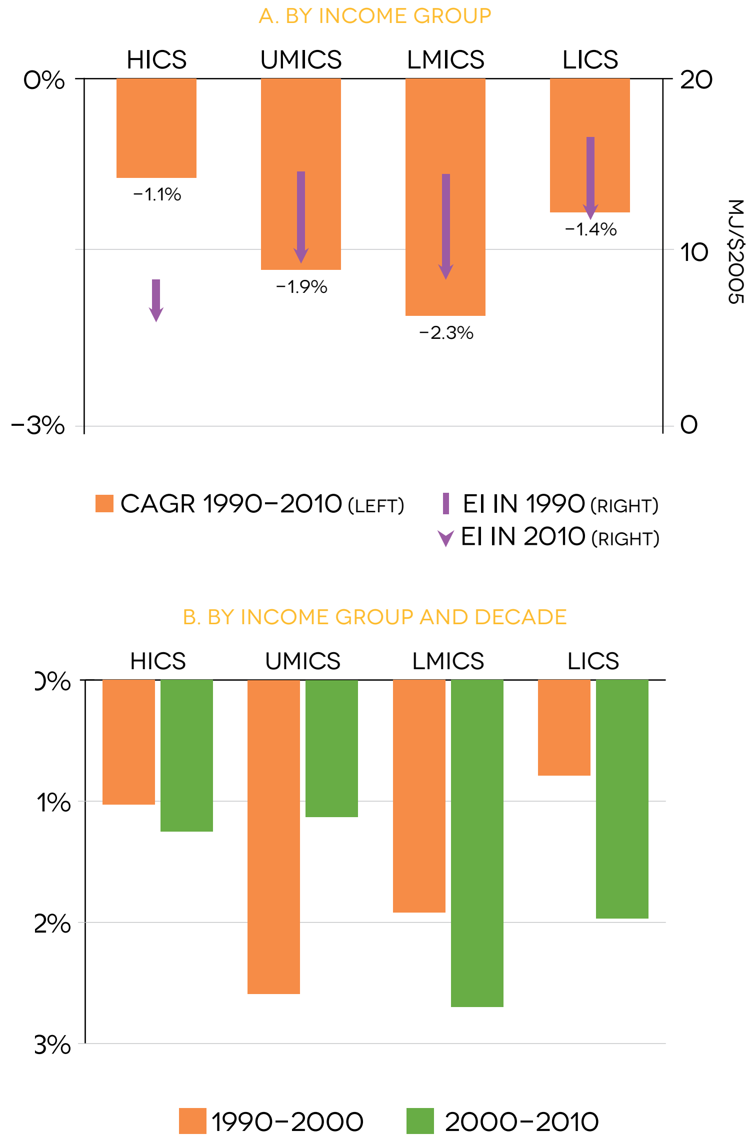


FIGURE 3.14 **RATE OF IMPROVEMENT IN ENERGY INTENSITY AT PPP VS. ENERGY INTENSITY LEVELS IN 1990 AND 2010, BY COUNTRY INCOME GROUP AND DECADE**

SOURCE: BASED ON WORLD BANK WORLD DEVELOPMENT INDICATORS; IEA 2012A; UN ENERGY STATISTICS DATABASE.
NOTE: CAGR = COMPOUND ANNUAL GROWTH RATE; EI = ENERGY INTENSITY; HICS = HIGH-INCOME COUNTRIES; LICS = LOW-INCOME COUNTRIES; LMICS = LOWER-MIDDLE-INCOME COUNTRIES; PPP = PURCHASING POWER PARITY; UMICS = UPPER-MIDDLE-INCOME COUNTRIES.

Despite the slowdown of energy intensity improvement in 2000s, upper-middle-income countries accounted for more than half of total energy savings over the past 20 years. High-income countries, on the other hand, consumed close to half of global energy but accounted for only one-third of energy savings (figure 3.15). The reason behind this disparity is that the upper-middle-income countries started with an energy intensity twice as high as that of high-income countries, and therefore had more opportunities to introduce energy saving measures.

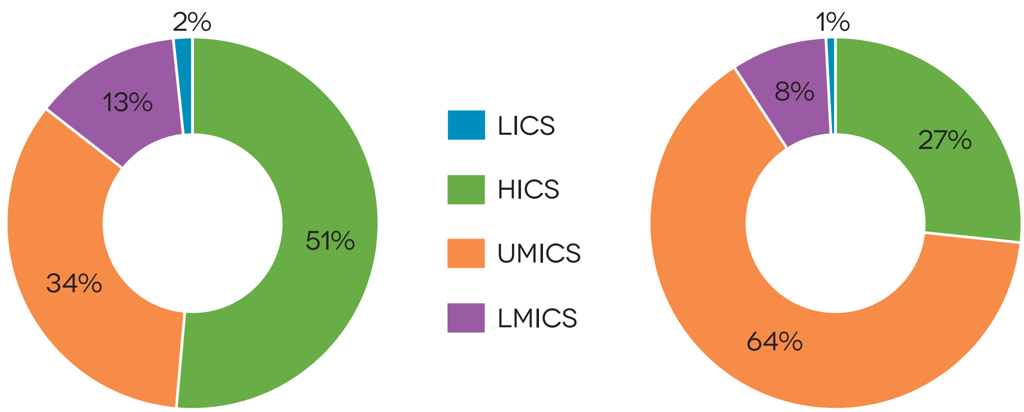


FIGURE 3.15A **PRIMARY ENERGY SUPPLY BY INCOME LEVEL, 1990–2010**

FIGURE 3.15B **ENERGY SAVINGS BY INCOME LEVEL, 1990–2010**

SOURCE: BASED ON WORLD BANK WORLD DEVELOPMENT INDICATORS; IEA 2012A; UN ENERGY STATISTICS DATABASE.
NOTE: HICS = HIGH–INCOME COUNTRIES; LICS = LOW–INCOME COUNTRIES; LMICS = LOWER–MIDDLE–INCOME COUNTRIES; UMICS = UPPER–MIDDLE–INCOME COUNTRIES.

SECTION 3. COUNTRY PERFORMANCES

Country performances varied greatly within and across regions, ranging from an energy intensity of 1.0 in Macau, China, to almost 60 in Liberia. (All energy intensities in this section are expressed in PPP terms as MJ/$2005.) Overall, 54 out of 181 countries experienced an increase in energy intensity over the past 20 years.

The world can be divided into four country blocks—countries with energy intensities below 5, those between 5 and 7, those between 7 and 10, and those above 10 (figure 3.16). There are 45 countries with energy intensities below 5; most countries in this category are found in Latin America and Caribbean, Europe, Oceania, and Sub-Saharan Africa. In the most energy-intensive category, there are 50 countries, with many of them in Sub-Saharan Africa and Western Asia.

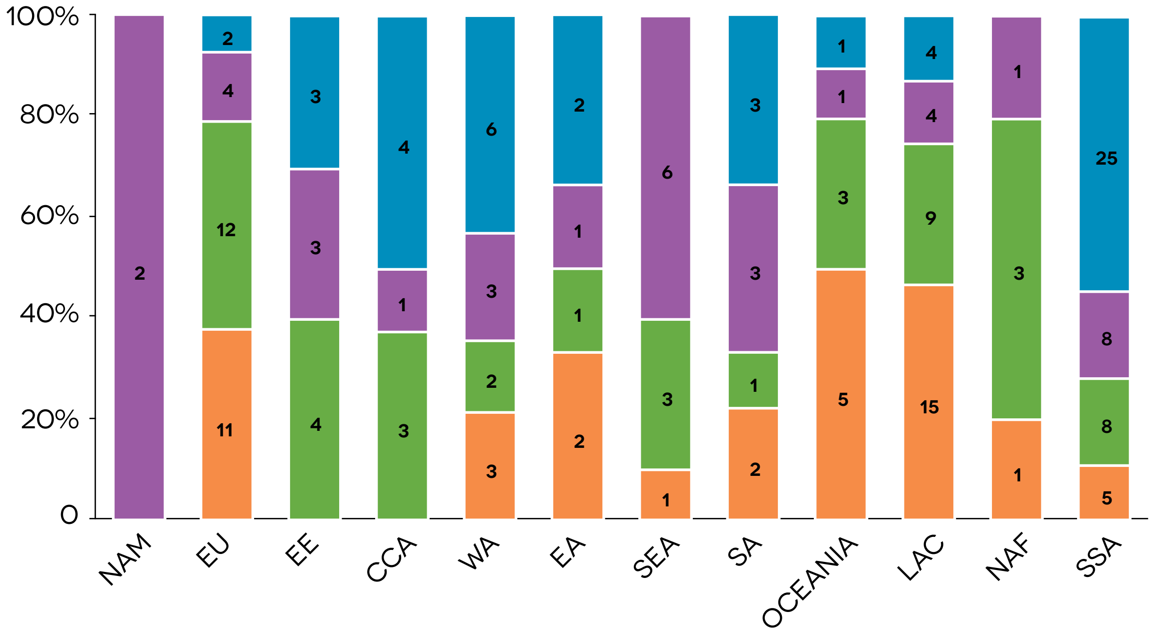


FIGURE 3.16 **ENERGY INTENSITY (MJ/$2005) AT PPP LEVEL BY REGION (NUMBER OF COUNTRIES), 2010**

BELOW 5 | BETWEEN 5–7 | BETWEEN 7–10 | ABOVE 10

SOURCE: BASED ON WORLD BANK WORLD DEVELOPMENT INDICATORS; IEA 2012A; UN ENERGY STATISTICS DATABASE.
NOTE: NAM = NORTH AMERICA; EU = EUROPE; EE = EASTERN EUROPE; CCA = CAUCASUS AND CENTRAL ASIA; WA = WESTERN ASIA; EA = EASTERN ASIA; SEA = SOUTHEASTERN ASIA; SA = SOUTHERN ASIA; LAC = LATIN AMERICA AND CARIBBEAN; NAF = NORTHERN AFRICA; SSA = SUB-SAHARAN AFRICA.

Further insights can be obtained by plotting energy intensity against energy consumption per capita. Low- and lower-middle-income countries show levels of energy consumption per capita that are uniformly below the global average. Yet within these same groups of countries there is great variation in individual energy intensity, from the lowest to the highest energy-intensity ranges observed globally (figure 3.17a). For example, Uzbekistan and Ukraine are two of the most energy-intensive countries in the world, while the Philippines is one of the least (figure 3.17b). High-income countries, on the other hand, show uniformly low levels of energy intensity, but vary hugely in their energy consumption per capita. For example, North America and some of the Gulf states have some of the highest levels of energy consumption per capita, while a number of European countries have some of the lowest. The upper-middle-income countries, by contrast, tend to present either both high energy intensity and consumption per capita, as in the Islamic Republic of Iran and several countries of the former Soviet Union, or both low energy intensity and low consumption per capita, as in Turkey and a number of Latin American countries.

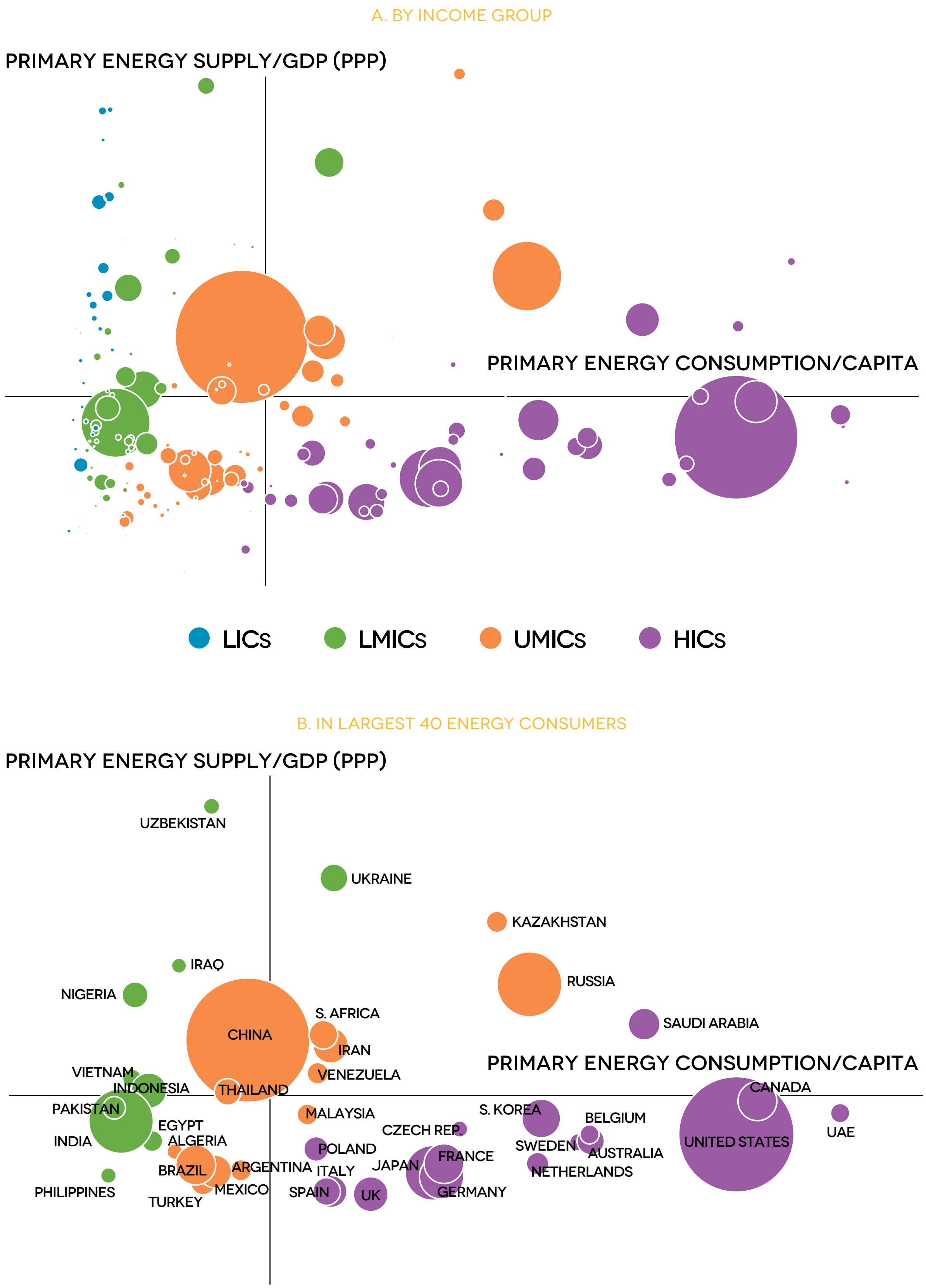


FIGURE 3.17 **ENERGY INTENSITY PPP VS. ENERGY CONSUMPTION PER CAPITA, 2010**

SOURCE: BASED ON WORLD BANK WORLD DEVELOPMENT INDICATORS; IEA 2012A; UN ENERGY STATISTICS DATABASE.
NOTE: VALUES ARE NORMALIZED ALONG THE AVERAGE. BUBBLE SIZE REPRESENTS VOLUME OF PRIMARY ENERGY SUPPLY.
GDP = GROSS DOMESTIC PRODUCT; HICS = HIGH-INCOME COUNTRIES; LICS = LOW-INCOME COUNTRIES; LMICS = LOWER-MIDDLE-INCOME COUNTRIES; PPP = PURCHASING POWER PARITY; UMICS = UPPER-MIDDLE-INCOME COUNTRIES.

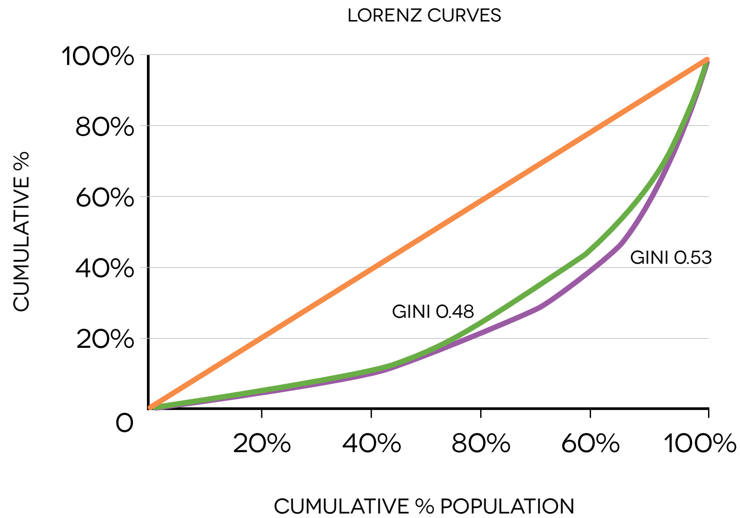


FIGURE 3.18 **DISTRIBUTION OF ENERGY DEMAND AND GDP BY POPULATION**

ENERGY DEMAND GDP

SOURCE: BASED ON WORLD BANK WORLD DEVELOPMENT INDICATORS; IEA 2012A; UN ENERGY STATISTICS DATABASE.
NOTE: GDP = GROSS DOMESTIC PRODUCT.

High-impact countries

Global total primary energy supply is heavily concentrated in a relatively small number of high- and middle-income countries. China and the United States alone account for about 40 percent of global primary energy supply. The 20 countries with the highest levels of energy demand together account for 80 percent of the global total, while the top 40 countries account for 90 percent.

One way of capturing the global inequalities in the distribution of energy demand is to calculate a pseudo-Gini coefficient[16] based on the cumulative percentage of global energy demand accounted for by a given cumulative percentage of global population. The resulting Gini coefficient for energy demand is 0.48, which represents a high degree of inequality, just slightly lower than the Gini coefficient of 0.53 for inequality in the global distribution of GDP (figure 3.18).

While improvements in energy efficiency are valuable and important for all countries, achievement of the SE4ALL global objective for energy efficiency will depend on targeting efforts in high-impact countries. The level of a country's impact depends in part on its overall energy demand. Higher energy demand translates into a greater potential impact of a country's efforts on the achievement of the global objective. Many high-consuming countries have already achieved relatively low levels of energy intensity. In identifying high-impact opportunities, it is therefore also relevant to consider a country's starting point in terms of energy intensity. Countries with relatively high energy intensity may have a greater potential for improvement, but as seen previously, the underlying drivers of energy demand must also be considered. For example, a country with a large mining industry or very cold climate may have high energy intensity, but nonetheless be very energy efficient.

In reality, there is very little overlap between those countries with the highest energy demand and the highest energy intensity. The group of 20 countries with the highest energy demand is dominated by high-income countries across Europe, Asia, the Middle East, and North America. India, Indonesia, and Ukraine are the only lower-middle-income countries among the 20 largest energy consumers (figure 3.19a). The group of 20 countries with the highest energy intensity, on the other hand, is dominated by low-income countries from Africa and the former Soviet Union, plus a few smaller countries from Latin America and South Asia and Iceland, which is the only European country in the group (figure 3.19b). Ukraine is the only country that is both one of the largest energy consumers and one of the most energy-intensive economies.

16 The Gini coefficient is a concept most commonly used in economics to measure inequality of income distribution within a population; a value of zero represents perfect equality, and a value of one represents maximum inequality.

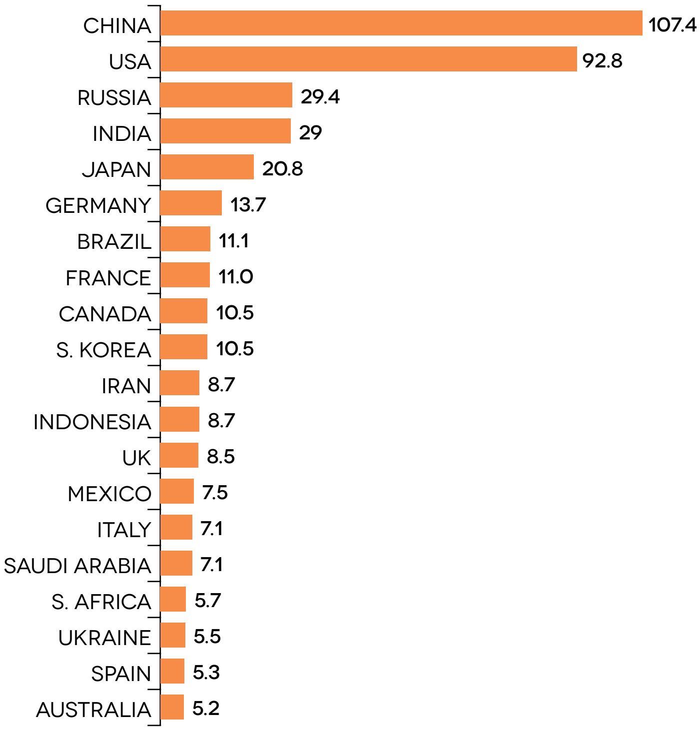


FIGURE 3.19A **COUNTRIES WITH HIGHEST LEVELS OF PRIMARY ENERGY DEMAND, 2010 (EJ)**

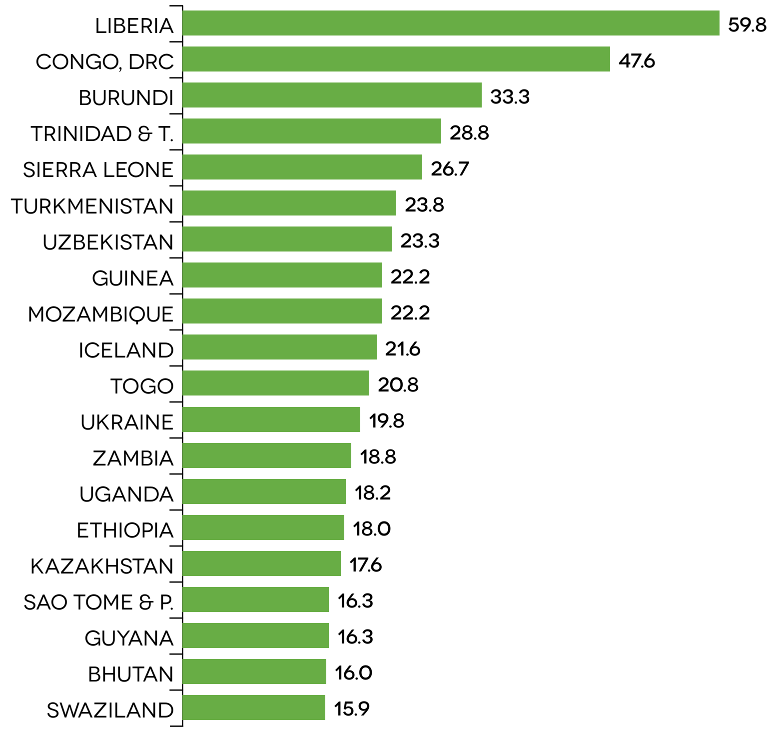


FIGURE 3.19B **COUNTRIES WITH HIGHEST LEVELS OF ENERGY INTENSITY PPP, 2010 (MJ/$2005)**

SOURCE: BASED ON WORLD BANK WORLD DEVELOPMENT INDICATORS; IEA 2012A; UN ENERGY STATISTICS DATABASE.

A combination of relatively high energy demand and relatively high energy intensity defines where the highest-impact opportunities exist. Table 3.3 lists the countries among the 20 largest energy consumers with the highest energy intensities overall and within each economic sector. When the analysis is done in PPP terms, the highest-impact opportunities can be found in Ukraine, Russia, Saudi Arabia, South Africa, and China. Canada, Iran, Brazil, Indonesia, and the United States also appear when analyzing economic sectors.

X 10 TIMES
– SPAN OF ENERGY INTENSITY AMONG
THE WORLD'S 20 MOST ENERGY INTENSIVE ECONOMIES AT 20–30 MEGAJOULES PER DOLLAR OF GDP AND THE WORLD' LEAST ENERGY INTENSIVE ECONOMIES AT 2–3 MEGAJOULES PER DOLLAR OF GDP

ALL SECTORS		INDUSTRY	AGRICULTURE	OTHER SECTORS
1	Ukraine	Ukraine	Canada	Iran
2	Russia	Russia	South Africa	Ukraine
3	Saudi Arabia	Canada	Russia	Saudi Arabia
4	South Africa	Brazil	United States	Indonesia
5	China	South Africa	Brazil	Russia

TABLE 3.3 **HIGHEST ENERGY INTENSITIES AMONG THE 20 LARGEST ENERGY CONSUMERS, 2010**

SOURCE: BASED ON WORLD BANK WORLD DEVELOPMENT INDICATORS; IEA 2012A..
NOTE: "OTHER SECTORS" INCLUDE THE TRANSPORTATION, RESIDENTIAL, AND SERVICE SECTORS.

Fast-moving countries

To reap the substantial potential for reducing energy demand, it will be important for countries around the world to learn from one another's experiences and best practices. In that sense, two groups of countries are of particular interest: those who have already achieved low levels of energy intensity and those who have made the most rapid progress in improving their energy intensity over the last decades.

−4.0%
IS THE COMPOUND ANNUAL GROWTH
RATE OF ENERGY INTENSITY AMONG THOSE 20 COUNTRIES MAKING THE FASTEST PROGRESS GLOBALLY 1990–2010

Most of the 20 countries that experienced the most rapid improvement in energy intensity over the 20 years between 1990 and 2010 are from the former Soviet Union and Eastern European, with annual rates of reduction ranging from 4 percent to 12 percent—several times higher than the global average of –1.3 percent (figure 3.20a). Many of these countries started from relatively high levels of energy intensity in 1990 and still remain at above global average levels of energy intensity in 2010. While they therefore cannot be regarded as models for best practice, their experience can help to shed light on where and how to begin the process of accelerating energy efficiency improvements.

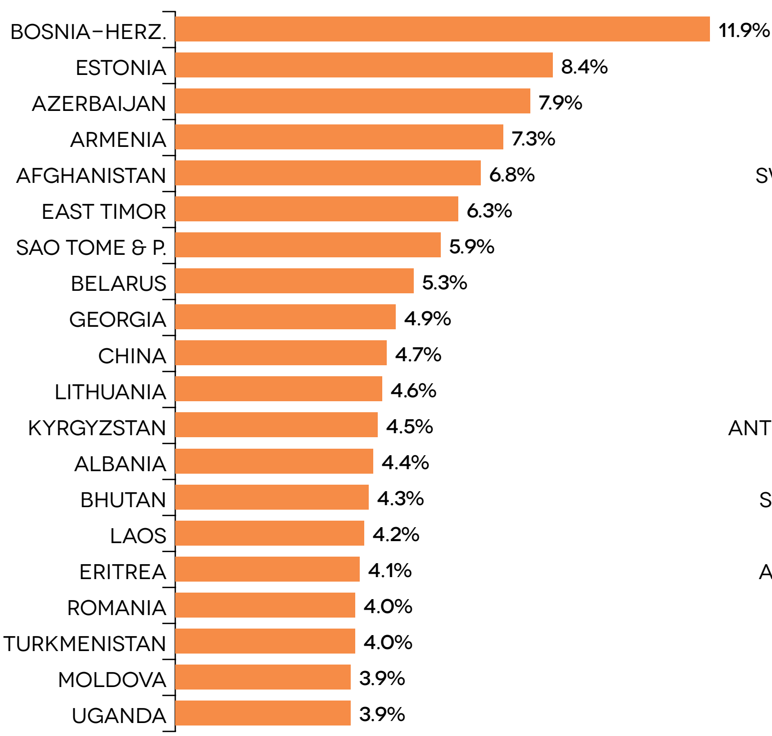


FIGURE 3.20A **FASTEST-MOVING COUNTRIES CAGR 1990–2010 IN PPP TERMS**

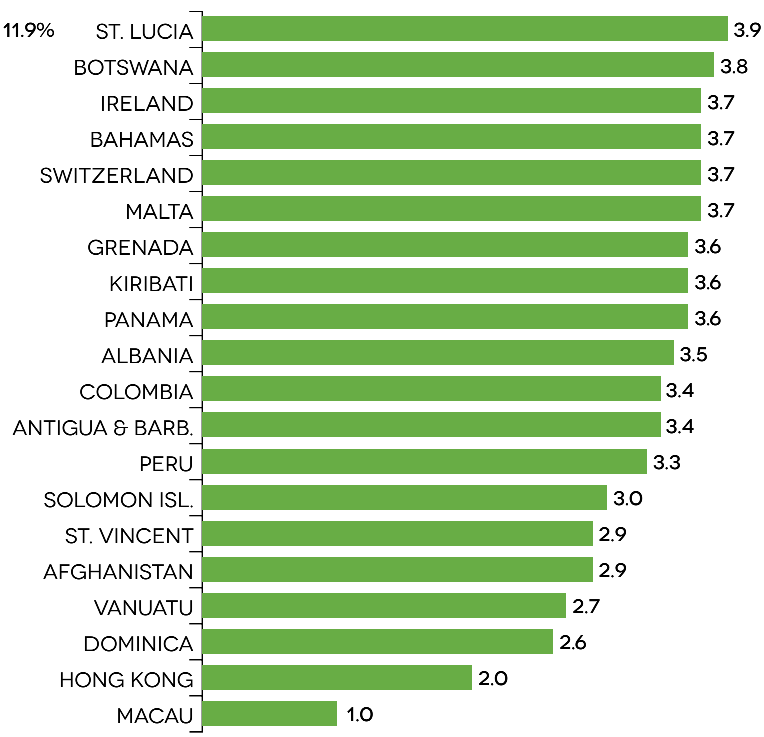


FIGURE 3.20B **FASTEST-MOVING COUNTRIES WITH LOWEST ENERGY INTENSITY IN 2010 IN PPP TERMS (MJ/$2005)**

SOURCE: BASED ON WORLD BANK WORLD DEVELOPMENT INDICATORS; IEA 2012A; UN ENERGY STATISTICS DATABASE.

The 20 countries exhibiting the lowest energy intensity (less than 3.9 MJ/$2005 GDP PPP) are a heterogeneous group, with a strong presence of small island countries in which energy costs tend to be exceptionally high (figure 3.20b). Confining attention to the least-energy-intensive countries in PPP terms among the 20 largest energy consumers, a handful of Western European countries—the United Kingdom, Spain, Italy, and Germany—and Japan show a strong performance with low energy intensity, both overall and across a number of sectors (table 3.4). Curiously, countries such as China, Indonesia, and Saudi Arabia—which are among the most energy intensive of the large energy consumers—exhibit relatively low energy intensity for agriculture.

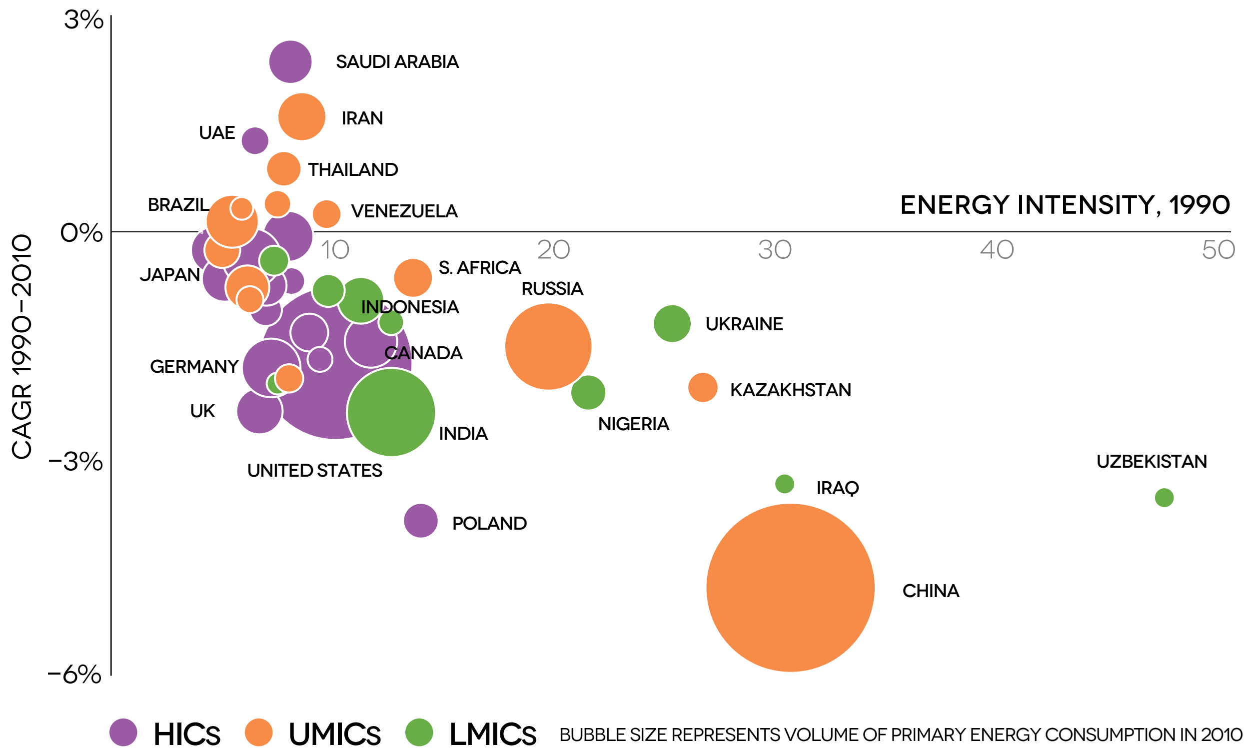
	ALL SECTORS	INDUSTRY	AGRICULTURE	OTHER SECTORS
1	United Kingdom	Japan	Saudi Arabia	Japan
2	Spain	Germany	Indonesia	United Kingdom
3	Italy	United Kingdom	India	Spain
4	Germany	Spain	Germany	Italy
5	Japan	Italy	China	Germany

TABLE 3.4 **LOWEST ENERGY INTENSITIES AMONG THE 20 LARGEST ENERGY CONSUMERS, 2010**

SOURCE: BASED ON WORLD BANK WORLD DEVELOPMENT INDICATORS; IEA 2012A.
NOTE: "OTHER SECTORS" INCLUDE THE TRANSPORTATION, RESIDENTIAL, AND SERVICE SECTORS.

Perhaps of greater interest is the interaction between a country's starting point in energy intensity and its rate of reduction of energy intensity over the two decades between 1990 and 2010. In principle, those starting out with the highest levels of energy intensity had the greatest opportunities to reduce it. The cross-plots below attempt to depict that. The first chart plots the CAGR of energy intensity during 1990–2010 against initial energy intensity in 1990; the second, against final energy intensity in 2010 (figure 3.21). The negative relationship between the starting point and the annual rate of change is clearly evident in the chart. The country that most clearly stands out is China, which started with one of the highest levels of energy intensity among the largest 40 energy users; despite the huge expansion in its industrial sector that took place over the same period, it also experienced the steepest decline in energy intensity in the last 20 years. Indeed, by 2010, China had reached a level of energy intensity comparable to that of other large, middle-income, emerging economies.

A. ENERGY INTENSITY, 1990 (MJ/$2005 PPP)



B. ENERGY INTENSITY, 2010 (MJ/$2005 PPP)

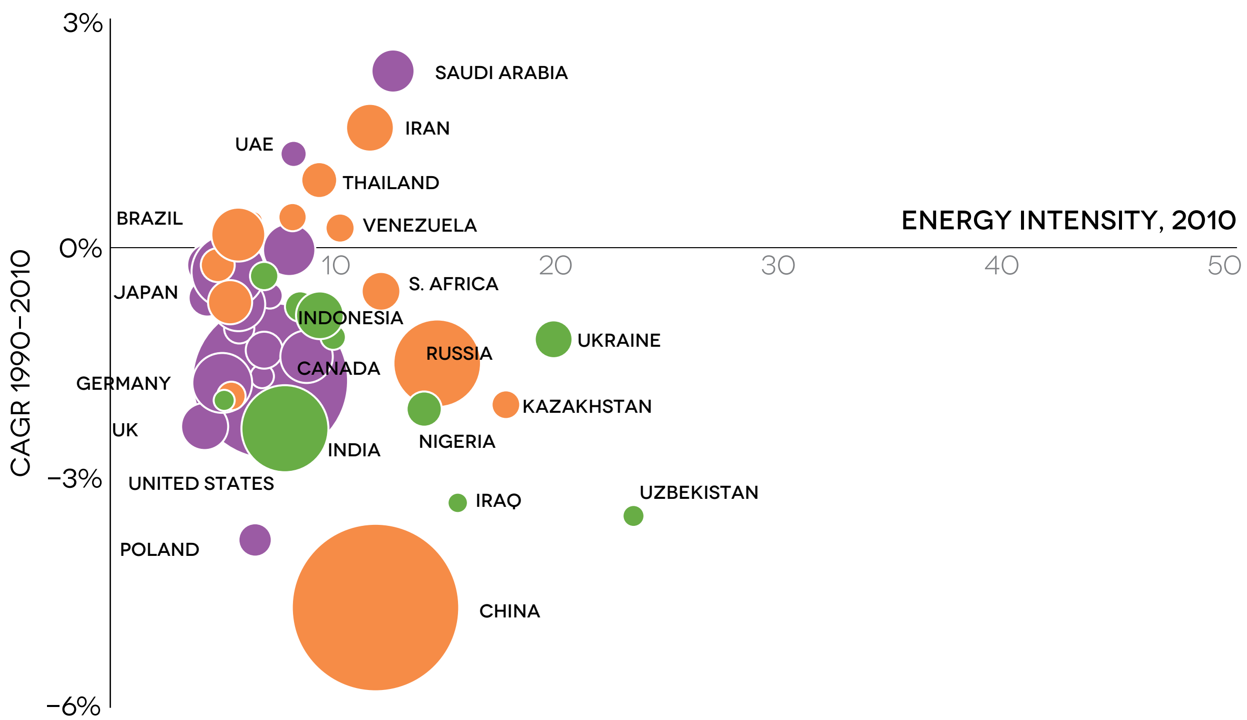


FIGURE 3.21 **ENERGY INTENSITY IN 1990 AND 2010 VS. CAGR 1990–2010**

SOURCE: BASED ON WORLD BANK WORLD DEVELOPMENT INDICATORS; IEA 2012A.
NOTE: BUBBLE SIZE REPRESENTS THE VOLUME OF PRIMARY ENERGY SUPPLY IN 2010. CAGR = COMPOUND ANNUAL GROWTH RATE; HICS = HIGH-INCOME COUNTRIES; LMICS = LOWER-MIDDLE-INCOME COUNTRIES; UMICS = UPPER-MIDDLE-INCOME COUNTRIES.

The decomposition of energy trends that was undertaken globally above (recall figure 3.7) is also of interest at the country level. Figure 3.22 clearly shows that among the top 20 energy consumers, the underlying energy efficiency effect for China and India after adjusting for activity levels and structural shifts is particularly large at 6 percent and 4 percent respectively, and significantly higher than the trend in overall energy intensity. Such efforts partially offset increases in energy demand due to expanded activity levels and structural changes. By contrast, the reduction in Ukraine´s energy intensity is attributable to reductions in all three factors (mainly activity, and to a lesser degree structure and pure intensity).

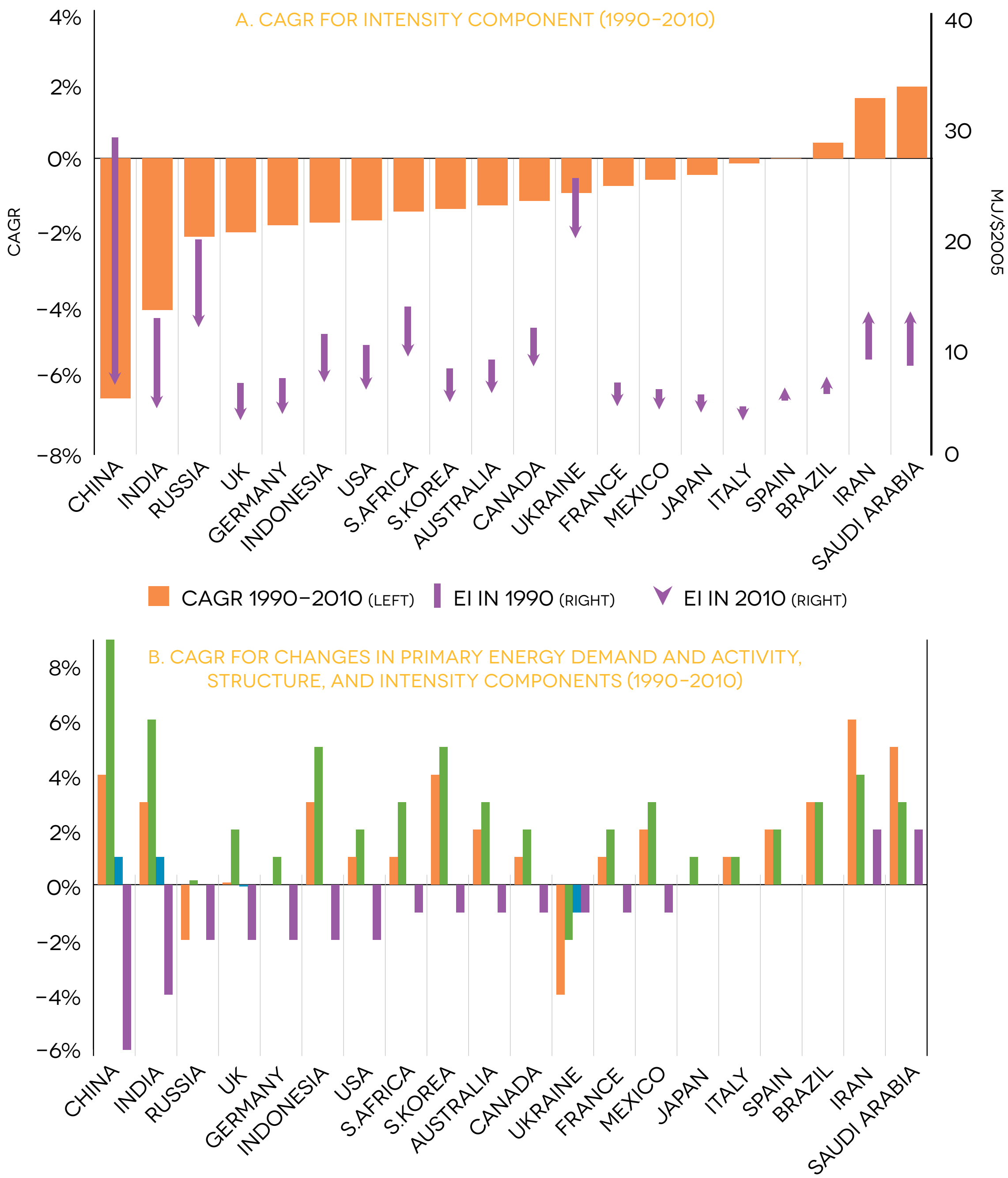


FIGURE 3.22 **DECOMPOSITION ANALYSIS OF ENERGY DEMAND IN 1990 AND 2010 VS CAGR 1990–2010**

TOTAL ENERGY ACTIVITY STRUCTURE INTENSITY

SOURCE: BASED ON WORLD BANK WORLD DEVELOPMENT INDICATORS; IEA 2012A.
NOTE: CAGR = COMPOUND ANNUAL GROWTH RATE; PPP = PURCHASING POWER PARITY.

Yet another way of identifying countries that made particularly significant progress in reducing energy consumption is to look at the extra energy these countries would be demanding today if their energy intensity had remained at 1990 levels (figure 3.23). Once again, China stands out as having achieved by far the largest reductions in energy consumption, with cumulative energy savings from 1990 to 2010 exceeding cumulative energy consumption during that same period. Overall, actions taken in China, the United States, Europe, and India accounted for more than 90 percent of the nearly 2,300 EJ of energy saved globally between 1990 and 2010.

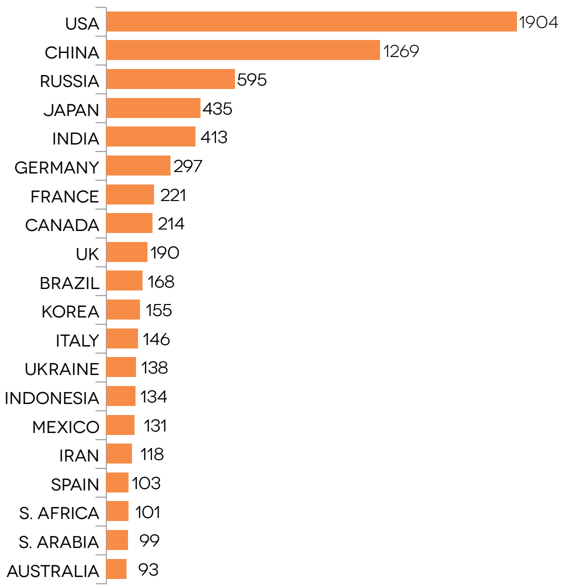


FIGURE 3.23A **LARGEST ENERGY CONSUMERS, CUMULATIVE 1990–2010 (EJ)**

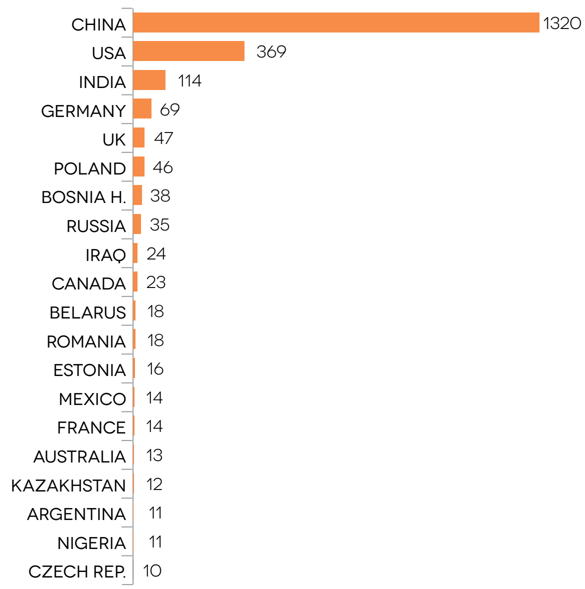


FIGURE 3.23B **LARGEST ENERGY SAVERS, CUMULATIVE 1990–2010 (EJ)**

SOURCE: BASED ON WORLD BANK WORLD DEVELOPMENT INDICATORS; IEA 2012A; UN ENERGY STATISTICS DATABASE.

Policies, targets, technological developments, and investments

There are many underlying factors that explain the trends and figures outlined in the previous section. The framework laid out here proposes to track them through a revision of the policies that affect energy demand, the targets that countries and regions (like the EU) give themselves, the technological developments that reduce specific energy consumption, and the flow of energy efficiency investments.

Though the global and country-level intensity indicators presented may serve to track progress toward the SE4ALL goal, the complementary indicators described above give a more complete picture to policy makers of what actions are being taken—and should be taken—to improve energy efficiency in each country. They also provide a guide of where to direct actions to address needs and reveal opportunities in a given country.

1,320 EJ
IS THE CUMULATIVE ENERGY SAVINGS
OF CHINA DUE TO REDUCTIONS IN ENERGY INTENSITY FROM 1990 TO 2010; EXCEEDING CHINA'S OWN PRIMARY ENERGY DEMAND OVER THE SAME PERIOD.

Policies include a range of instruments—including market-based and financial instruments, regulations, information, and awareness—that can be voluntary or mandatory. Of particular relevance in 1990–2010 have been building codes, labeling, and minimum energy performance standards (MEPS) for appliances and motors, and fuel-efficiency standards and fiscal incentives for vehicles. Countries such as Italy and India have implemented market-based cap and trade mechanisms like the white certificates and the Perform, Achieve, and Trade (PAT) scheme. Box 3.5 summarizes the 25 energy efficiency policies that the IEA is recommending governments to adopt. The same organization is also starting the process of developing a set of governance and policy recommendations for developing countries.

Targets can take several forms. China aims to decrease its energy intensity by 16 percent during the period 2011–15 (its 12th Five-Year Plan). The EU, through its Energy Efficiency Directive, mandates a reduction in primary energy consumption of 20 percent by the year 2020, while Japan and Brazil want to reduce electricity demand by 10 percent by 2030. Recently, the United States announced that it aims to cut in half the energy wasted in homes and businesses in the next 20 years. Meanwhile, India, in its draft 12th Five Year Plan, is proposing to reduce the carbon emissions intensity of its economy by 20–25 percent from 2005 levels by 2020.

Section 4 and annex 2 provide an overview of policies and targets for selected countries,[17] while annex 3 shows the specific energy consumption of selected energy-intensive products, both for current practice and a benchmark of the best available practice.

As noted in section 1, there is no established methodology to track investments in energy efficiency. One will have to be developed for the medium term. This report relies on the work done by IEA'S WEO 2012. The results are presented in the following section.

BOX 3.5 IEA's 25 energy efficiency policy recommendations

To support governments in their implementation of energy efficiency, the International Energy Agency (IEA) recommended the adoption of specific energy efficiency policy measures to the G8 summits in 2006, 2007, and 2008. The consolidated set of recommendations to these summits covers 25 fields of action across seven priority areas: cross-sectoral activity, buildings, appliances, lighting, transport, industry, and power utilities. The fields of action are outlined below.

1. The IEA recommends action on energy efficiency across sectors. In particular, the IEA calls for action on:

- Data collection and indicators
- Strategies and action plans
- Competitive energy markets, with appropriate regulation
- Private investment in energy efficiency
- Monitoring, enforcement, and evaluation

2. Buildings account for about 40 percent of energy used in most countries. To save a significant portion of this energy, the IEA recommends action on:

- Mandatory building codes and minimum energy performance requirements
- Net-zero energy consumption in buildings
- Improved energy efficiency in existing buildings
- Building energy labels or certificates
- Energy performance of building components and systems

[17] Further details are provided in IEA 2012b.

3. Appliances and equipment represent one of the fastest-growing energy loads in most countries. The IEA recommends action on:

- Mandatory minimum energy performance standards and labels
- Test standards and measurement protocols
- Market transformation policies

4. Saving energy by adopting efficient lighting technology is very cost-effective. The IEA recommends action on:

- Phaseout of inefficient lighting products
- Energy-efficient lighting systems

5. To achieve significant savings in the transport sector, the IEA recommends action on:

- Mandatory vehicle fuel-efficiency standards
- Measures to improve vehicle fuel efficiency
- Fuel-efficiency for nonengine components
- Transport system efficiency

6. To improve energy efficiency in industry, action is needed on:

- Energy management
- High-efficiency industrial equipment and systems
- Energy efficiency services for small- and medium-sized enterprises
- Complementary policies to support industrial energy efficiency

7. Energy utilities can play an important role in promoting energy efficiency. Action is needed to promote:

- Utility end-use energy efficiency schemes

SECTION 4. THE SCALE OF THE ENERGY EFFICIENCY CHALLENGE

Doubling the rate of improvement in energy intensity from –1.3 percent to –2.6 percent per annum in the 20 years between 2010 and 2030 will present an immense challenge. Examining the scale of that challenge is the subject of this section. The analysis is based on the scenarios developed by WEO (2012).[18]

The New Policies Scenario is WEO's central scenario. It takes into account broad policy commitments and plans that have already been implemented to address energy- and climate-related challenges, as well as those that have been announced, even where the specific measures to implement these commitments have yet to be introduced. To illustrate the outcome of the current course in energy trends, if unchanged, the Current Policies Scenario embodies the effects of only those government policies and measures that had been enacted or adopted by mid-2012. The Efficient World Scenario is based on the core assumption that all investments capable of improving energy efficiency are made so long as they are economically viable and any market barriers obstructing their realization are removed.

The outlook for efficiency improvements by sector and region

According to the WEO 2012, the SE4ALL objective for energy efficiency can be met only if countries implement policies beyond those in the New Policies Scenario. That conclusion is highly dependent on the chosen reference period. For example, doubling the performance of the last decade, when the pace of improvement in energy intensity was slow, would be only a moderately ambitious goal. In the New Policies Scenario, energy demand is projected to grow from 530 EJ in 2010 to 670 EJ in 2030, equivalent to an increase of nearly 30 percent. That is about 45 EJ, or 6 percent, lower than if only the world's current energy efficiency policies continued, as assumed in the Current Policies Scenario (figure 3.24).

Energy efficiency in end uses and in the supply sectors accounts for almost three-quarters of the total potential for improving energy efficiency by 2030. The New Policies Scenario projects global energy intensity (where GDP is measured at PPP) to decline at a rate of 2.3 percent per year on average over the period 2010–2030, a significant improvement on the trend seen in 1990–2010, when it was –1.3 percent per year.

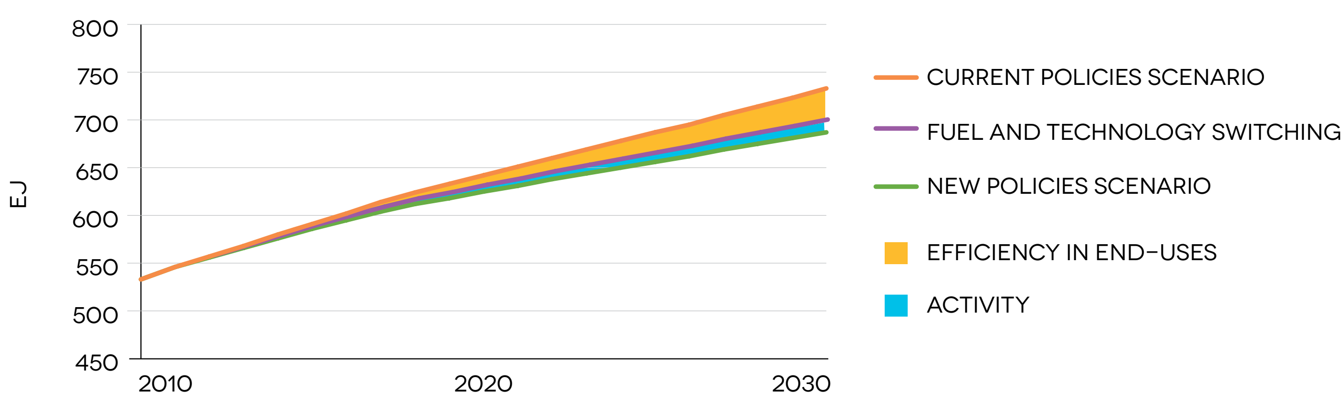


FIGURE 3.24 **CHANGE IN GLOBAL PRIMARY ENERGY DEMAND: CURRENT POLICIES SCENARIO AND NEW POLICIES SCENARIO (EJ)**

SOURCE: IEA 2012B.
NOTE: "ACTIVITY" REFLECTS A CHANGE IN THE DEMAND FOR ENERGY SERVICES DUE TO A CHANGE IN END-USER PRICES.

[18] Figures are also compared to those developed by the International Institute for Applied Systems Analysis (IIASA).

When looking at the economically viable potential of energy efficiency, it becomes apparent that current and planned policies globally would utilize only a third of the economically viable efficiency measures. From a sectoral perspective, industry utilizes most of the potential (44 percent), followed by transport (37 percent), power generation (21 percent), and buildings (18 percent). The uptake of more efficient technologies is strong in industries in OECD countries and China because of the introduction of MEPS and CO_2 pricing, and because rising energy prices strengthen the economic case for improving energy efficiency.

The second-most-important sector in terms of efficiency-related energy savings is transport, where several countries are discussing the introduction of ambitious fuel-economy standards, often with the goal of reducing oil imports or air pollution. Energy savings in the buildings sector are relatively small because of high transaction costs. Most of the savings occur in commercial buildings, where the business case is often stronger and regulation is easier to apply than in residential construction. Some demand reduction also occurs in the residential sector, however, thanks to the assumed reduction in fossil-fuel subsidies in some countries, including India, Russia, and parts of the Caspian region. Depending on the region, some of the key measures applied in the buildings sector include mandatory energy requirements in building codes and energy efficiency labels for appliances.

An increasing number of countries and regions are focusing on energy efficiency and strengthening their respective policies in this area. Annex 2 tabulates current policies in selected countries.

Energy efficiency policies in developing Asia, North America, Europe, and Asia Oceania account for more than three-quarters of the reduction in global primary energy demand under the New Policies Scenario, compared with the Current Policies Scenario. This reflects the sheer size of the energy markets of these regions and their emphasis on energy efficiency. In Europe the EU has established a comprehensive energy efficiency policy framework with targets for 2020, notably a 20 percent reduction in energy demand in 2020 against their reference projection. The energy efficiency directive enlists energy providers in helping consumers—industry and households—to increase their investment in energy efficiency.

In developing Asia China has set a goal of reducing energy intensity by 16 percent between 2011 and 2015. An ongoing restructuring of the national economy is expected to bring about significant savings in energy consumption per unit of GDP. Other key elements of China's strategy include innovation and energy savings in 10,000 energy-intensive enterprises identified by the government, which collectively make up 37 percent of the targeted savings by 2015. The centerpiece of India's efforts to save energy is its innovative PAT scheme, which aims at saving energy in large energy-intensive industries by imposing mandatory energy intensity targets. In addition, it allows trading of excess energy savings with other participants in the form of so-called white certificates for compliance.

In North America, the United States is currently revising its MEPS for appliances and equipment, a policy initially introduced in 1978. Twenty-four states have adopted long-term energy savings targets, which drive utility investments in energy efficiency. Another focus is road transport, with the introduction of a 2025 fuel economy target for passenger cars that would exploit much of the known (but so far unused) technical potential of conventional vehicles.

33%
IS THE SHARE OF ALL ECONOMICALLY
VIABLE ENERGY EFFICIENCY OPPORTUNITIES THAT WILL BE HARNESSED BY CURRENT OR PLANNED POLICIES GLOBALLY

In Asia Oceania Japan's Innovative Strategy for Energy and the Environment, released in 2012, includes a major focus on energy efficiency, with a target to reduce electricity demand by 10 percent in 2030 compared with 2010. This is expected to be backed up by measures to incentivize the introduction of more efficient technologies in the residential sector and, to a lesser extent, in industry.

Because energy resources have been plentiful and prices low, improving energy efficiency has historically not been a key priority throughout much of the Middle East, though in recent years this has begun to change, as fast-increasing domestic demand is restraining oil and gas exports that bring much-needed revenue. Saudi Arabia established an energy efficiency center in 2012, and the United Arab Emirates has launched a national energy efficiency and conservation program to improve efficiency in buildings. With the exception of a few countries, subsidized prices have significantly hampered the uptake of efficient technologies in the power sector, road transport, and buildings. In much of Africa, with the exception of South Africa and a few countries in North Africa, the focus has been on providing access to basic energy services and increasing the availability of energy to boost economic growth rather than on energy efficiency. Improving energy access is fundamental for economic development, but integrating energy efficiency strategies into such programs, ideally from the outset, would make it possible to widen access faster and more economically.

The above-mentioned policy efforts are expected to reduce primary energy demand in 2030 by almost 45 EJ. The biggest contributions come from developing Asia (25 EJ), North America (6 EJ), Europe (4 EJ), Eastern Europe/Eurasia (3 EJ), and the Middle East (2.5 EJ) (figure 3.25).

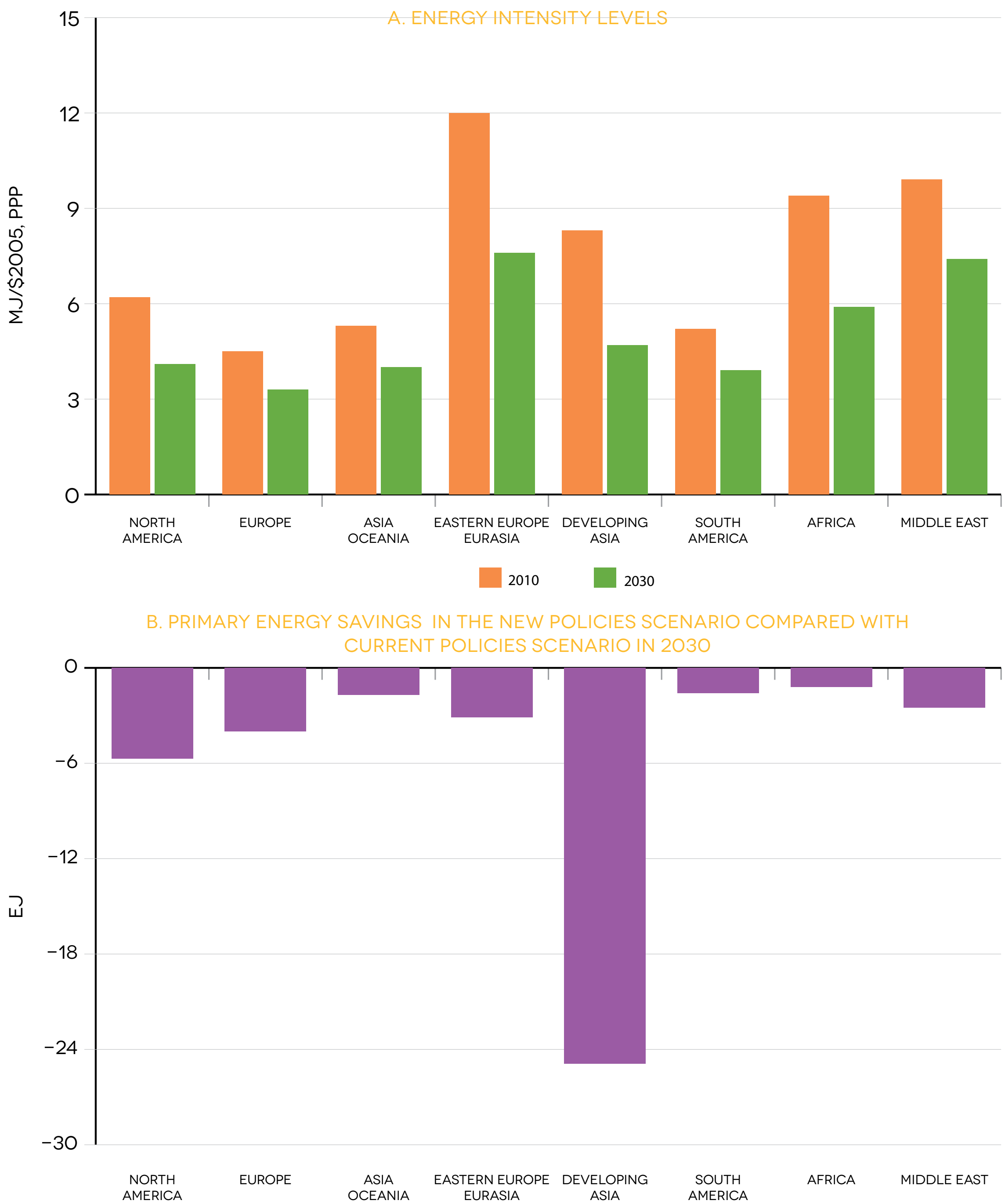


FIGURE 3.25 **RESULTS OF THE NEW POLICIES SCENARIO**

SOURCE: BASED ON DATA/ANALYSIS TAKEN FROM IEA (2012B).

Energy efficiency investments needed to achieve the New Policies Scenario

The current status of energy efficiency investments is difficult to quantify, as investments in energy efficiency are seldom tracked systematically and there is no comprehensive estimate of current global investment in energy efficiency. The lack of an estimate is due to the fact that energy efficiency investments are made by a multitude of agents, households, and firms, often using their own funds. Moreover, there is no standard definition of what constitutes an energy efficiency investment, and while investments in energy efficiency in buildings and industry are tracked in many countries, data for the transport and power sectors are more difficult to obtain. Based on a country-by-country survey, however, it is estimated that current global investment in projects aimed principally at improving energy efficiency amounted to about $180 billion in 2011—significantly lower than the investment in expanding or maintaining the fossil-fuel supply (nearly $600 billion in the same year). About two-thirds of the estimated investment in energy efficiency in 2011 was undertaken in OECD countries.

To achieve the savings from energy efficiency laid out in the New Policies Scenario, cumulative additional investments of $2.3 trillion are needed through 2030 (or $128 billion per year, on average, above current levels of investment in transport, residential, industry, and services) (figure 3.26).[19] Investment in transport increases by $0.9 trillion (almost 40 percent of the total additional investment for all sectors worldwide), largely to improve fuel economy. Residential and service-sector buildings account for another $1.1 trillion from 2012 to 2030, in the form of investments in retrofits, insulation, and thermal efficiency, as well as for electrical equipment (appliances and lighting). Additional investment in industry amounts to $340 billion between 2012 and 2030, about two-thirds of which is to improve the efficiency of heat systems, where much unrealized potential exists. The remainder of the investment is in electrical equipment, mostly industrial motors.

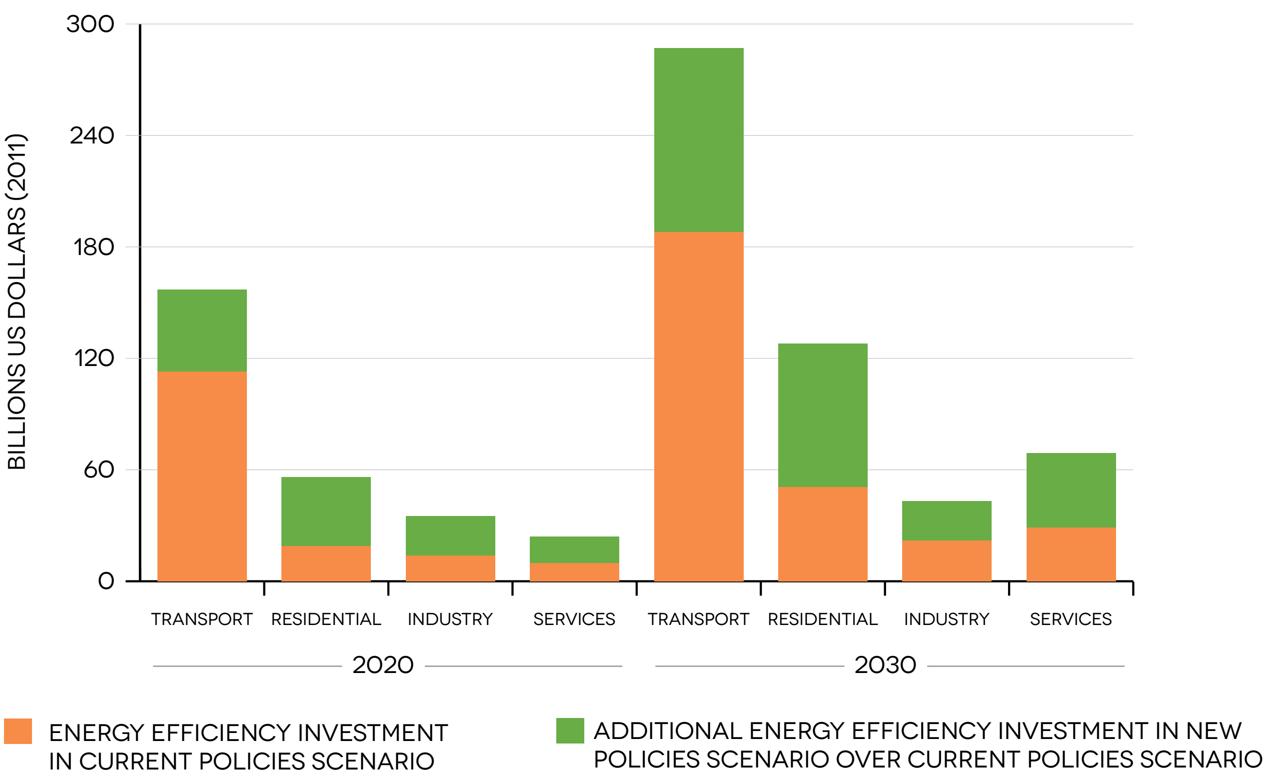


FIGURE 3.26 **AVERAGE ANNUAL INCREASE IN ENERGY EFFICIENCY INVESTMENT: NEW POLICIES SCENARIO VERSUS CURRENT POLICIES SCENARIO**

SOURCE: BASED ON DATA/ANALYSIS TAKEN FROM IEA (2012B).

The IEA Efficient World Scenario

The New Policies Scenario does not fully exploit the potential for cost-effective energy efficiency improvements or achieve the SE4ALL energy efficiency objective. Under the Efficient World Scenario, however, it is possible to improve energy intensity by 2.8 percent per year, on average, through 2030, compared with the annual rate of –1.3 percent achieved from 1990 to 2010. The central assumption of the Efficient World Scenario is that policies are put in place to allow the market to realize the full potential of all economically viable energy efficiency measures. Projections for energy savings under the Efficient World Scenario, compared with the Current Policies Scenario and New Policies Scenario, are presented in figure 3.27.

In the Efficient World Scenario, oil demand peaks at 91 million barrels per day (mb/d) before 2020 and then declines to 88.7 mb/d in 2030. Global coal demand also peaks before 2020, at around 5,400 million tons of coal equivalent (Mtce), before dropping to about 4,800 Mtce in 2030—19 percent lower than under the New Policies Scenario. Unlike for the other fossil fuels, global demand for natural gas still increases under the Efficient World Scenario, as it remains an important fuel in the power, industry, and buildings sectors. Total demand reaches 3,700 billion cubic metres (bcm) in 2020 and almost 4,100 bcm in 2030.

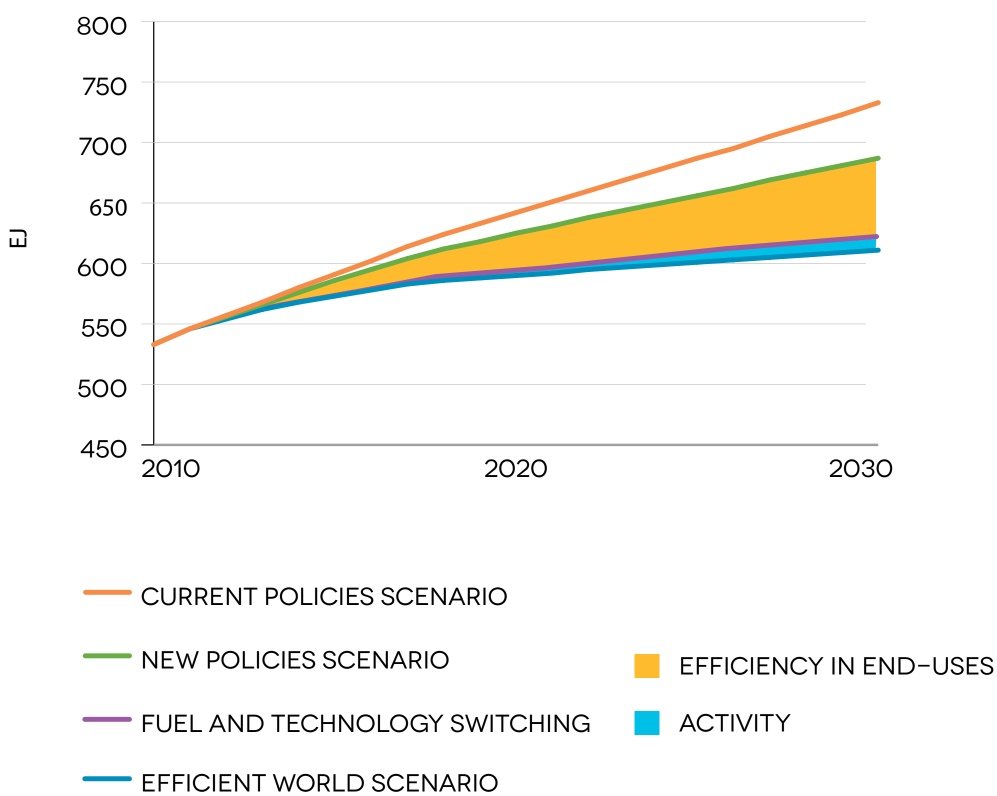


FIGURE 3.27 **CHANGE IN GLOBAL PRIMARY ENERGY DEMAND: EFFICIENT WORLD SCENARIO VERSUS OTHER SCENARIOS (EJ)**

SOURCE: IEA (2012B)

Two steps were taken to calculate the economic potential of the Efficient World Scenario, which varies by sector and region.

First, technical potentials were determined, identifying key technologies and measures to improve energy efficiency by sector. This process involved analysis of a substantial amount of data and information from varied sources pertaining to a variety of subsectors and technologies. The Efficient World Scenario assumes no major or unexpected technological breakthroughs. Nor does it assume the application of holistic concepts such as prioritizing energy efficiency at all levels of urban planning or changes in consumer behavior (except where induced by lower energy prices). The scenario is, rather, based on a bottom-up analysis of currently available technologies and practices, and considers incremental changes in the level of energy efficiency deployed.

A second step identified those energy efficiency measures that are economically viable. The criterion adopted was the amount of time an investor might reasonably be willing to wait to recover the cost of an energy efficiency investment (or the additional cost, where appropriate) through the value of undiscounted fuel savings. Acceptable payback periods were calculated as averages over the 2012–2035 projection period and take account of regional and sector-specific considerations (see also figure 10.2 in IEA 2012b). In countries with carbon pricing, these prices are lower than in the New Policies Scenario, as energy efficiency measures are assumed to contribute to targeted emissions reductions. In the Efficient World Scenario, no additional carbon pricing beyond the New Policies Scenario is assumed. Fossil-fuel subsidies are phased out by 2035 at the latest in all regions except the Middle East, where they are reduced to a maximum rate of 20 percent by 2035. Additional efforts toward energy efficiency lead to a lower energy demand and thereby to lower international energy prices. This again causes a rebound in energy consumption, offsetting roughly 9 percent of the energy savings.

On a regional level, the implemented energy efficiency measures lead to different conclusions. While the largest relative savings potential in terms of energy intensity exist in developing Asia, Eastern Europe/Eurasia, and North America, it is developing Asia, North America, and Europe that save the most primary energy by 2030 under the Efficient World Scenario (figure 3.28).

The energy savings in the Efficient World Scenario are achieved by a raft of policy measures across different end-use energy demand sectors,[20] leading to a significant improvement in energy intensity (table 3.5).

[20] For more detail on policy measures in each sector see chapter 11 in IEA (2012b).

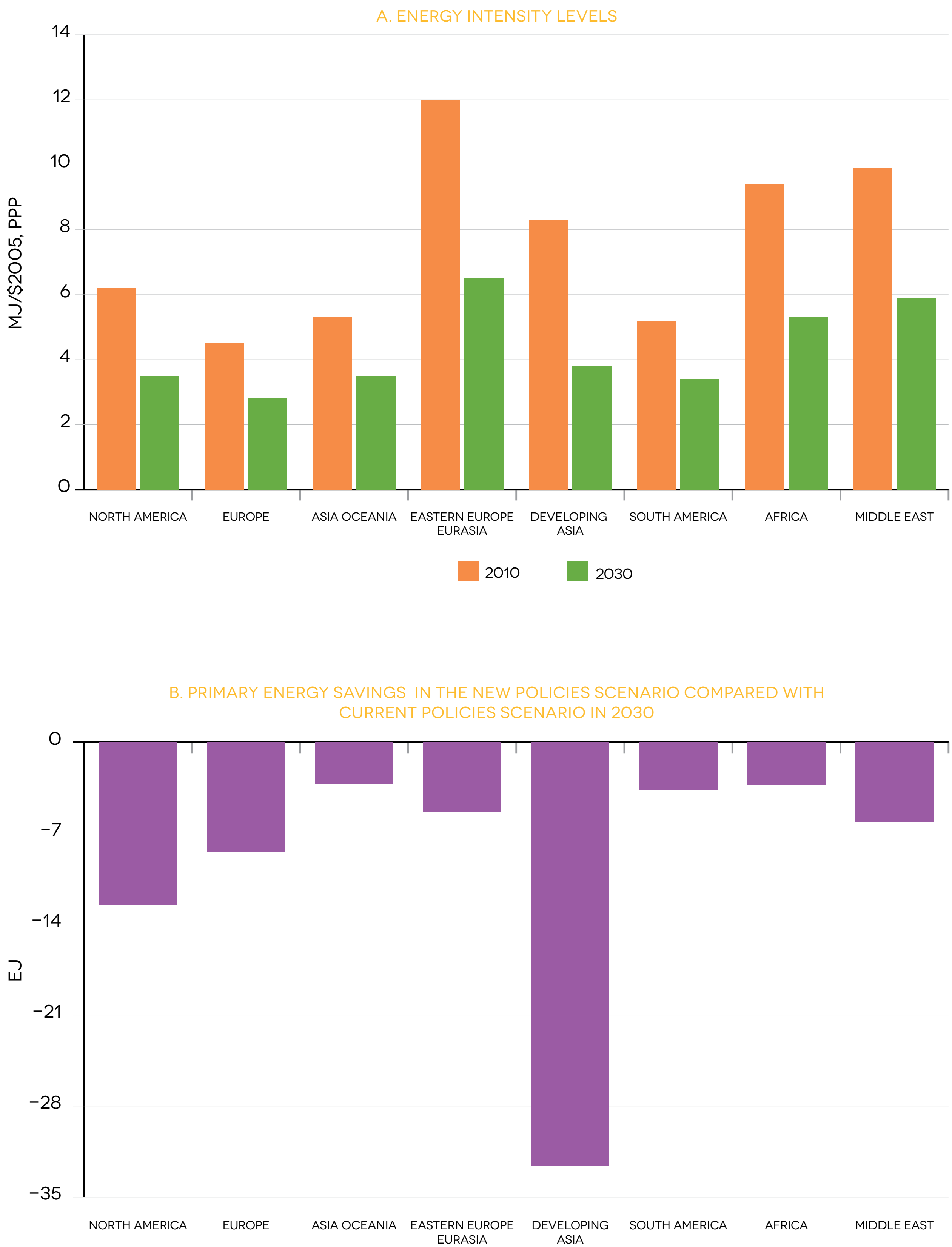


FIGURE 3.28 **CHANGES IN ENERGY INTENSITY AND PRIMARY ENERGY SAVINGS UNDER THE EFFICIENT WORLD SCENARIO, BY REGION**

SOURCE: BASED ON DATA/ANALYSIS TAKEN FROM IEA (2012B).

	WORLD		NORTH AMERICA		EUROPE		ASIA OCEANIA		EASTERN EUROPE/ EURASIA	
	2010	2030	2010	2030	2010	2030	2010	2030	2010	2030
Energy intensity (MJ/dollar, PPP)	7.0	3.9	6.2	3.5	4.6	2.8	5.3	3.5	12.0	6.5
Energy demand per capita (GJ/capita)	77.9	74.1	242.4	191.3	137.3	115.1	183.4	172.9	141.9	152.8
Residential energy intensity (2010 = 100)	100	75	100	73	100	74	100	73	100	82
Service energy intensity (2010 = 100)	100	62	100	61	100	72	100	69	100	52
Fuel consumption, new PLDVs, test cycle (l/100 km)	7.6	4.1	8.7	4.3	6.2	3.6	6.8	3.7	7.1	3.8
Fuel consumption, new heavy trucks on-road (l/100 km)	36	22	38	21	31	19	27	16	33	19
Energy intensity of industries (TJ/$1,000 VA industry)	4.3	2.6	3.8	2.6	2.9	2.2	3.3	2.6	6.2	3.6
Fossil-fuel power plant efficiency (%)	43%	48%	42%	49%	51%	59%	43%	50%	60%	68%

	DEVELOPING ASIA		SOUTH AMERICA		AFRICA		MIDDLE EAST	
	2010	2030	2010	2030	2010	2030	2010	2030
Energy intensity (MJ/dollar, PPP)	8.3	3.8	5.2	3.4	9.4	5.3	9.9	5.9
Energy demand per capita (GJ/capita)	46.1	55.7	54.4	61.1	28.1	22.6	131.5	119.7
Residential energy intensity (2010 = 100)	100	73	100	93	100	70	100	81
Service energy intensity (2010 = 100)	100	48	100	72	100	64	100	58
Fuel consumption, new PLDVs, test cycle (l/100 km)	7.7	4.0	8.1	4.5	7.4	4.4	11.7	6.4
Fuel consumption, new heavy trucks on-road (l/100 km)	40	24	36	21	41	25	40	25
Energy intensity of industries (TJ/$1,000 VA industry)	5.6	2.7	4.1	2.9	3.2	1.9	3.5	2.2
Fossil-fuel power plant efficiency (%)	38%	43%	39%	47%	37%	43%	33%	42%

TABLE 3.5 **KEY ENERGY EFFICIENCY INDICATORS FOR SELECTED REGIONS**

SOURCE: = IEA.

NOTE: FOR THE DEFINITION OF REGIONS AND ADDITIONAL DETAIL ON INDICATORS, SEE ANNEX 2. GJ = GIGAJOULES; MJ = MEGAJOULES; PPP = PURCHASING POWER PARITY; PLDV = PASSENGER LIGHT DUTY VEHICLE; TJ = TERAJOULES; VA = VALUE ADDED.

Why do we want to achieve the Efficient World Scenario?

The Efficient World Scenario requires cumulative additional investments in energy efficiency of $8 trillion over the investments already realized under the New Policies Scenario from 2012 to 2030 (figure 3.29). The additional investment level for the Efficient World Scenario is about three-and-a-half times higher than for the New Policies Scenario. The majority of the additional investments under the Efficient World Scenario accrue in the transport sector ($3.0 trillion). The remaining investments are split among the residential sector ($2.7 trillion), services sector ($1.4 trillion), and industry ($1.1 trillion).

Achieving the Efficient World Scenario brings many regional and global benefits, including fuel savings, improved energy security, health improvements, environmental benefits, and reduced energy import bills. For example, the required investment of $8.2 trillion in energy efficiency is more than offset by fuel expenditure savings of $10.6 trillion, freeing up economic resources and stimulating additional demand for efficient goods and services. Achieving the Efficient World Scenario would give a $11.4 trillion boost to the global economy from 2012 to 2030. Countries that have a competitive advantage in producing less energy-intensive goods would see their economy grow the most. This is the case for China, India, the EU, and the United States. The particularly high growth in China and India is stimulated both by domestic demand and exports.

$400 BILLION IS THE ANNUAL INVESTMENT

REQUIREMENT TO MEET SE4ALL OBJECTIVE FOR ENERGY EFFICIENCY; AROUND TRIPLE HISTORICAL LEVELS

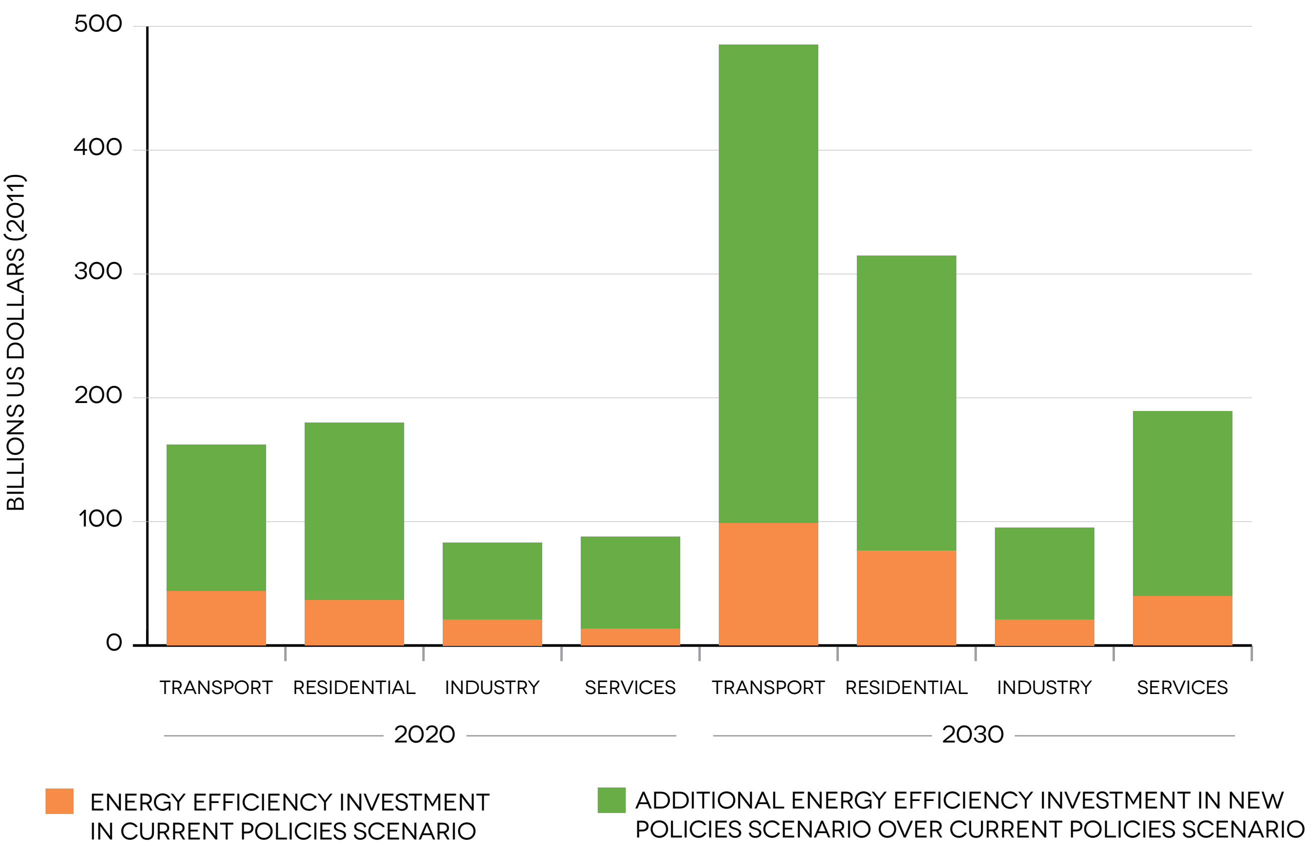


FIGURE 3.29 **AVERAGE ANNUAL INCREASE IN ENERGY EFFICIENCY INVESTMENT: EFFICIENT WORLD SCENARIO VERSUS NEW POLICIES SCENARIO**

SOURCE: BASED ON DATA/ANALYSIS TAKEN FROM IEA (2012B).

From the perspective of mitigating climate change, a rapid and widespread adoption of energy-efficient technologies can reduce CO_2 emissions in the short term. Energy-related CO_2 emissions under the Efficient World Scenario peak before 2020 at 32.4 gigatons (Gt) before beginning a steady decline to 31.0 Gt in 2030. Owing to the faster development of energy-efficient technologies, emissions in 2030 are 5.2 Gt lower than under the New Policies Scenario.

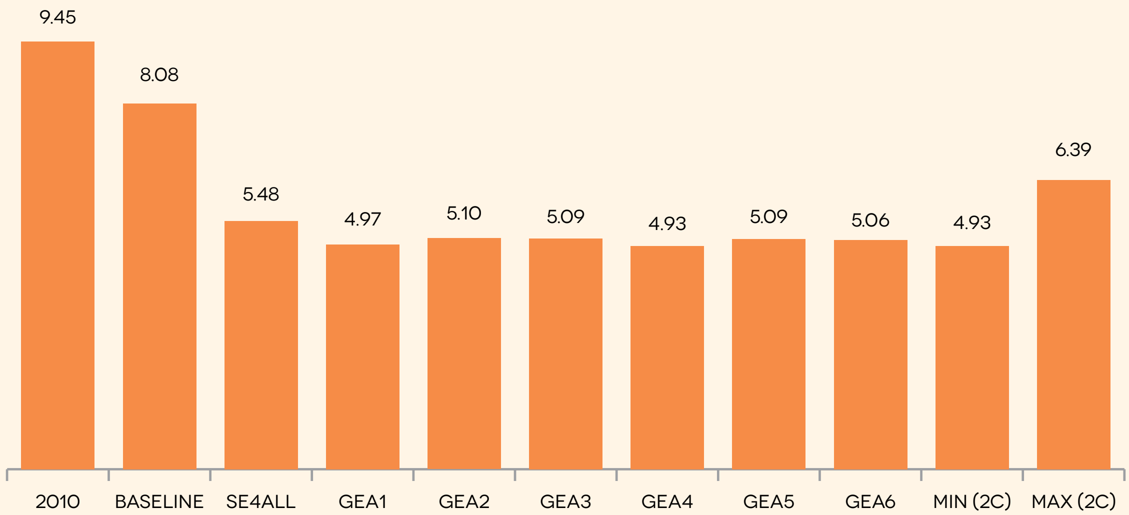
An analysis of the global capital stock in place in all energy sectors shows that the infrastructure that either exists today or is under construction emits, in normal use, about 80 percent of the cumulative emissions allowed over the period to 2035 in a 2°C world. If infrastructure investments continue in line with the New Policies Scenario and are operated as projected in that scenario, infrastructure in existence in 2017 would emit 100 percent of the allowed cumulative emissions. Energy efficiency can delay by five years (to 2022) the complete locking in of all CO_2 emissions allowed in a 2°C world. This additional time is crucial in the immediate future, because a new climate agreement is expected to be reached by 2015 and to take effect by 2020.

BOX 3.6 Overview of the energy intensity projections of the Global Energy Assessment

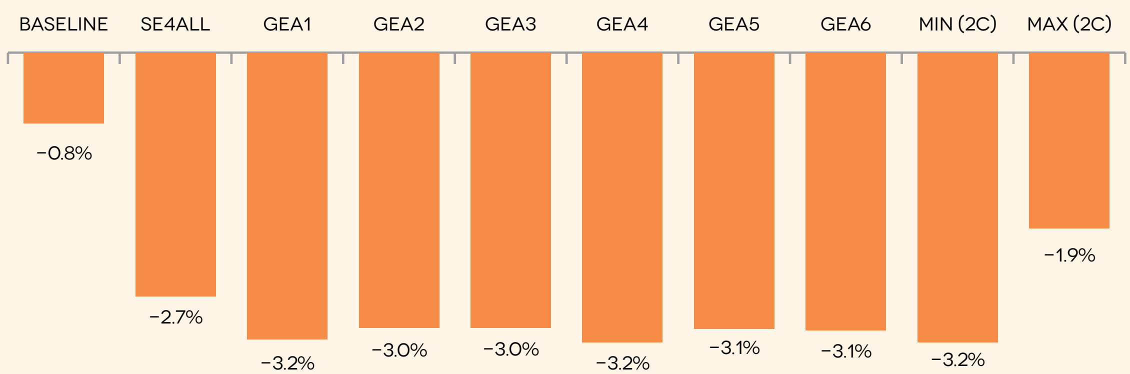
The figures below present the main energy intensity projections from the Global Energy Assessment (GEA) developed by the International Institute for Applied Systems Analysis (IIASA). The bases and regional groupings on which the IIASA scenarios are constructed are different from those of the International Energy Agency (IEA). It is outside the scope of this report to make them compatible.

The baseline scenario is consistent with the annual rate of improvement of energy intensity observed over the last 20 years (–0.8 percent). The SE4ALL scenario—a scenario that meets the access, renewables, and efficiency targets—assumes an annual improvement in energy intensity of –2.7 percent, which is actually greater than the needed rate of improvement of –1.5 percent if measured at market exchange rate (MER). The six GEA "pathways"—each of which assumes the future availability of various key technologies—do not differ much in actual energy intensity or in the rate of improvement. All meet the SE4ALL energy efficiency target and assume faster energy intensity improvement as compared to SE4ALL.

PROJECTIONS OF GLOBAL PRIMARY ENERGY INTENSITY BY SCENARIO, 2010 VS. 2030 (MJ/$2005), MER



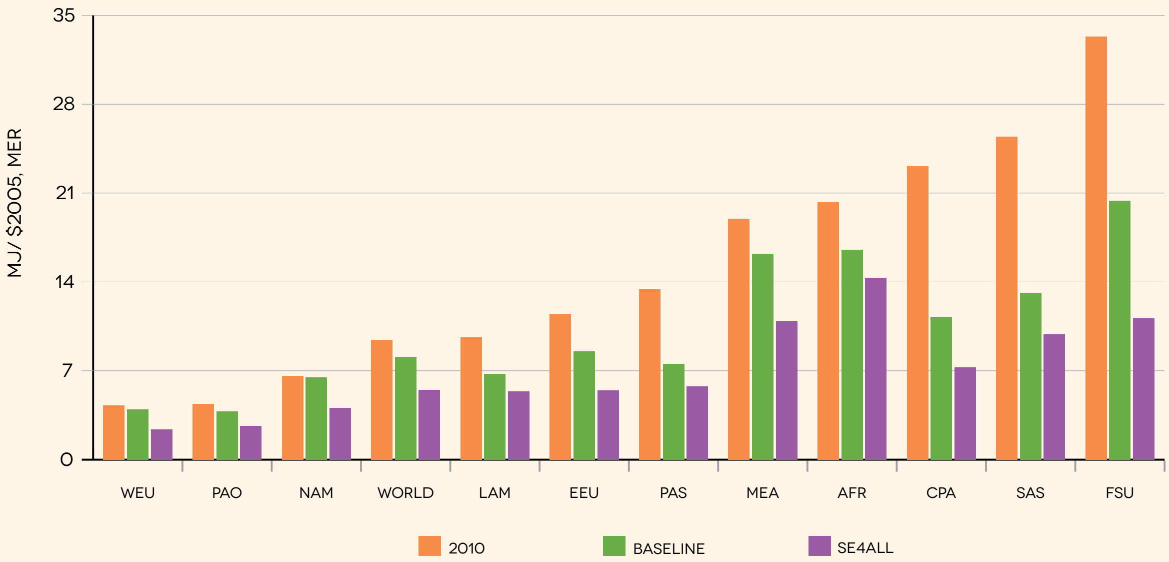
PROJECTED ANNUAL RATE OF IMPROVEMENT IN GLOBAL PRIMARY ENERGY INTENSITY BY 2030, BY SCENARIO (MER)



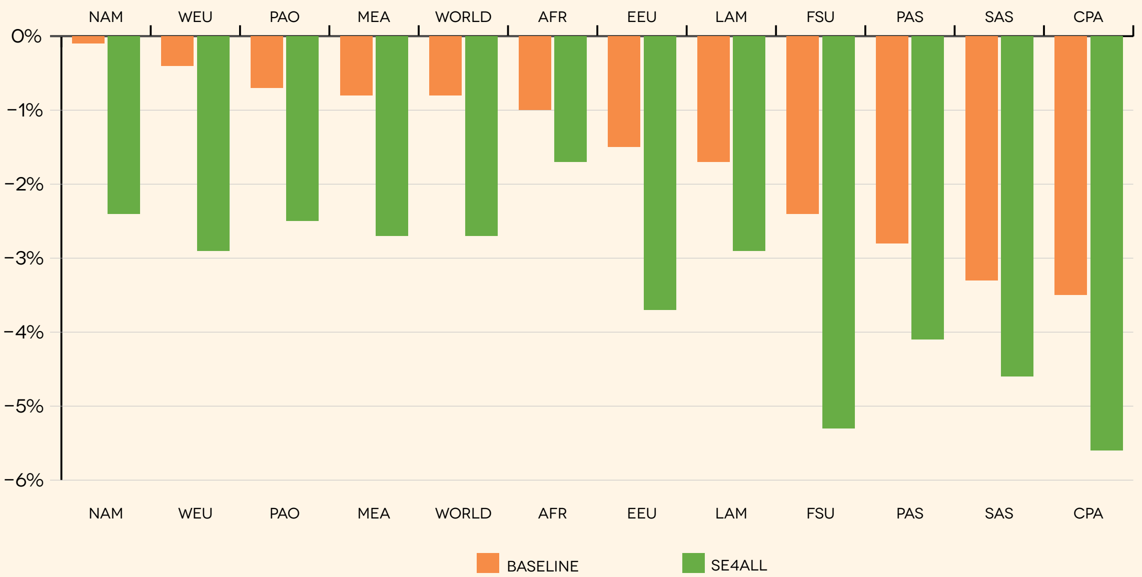
Looking at the world's regions, substantial reductions in the absolute level of energy intensity are expected from the former Soviet Union, centrally planned Asia (including China), and South Asia. These regions are projected to decrease their current energy intensity levels by more than 60 percent and to meet the SE4ALL target—reflecting that the SE4ALL target is not that far off from the business-as-usual, or IIASA's baseline, scenario in these regions.

By contrast, an effort far beyond that of the baseline scenario would be needed from those regions that have already achieved low levels of energy intensity, such as North America and Western Europe. Substantial effort would also be required in the former Soviet Union and Middle East. Some improvements are expected in Africa, but they do not go far beyond the business-as-usual projection.

PRIMARY ENERGY INTENSITY: 2010 VERSUS 2030 BASELINE AND SE4ALL SCENARIOS (MJ/$2005), MER



PRIMARY ENERGY INTENSITY ANNUAL RATE OF IMPROVEMENT: BASELINE VERSUS SE4ALL SCENARIO (CAGR 2010–30), MER



SOURCE: INTERNATIONAL INSTITUTE FOR APPLIED SYSTEMS ANALYSIS (IIASA).

NOTE: PRIMARY ENERGY PRESENTED ON THE CHARTS ABOVE IS MEASURED USING DIRECT EQUIVALENT METHOD AS OPPOSED TO THE PHYSICAL CONTENT METHOD USED IN THE REST OF THE REPORT. AFR = SUB-SAHARAN AFRICA; CPA = CENTRALLY PLANNED ASIA AND CHINA; EEU = CENTRAL AND EASTERN EUROPE; FSU = FORMER SOVIET UNION; LAM = LATIN AMERICA AND CARIBBEAN; MEA = MIDDLE EAST AND NORTH AFRICA; NAM = NORTH AMERICA; PAO = PACIFIC OECD; PAS = OTHER PACIFIC ASIA SAS = SOUTH ASIA; WEU = WESTERN EUROPE.

Overcoming the barriers

The energy savings identified in the Efficient World Scenario will not be realized if market actors are left to their own devices. For that reason, the Efficient World Scenario rests on a raft of policy measures taken to overcome market barriers. Various countries have successfully implemented policies that were effective in saving energy. It is important to learn from those experiences and the approaches used.

Because the nature of the barriers to energy efficiency differs by the end use and economy considered, a portfolio of measures is needed. But, whatever the specifics of the sector or economy being addressed, certain key principles need to be adhered to.

Make it visible. The energy performance of each energy end-use and service needs to be made visible to the market. Governments need to ensure that the energy performance of all major energy services and end-uses is measured and reported to consumers, clients, and statistical agencies in a consistent, accessible, timely, and reliable manner. Increased visibility lowers information costs, an important element of transaction costs.

Make it a priority. The profile and importance of energy efficiency needs to be raised. Visibility stimulates market actors to consider energy efficiency, but is often not enough to motivate them to demand it. Governments need to take additional steps to ensure that the full value of higher energy efficiency is made clear to individuals and to society at large and integrated into decision-making processes in government, industry, and society.

Make it affordable. It is essential to identify and support business models, financing vehicles, and incentives that provide those who invest in energy efficiency an appropriate share of the rewards that flow from efficiency improvements. Tailored economic instruments such as tax policies, loans, grants, trading schemes, white certificates, public procurement, and investment in R&D or infrastructure are needed to address the various principal–agent barriers and other split incentives where investors may not directly reap the return on investments to energy efficiency, including short asset-ownership periods vis-à-vis payback periods for building retrofits (Hilke and Ryan 2012). Perception of financial risk is another barrier to energy efficiency investment and can be overcome by lowering the risk premiums applied to lending for energy efficiency projects and by providing risk guarantees, credit lines, mechanisms to standardize and bundle project types, and awareness and capacity-building efforts among the finance community.

Make it standard. Energy efficiency needs to be standardized if it is to endure. Once a high-efficiency technology or service solution has been widely adopted, there is rarely a step backwards: the less-efficient technology or approach is rapidly forgotten, and the cost differentials for higher-efficiency technologies decline substantially as adoption rates increase. Under the Efficient World Scenario, a mix of regulations is deployed to prohibit the least-efficient approaches and to impose MEPS for equipment, vehicles, buildings, and power plants.

Make it real. Monitoring, verification, and enforcement activities are needed to verify claimed energy efficiencies. Without such efforts, experience has shown that savings will turn out to be less than expected, undermining policy objectives. Under the Efficient World Scenario, there is a substantial increase in the scale of such activities.

Make it realizable. Achieving the supply and widespread adoption of energy-efficient goods and services depends on an adequate body of skilled practitioners in government and industry and requires improved energy efficiency governance, including legislative frameworks, funding mechanisms, institutional arrangements, and coordination bodies that work together to support the implementation of energy efficiency strategies, policies, and programs (IEA 2010).

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ANNEX 1: Proposed energy efficiency indicators for the medium term

SECTOR	ENERGY INTENSITY INDICATOR PROPOSED IN THIS BASELINE REPORT	CHALLENGES ASSOCIATED WITH ENERGY EFFICIENCY MONITORING, USING THE PROPOSED ENERGY INTENSITY INDICATORS	MEDIUM -TERM AND PREFERRED ENERGY INDICATORS TO TRACK ENERGY EFFICIENCY	RATIONALE FOR INCREASING THE SCOPE OF MONITORING AND DATA COLLECTION	DATA SOURCES
Residential	Included under other sectors	Does not permit tracking of the sector, as it also includes transport, residential, and others.	MJ/floor area MJ/number of households MJ/total population MJ/end use (for example space heating, cooking, cooling, appliances)	Floor area is a better proxy to identify changes in the residential sector. Household number can be informative, but size of each household may also be relevant. End-use energy consumption such as for space heating, cooling, and cooking needs is of importance to the residential sector main activities.	Activity data such as floor area and number of households can be obtained from existing national census. Floor area measurements should follow UN census guidelines. National household surveys also track total floor area on a more frequent basis. These surveys are essential to capture physical building and equipment characteristics and total annual energy consumption. Energy consumption by end use can be estimated by combining output from household surveys, metering/measuring of household activity, and modeling techniques. The final breakdown needs to be validated against total residential energy consumption from energy balances.

SECTOR	ENERGY INTENSITY INDICATOR PROPOSED IN THIS BASELINE REPORT	CHALLENGES ASSOCIATED WITH ENERGY EFFICIENCY MONITORING, USING THE PROPOSED ENERGY INTENSITY INDICATORS	MEDIUM-TERM AND PREFERRED ENERGY INDICATORS TO TRACK ENERGY EFFICIENCY	RATIONALE FOR INCREASING THE SCOPE OF MONITORING AND DATA COLLECTION	DATA SOURCES
Services	MJ/service sector GDP	There has been little evidence that the two variables are directly linked (that is, correlated). Because of data disaggregation limitations, services value added includes residential, transport, and others. Therefore, the indicator combines sectors with very different intensities and drivers. Using physical parameters is a better indicator of energy efficiency improvements.	MJ/floor area MJ/floor area by type of service	Total floor area is one of the key physical variables essential to track overall improvement in the service sector efficiency. Long-term monitoring of the service sector by type of service (or type of building where service is provided) such as government and public buildings, education, hospitals, lodging, and so on. In some sectors such as hospitals, number of hospital beds may be a better indicator of the activity in the building. Challenge will remain as some countries may choose to cut off surveying of small entities and only focus on large institutions.	Services sector floor area can be derived from a number of sources such as national building surveys and business tax offices. Some monitoring may be essential to capture the behavioral aspect of energy consumption in buildings. Finally, bottom-up modeling and estimation techniques will be needed as the sector is highly heterogeneous and some assumptions need to be made.
Industry	Total industry MJ/GDP	The variable is highly aggregated, missing the information at subsector level. Literature points to poor correlation in monitoring energy efficiency improvements industry based on value added alone.	Industry subsector MJ/value added of industry subsector GDP MJ/output volume	Where possible use physical output in the following sectors: aluminum, cement, iron and steel, pulp and paper, fertilizers, and others.	The existing IEA energy balances structure provides industry subsector information according to the UN ISIC code definitions. National energy consumption industry surveys. Physical activity data exist in international organizations. Bottom-up modeling validated at the aggregate level against energy balances.

SECTOR	ENERGY INTENSITY INDICATOR PROPOSED IN THIS BASELINE REPORT	CHALLENGES ASSOCIATED WITH ENERGY EFFICIENCY MONITORING, USING THE PROPOSED ENERGY INTENSITY INDICATORS	MEDIUM-TERM AND PREFERRED ENERGY INDICATORS TO TRACK ENERGY EFFICIENCY	RATIONALE FOR INCREASING THE SCOPE OF MONITORING AND DATA COLLECTION	DATA SOURCES
Transport	Included under other sectors	Does not permit tracking of the sector, as it also includes services, residential, and others.	MJ/vehicle-kilometers MJ/passenger-kilometers MJ/freight kilometers MJ/total passenger vehicles MJ/total freight vehicles	The need to split passenger and freight transport energy consumption in MJ. Currently there are no publicly available global data that properly split passenger and freight transportation energy consumption. Within domestic boundaries, the IEA energy balances reports these data in aggregate form by road, rail, marine, and domestic aviation. Age of vehicles would be another important parameter to capture, especially in countries where used vehicles are imported.	National mobility surveys. Tax offices where actively used vehicles are registered with data such as vehicle kilometers and age of vehicle. Monitoring using the latest GPS data logger technology. Modeling to estimate mode split and average fuel consumption of existing vehicle stock by mode type. Bottom-up modeling validated at the aggregate level against energy balances.

SOURCE: AUTHORS.
NOTE: GDP = GROSS DOMESTIC PRODUCT; GPS = GLOBAL POSITIONING SYSTEM; IEA = INTERNATIONAL ENERGY AGENCY; ISIC = INTERNATIONAL STANDARD INDUSTRIAL CLASSIFICATION; MJ = MEGAJOULE.

ANNEX 2: Overview of energy efficiency policies and targets by country and sector

	AUSTRALIA	CANADA	EU MEMBER STATES	JAPAN	KOREA	NEW ZEALAND	UNITED STATES
Cross-sectoral							
Energy efficiency strategy or target	Clean Energy Future Plan National Strategy on Energy Efficiency (NSEE)	Moving Forward on Energy Efficiency in Canada: Achieving Results to 2020 and Beyond	National Energy Efficiency Action Plans	Innovative Energy Savings Plan September 2012	The National Energy Master Plan and Energy Use Rationalization Master Plan	New Zealand Energy Efficiency and Conservation Strategy	Target: Cut in half the energy wasted in homes and businesses over the next 20 years. Energy efficiency action plans at state level.
Buildings and appliances							
Building energy codes	Mandatory for new and existing residential and commercial buildings. Codes updated in 2011.	Voluntary national Energy Code for new and existing residential and commercial buildings, published in 2011 for adoption by subnational regulators.	Mandatory for new and existing buildings when renovation is undertaken.	Voluntary guidelines.	Mandatory for residential buildings and commercial buildings 500–300 m². Codes updated in 2010.	Mandatory for new residential and commercial buildings.	Mandatory for new residential and commercial buildings, and major renovations, with some exceptions. Variation of stringency across states.
Energy labeling	National framework replacing seven state and territory legislative frameworks. Seven appliances covered by the mandatory Energy Rating Labeling Scheme. Mandatory disclosure of commercial building energy efficiency.	Mandatory EnergyGuide label for eight major household appliances and light bulbs. International ENERGY STAR symbol promoted in Canada.	Energy performance certificates mandatory for all new buildings. Labeling in place for household appliances.	Voluntary building labeling program and Energy Star for office equipment.	Labeling system expanded from 26 products in 2011 to 35 products in 2012.	Eight products covered.	Mandatory EnergyGuide labeling for most household appliances. Voluntary energy star labeling for over 60 categories of appliances, equipment, and buildings.

	AUSTRALIA	CANADA	EU MEMBER STATES	JAPAN	KOREA	NEW ZEALAND	UNITED STATES
Buildings and appliances (continued)							
Appliance, equipment and lighting MEPS	20 products covered.	47 products covered.	15 product groups covered by EcoDesign Directive.	Top Runner: 23 products covered.	26 products covered.	16 products covered.	45 products covered.
Transport							
Fuel-efficiency standards	LDV: Implementation from 2015. HDV: Included in carbon price mechanism from 2014.	LDV: published October 2010 for model years 2011–2016. HDV: under consideration.	LDV: 130 g/CO2 per km by 2015.* HDV: under consideration. *Switzerland is also implementing these standards.	LDV: 16.8 km/l (45.1 mpg). HDV: starting MY 2015.	LDV: 17 km/l by 2015; 140 g/CO2 per km by 2015. HDV: starting after 2015	None	LDV: 34.1 mpg by 2016 (6.90 l/100 km); large increases by 2025. HDV: starting MY 2014.
Fuel-efficiency labeling	LDV: Yes HDV: None	LDV: EnerGuide Label HDV: None	LDV: Yes HDV: None	LDV: Yes HDV: Yes	LDV: Yes HDV: None	LDV: Yes HDV: None	LDV: Yes HDV: None
Fiscal incentives for new efficient vehicles	None	Several provinces and territories offer incentives or rebates for the purchase of fuel-efficient vehicles, including EVs.	Most countries align vehicle taxes with CO2 emissions.	Registration taxes according to CO2 emissions and fuel economy.	None	None	Tax at federal level; 20 states plus DC offer tax incentives, rebates, or voucher programs for advanced vehicles (EVs, PHEVs, HEVs, and/or fuel cell vehicles)

	AUSTRALIA	CANADA	EU MEMBER STATES	JAPAN	KOREA	NEW ZEALAND	UNITED STATES
industry							
Energy man-agement programs	Energy Efficiency Opportunities (EEO) Program mandatory for corporations using more than 0.5 PJ of energy per year. Expansion of program announced.	ecoEnergy Efficiency for Industry program, which supports the early implementation of the new ISO 50001 Energy Management Systems standard.	Voluntary agreements in place in Belgium (Flanders), Denmark, Finland, Ireland, Netherlands, Sweden.	Energy managers required for large industries.	Voluntary Energy Saving through Partnership program.	Energy management diagnostic tools, training for energy managers and other support.	Voluntary energy management certification program, implementation of ISO 50001. Technical support programs in place, especially for SMEs.
MEPS for electric motors	IE2 for three-phase industrial electric motors.	Must meet or exceed the efficiencies outlined in either table 2 or table 3 of CAN/CSA C390-10.	IE3 (premium efficiency). MEPS for three-phase induction motors <7.5kW by 2015; all IE3 (IE2+Variable Speed Drive) in 2017.	Adding three-phase induction MEPS to Top Runner program.	IE2 (high efficiency) three-phase electric motors.	MEPS are in place at level II Standards. Investigation under way to advance to level III.	IE3 (premium-efficiency) MEPS for three-phase induction motors.

	RUSSIA	CHINA	INDIA	BRAZIL	SOUTH AFRICA	MEXICO
Cross-sectoral						
	2009 Federal Law No. 261-FZ on energy saving and improving energy efficiency; reduce energy intensity by 40 percent by 2020.	12th Five Year Plan (2011–2015): target to reduce energy intensity by 16 percent by 2015.	11th Five-Year plan (2007–2012): target to improve energy efficiency by 20 percent. An "Approach to the 12th Five-Year" has been published.	2011 National Energy Efficiency Plan: reduce projected power consumption by 10 percent by 2030.	Energy Efficiency Strategy of the Republic of South Africa: sets a national target of energy efficiency improvement of 12 percent by 2015.	2008 Law on Sustainable Energy Use Goal: reduce electricity demand 12 percent by 2020 and 18 percent by 2030.
Buildings and appliances						
Building energy codes	Mandatory building codes (but not yet fully implemented).	Mandatory codes for all new large residential buildings in big cities.	Energy Conservation Building Code (2007), with voluntary guidelines for commercial and residential buildings.	Voluntary guidelines in place.	National Building Regulation with voluntary guidelines for new buildings.	National Thermal Insulation and Lighting Standards for commercial buildings.
Energy labeling	Information on energy efficiency classes for appliances required since January 2011.	Labeling mandatory for new, large, commercial and governmental buildings in big cities.	Voluntary Star Ratings for office buildings.	Voluntary for residential and commercial buildings.	Voluntary Green Star South Africa label.	Green Building Labeling System.
Appliance, equipment and lighting MEPS	Phaseout of incandescent >100 watt bulbs.	46 products covered by labeling schemes.	Mandatory S&L for room air conditioners and refrigerators, voluntary for 5 other products.	13 products covered by voluntary labels.	Standards under development for lighting; planned for air conditioners, solar water heaters, heat pumps, and shower heads.	Standards for freezers, refrigerators, washing machines, and fluorescent lamps; 186 products covered by mandatory labels.

	RUSSIA	CHINA	INDIA	BRAZIL	SOUTH AFRICA	MEXICO
Transport						
Fuel-efficiency standards	None	PLDV: 6.9l/100 km by 2015, 5.0 l/100 km by 2020; trucks: proposed MY 2015. HDV: None	LDV: Under development HDV: None	None	None	LDV: Average new car fleet average fuel economy of 14.9 km/l (35 mpg) in 2016 HDV: None
Fuel-efficiency labeling	None	LDV: Yes HDV: None	None	None	None	None
Fiscal incentives for new efficient vehicles	None	Acquisition tax based on	Registration taxes by vehicle and engine size, sales incentives for advanced vehicles.	None	None	None
Industry						
Energy man-agement programs	Periodic energy audits required for some industries.	Top 10,000 program setting energy savings targets by 2015 for the largest 10,000 industrial consum-ers.	PAT in force since 2011. Audits mandated for designated consumers.	None.	Voluntary "Energy Efficiency and Energy Demand Management Flagship Programme" involving 24 major indus-trial energy users and associations.	
MEPs for electric motors	None	High-efficiency (IE2) MEPs for three-phase induction motors in place.	None	High-efficiency (IE2) MEPs for three-phase induction motors in place.	None	Premium efficiency (IE3) for output power ratings of 0.75–150 kW

SOURCE: IEA.
NOTE: CAN/CSA = CANADIAN STANDARDS ASSOCIATION; CO2 = CARBON DIOXIDE; EV = ELECTRIC VEHICLE; HDV = HEAVY-DUTY VEHICLE; HEV = HYBRID-ELECTRIC VEHICLE; IE2 = HIGH-EFFICIENCY MOTOR; IE3 = PREMIUM EFFICIENCY MOTOR; MEPS = MINIMUM ENERGY PERFORMANCE STANDARDS; ISO = INTERNATIONAL ORGANIZATION FOR STANDARDIZATION; KW = KILOWATTS; LDV = LIGHT-DUTY VEHICLE; MPG = MILES PER GALLON; PAT = PERFORM, ACHIEVE, TRADE; PHEVS = PLUG-IN HYBRID ELECTRIC VEHICLE; PJ = PETAJOULE; PLDV = PASSENGER LIGHT-DUTY VEHICLE; S&L = STANDARDS AND LABELING; SME = SMALL AND MEDIUM ENTERPRISE.

ANNEX 3: Specific energy consumption of energy-intensive products

The tables below list the status of energy consumption in major industries, along with the existing best practices and their savings potential.

SECTOR OR PROCESS	CURRENT PRACTICE	BEST AVAILABLE PRACTICE BENCHMARKS
Iron and steel	90 percent of the production of crude steel is in the range of 14–30 GJ final energy/ton. Includes total energy consumption for steel production—from coke making to furnace firing to steel finishing—and refers to crude steel production. Electricity consumption is not corrected for the efficiency of power generation.	Practical minimum energy consumption for a blast furnace is 10.4 GJ/t iron.
Cement		Dry-process kilns thermal energy consumption: 2.9–3.3 GJ/t clinker. Dry-process kilns electricity consumption: 95–100 kWh/t cement.
Chemicals and petrochemicals		Olefin production from steam cracking: 12 GJ/t olefin (excluding feedstocks). Ammonia production from natural gas: 11 GJ/t ammonia (excluding feedstocks). Methanol production from natural gas: 9 GJ/t methanol (excluding feedstocks).
Aluminum		Total fuel and electricity consumption of Bayer process: 9.5–10 GJ/t alumina. The current best practice of Hall–Heroult electrolysis cells (using currents of 300–315 kA) is estimated at 12.9–13 MWh/t aluminum.
Pulp and paper	Large modern chemical pulp mills are largely self-sufficient in energy terms, using only biomass and delivering surplus electricity to the grid. Steam consumption of 10.4 GJ/ adt and an excess of electricity production of 2 GJ/adt.	Mechanical pulping 7.5 GJ elec/t. Chemical pulping 12.5 GJ/t + 2.08 GJ elec/t. Waste paper pulp 0.5GJ/t + 0.36 GJ elec/t. De-inked waste paper pulp 2.0 GJ/t + 1.6 GJ elec/t. Depending on final paper quality energy intensities vary from 3.7 –5.3 GJ/t + 1.8–3.6 GJ elec/t.

SOURCE: : IEA.
NOTE: GJ/ADT = GIGAJOULE/AIR DRY TON PULP; KA = KILO AMPERE; KWH = KILOWATT–HOUR; MWH/T = MEGAWATT–HOUR/TON.

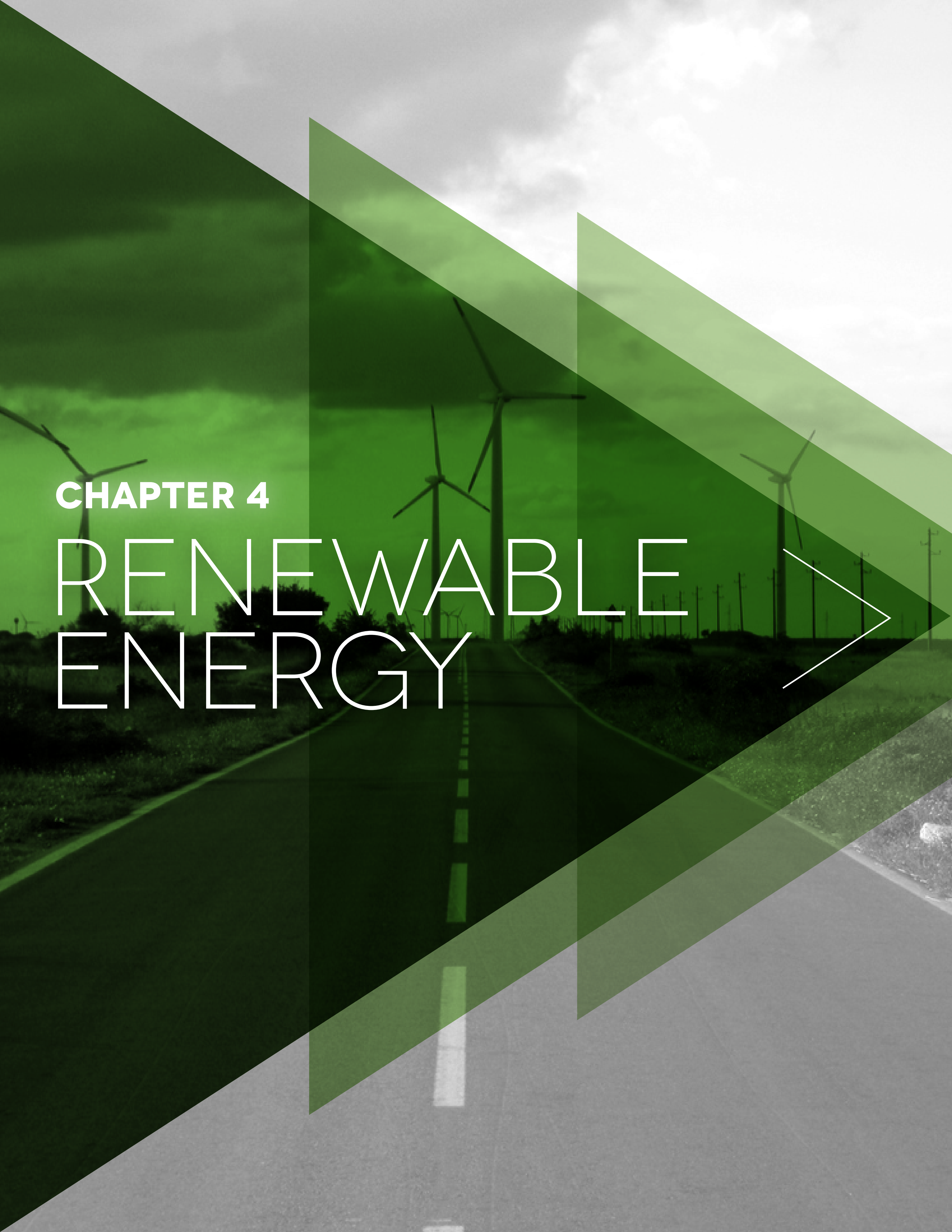
Comparison of estimated short-term potential for industrial energy savings in industrialized and developing countries, 2007

IMPROVEMENT POTENTIAL (%)			TOTAL SAVINGS POTENTIAL (EJ/YEAR)		SHARE OF ENERGY COSTS (%)
Sectors and products	Industrializing countries	Developed countries (including economies in transition)	Industrializing countries	Developed countries (including economies in transition)	Industrializing and developing countries (including economies in transition)
Petroleum refineries	10–25	40–45	0.7	2.9	50–60
Chemical and petrochemical			0.5	1.8	
Steam cracking (excl. feedstock)	20–25	25–30	0.4	0.3	50–85
Ammonia	11	25	0.1	0.3	
Methanol	9	14	0.0	0.1	
Nonferrous			0.3	0.7	30
Alumina production	35	50	0.1	0.5	35–50
Aluminum smelters	5–10	5	0.1	0.15	—
Copper smelters		45–50	0.0	0.1	—
Zinc	16	46	0.0	0.1	10–30
Iron and steel	10	30	0.7	5.4	
Nonmetallic minerals			0.8	2.0	25–50
Cement	20	25	0.4	1.8	40
Lime					7–20
Glass	30–35	40	0.4	0.2	30–50
Ceramics					15–35
Pulp and paper	25	20	1.3	0.3	5–25
Textile					5–25
Spinning	10	20	0.1	0.3	5–15
Weaving					
Food and beverages	25	40	0.7	1.4	1–10
Total of all sectors (excl. feedstock)	15	30–35	7.6	23	–

SOURCE: UNIDO 2010.

CHAPTER 4

RENEWABLE ENERGY



CHAPTER 4: RENEWABLE ENERGY

One of the three objectives of the UN Secretary General under the Sustainable Energy for All (SE4ALL) initiative is to double the share of renewable energy in the global energy mix by 2030, with an emphasis on promoting sustainable forms of renewable energy.

This chapter proposes a methodology for establishing a starting point against which future global progress can be measured and provides an indicator framework for tracking that progress. The chapter also describes global trends in renewable energy and discusses market growth, barriers, high-impact opportunities, as well as future scenarios and the scale of the challenge.

SECTION 1: METHODOLOGICAL CHALLENGES IN DEFINING AND MEASURING RENEWABLE ENERGY

There are various definitional and methodological challenges in measuring and tracking the share of renewable energy in the global energy mix:

- Defining renewable energy, taking into account sustainability considerations
- Data availability, collection, and management issues
- Determining what convention to use for measuring the share of renewables in the global energy mix
- Measuring other relevant indicators

Defining renewable energy

While there is a broad consensus among international organizations, government institutions, and regional commissions on what constitutes renewable energy, these groups employ legal or formal definitions that vary slightly in the types of resources and sustainability considerations included.

The International Renewable Energy Agency (IRENA) has a statutory definition, ratified by 108 members (107 states and the European Union) as of February 2013: “renewable energy includes all forms of energy produced from renewable sources in a sustainable manner, including bioenergy, geothermal energy, hydropower, ocean energy, solar energy and wind energy.”

The International Energy Agency (IEA) defines renewable energy resources as those “derived from natural processes” and “replenished at a faster rate than they are consumed” (IEA 2002, OECD, IEA and Eurostat, 2005). The IEA definition of renewable energy includes the following sources: “electricity and heat derived from solar, wind, ocean, hydropower, biomass, geothermal resources, and biofuels and hydrogen derived from renewable resources” (IEA 2002).

These definitions vary in the type of sources included and in whether sustainability considerations are explicitly incorporated. These differences illustrate the fact that there is no common or global definition of renewable energy.

For the purposes of the SE4ALL tracking framework, it is recommended that the definition of renewable energy specify the range of sources to be included, embrace the notion of natural replenishment, and espouse sustainability. But data are not currently available to distinguish whether renewable energy – notably biomass – has been sustainably produced. Until adequate data become available, it is thus recommended that renewable energy be defined and tracked without the application of specific sustainability criteria. The SE4ALL initiative will support the strengthening of methodologies for tracking sustainability across all renewable energy sources.

Ensuring sustainability

It is clear that the SE4ALL initiative should encourage renewable energy where this contributes to overall sustainable development, taking into account all three pillars of sustainability—environmental, economic, and social. In general, the renewable technologies score high in terms of sustainability criteria, but energy production from these sources inevitably has both positive and negative environmental, economic, and social impacts, which must be carefully managed. These considerations are most pronounced in the case of bioenergy and hydropower, but are also relevant to the widespread deployment of other technologies. Assessment methodologies and best practice guidelines that can be used to manage these impacts are often available at the national level. But there are no internationally accepted sustainability criteria covering the major technologies, and it is therefore very difficult to distinguish between sustainable and less-sustainable deployment.

Bioenergy

Bioenergy is a very complex field; concerns associated with the sustainability of its production and use require a case-by-case assessment, considering feedstock, location, production methods, land use, conversion pathways, infrastructure, and so on. These concerns span all types of bioenergy, from traditional uses of biomass in the residential sector to bioenergy used in the transport sector and power generation, across the three pillars of sustainability. For example, the greenhouse gas (GHG) balance needs to be carefully evaluated on a case-by-case basis with proper assessment of the full life cycle of GHG emissions, from land use conversion to end use. There are some unresolved methodological issues, such as how to account for the indirect impacts of bioenergy production on land use (that is, indirect land use change, ILUC). Potential economic and social impacts, including on food security, must also be carefully considered. Substantial progress has been made in identifying the key sustainability issues and creating methodologies for impact assessment, notably through the work of UN Energy [1] and the Global Bioenergy Partnership (GBEP).[2] The GBEP has established international consensus around sustainability indicators for bioenergy. While the inclusion of sustainability considerations for bioenergy is still under development in the legal and regulatory regimes of many countries, improved frameworks are beginning to emerge.

Bioenergy provides around 14 percent of global energy consumption. Some 70 percent of this biomass energy is believed to be consumed in developing countries for cooking and heating with open fires and very inefficient stoves, the traditional uses of biomass. It is widely recognized that these uses, including the inefficient production and use of charcoal, lead to deforestation and are closely linked to indoor air pollution (Goldemberg 2004).

But biomass can also be used to produce household-level energy more efficiently via improved cooking and heating appliances. It can also be used to produce heat efficiently for commercial and industrial needs, as well as electricity and transport fuels. Ambitious renewable energy scenarios rely heavily on these "modern" forms of bioenergy use to meet their goals, but some also recognize that traditional uses of biomass will continue to be an important energy source for many people for some time to come. Indeed, it is not possible to distinguish, using available data, the extent to which bioenergy is used by modern or traditional conversion methods, at least as far as the residential sector is concerned. For example, in some IEA analysis it is assumed that the use of bioenergy in the residential sector of non-OECD (Organisation for Economic Co-operation and Development) countries is made up of "traditional biomass," whereas in the OECD countries it counts as modern bioenergy. This is obviously a simplification given the fact that informal use of wood fuels in low-efficiency appliances also occurs in many OECD countries.[3] Clearer criteria are needed. For example, should the use of biomass in an improved stove be counted as "sustainable" use? In addition, data on household use of biomass for fuel is difficult to establish with any precision, with different methodologies and estimates providing a range of differing results. Within the monitoring process associated with the SE4ALL initiative, it would clearly be desirable to distinguish between "sustainable" and "unsustainable" bioenergy use. While the GBEP framework of sustainability indicators would provide a good basis for making this distinction, no internationally accepted standards based on these indicators have yet been developed. Given the additional difficulties of collecting appropriate information in the field, such distinctions are not feasible at this stage.

1 UN Energy Bioenergy Decision Support Tool at http://www.bioenergydecisiontool.org.

2 http://www.globalbioenergy.org.

3 Note that it is possible to estimate traditional biomass use based on data from national household surveys. But this approach require assumptions on a set of issues; for example, these surveys report on what is the primary fuel being used by households but do not provide volume or quantity or the actual total level of fuel household consumption. Thus, the proportion of primary fuel could vary widely depending on the number and extent of consumption of other fuels used. Also, the actual household consumption needs to be assumed.

Since it is not currently possible to distinguish consistently between the sustainable and less-sustainable ways of using bioenergy (including traditional biomass) the SE4ALL initiative will track all types of bioenergy uses. But progress toward the target should be monitored in as disaggregated a manner as the data allow so that trends can be assessed.

Hydropower

There is a degree of international consensus around sustainability considerations for hydropower. For example, the IEA Hydropower Agreement published guidelines on "Hydropower and the Environment" in 2000, which were updated in 2010 (IEA 2000; 2010). The World Commission on Dams also produced a "Decision Making Framework" to guide planners in protecting people from the negative impacts of water and energy projects. Brazil has produced a detailed manual for river basin inventory studies and management. In 2010 the International Hydropower Association published the "IHA Sustainability Assessment Protocol" based on a multistakeholder development process involving representatives from social and environmental nongovernmental organizations (NGOs), governments, commercial organizations, development banks (including the World Bank), and the hydropower sector (International Hydropower Association 2010).

Other technologies

For other technologies, guidelines are established on a national or regional basis in the absence of international consensus. To encourage the highest levels of sustainability in the deployment of all renewables, a necessary first step is to establish internationally accepted indicators and protocols for the sustainability of each technology. Although it would be desirable to differentiate between sustainably and unsustainably produced renewable energy—in line with the overall aim of the initiative—this is not possible in the short term, based on existing data and protocols. The SE4ALL initiative presents a unique opportunity to improve existing methods of data collection and enhance the available knowledge base as a step toward the ability to track progress on sustainability.

Data availability, collection, and measurement

Availability

Tracking progress toward the renewable energy SE4ALL objective requires accurate, consistent data on both overall energy production and use of energy from all sources.

Many organizations and companies generate reports on global energy statistics. But only three organizations collect primary global and country-level data on energy consumption and production:

- IEA
- UN
- World Health Organization (WHO) (focusing particularly on household energy use)

Many other institutions and companies use these IEA, UN, and WHO databases, and complement them with both primary data and secondary information to create customized databases and analyses (for example, Enerdata, US-EIA, BP, and REN21; see table A1.1 in annex 1).

The IEA compiles a comprehensive and comparable set of energy data that is used as the reference source for most reporting of global energy demand and renewable energy production. The IEA database contains comprehensive and accurate data for OECD countries and also covers about 75 non-OECD countries that provide their national energy balances to the IEA. For 10 other countries, tertiary sources and estimations are used to compile the data. Data from some smaller developing countries are not individually reported in the IEA statistics and are based on extrapolations of country data provided by the UN Statistics Division.

The UN database contains long-time series data for almost all countries, but is more heterogeneous and not available until sometime after the IEA information is reported. The WHO collects primary data on energy use but mainly at the household level.

Collection and measurement

As discussed above, the major issue affecting the contribution from renewable energy to the global energy mix relates to the use of biomass for heating and cooking. In many countries this is an informal sector, and data availability and accuracy are acknowledged to be poor and subject to large errors. Different data sources and methodologies produce varying estimates. This makes it very difficult to establish the starting point and to track progress toward the goal with any precision. So there is an urgent need to improve the overall quality of data on bioenergy use, particularly in regard to heating and cooking, and to refine the definitions and classifications relating to this sector.

There are some other categories of renewable energy production that are not fully or consistently represented in the data. While these data gaps may not significantly affect the overall proportion of renewables within the current energy mix, as new technologies are more widely deployed their shares may become more significant and would need to be better monitored in any comprehensive tracking system. These categories include:

- Small, distributed grid-connected generation, such as small-scale photovoltaic (PV) or wind and solar water heating. These may not be included in statistical reports, and a correction based on installed capacity may be needed. Indeed, current practice is inconsistent across countries.
- Renewable energy production that is estimated based on installed capacities may be inaccurate, particularly because some systems may be installed but not producing energy effectively.
- Biofuels are currently measured at final, not primary, energy levels.
- Off-grid and mini-grid electricity generation, which are often not captured by energy statistics.
- Direct production of heat (for example, by solar water heaters). Contribution of direct use of solar heat is often estimated based on installed capacity of solar collectors, but there are inconsistencies in how the data is collected and reported.
- Waste fuels, where the methodologies do not consistently differentiate between renewable (biogenic) and other waste fractions.
- The treatment of heat pumps within the statistics is somewhat complex, and there are inconsistencies in how the net energy produced by the heat pump is accounted for, and whether this is classified as renewable.
- "Passive solar" energy makes a substantial contribution to energy needs, both in industrial processes (salt production, food processing, and drying) and buildings (passive solar heating and lighting). This contribution can be further optimized by careful design, reducing the need for fossil fuels. But it is difficult to explicitly identify the contribution from passive solar, and so it is usually excluded.
- Interregional integration of electricity or biomass trade.

Given the need to develop a comprehensive and comparable analysis at a global level, we recommend that the IEA energy statistics—complemented with UN data for the smaller non-OECD countries—be used as the basis for tracking progress toward the target. Furthermore, a review of the methodologies for collecting data and reporting on the sources listed above is needed to ensure that the share of energy from these sources is accurately represented in the energy statistics as their importance grows.

Primary and final energy

To track the share of renewables in the global energy mix it is necessary to define at which level of the energy balance the measurement must be taken. The choice has a material impact on the starting and target levels of deployment. Tracking can be done at the primary energy level or on the basis of final energy.[4] Each of the choices has different advantages and disadvantages.

[4] In some countries, such as the United States, the term "delivered energy" is used, which is defined as the energy value of the fuel or electricity that enters the point of use (for example, a building).

Primary energy accounting

Many energy production statistics (for example, those used by the IEA, Eurostat, and the U.S. Energy Information Administration [EIA]) are based on a physical energy content or primary energy accounting method. In these systems, energy is accounted for in the form in which it first appears. For fossil fuels and bioenergy, the energy content in the fuels before conversion is used as the measure. For nuclear and renewable energy, the primary energy content is calculated based on a number of different conventions. The comparison between the roles of renewables and other sources is obscured by assumptions about the efficiencies of the various processes in these conventions. Wherever high efficiencies are used, the share of renewables in the overall system is underrepresented in terms of the useful energy produced.

There are, in fact, three different conventions for presenting the primary energy data, which can affect the overall size of the global energy mix and of the renewable share within it. These are:[5]

- The physical energy content method (used by IEA and Eurostat)
- The partial substitution method (used by EIA)
- The direct equivalent method (used in some Intergovernmental Panel on Climate Change [IPCC] reports)

Table 4.1 provides a comparison of total world energy supply in 2010 that illustrates the differences in the proportion of renewables in the energy mix estimated using these methodologies.

The advantage of estimating primary energy is that figures are based directly on the physical measurement of the energy content in fossil fuels. The disadvantages are that for low-carbon electricity sources the primary energy content has to be calculated and the result depends on the accounting convention used. It is difficult to make a clear comparison between the contribution of renewable and nonrenewable sources because this is obscured by assumptions about efficiencies. The resulting figures tend to underrepresent the share of electricity-producing renewables.

	RE CONTRIBUTION TO WORLD PRIMARY ENERGY SUPPLY						RE CONTRIBUTION TO TOTAL WORLD FINAL ENERGY CONSUMPTION	
% renewables in global energy mix	Physical content method		Direct equivalent method		Substitution method			
	EJ	%	EJ	%	EJ	%	EJ	%
2010	69	13	68	13	91	17	60	18

TABLE 4.1 **COMPARISON OF PRIMARY AND FINAL ENERGY CONSUMPTION METHODOLOGIES**

SOURCE: SOURCE: IEA ANALYSIS. (2010)
NOTE: RE = RENEWABLE ENERGY.

Final energy accounting

The data for this methodology come from the Total Final Energy Consumption (TFEC) figures within the IEA statistics (these exclude nonenergy uses of fossil fuels such as their use as raw material for the production of plastics and chemicals). Within the TFEC figures, heat and electricity are reported directly in the form ready for consumption. Although other primary energy sources (for example, fossil fuels and bioenergy used for heating in the residential sector) are still reported in terms of their fuel content, this methodology comes closer to representing the energy in

5 Definitions of the methods as well as more details on how to calculate primary and final energy can be found in annex 1.

the forms useful to users. To establish the contribution of each technology, the aggregated figures for electricity and commercial heat have to be allocated to the relevant technology. This can be done based on the proportions exhibited in production data, attributing the losses proportionally.

Table A1.5 in annex 1 shows the breakdown of final consumption figures for 2010 before and after allocation of electricity and heat.

The advantage of using TFEC as the basis for monitoring is that it allows a straight comparison (in GWh) of electricity-producing renewables (or nuclear sources) as well as of commercial heat—and gets closer to measuring useful energy.

The merits and disadvantages of using primary and final energy as the basis for tracking are summarized in table 4.2.

	PRIMARY ENERGY SUPPLY	FINAL ENERGY CONSUMPTION
Advantages	• Widely used. • Based on physical measurement of fuels.	• Heat and electricity in form ready for consumption. • Closer to useful energy output valued by end-users • Better balance for directly produced RE.
Disadvantages	• Different conventions for assumptions on efficiencies means that contribution of RE depends on calculation procedure. • Underrepresents directly produced RE.	• Losses need to be allocated.

TABLE 4.2 **ADVANTAGES AND DISADVANTAGES OF PRIMARY AND FINAL ENERGY CONSUMPTION METHODOLOGIES**

NOTE: RE = RENEWABLE ENERGY.

Given the decarbonization efforts under way around the globe, we can expect that more and more energy will be delivered by noncombustible energy sources. These are precisely the sources that are measured in the energy balance only once they have produced power or heat (that is, at the secondary energy level). Because the aim is to track the contribution of renewables to the global energy mix, we suggest using progress measurement at the final energy consumption level of the energy balance.

Measuring additional indicators

In addition to tracking deployment levels, it will be useful to track some supplementary indicators to improve the overall analysis of the global evolution of renewable energy markets. These could include trends in deployment diversification, policy developments, evolution of technology costs, and investment.

Deployment diversification

In order to meet the SE4ALL goals it will be important for an increasing number of countries to develop significant renewable energy portfolios. This diversification trend is already in progress; for example, the recent IEA Medium Term Renewable Energy Market Report shows an increasing number of countries reaching a 100-megawatt (MW) threshold level of installed renewable energy capacity (IEA 2012b). Tracking such diversification could be based on the:

- Number of countries exceeding threshold capacity levels for key technologies, which would identify only those countries with a larger absolute and globally significant level of production.
- Number of countries reaching threshold levels of renewable energy as a proportion of final energy consumption, which would identify countries that made significant efforts.

Renewable energy policy

It will also be useful to track the adoption of formal renewable energy targets and the introduction of fiscal, financial, and economic incentives for the purposes of future analyses and tracking of renewable energy development across countries and regions.

The IEA has a policy database that covers policies within a wide range of countries. This is now being expanded as a joint database with IRENA, and will eventually cover all the member countries of both organizations. The data will be regularly updated and validated by the responsible organizations in the countries. Other international organizations, such as REN 21 in its annual Renewables Global Status Report,[6t] also track renewable energy policies. The tracking could include:

- Number of countries with renewable energy targets
- Number of countries with specific legislation or regulations supporting the development of renewables within the electricity, heat, and transport sectors

At present, there is no common basis for the way that countries establish renewable energy targets; some are based on technology capacities, others on a percentage that is based on primary energy production, and some on final energy consumption. This makes it impossible to establish the extent to which, taken together, country targets are aligned with the overall SE4ALL goal. We recommend that countries establish goals based on final energy consumption, and that a target for 2030 be included along with intermediate targets to improve the consistency of tracking efforts.

Technology cost

Tracking the evolution of technology costs will also be essential to future analyses of the development of renewable energy markets. Many institutions, including IRENA and the IEA, are playing an important role in collecting data and reporting on costs for a range of renewable energy technologies.

Cost estimates are not always consistent due to the different conventions and assumptions applied in their calculation (for example, different cost allocation rules for combined heat and power plants may be applied, or different grid connection costs and rules).

Considering the advantages and disadvantages of different cost analyses, we suggest that a number of different cost indicators are used for the analysis, including:

- Equipment cost
- Total installed project cost, including fixed financing costs
- The levelized cost of energy (LCOE)

The cost of equipment at the factory gate and installed project costs are often available from market surveys or from other sources, such as the IRENA.

The LCOE is the price of electricity required for a project where revenues would equal costs, including making a return on the capital invested equal to the discount rate, as measured by a discounted cash flow analysis.

Investment

Tracking global trends in renewable energy investment will help to identify emerging trends and to highlight bottlenecks. It will be particularly important to track private sector investment, the role of development banks, and the extent to which public and concessional finance is leveraged with other sources of finance including asset finance, venture capital, and private equity. Bloomberg New Energy Finance (BNEF) and UNEP have been reporting data on investment on an annual basis from 2004 (BNEF, UNEP, and Frankfurt School 2012).

[6] http://www.ren21.net/gsr.

Suggested methodology for defining and measuring renewable energy

While it is not possible to fully resolve all of the methodological challenges outlined in the preceding section, the preferred approach for tackling them is summarized in table 4.3.

CHALLENGE	PROPOSED APPROACH
Definition of renewable energy	Energy from natural sources that are replenished at a faster rate than they are consumed, including hydro, bioenergy, geothermal, aerothermal, solar, wind and ocean
Sustainability of renewable energy	Develop sustainability protocols for different forms of renewable energy over time, so that sustainability considerations can be incorporated to the definition in the medium term
Primary versus final energy accounting	Track renewable energy as a share of total final energy consumption, and as a subsidiary indicator the share of renewable energy in electricity generation
Measuring additional indicators	Track complementary indicators such as deployment diversification, renewable energy policy, technology cost and diversification

TABLE 4.3 **ADDRESSING METHODOLOGICAL CHALLENGES IN GLOBAL TRACKING OF RENEWABLE ENERGY**

SOURCE: AUTHORS.

Definition of renewable energy

For the purposes of the SE4ALL tracking framework, we recommend that renewable energy be defined broadly as:

"Energy from natural sources that are replenished at a faster rate than they are consumed, including hydro, bioenergy, geothermal, aerothermal, solar, wind, and ocean."

We also propose that, in the short term, sustainability criteria not be applied so as to exclude any of these resources or associated technologies, given the difficulties of making these distinctions based on currently available data. This implies that the traditional uses of biomass would be included in the definition of renewable energy.

But since it is also important that the SE4ALL initiative emphasizes and promotes the sustainable use of renewable energy resources, we recommend that, in parallel, the SE4ALL initiative promotes or commissions a formal assessment to tackle the methodological aspects necessary for tracking sustainability in the long term. This will require the development of a consensus around sustainability indicators and criteria for each of the main technologies considered. These efforts will need to be introduced in tandem with strong capacity building at the country level, especially in less-developed economies.

Method for accounting and measuring renewable energy

For the purposes of the SE4ALL initiative, we recommend that the estimation of the proportion of the global energy mix from renewable energy be based on the TFEC data.

To improve the tracking of the contribution of renewable energy to TFEC, it will be necessary to enhance measurement and data collection to improve the issues identified previously, particularly relating to bioenergy use. We therefore propose that the SE4ALL initiative promote or commission the assessments necessary for improving measurement and data collection in those categories.

Measuring and tracking complementary indicators

In tracking the contribution of renewable energy to TFEC under the SE4ALL initiative, the analysis of complementary indicators will be necessary to understand patterns and overall market evolution at the global, regional, and country levels.

We recommend monitoring the following additional indicators:

- Deployment diversity, including threshold levels of installed capacity for key renewable energy technologies or resources and number of countries reaching threshold levels of renewable energy as a proportion of final energy consumption
- Policy development, including number of countries with a policy target and level of target in each country for an aggregated global baseline; and adoption of fiscal, financial, and economic incentives at the country level
- Technology costs for each of the renewable energy technologies considered, initially in terms of LCOE, but if suitable procedures can be developed this should be complemented by manufacturing cost data where possible
- Investment in renewable energy (by asset class, country, and region)

Baseline year

Given the availability of data, we propose that the baseline year should be established as 2010, providing a 20-year period for reaching the target.

Data sources

We recommend using the IEA data as the main source for measuring the starting point and for tracking the contribution of renewable energy to TFEC, complemented with the UN data for the case of smaller non-OECD countries.

The use of IEA statistics as a basis for tracking should also be supplemented by enhanced efforts to track direct use of renewable energy for heat, improve data on bioenergy use (particularly relating to the traditional uses of biomass), and identify small-scale and off-grid electricity generation (as well as other sources not currently measured or included in the energy statistics described earlier).

Global baseline and tracking

Immediate and short term

In the immediate and short term (that is, for establishing the starting point and for tracking progress within the next five years), the SE4ALL initiative will track TFEC of different renewable energy resources used for heating, electricity, and transport on a global basis.

These resources include: hydro (all sizes), bioenergy (all types, but including only the estimated biodegradable fraction of products or waste), geothermal, aerothermal, solar (including PV and solar thermal), wind, and ocean.

The tracking of TFEC will be conducted primarily based on the statistics already produced by the IEA. These are based on country information gathered through annual questionnaires that the IEA designed to ensure consistency of reporting variables (for example, use of the same reporting conventions and definitions, use of the international standard industrial classification, application of the same definitions for different categories, and so on). This information is supplemented with other data sources in countries that have not signed data-reporting conventions with the IEA. The IEA aggregates the country-level data and reports on an annual basis.

During the first five years, the SE4ALL initiative will seek to complete the recommended assessments for improving methodological issues and to enhance data collection to cover identified data gaps. Once the assessments are completed, these new concepts, definitions, and questions will be integrated into the procedures for collecting and reporting the energy statistics.

A parallel review of sustainability indicators and criteria for each of the main technologies will be carried out and used as the basis for developing internationally accepted standards that can be used to assess the degree to which deployment meets the highest sustainability standards.

These new procedures and the necessary country-leve-training will be introduced before the end of the fifth year after the SE4ALL initiative is launched.

The SE4ALL initiative will track four additional indicators:

- Deployment diversity
- Policy developments
- Technology costs
- Investment in renewable energy

All indicators will be tracked on a country level and aggregated globally for the purposes of reporting under the SE4ALL initiative.

Medium term

In the medium term, we recommend that the SE4ALL initiative move toward a working definition of renewable energy that includes only renewable energy produced in a sustainable manner. To do this it will be necessary to develop and promote methodologies for tracking sustainability across the use of all types of resources; improving definitions and data on bioenergy use, particularly relating to traditional vs. modern uses of biomass; organic versus inorganic fraction of waste and products; output and use of heat pumps; use of small-scale renewable energy in distributed generation; and use of renewable energy in off-grid schemes.

In addition, we recommend that countries adopt a consistent targeting approach, setting targets in terms of the proportion of energy in their energy mix based on TFEC, which would allow for the calculation of an aggregate figure that would provide a measure for the cumulative ambition for comparison with the SE4ALL goal.

Toward the fifth year of the SE4ALL implementation, these additional aspects could be incorporated into the reporting systems on an annual basis.

Country-level tracking

At this stage there is no attempt to disaggregate the increases in the share of renewable energy to the individual SE4ALL commitments (that is, the impact of particular UN SE4ALL measures is not considered). Nor does the report attempt to address the allocation of the SE4ALL objective on a regional or country level.

In the medium term it would be beneficial for country-level targets to be reformulated in line with the proposed SE4ALL methodology—that is, as the percent of renewable energy in TFEC.

Also in the medium term, the revised information-gathering systems and definitions will need to be implemented at the country level, along with the application of sustainability criteria for bioenergy and other technologies as appropriate.

A summary of the strategy for tracking is provided in table 4.4.

	IMMEDIATE	MEDIUM TERM
Global tracking	• TFEC. • Electricity (MW, GWh). • Number of countries exceeding threshold levels of installed capacity for key RE technologies and exceeding threshold levels as a proportion of final energy consumption. • Number of countries with policy targets and incentives. • Technology costs. • Investment levels.	• Improved definitions and data associated with bioenergy. • RE in distributed generation. • RE in off-grid (including micro-grids). • Harmonized approach to target setting.
Country-level tracking	• Nil.	• Development of consistent targets expressed in terms of renewable energy share of TFEC by 2030. • Support and implementation of revised information gathering systems aimed at improving coverage of the full range of renewable energy technologies in selected countries. • Piloting of the application of sustainability criteria in bioenergy in selected countries. • Developing sustainability criteria for other renewable energy technologies and piloting their application in selected countries.

TABLE 4.4 **TRACKING FRAMEWORK**

SOURCE: AUTHORS.
NOTE: GWH = GIGAWATT-HOURS; MW = MEGAWATTS; RE = RENEWABLE ENERGY; TFEC = TOTAL FINAL ENERGY CONSUMPTION.

SECTION 2. GLOBAL TRENDS IN RENEWABLE ENERGY

This section establishes the initial conditions of the share of renewable energy in global final energy consumption using the methodology described in section 1, and presents global trends including breakdowns for different regions and income groupings. It also discusses trends in renewable energy policy, technology progress, investment and, deployment diversification.

Total final energy consumption and electricity

Based on existing data sources (with their associated statistical limitations), the share of renewable energy in TFEC is estimated to be 18 percent at the starting point in 2010[7]. This implies a SE4ALL objective of 36 percent for the year 2030. For immediate tracking purposes, it is not possible to take sustainability considerations into account, so as to exclude any unsustainable forms of renewable energy; though it is recommended that these considerations be incorporated over time. As a result, the starting point of 18 percent as well as the associated target can be regarded as upper bounds.

It is estimated that traditional biomass accounts for about half of the renewable energy total (figure 4.1).[8] A further quarter of the renewable energy total relates to modern forms of bioenergy, and most of the remainder is hydropower. Other forms of renewable energy—including wind, solar, geothermal, waste, and marine—together contribute barely 1 percent of global energy consumption.

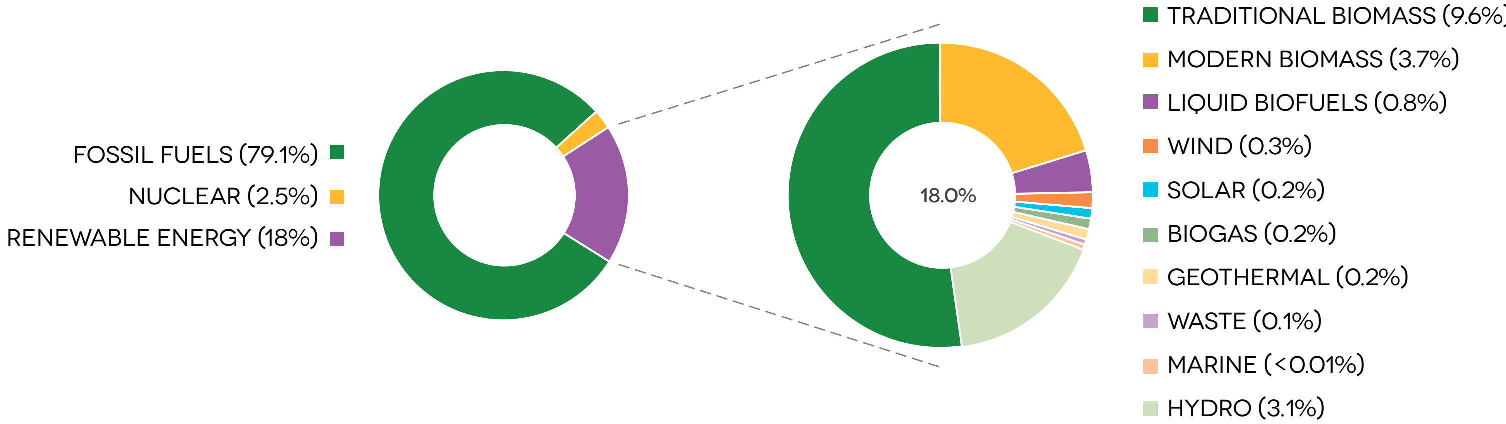


FIGURE 4.1 **GLOBAL SHARE OF RENEWABLE ENERGY IN TFEC, 2010**

SOURCE: AUTHORS' ANALYSIS BASED ON IEA 2012D

Indeed, although the consumption of traditional biomass increased in terms of volume between 1990 and 2010, its share of TFEC declined from 10.2 percent in 1990 to 9.6 percent in 2010. This trend may be partially attributed to a slow shift toward the use of more modern energy sources at the global level. The modern biomass share of TFEC increased slightly from 3.5 in 1990 to 3.7 percent in 2010.

Nonetheless, as mentioned previously, the methodology for collecting data on biomass (both traditional and modern) must be enhanced for a more accurate disaggregation of sources and uses and a better understanding of the degree to which these sources are being utilized sustainably.

[7] During the 2012 Year of Sustainable Energy for All a provisional estimate of 15 percent was used for the share of renewable energy in the global energy mix, with an associated target of 30 percent. This was based on 2005 data and a slightly different methodological approach to that finally agreed in this report.

[8] The UN Food and Agriculture Organization defines traditional biomass as "woodfuels, agricultural by-products, and dung burned for cooking and heating purposes." In developing countries, traditional biomass is still widely harvested and used in an unsustainable and unsafe way. It is mostly traded informally and non-commercially. So-called modern biomass, by contrast, is produced in a sustainable manner from solid wastes and residues from agriculture and forestry.

3.0% VS 1.5% GROWTH – THE COMPOUND

ANNUAL GROWTH RATE OF GLOBAL TOTAL FINAL ENERGY CONSUMPTION FROM RENEWABLE SOURCES (EXCLUDING TRADITIONAL BIOMASS) VERSUS THE GROWTH RATE OF TOTAL FINAL ENERGY CONSUMPTION OVERALL

The renewable energy sources other than traditional biomass and hydropower (including modern solid biomass, biofuels, biogas, waste, geothermal, wind, solar, and marine energy) contributed only 5.4 percent to TFEC in 2010. In the same year, the global consumption of hydropower reached a comparatively high share of 3.1 percent of TFEC.

The use of different sources has evolved at contrasting rates. While the share of traditional biomass in the global energy mix steadily declined between 1990 and 2010, increasing at a compounded annual growth rate (CAGR) of only 1.2 percent, the share of all other renewable sources (including hydro) grew at 3.0 percent CAGR, with the last five years marked by an unprecedented 4.9 percent CAGR.

The renewable energy sources other than traditional biomass and hydropower grew at an even higher annual rate, on the order of 11 percent between 1990 and 2010. Thus, the incremental increase in the share of renewable energy in TFEC during that period was to some extent driven by wind, biofuels, biogas, solar, waste, and geothermal sources (figure 4.2).

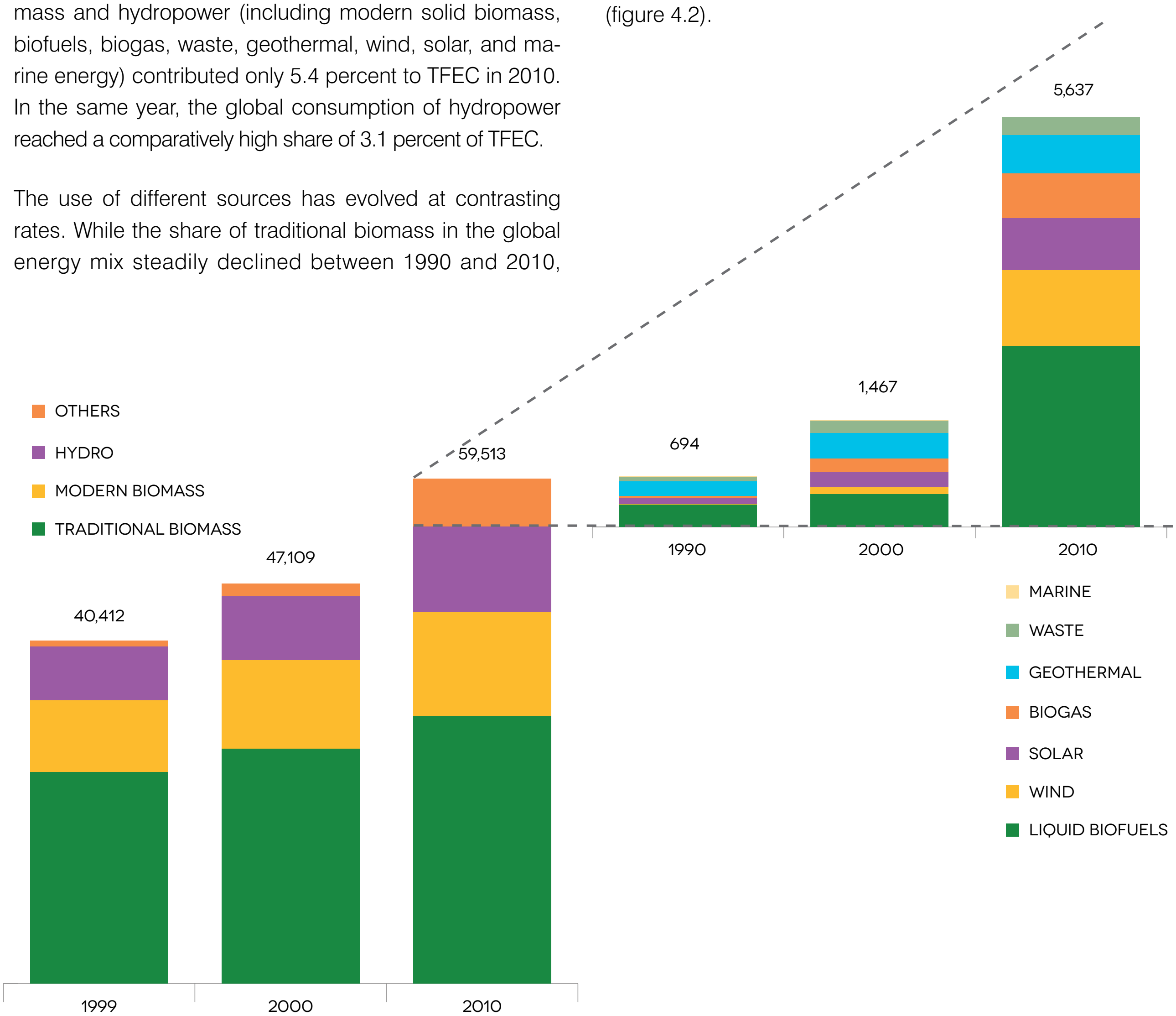


FIGURE 4.2 **EVOLUTION OF RENEWABLE FINAL ENERGY CONSUMPTION (PJ)**

SOURCE: AUTHORS' ANALYSIS BASED ON IEA 2012D.

Indeed, over the past ten years the use of renewable energy sources other than biomass and hydro almost quadrupled at the global level. Wind, biogas, and solar exhibited the most dramatic growth in both absolute and relative terms, growing at 25, 16.7, and 11.4 percent CAGR, respectively (as illustrated in figure 4.3). The impressive scale-up in the use of these sources is largely attributed to the provision of sustained policy incentives that triggered high investment volumes and remarkable reductions in technology costs.

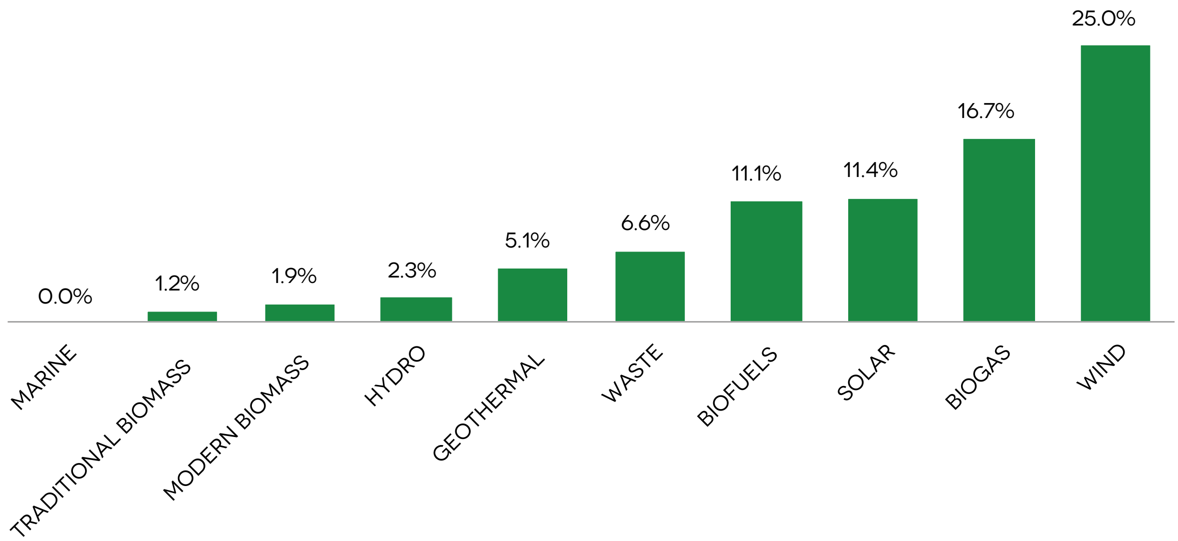


FIGURE 4.3 **COMPOUNDED ANNUAL GROWTH RATES (CAGR) OF RENEWABLE ENERGY TFEC BY SOURCE, 1990–2010**

SOURCE: AUTHORS' ANALYSIS BASED ON IEA 2012D.

Renewable energy sources are used for heating, electricity, and transport. Renewables for heating (cooking, space, and water heating) accounted for 75 percent of all renewable energy use in 2010, with biomass contributing 96 percent of this share.[9] Commercial-scale heating, in particular, increased rapidly between 1990 and 2010, although it still represented only 1 percent of total heating consumption by the end of 2010. Indeed, the use of modern renewable energy technologies for heating and cooling is still limited relative to their potential for meeting global demand.

Despite its significant share, renewable energy for heating declined 7.5 percent over the period 1990-2010. This trend may be also partially attributed to substitution of traditional for more modern sources of energy. The CAGR associated with the global use of biomass for heating between 1990 and 2010 is estimated at only 1.3 percent, while those of geothermal and solar thermal for heating reached 6.7 and 10.6 percent respectively.

The share of renewable energy in electricity production fluctuated between 1990 and 2010, decreasing from 19.5 percent in 1990 to a low of 17.5 percent in 2003, and then rebounding to 19.4 percent in 2010. The reason for the decline between 1990 and 2000, despite the absolute growth, is that electricity demand grew at a faster pace than renewable energy. Hydropower contributed 83 percent to this global share, followed by wind-based generation, which accounted for a little more than 8 percent. All other sources combined accounted for about 10 percent of total renewable-source-based electricity supply in 2010 (figure 4.4a).

25% GROWTH
– THE COMPOUND ANNUAL GROWTH
RATE OF WIND ENERGY OVER THE PERIOD 1990–2010.

While the historic share of renewable energy in electricity production was relatively flat through 2010, more recent trends suggest that it may be increasing. Renewables accounted for almost half of the estimated 208 gigawatts (GW) of new electric capacity added globally during 2011. Wind and solar photovoltaic (PV) accounted for almost 40 percent and 30 percent of new renewable capacity, respectively, followed by hydropower (nearly 25 percent). By the end of 2011, total renewable power capacity worldwide exceeded 1,360 GW, up 8 percent over 2010; renewables comprised more than 25 percent of total global power-generating capacity (estimated at 5,360 GW in 2011) and supplied an estimated 20.3 percent of global electricity. Renewable technologies are also expanding into new markets. In 2011, around 50 countries installed wind power capacity, and solar PV capacity is moving rapidly into new regions and countries. Solar hot water collectors are used

[9] Traditional biomass alone contributed approximately 70 percent to the share of renewable energy sources used for heating.

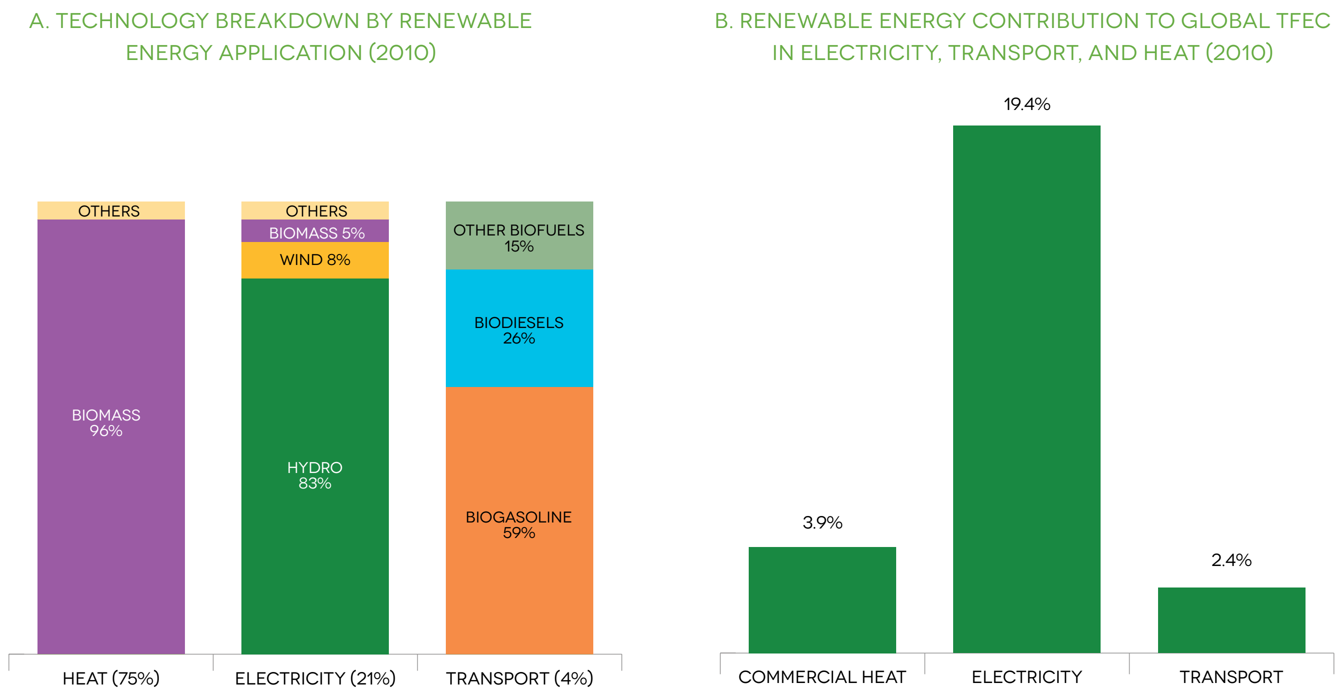


FIGURE 4.4 **RENEWABLE ENERGY APPLICATIONS**

NOTE: BIOMASS INCLUDES PRIMARY SOLID BIOFUELS AND CHARCOAL. BIOGASOLINE INCLUDES BIOETHANOL, BIOMETHANOL, BIOETBE, AND BIOMTBE AND "OTHER BIOFUELS" INCLUDES THOSE THAT CANNOT BE SPECIFIED AS EITHER BIOGASOLINE OR BIODIESEL DUE TO LACK OF DATA. COMMERCIAL HEAT REFERS TO HEAT PRODUCED FOR SALE BY COMBINED HEAT AND POWER (CHP) AND HEAT PLANTS. TFEC = TOTAL FINAL ENERGY CONSUMPTION.
SOURCE: AUTHORS' ANALYSIS BASED ON IEA 2012D.

by more than 200 million households, as well as in many public and commercial buildings around the world. Interest in geothermal heating and cooling is also on the rise globally, as is the use of modern biomass for energy purposes.

The contribution of renewable energy to global final consumption in commercial heat—mainly combined heat and power—and transport reached 3.9 and 2.4, respectively, in 2010 (figure 4.4b).

Renewable energy is used in the transport sector in the form of gaseous and liquid biofuels; liquid biofuels provided about 3.3 percent of global road transport fuels in 2010-11, more than any other renewable energy source in the transport sector.[10] Electricity powers trains, subways, and a small but growing number of passenger cars and motorized cycles, and there are limited but increasing initiatives that link electric transport with renewable energy.

But despite the remarkable growth of wind, biogas, solar, geothermal, and smaller renewable-source-based developments, the overall share of renewable energy in TFEC remained relatively stable between 1990 and 2010 because of the central role of traditional biomass, which accounted for about 53 percent of the renewable energy share of TFEC in 2010 (figure 4.5).

50%
OF NEWLY INSTALLED POWER GENERATION
IN 2011 CAME FROM RENEWABLE SOURCES.

Global TFEC increased from 243 to 330 exajoules (EJ) over that period, at a CAGR of 1.5 percent. Meanwhile, the consumption of renewable energy increased from 40 to about 60 petajoules (PJ), at 2 percent annually.

[10] Road transport is a subcategory of total transport shown on figure 4.4b, with the latter also including rail, pipeline, navigation, aviation, and other nonspecified transport categories. It is important to note that most biofuels are used in road transport.

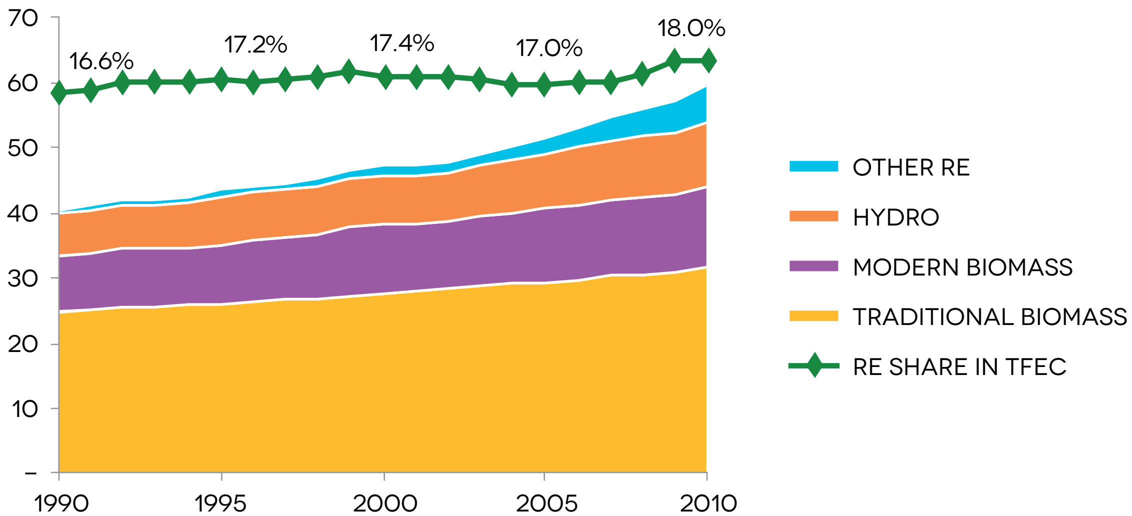


FIGURE 4.5 **GLOBAL TFEC (PJ) VS. SHARE OF RENEWABLE ENERGY (%)**

NOTE: TFEC = TOTAL FINAL ENERGY CONSUMPTION.
SOURCE: AUTHORS' ANALYSIS BASED ON IEA 2012D.

Global trends by region

The evolution of the share of renewable energy in regional TFECs has been influenced by a number of factors, including growth in overall energy consumption, trends in the use of traditional biomass, and growth in the production of renewable energy other than traditional biomass and hydropower per se.

The regional share of renewable energy between 1990 and 2010 increased in Europe, North America, and Sub-Saharan Africa but decreased in Latin America, Northern Africa, and most subregions of Asia (table 4.5).

The increased share of renewables in Europe has been attributed to the adoption of bold and sustained policy measures that triggered a large volume of investments primarily in renewable source-based initiatives other than hydropower, although this trend has also been influenced by a low growth in overall energy demand. In Europe renewables have directly displaced other sources of energy, most notably fossil fuels.

The share of renewables in Southern Asia and Sub-Saharan Africa is particularly high due to the use of traditional biomass, especially in the residential sector. But the share of renewables in Southern and Southeastern Asia declined significantly over the 1990–2010 period, in part owing to decreased reliance on traditional biomass for cooking and wider adoption of non-solid cooking fuels.

At the same time, the analysis of the data by income group reveals that traditional biomass is being consumed predominantly by middle-income economies, while renewable energy sources other than hydro and traditional biomass are primarily being consumed by upper-middle- and high-income countries (figure 4.6).

If we confine attention to power generation only, the regional picture for the share of renewable energy in the electricity mix looks quite different. Latin America and Caribbean emerges as the region with by far the highest share of renewable energy in the electricity generation portfolio of 56 percent, which is more than twice the level in the next highest regions – Caucuses and Central Asia, Europe, Oceania and Sub-Saharan Africa – all of them above 20 percent. Globally, 80 percent of renewable electricity generation is found evenly spread across just four regions: East Asia, Europe, Latin America and Caribbean and North America.

65% VS 20%
– THE SHARE OF GLOBAL TOTAL FINAL
ENERGY CONSUMPTION FROM RENEWABLE SOURCES CONTRIBUTED BY AFRICA AND ASIA VERSUS EUROPE AND NORTH AMERICA

REGION	SHARE OF RE IN EACH REGION			CONTRIBUTION TO GLOBAL SHARE		
	1990	2000	2010	1990	2000	2010
North America	6.0	7.1	9.0	8.1	9.8	9.7
Europe	8.1	9.4	14.1	7.6	8.2	10.0
Eastern Europe	3.0	4.2	5.4	2.9	2.3	2.4
Caucasus and Central Asia	3.1	5.2	4.4	0.5	0.4	0.3
Western Asia	8.2	5.8	4.3	1.1	0.9	0.9
Eastern Asia	22.2	19.1	15.3	23.2	20.8	19.9
Southeastern Asia	52.2	37.9	31.1	8.8	8.5	7.7
Southern Asia	50.9	43.4	34.8	18.1	17.5	16.4
Oceania	15.0	15.6	15.1	1.1	1.2	1.0
Latin America and Caribbean	32.3	28.2	29.0	10.7	10.4	10.7
Northern Africa	6.5	6.2	5.0	0.3	0.3	0.3
Sub-Saharan Africa	72.5	74.6	75.4	17.7	19.8	20.7
World	**16.6**	**17.4**	**18.0**	**100.0**	**100.0**	**100.0**

TABLE 4.5 **REGIONAL CONTRIBUTION TO THE SHARE OF RENEWABLES IN TFEC (AFTER ALLOCATION) (%)**

SOURCE: AUTHORS' ANALYSIS BASED ON IEA 2012D.

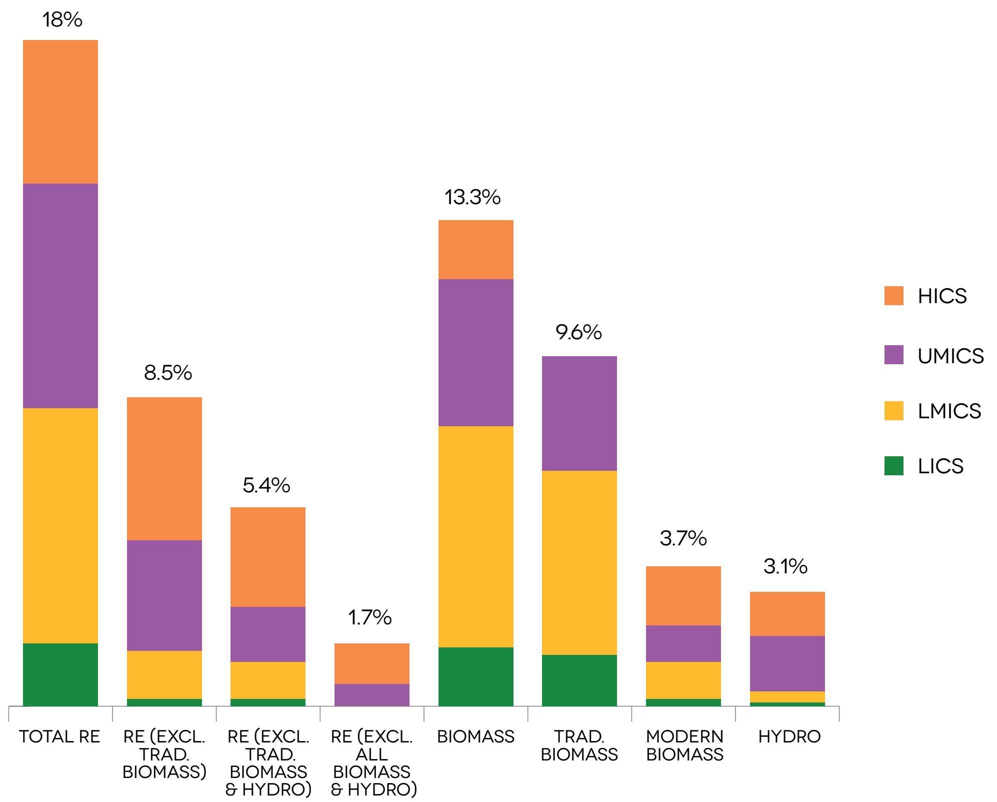


FIGURE 4.6 **CONTRIBUTIONS TO THE SHARE OF RENEWABLE ENERGY IN TFEC BY SOURCE AND INCOME GROUP, 2010**

SOURCE: AUTHORS' ANALYSIS BASED ON IEA 2012D.
NOTE: HICS = HIGH-INCOME COUNTRIES; LICS = LOW-INCOME COUNTRIES; LMICS = LOWER-MIDDLE-INCOME COUNTRIES; UMICS = UPPER-MIDDLE-INCOME COUNTRIES.

Trends in relevant indicators

Policies and dramatic technology cost reductions have driven renewable energy investment and market development in unanticipated ways. This subsection discusses general trends in renewable energy policy, technology progress, investment, and deployment diversification.

Policies to promote renewable energy development

Policy makers are increasingly aware of renewable energy's wide range of benefits, including energy security, reduced import dependency, reduction of GHG emissions, prevention of biodiversity loss, improved health, job creation, rural development, and energy access, leading to closer integration of renewable energy policy with policies in other economic sectors in some countries. Globally there are more than 5 million jobs in renewable energy industries, and the potential for job creation continues to be a main driver of renewable energy policies (REN21 2012).

To a large extent, policy incentives targeting different stages of the technology innovation and market development chain have driven the remarkable growth of renewable energy other than hydropower. Policy instruments include targets and a combination of economic, fiscal, and financial incentives.

Renewable energy targets have increasingly been adopted around the world over the past few years. Today, about 120 countries have a national target on renewable energy, more than half of which are developing countries (REN21 2012).

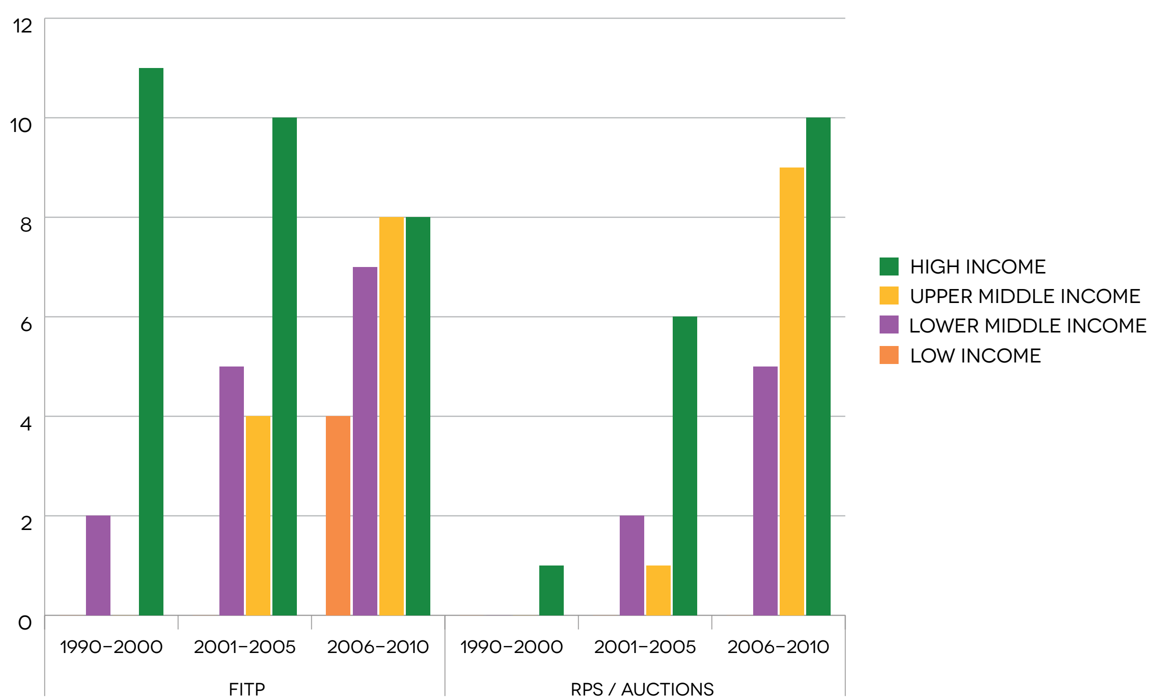


FIGURE 4.7 **NUMBER OF COUNTRIES INTRODUCING PRICE AND QUANTITY SETTING INSTRUMENTS**

SOURCE: REN21 2012.
NOTE: FITP = FEED–IN TARIFF POLICY; RPS = RENEWABLES PORTFOLIO STANDARD.

Indeed, developed and emerging economies have accumulated years of experience with the design and implementation of various types of policy instruments, including price-setting mechanisms and policies that impose a quota and introduce competitive bidding or auctions. In particular, feed-in tariff policies have been necessary to lower the range of risks associated with the introduction of capital-intensive technologies and the development of new markets.

Increasingly, low- and middle-income countries are adopting price/quantity setting instruments in combination with fiscal and financial incentives to promote different segments of the renewable energy market (figure 4.7). Even oil- and gas-exporting economies such as Saudi Arabia and the Gulf States are beginning to introduce incentives to develop renewable energy, with the intention of lowering domestic consumption of fossil fuels and developing industrial capacity for the manufacture of renewable energy equipment.

Most recently, however, policy support for renewable energy weakened in Europe due to the economic crisis and associated austerity measures. As a result, efforts have increased to improve the effectiveness and economic efficiency of policy incentives, especially in countries with a long track record of their implementation (box 4.1 discusses the issue of policy performance).

BOX 4.1 Policy effectiveness and economic efficiency

Between 1990 and 2010, many countries, especially developed and emerging economies, introduced a combination of economic, fiscal, and financial incentives to promote renewable energy development. Policy makers and regulators have gradually learned that the choice of policy mechanism, the features of policy design, the setting of tariff levels, and the compatibility of different instruments are all crucial aspects of an effective and economically efficient regime.

Indeed, policy and regulatory frameworks have been repeatedly reformed and adjusted in most countries that have introduced renewable energy policies. For example, almost all countries using feed-in tariffs to promote one or many segments of the renewable energy market— different types of technologies, project scales, or geographic areas— have successively adjusted the tariff levels to avoid high infra-marginal rents and policy costs or subsidy volumes. In this process, countries have introduced automatic adjustment mechanisms and other design features to ensure that the cost to taxpayers or consumers is acceptable while also lowering regulatory uncertainty for potential investors.

The design of auction mechanisms to competitively determine the price of renewable energy has also required adjustments to avoid speculative behavior and ensure the construction of plants (for example, bid bonds, guarantees on project completion, penalties on construction delays, and so on).

The use of price- and quota-based instruments is necessary in the absence of externality pricing. Today, many countries have adopted emissions trading frameworks and have also learned many lessons in the process of establishing carbon markets.

Ultimately, it is clear that a policy package needs to be not only effective in terms of the capacity deployed and electricity generated but also economically efficient—that is, delivered at the lowest possible cost while remaining sustainable and socially inclusive.

SOURCE: JACOBS 2012; ELIZONDO–AZUELA AND BARROSO 2011; IEA 2008.

Technology progress

On the technology development front, there has been continuous progress in efficiency, and cumulative experience has translated into increasingly cost-effective solutions. For instance, the investment cost of wind energy fell from $2,500/kilowatt (kW) in the mid-1980s to $630-1,270/kW in 2012, while the cost of PV systems fell from about $7,000/kW to $750–$1,100/kW over the same period (IRENA 2013b) (figure 4.9). Similar trends occurred in the sugarcane-based bioethanol industry (see learning curve in annex 2).

Today, many countries manufacture solar PV modules, although China, the United States, Japan, Canada, and Norway have the largest market shares (China supplies 30 percent of the global market volume). Wind turbines, on the other hand, are manufactured mainly by China, Denmark, the United States, Spain, Germany, and India.

About 30 GW of solar PV was installed globally every year between 2010 and 2012, bringing the total installed PV capacity from 40 GW to more than 100 GW (EPIA 2013). In addition, total wind power capacity reached over 282 GW globally in 2012, representing an increase of almost 20 percent from 2011 (GWEC 2013). The market expansion of renewable technologies in many regions of the world has also brought considerable cost reductions. For instance, the cost of solar PV modules dropped by 42 percent in 2011 while the cost of onshore wind turbines fell by 10 percent.

FIGURE 4.8 **LEARNING CURVES FOR WIND AND SOLAR PV MODULES**

▲ SOLAR THIN FILM PANEL – CDTE (IRENA 2012) ◆ SOLAR PANEL CRYSTALINE C-SI – CDTE (IRENA 2012) ● ONSHORE WIND POWER PLANTS (US) (IPCC 2011)

SOURCE: IRENA ANALYSIS WITH DATA FROM EPIA AND PHOTOVOLTAIC TECHNOLOGY PLATFORM (2011), IPCC (2011), BAZILIAN AND OTHERS (2012), AND SOLOGICO (2012).
NOTE: PV = PHOTOVOLTAIC.

Critical for the widespread integration of renewable energy sources into power systems will be the introduction of technologies, operational protocols, and practices to manage the issue of variability. This can involve a number of options, including more flexible generation from nonvariable sources (renewable and fossil), grid extension, demand-side management, and storage. Although energy storage solutions are in different stages of development, they are quickly progressing along the technology development path (IRENA 2012, Chen and others 2009) (box 4.2).

Technology innovation has played a critical role in the development and commercialization of renewable energy solutions. According to BNEF, UNEP, and Frankfurt School (2012), despite the fact that corporate research and development (R&D) in renewable energy has decreased over the past few years, venture capital and government R&D increased substantially between 2004 and 2011 (with CAGRs of 30 and 14 percent, respectively).

BOX 4.2 Electricity storage

At present, the only commercial storage option is pumped hydro power by which surplus electricity (for example, electricity produced overnight by base-load coal or nuclear power) is used to pump water from a lower to an upper reservoir. The stored energy is then used to produce hydropower during daily high-demand periods. Pumped hydro plants are large-scale storage systems with a typical efficiency between 70 percent and 80 percent, which means that a quarter of the energy is lost in the process.

Other storage technologies with different characteristics (that is, storage process and capacity, conversion back to electricity and response to power demand, energy losses and costs) are currently in demonstration or pre-commercial stages, including compressed air energy storage (CAES), flywheels, electrical batteries and vanadium redox flow cells, super capacitors, and superconducting magnetic storage. In addition, thermal energy storage is under demonstration in concentrating solar power (CSP) plants where excess daily solar heat is stored and used to generate electricity at sunset.

No single electricity storage technology scores high in all dimensions. The technology of choice often depends on the size of the system, the specific service, the electricity sources, and the marginal cost of peak electricity.

For example, pumped hydro currently accounts for 95 percent of the global storage capacity and still offers a considerable expansion potential but does not suit residential or small-size applications. CAES expansion is limited due to the lack of suitable natural storage sites. Electrical batteries have a large potential with a number of new materials and technologies under development to improve performance and reduce costs. Heat storage is practical in CSP plants. The choice between large-scale storage facilities and small-scale distributed storage depends on the geography and demography of the country, the existing grid and the type and scale of renewable technologies entering the market.

While the energy storage market is quickly evolving and expected to increase 20-fold between 2010 and 2020, many electricity storage technologies are under development and need policy support for further commercial deployment. Electricity storage considerations should be an integral part of any plans for electric grid expansion or transformation of the electricity system. Storage also offers key synergies with grid interconnection and methods to smooth the variability of electricity demand (demand-side management).

SOURCE: IRENA 2012.

Evolution of investment

BNEF reports that global investments in renewable -source-based power generation and fuels reached a record of $277 billion in 2011 (figure 4.10) (BNEF database 2012).[11] This was more than six times the figure for 2004 and almost twice the total investment in 2007, the last year before the acute phase of the recent global financial crisis.

In 2011 renewable-source-based power generation capacity (excluding large hydro) accounted for 44 percent of new generation capacity added worldwide, up from 34 percent in 2010. This increase in investment and capacity came at a time when the cost of renewable power equipment was falling rapidly. Furthermore, renewable energy technologies continued to attract investments despite overall uncertainty about economic growth and policy priorities in developed countries.

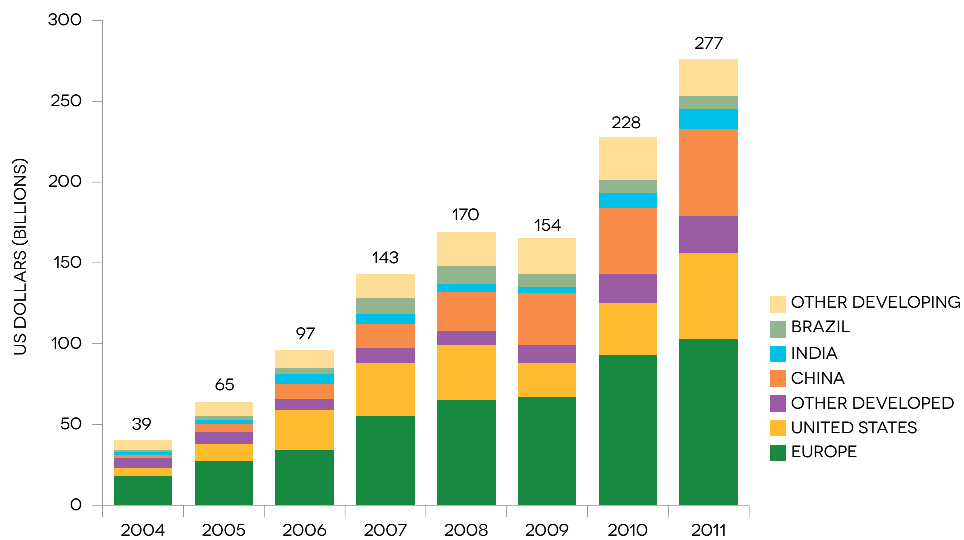


FIGURE 4.9 GLOBAL INVESTMENTS IN RENEWABLE ENERGY BY COUNTRY, 2004–2011 (US$ BILLION)

SOURCE: BNEF DATABASE 2013; BNEF, UNEP, AND FRANKFURT SCHOOL 2012.
NOTE: DATA INCLUDE INVESTMENTS IN HYDROPOWER PLANTS WITH CAPACITIES IN THE RANGE OF 1–50 MW. INVESTMENT DATA INCLUDE THE FOLLOWING CATEGORIES: ASSET FINANCE, PUBLIC MARKETS, VENTURE CAPITAL AND PRIVATE EQUITY, INVESTMENTS IN SMALL DISTRIBUTED CAPACITY, GOVERNMENT R&D, AND CORPORATE R&D

Developing countries, especially emergent economies, made up 35 percent of this total investment, compared to 65 percent for developed economies. Indeed, Brazil, China, and India together accounted for about $74 billion, or 27 percent of the total new investments in renewable energy globally in 2011 (BNEF, UNEP, and Frankfurt School 2012).

Renewable energy markets are also expanding into middle- and lower-income developing nations. In 2011 an estimated 8.4 percent of total new investments in renewable energy took place in developing countries outside large emergent economies, most notably in Thailand, Indonesia, Ukraine, Romania, Bulgaria, Turkey, and Costa Rica.

Overall, developed countries led the way in investments in solar initiatives, while developing economies had the upper hand in new investments in wind-based generation.

[11] Almost 90 percent of this investment went to either solar (57 percent) or wind-based projects (33 percent).

Deployment diversification

Development of newer renewable deployment—other than traditional biomass and hydropower—is becoming increasingly widespread, with growth shifting beyond traditional support markets in the developed world. The number of countries with cumulative renewable source–based electricity capacities above 100 megawatts (MW) increased significantly in the period 2005–2010. The number of countries with wind-based capacity above this threshold increased from 23 in 2005 to 38 in 2010. Solar has also seen a significant increase in terms of the number of countries that reached this threshold in these five years, growing from 3 to 15 countries in total. Biomass and waste also achieved a high level of capacity deployment, expanding by another 5 countries in 2005–2010.

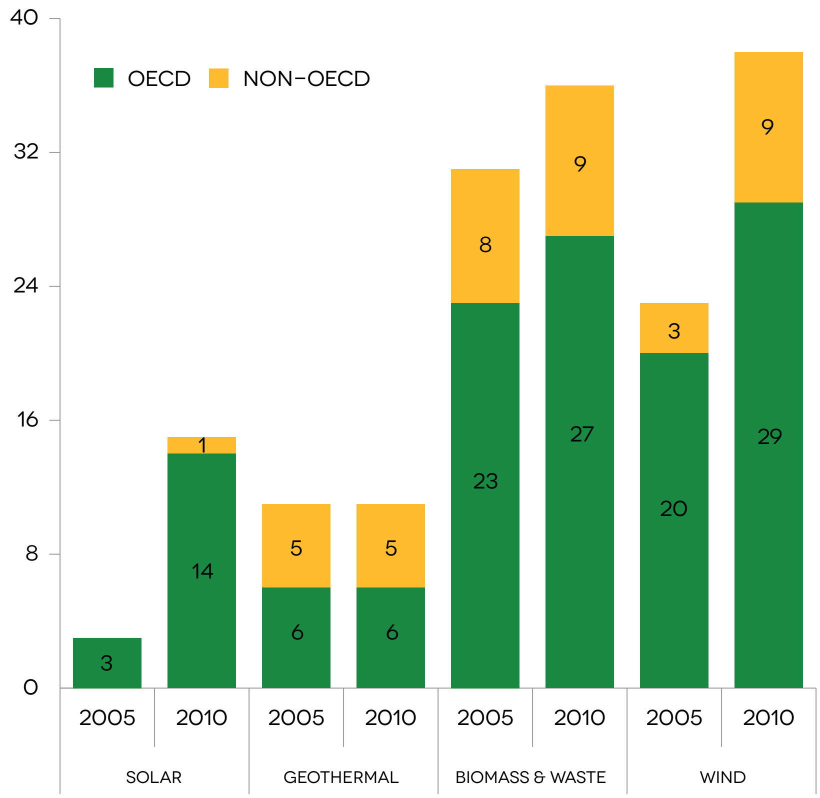


FIGURE 4.11 **NUMBER OF COUNTRIES WHOSE CUMULATIVE INSTALLED CAPACITY EXCEEDED 100 MW AS OF 2010**

SOURCE: EIA DATABASE (2012).
NOTE: OECD = ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT.

SECTION 3. COUNTRY PERFORMANCE

Key drivers for country support to renewable energy development

The introduction of renewable energy brings multiple benefits to society. Indeed, most countries deploying renewable energy are motivated by a combination of social objectives that vary depending on their economic conditions, resource endowments, and strategic priorities. This combination of objectives may include reducing greenhouse gas emissions and local environmental impacts, enhancing energy security, stimulating economic and industrial development, and increasing access to reliable, affordable, and clean modern energy services.

Many countries have strongly supported renewable energy as part of an *environmental and climate change policy* in addition to other social objectives. For instance, renewables play a key role in the climate change mitigation strategies of all EU member states, Norway, Australia, Mexico, India, and many others.

The overall contribution of renewable energy to *local environmental sustainability* has also driven many countries to introduce specific renewable energy policies, especially in nations where the consumption of traditional biomass or the use of fossil fuels results in acute air pollution levels, biodiversity loss, or deforestation. In Nepalese villages, for example, modern renewable energy systems have been deployed to mitigate the negative impacts on biodiversity and deforestation resulting from the unsustainable use of biomass. China, in particular, has explicitly aimed at increasing renewable energy to lower and avoid the regional and local environmental impacts of coal-based power generation. Many other countries have also explicitly supported renewables to reduce local environmental impacts.

At the same time, *energy security* is a key strategic priority of almost all nations. Renewable energy can improve security of supply in a variety of ways, including reducing dependence on imported fuels, contributing to technological and fuel diversification, hedging against fuel price volatility, and enhancing the national trade and fiscal balances. Since the early 1970s, for example, Brazil has promoted the production of ethanol from sugarcane to decrease dependency on imported fossil fuels for transport. Also, in many fuel-dependent countries where the avoided cost of power generation or heating is high, renewable energy represents a competitive alternative that comes without an incremental cost or additional burden on taxpayers or consumers.

Indeed, the justification of renewable energy deployment on economic grounds, including a solid understanding of the full range and valuation of benefits, is essential to policy making and regulatory design.

$277 BILLION
WAS SPENT ON
RENEWABLE ENERGY FINANCING
IN THE YEAR 2010.

A few high- and middle-income economies have also strongly focused on renewable energy to support economic *growth and job creation*. Denmark, Germany, China, and India among others have provided specific incentives to stimulate technology innovation, promote the domestic manufacture of renewable energy equipment, and create a local market for companies installing and developing renewable energy projects. Germany, for instance, has spent more on PV R&D than any other country in Europe, with the aim of growing a competitive export industry of components, final products, and manufacturing equipment (IPCC 2011).

Renewable energy can also contribute to *increasing energy access* in peri-urban and rural areas. Many developing countries (including, for example, Argentina, Bolivia, Brazil, Bangladesh, China, India, Sri Lanka, Tonga, and Zambia) have introduced energy access programs and policies to increase access to energy services with renewable-energy-based solutions.

Growth of renewable energy markets

Fast-moving countries

Renewable energy sources beyond traditional biomass and hydropower, including modern solid biomass, biofuels, biogas, waste, geothermal, wind, solar, and marine energy, contributed 5.4 percent to TFEC in 2010. About 97 percent of this volume was produced and consumed by high-income and emerging economies, most notably the United States, Europe, Japan, Brazil, China, and India.

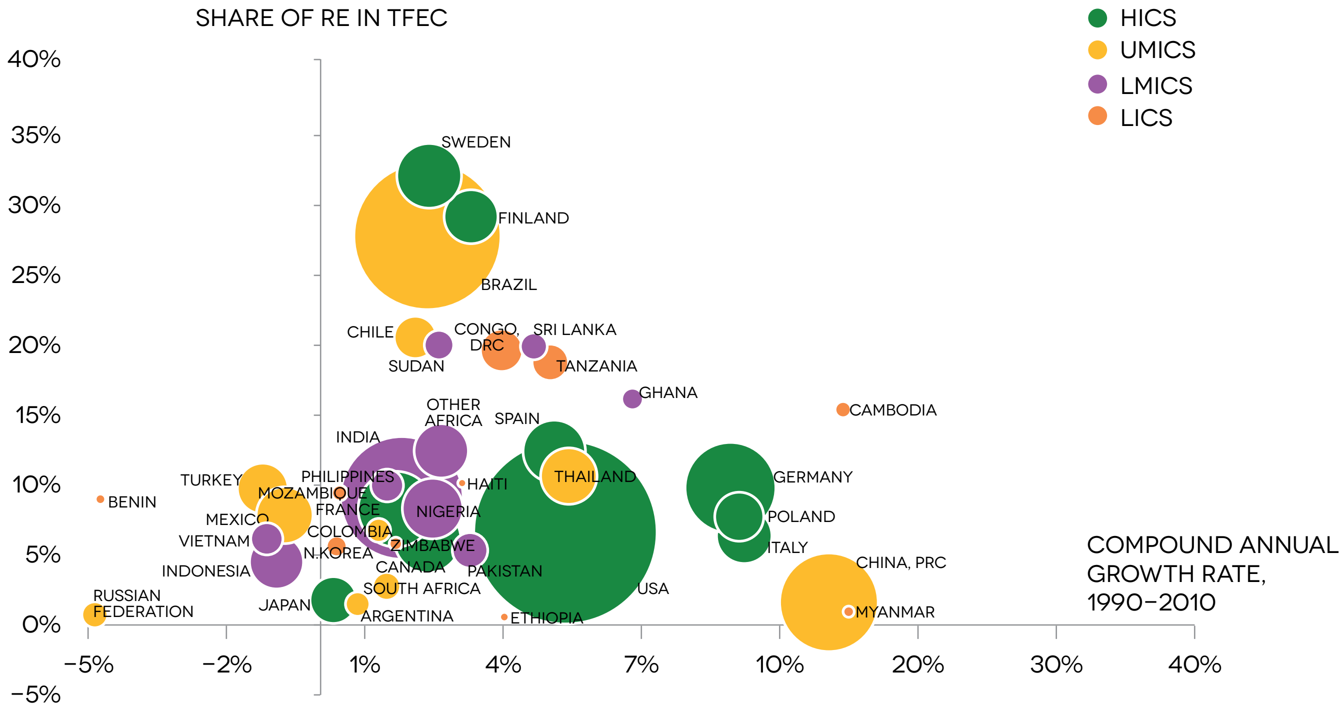


FIGURE 4.11 RENEWABLE ENERGY'S SHARE (EXCLUDING TRADITIONAL USE OF BIOMASS AND HYDRO-POWER) OF COUNTRY TFEC AND CAGR, 1990-2010

SOURCE: AUTHORS' ANALYSIS BASED ON IEA 2012D.
NOTE: FIGURE INCLUDES THE USE OF MODERN BIOMASS. (DRC AND TANZANIA APPEAR DUE TO THEIR HIGH USE OF MODERN BIOMASS IN THE INDUSTRIAL SECTOR). BUBBLE SIZE DEPICTS VOLUME IN TERMS OF PJ OF FINAL ENERGY CONSUMPTION. THE NEGATIVE CAGRS EXHIBITED IN TURKEY, MEXICO, INDONESIA, COLOMBIA, RUSSIA, AND BENIN ARE PRIMARILY DUE TO REDUCTION IN THE USE OF NON-TRADITIONAL SOLID BIOMASS (MOST NOTABLY IN INDUSTRY). TFEC = TOTAL FINAL ENERGY CONSUMPTION; CAGR = COMPOUND ANNUAL GROWTH RATE; DRC = DEMOCRATIC REPUBLIC OF CONGO.

Indeed, the development of these renewable energy markets has been led by a small group of pioneering countries that consistently introduced innovation on the technology, policy, and financing fronts in 1990–2010.

China, Germany, Italy, and Spain have rapidly increased their renewable-source-based consumption, while Sweden, Finland, and Brazil have achieved high shares of renewable energy in their total domestic consumption (as illustrated in figure 4.11).[12]

In hydropower Mozambique, China, Vietnam, Iceland, and Albania increased their consumption rapidly between 1990 and 2010, while China, Brazil, the United States, Canada, Norway, India and Russia maintained very high volume of consumption (figure 4.12).

[12] Bubble charts for each of the technologies considered are included in annex 3.

FIGURE 4.12 **SHARE OF HYDRO IN COUNTRY TFEC AND CAGR, 1990–2010**

SOURCE: AUTHORS' ANALYSIS BASED ON IEA 2012D.
NOTE: HICS = HIGH–INCOME COUNTRIES; LICS = LOW–INCOME COUNTRIES; LMICS = LOWER–MIDDLE–INCOME COUNTRIES; UMICS = UPPER–MIDDLE–INCOME COUNTRIES; TFEC = TOTAL FINAL ENERGY CONSUMPTION; CAGR = COMPOUND ANNUAL GROWTH RATE.

In 2010 the volume of renewable energy sources other than traditional biomass and hydropower consumed by Brazil, China, and India represented 76 percent of the volume consumed in the United States and European countries combined. When including hydro, these three emerging economies are among the top five renewable energy consumers in the world (as shown in figure 4.13).

China, in particular, has rapidly increased its hydro base in electricity and introduced bold industrial and renewable energy policies and strategies to promote the scale-up of wind-based electricity generation and solar PV.

The United States also stands out for the volume of renewable energy consumed, mainly due to its high consumption of biofuels (most in the form of corn-based bioethanol) and wind-based electricity generation. Brazil is ranked third in renewable energy consumption for its aggressive and pioneering support of sugarcane-based bioethanol production, its use of bagasse-based combined heat and power, and its high share of hydropower in electricity.

1,000 EJ
IS THE CUMULATIVE AMOUNT OF
RENEWABLE ENERGY SUPPLIED GLOBALLY BETWEEN 1990 AND 2010; EQUIVALENT TO THE CUMULATIVE FINAL ENERGY CONSUMPTION OF CHINA AND FRANCE OVER THE SAME PERIOD.

Table 4.6 lists the top five countries by region in terms of annual capacity additions in electricity from 2009 to 2010.

INCREMENTAL RENEWABLE ENERGY CONSUMPTION IN THE PERIOD 1990–2010 (PJ)

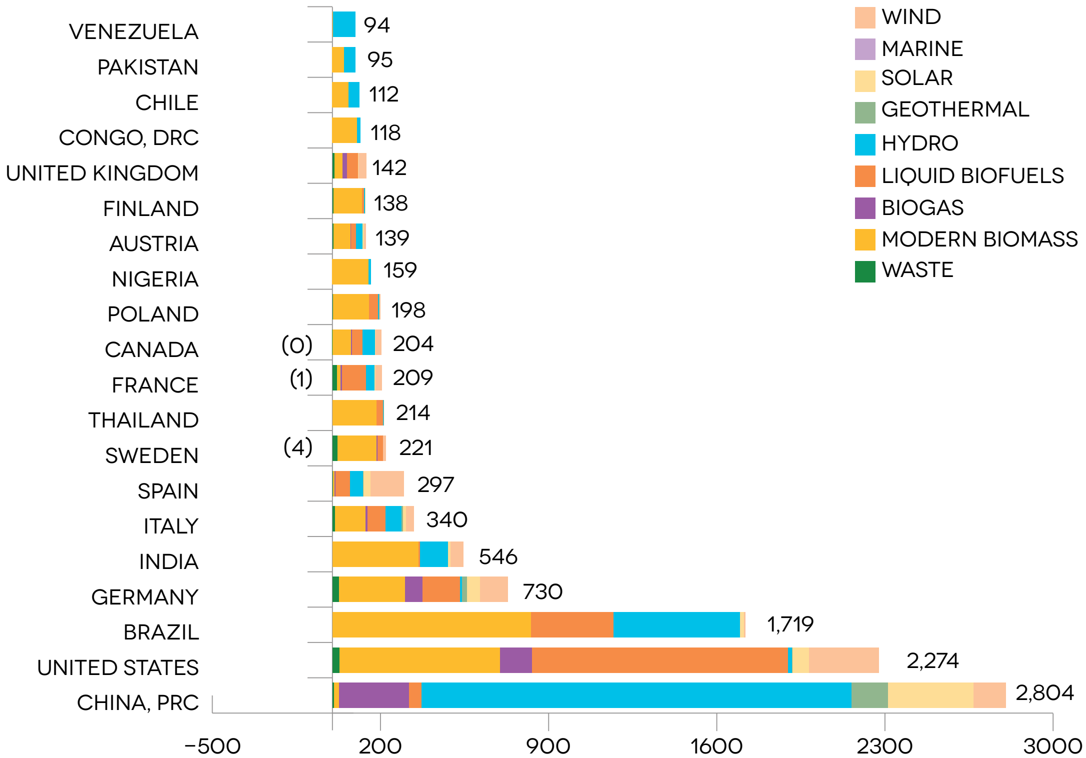


FIGURE 4.13 **TOP 20 COUNTRIES:** INCREMENTAL RENEWABLE ENERGY CONSUMPTION IN THE PERIOD 1990–2010 (PJ)

SOURCE: AUTHORS' ANALYSIS BASED ON IEA 2012D.
NOTE: FIGURE EXCLUDES TRADITIONAL BIOMASS. DRC = DEMOCRATIC REPUBLIC OF CONGO.

56%
OF ELECTRICITY GENERATION IN
LATIN AMERICA COMES FROM RENEWABLE SOURCES – HIGHER THAN ANY OTHER REGION OF THE WORLD

	HYDRO	WIND	SOLAR AND MARINE	GEO-THERMAL	BIOMASS AND WASTE	TOTAL
North America	Canada	United States	United States	United States	United States	United States
	United States	Canada	Canada		Canada	Canada
Europe	Germany	Spain	Germany	Italy	Germany	Germany
	Switzerland	Germany	Italy	Germany	Austria	Italy
	Italy	France	Spain		Italy	Spain
	Sweden	UK	France		UK	France
	Croatia	Italy	Belgium		Netherlands	UK
Eastern Europe	Bulgaria	Poland	Slovakia		Czech Rep.	Poland
	Ukraine	Bulgaria	Bulgaria		Poland	Bulgaria
	Slovakia	Hungary	Hungary		Slovakia	Hungary
	Romania	Czech Rep.	Poland		Hungary	Slovakia
	Czech Rep.	Romania	Romania			Romania
Caucasus and Central Asia	Armenia	Azerbaijan				Armenia
		Kazakhstan				Azerbaijan
						Kazakhstan
Western Asia	Turkey	Turkey	Israel	Turkey	Turkey	Turkey
		Israel	Cyprus		Israel	Israel
		Cyprus				Cyprus
Eastern Asia	China	China	Japan	Japan	China	China
	Japan	Japan	China		S. Korea	Japan
	S. Korea	S. Korea	S. Korea			S. Korea
Southeastern Asia	Philippines	Vietnam		Philippines		Philippines
	Laos	Thailand		Indonesia		Laos
	Myanmar					Myanmar
						Vietnam
						Indonesia
Southern Asia	India	India	Bangladesh		India	India
	Iran	Iran				Iran
	Nepal					Bangladesh
						Nepal
						Maldives
Oceania	Australia	Australia	Australia	N. Zealand		Australia
		N. Zealand				N. Zealand

	HYDRO	WIND	SOLAR AND MARINE	GEO-THERMAL	BIOMASS AND WASTE	TOTAL
Latin America and Caribbean	Brazil	Brazil	Mexico		Brazil	Brazil
	Ecuador	Mexico			Chile	Ecuador
	Peru	Chile				Peru
	Guatemala	Dominica				Chile
	Panama	Nicaragua				Guatemala
Northern Africa	Algeria	Egypt				Egypt
		Morocco				Morocco
		Tunisia				Tunisia
						Algeria
Sub-Saharan Africa	Ethiopia	Kenya			Uganda	Ethiopia
	Sierra Leone	S. Africa				Sierra Leone
	Uganda	Eritrea				Uganda
	Kenya					Kenya
	Guinea					Guinea
World	China	China	Germany	N. Zealand	Brazil	China
	Brazil	United States	Italy	Italy	China	Germany
	Turkey	India	Japan	United States	Germany	United States
	India	Spain	Spain	Turkey	Austria	Italy
	Ethiopia	Germany	France	Philippines	India	India

TABLE 4.6 **TOP FIVE COUNTRIES IN ANNUAL CAPACITY ADDITIONS, 2009–2010, BY REGION**

SOURCE: U.S. ENERGY INFORMATION ADMINISTRATION DATABASE 2012.

In addition to these pioneering countries, many others have begun to introduce renewable energy for several reasons, most notably energy security and local environmental sustainability.

In Africa, for instance, countries such as Kenya, Uganda, Ethiopia, Mali, and Tanzania are consistently progressing toward the deployment of renewable energy. Other developing nations, such as Bangladesh, Honduras, Nepal, and Maldives, are also working toward assessing the magnitude of their renewable energy resource potential.

62%
OF TOTAL FINAL ENERGY CONSUMPTION
IN AFRICA COMES FROM RENEWABLE SOURCES – HIGHER THAN ANY OTHER REGION OF THE WORLD

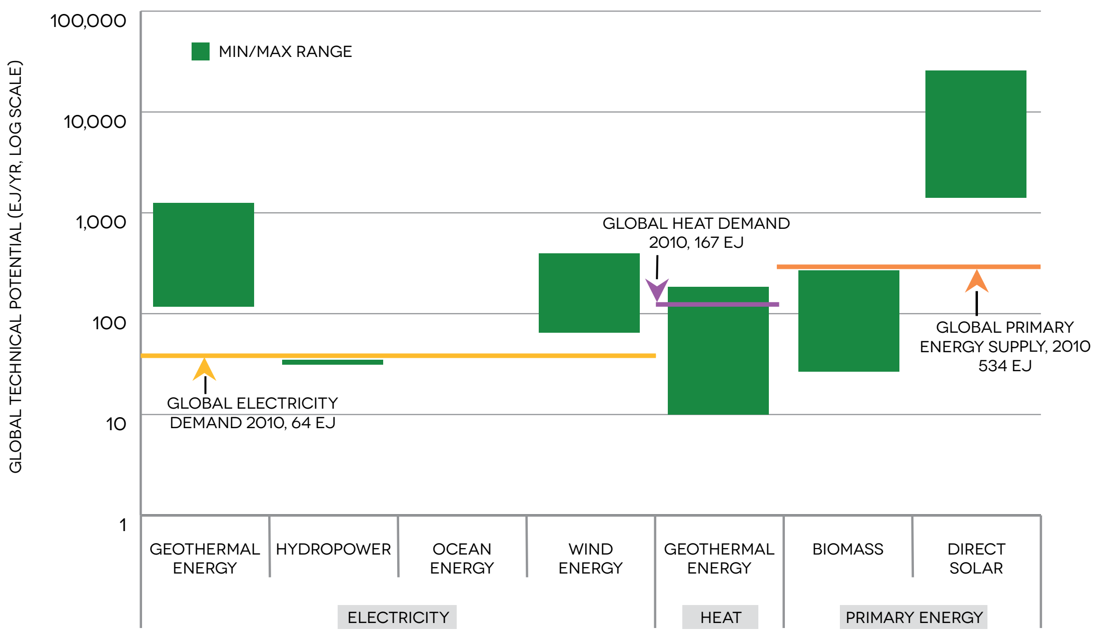


FIGURE 4.14 **ESTIMATED GLOBAL TECHNICAL RE POTENTIAL**

SOURCE: IPCC 2011.

High-impact opportunities

Technical potential

Technical studies have consistently found that total global technical potential for renewable energy is substantially higher than global energy demand projected to 2050 (IPCC 2011) (figure 4.14). Technical potential for solar energy is the highest among renewable energy sources, but substantial potential also exists for biomass, geothermal, hydro, wind, and ocean energy.

Available data suggest that most of this technical potential is located in the developing world (figure 4.15 and table 4.7). For instance, at least 75 percent of the world's unexploited potential in hydropower is located in Africa, Asia, and South America, and about 65 percent of total geothermal potential is found in non-OECD countries (IJHD 2011; IPCC 2011). Also, many developing nations are located in the solar belt, the area with the highest solar irradiance across the globe.

Clearly, the challenge will be to capture and utilize a sizable share of this vast global technical potential in a cost-effective and environmentally and socially sound manner.

Meeting a higher share of global consumption with renewable energy sources will pose important technical challenges. For instance, scaling up the use of renewable energy will require the proactive planning of transmission systems, often on a broader regional scale, to allow for optimization of sources and balancing of variability. In fact, regional integration can allow increased resource use efficiency due to seasonal and dispatching complementarities (for example, among hydro, wind and solar resources). This can be particularly important in regions with a high potential for large hydropower (for example, South Asia), or regions where resource endowments exhibit high complementarities (for example, East Africa).

At the same time, the parallel deployment of energy efficiency measures that reduce peak demand on the grid while easing transmission losses and bottlenecks will help make renewable energy objectives more attainable. Indeed, energy systems will need to be planned and operated with both the use of renewable sources and deployment of energy efficiency measures in mind.

75%
OF THE WORLD'S UNEXPLOITED
POTENTIAL IN HYDROPOWER IS LOCATED IN AFRICA, ASIA AND SOUTH AMERICA.

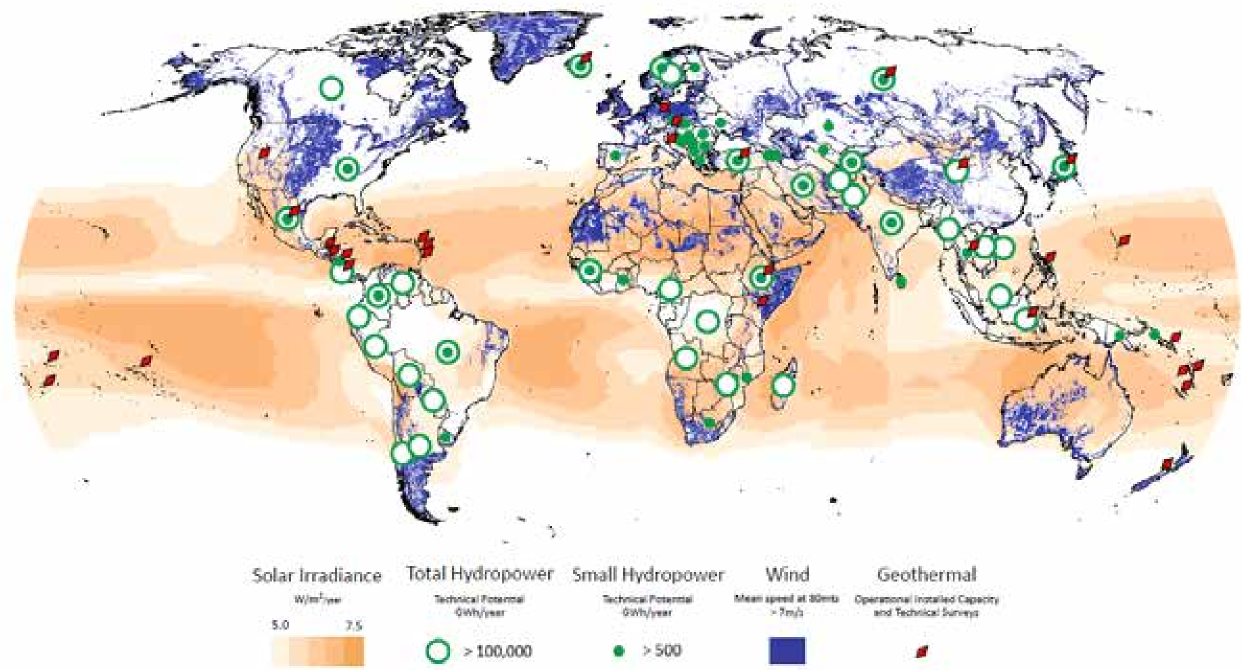


FIGURE 4.15 **HOT SPOTS: POTENTIAL FOR HYDRO, SOLAR, WIND, AND GEOTHERMAL**

SOURCE: MAP PREPARED BY AUTHORS WITH DATA FROM ÁSMUNDSSON 2008; IJHD 2011; IPCC 2011; MCCOY–WEST AND OTHERS 2011; UNEP AND NREL/U.S. DOE 2012.

The following table lists countries with high potential for renewable energy development by region and source.

REGION	SOLAR	WIND	GEOTHERMAL	LARGE HYDROPOWER[a]	SMALL HYDROPOWER[b]
EUR	Greece, southern Italy, southern Portugal and Spain	Iceland, Baltic Countries, Corsica, northern Spain, northern Europe, Scandinavia, southern France, southern Italy, Switzerland, the United Kingdom	Austria, France, Germany, Iceland, Italy, Portugal	Italy, Norway, Sweden	Bosnia and Herzegovina, Croatia, Estonia, Finland, Greece, Ireland, Latvia, Luxembourg, Macedonia (FYROM), Montenegro, Norway, Poland, Serbia, Spain
EE		Balkan countries, Russia, Ukraine	Russia		Hungary, Ukraine, Romania, Russia, Slovak Republic, Bulgaria, Czech Republic
CCA		Kazakhstan, Tajikistan, Turkmenistan, Uzbekistan		Georgia, Kyrgyzstan, Tajikistan,	Armenia, Azerbaijan, Georgia, Kazakhstan, Tajikistan, Uzbekistan
WAS	Central China, Iraq, Arabian Peninsula, India, Turkey	Black Sea countries (Turkey), Urals region (Russia),	Tonga, Turkey	Iraq, Turkey	Israel,Turkey
EAS		Southwestern China, northeastern China, Japan, Mongolia	China, Japan	Japan, China, Mongolia	Japan, Taiwan

REGION	SOLAR	WIND	GEOTHERMAL	LARGE HYDROPOWER[a]	SMALL HYDROPOWER[b]
SEA		Parts of Indonesia	Indonesia, Philippines, Thailand	Cambodia, Indonesia, Laos, Malaysia, Myanmar, Vietnam	Philippines, Thailand
SAS	Eastern Iran, southern Pakistan	India, Nepal, Pakistan		Afghanistan, Bhutan, India, Iran, Nepal, Pakistan,	India, Iran, Pakistan, Sri Lanka
NAF	Algeria, Egypt, Lybia, Morocco	Algeria, Egypt			Egypt
SSA	Saharan countries (particularly Mauritania, Mali, Niger, Chad, Sudan), eastern Africa (Somalia and Ethiopia), southern Africa (particularly Namibia, South Africa, and Botswana)	Central Chad, eastern Africa, Madagascar, Namibia, western Sahara, Somalia, South Africa, Sudan	Ethiopia, Kenya	Angola, Ethiopia, Cameroon, Congo, Gabon, Guinea, Madagascar, Mozambique, Zimbabwe	Burkina Faso, Burundi, Cameroon, Central African Republic, Chad, Ethiopia, Ghana, Guinea, Mauritius, Mozambique, Namibia, South Africa, Sudan, Uganda, Zambia
NAM	Southwestern North America (the U.S. Southwest, the northwest and Yucatan Peninsula of Mexico)	Alaska, central North America (the United States, Canada), Greenland, northeastern North America (the United States, Canada)	Mexico, United States	Canada, Mexico, United States	Mexico, United States
LAC	Andean region (Peru, Bolivia, Ecuador, northern Chile), Caribbean islands, El Salvador, Guatemala, Nicaragua, northeastern Brazil	Central America, northeastern Brazil, Patagonia (Argentina, Chile)	Costa Rica, Dominica, El Salvador, Guatemala, Nicaragua, St. Kitts and Nevis, St. Vincent and the Grenadines	Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Ecuador, Paraguay, Peru, Venezuela	Belize, Brazil, Colombia, Dominica, El Salvador, Grenada, Honduras, Nicaragua, Panama, Suriname, Uruguay
Oceania	Australia, Indonesia, Philippines	Australia and New Zealand (southwest, northeastern coastal zones, and Tasmania), parts of Papua New Guinea	Australia, Fiji, French Polynesia, New Zealand, New Caledonia, northern Mariana Islands, Papua New Guinea, Samoa, Solomon Islands, Vanuatu	Australia, New Zealand	New Caledonia, French Polynesia, Papua New Guinea

TABLE 4.7 **HOT SPOTS: COUNTRIES WITH HIGH POTENTIAL IN RENEWABLE ENERGY (AS SUGGESTED FROM AVAILABLE DATA)**

SOURCE: ÁSMUNDSSON 2008; IJHD 2011; IPCC 2011; MCCOY–WEST AND OTHERS 2011; UNEP AND NREL/U.S. DOE 2012.

NOTE: CCA: CAUCASUS AND CENTRAL ASIA; EAS: EASTERN ASIA; EEU: EASTERN EUROPE; EUR: EUROPE; LAC: LATIN AMERICA AND CARIBBEAN; NAF: NORTHERN AFRICA; NAM: NORTH AMERICA; OCEANIA: OCEANIA; SAS: SOUTHERN ASIA; SEA: SOUTHEASTERN ASIA; SSA: SUB–SAHARAN AFRICA; WAS: WESTERN ASIA.

a. Total hydropower for countries with technical potential greater than 100,000GWh/yr.

b. Definitions of small hydropower vary by country but are generally in the range of 5–30 MW.

Economic potential

Renewable energy is becoming increasingly competitive when compared to fossil-fuel-based alternatives (figure 4.16). For instance, the levelized costs of small- and large-scale hydropower and on-shore wind are already in the same cost range as fossil-fuel-fired electricity generation. When the resource potential or quality is high, biomass and geothermal-based power generation may also exhibit competitive costs, especially in non-OECD countries. In particular, a recently dominant feature of renewable energy market dynamics has been the falling price of photovoltaic modules, which are making this technology more competitive. Solar PV is on grid-parity in areas with very high solar irradiance, such as North Africa, Saudi Arabia and Australia.

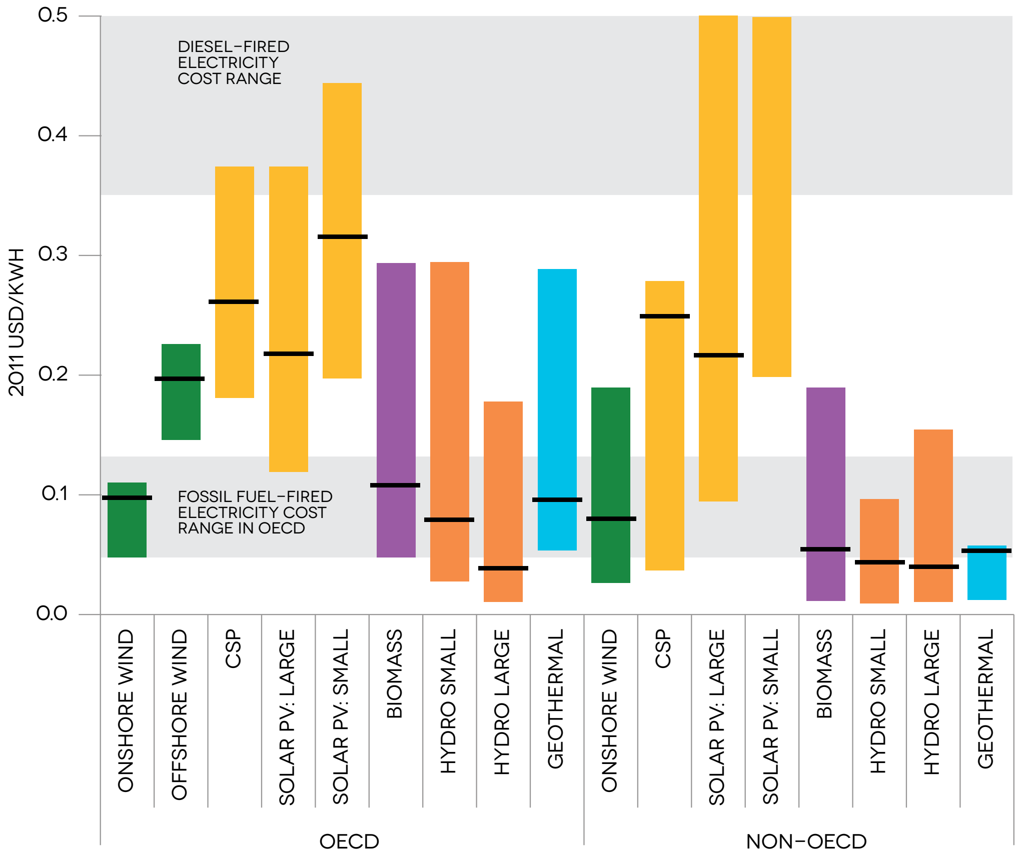


FIGURE 4.16 **LEVELIZED COSTS OF POWER GENERATION, 2012**

SOURCE: IRENA 2013B
NOTE: LEVELIZED COST REPRESENTS THE PER KILOWATT-HOUR COST OF BUILDING AND OPERATING A GENERATING PLANT OVER AN ASSUMED FINANCIAL LIFE AND DUTY CYCLE. WHILE LEVELIZED COSTS ARE A CONVENIENT SUMMARY MEASURE OF THE OVERALL COMPETITIVENESS OF DIFFERENT GENERATING TECHNOLOGIES, THE MEASURE DOES NOT COVER THE OVERALL SYSTEM COSTS. THE FULL COST OF INTRODUCING DIFFERENT GENERATION OPTIONS (ESPECIALLY VARIABLE) DEPEND ON THE SPECIFIC CONDITIONS OF THE SYSTEM; FOR EXAMPLE, THE EXTENT TO WHICH VARIABLE SOURCES MATCH THE DEMAND PROFILE AND COMPLEMENT THE MIX OF EXISTING SOURCES AND TECHNOLOGIES.

At the same time, renewables are competitive in countries vulnerable to high and volatile oil prices or those with high electricity prices; this is especially true in net-oil-importing countries particularly landlocked countries and SIDS. For instance, all countries in Central America and the Caribbean are net oil importers. In both subregions, oil provides more than 90 percent of primary energy needs and supplies more than half of power generation. The impact of oil price levels and changes on power generation costs is significant in these countries, and so electricity tariffs are very high. For example, the average residential tariff in Central America for consumption of 100 kWh reached 15 cents/kWh in 2010 (CEPAL 2011). In this subregion, only 9 percent of power generation is supplied by renewables other than hydropower, mainly geothermal, but also wind (CEPAL 2011).

In West Africa, where many countries are net oil importers, residential electricity tariffs are in the range of 15–30 cents/kWh (for consumption of 100 kWh), mainly due to high oil prices and the need to use emergency thermal generation (Briceño-Garmendia and Shkaratan 2011). In Uganda the levelized cost of diesel-HFO-based thermal generation is roughly 20–25 cents/kWh, much higher than the costs of biomass, small hydropower, or wind-based generation (estimated at 8 cents, 10 cents, and 12.4 cents per kWh, respectively). In countries with such problems, renewable energy has the potential to play a key role in hedging against high and volatile fuel oil prices.

Indeed, more than 55 developing economies exhibit high oil dependencies with imports supplying at least 50 percent of their domestic consumption needs. At the same time, almost all of the 53 small island developing states (SIDS) are completely dependent on oil and gas.[13] Even when considering the diversity of available fuels and energy sources, developing countries are more vulnerable (see Figure 4.17).

The competitiveness of renewable energy still depends on its relative cost vis-à-vis fossil fuels. Today, fossil fuels benefit from huge subsidies of around $523 billion annually around the world, while renewable energy support stands at just $88 billion (IEA 2012c). Phasing out fossil fuel subsidies while incorporating carbon-pricing mechanisms that fully reflect the externality cost of fossil-fuel-based energy would be critical steps toward accelerating the scale-up of renewable energy.

Nevertheless, levelized cost comparisons between variable sources of renewable energy (notably wind and solar) and others (such as large hydro, geothermal and fossil fuels) are not straightforward. The full cost of introducing different generation options (especially variable) depends on the specific conditions of the system—for example, the extent to which variable sources match the demand profile and complement the mix of existing sources and technologies.

Ultimately, attaining the SE4ALL target for renewable energy depends to a large extent on the efforts of countries with high energy demand and consumption. These countries (including most developed and emerging economies) would have to significantly increase their efforts to scale up renewables, introducing effective and efficient policy mechanisms across all segments of the energy sector and strengthening the overall business environment to attract and leverage different sources of finance.

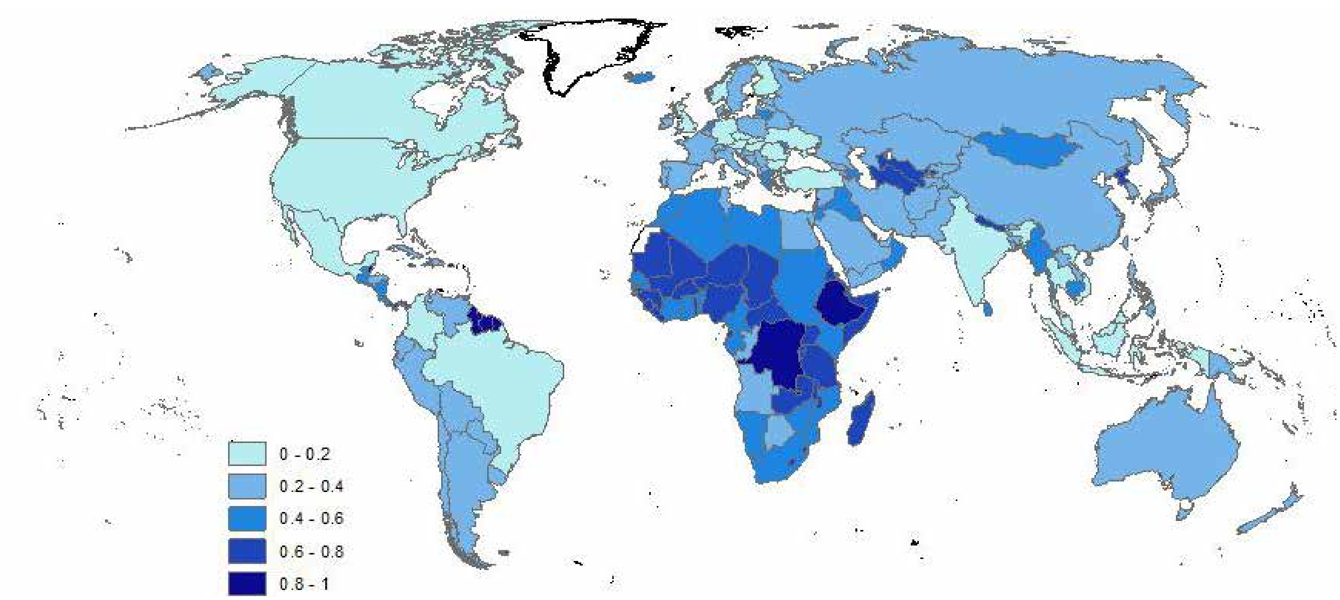


FIGURE 4.16 **DIVERSITY INDEX OF PRIMARY ENERGY MIX (BASED ON HERFINDAHL–HIRSCHMAN INDEX HHI)**

SOURCE: PREPARED BY AUTHORS FROM IEA DATA FOLLOWING BACON AND KOJIMA (2008), KOJIMA (2012)
NOTE: THE ENERGY SOURCES CONSIDERED IN THE PRIMARY ENERGY MIX ARE NATURAL GAS, OIL AND OIL PRODUCTS, COAL (COAL AND PEAT), HYDROPOWER, OTHER RENEWABLES (BIOFUELS, WASTE, GEOTHERMAL, SOLAR, WIND, OTHER), AND NUCLEAR. HIGHER INDEX VALUES INDICATE LOWER DIVERSITY IN PRIMARY ENERGY MIX, AND THEREFORE, INCREASED VULNERABILITY TO CHANGES.

[13] A notable exception is Trinidad and Tobago, an island country that produces both oil and gas.

SECTION 4. THE SCALE OF THE RENEWABLE ENERGY CHALLENGE

This section looks at the scale of the challenge to double the proportion of renewable energy in the global energy mix. It does this by comparing current trends with the trajectory required to meet the target. It then looks at projections of the proportion of renewable energy under various scenarios, and attempts to draw some lessons about the conditions needed to achieve the target. Finally, it highlights some of the main challenges associated with this ambitious target, discusses opportunities, and concludes with general policy recommendations.

Current trends in the use of renewable energy

As shown in section 2 of this chapter, there have been rapid rises in the deployment of several renewable energy sectors in recent years. Generation from wind and solar has grown at double-digit annual percentage rates, and the transport fuel sector has also grown strongly. Overall, the level of energy generation from renewables has been growing steadily, at a 2 percent CAGR (in terms of TFEC), and has increased in absolute terms by 36 percent since 1990.

But as shown in figure 4.18, overall global energy consumption has also been rising at nearly the same rate (1.5 percent). As a result, despite the sustained growth in renewable energy production, the overall level of renewables as a proportion of global energy needs has essentially remained stable, at close to 18 percent.

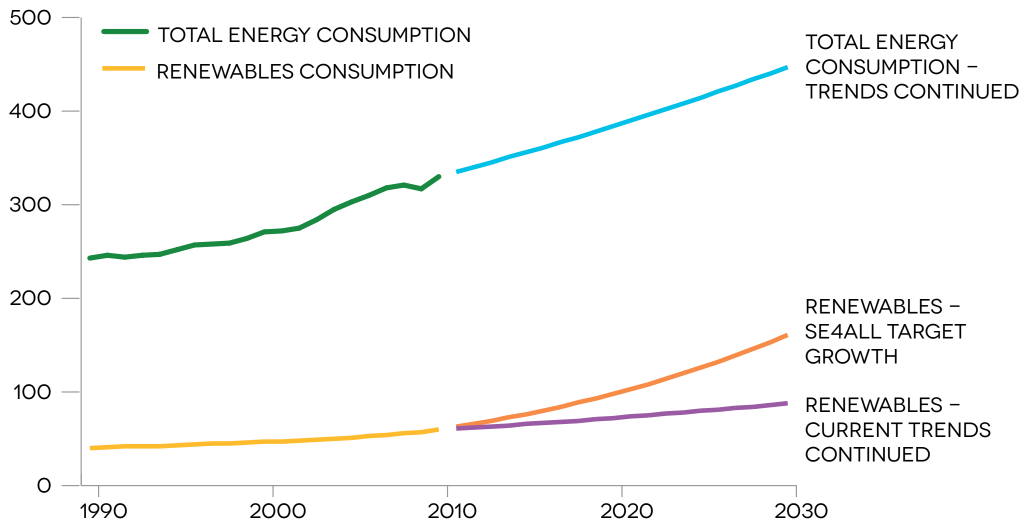


FIGURE 4.18 **GLOBAL TRENDS IN RENEWABLE ENERGY AND TOTAL FINAL ENERGY CONSUMPTION, 1990–2030**

SOURCE: AUTHORS' ANALYSIS BASED ON IEA 2012D.

Figure 4.18 also shows that if current trends continued to 2030, renewable energy consumption would rise by 56 percent to around 95 EJ. But if trends in TFEC were also to continue to 2030, this would increase by 48 percent to 490 EJ, and the share of renewables in the global energy mix would increase only to 19.4 percent.

If overall energy consumption were to stabilize, doubling the contribution of renewables would imply consumption of around 118 EJ by 2030, requiring an annual growth rate of 3.5 percent (a 50 percent increase over current levels). If current overall growth in energy demand continues, meeting the target would require the consumption of renewables to triple to around 177 EJ by 2030, an annual growth rate of 5.9 percent, which is 2.5 times the current growth rate. Given the likely reduction in the "traditional" use of biomass, the increase in sustainable renewable production would have to be even larger.

19.4 %
OF TOTAL FINAL ENERGY CONSUMPTION
FROM RENEWABLE SOURCES PROJECTED FOR THE YEAR 2030 UNDER BUSINESS AS USUAL; BARELY ONE PERCENTAGE POINT HIGHER THAN TODAY.

This highlights how challenging it will be to meet this goal, and underscores the importance of the link between the SE4ALL goals for renewable energy, energy efficiency, and energy access. Achieving the renewable energy goal is likely to depend both on rapid expansion of deployment rates for renewables as well as on considerable progress being made in reducing overall global energy consumption via energy efficiency improvements.

Future scenarios

There are a wide range of energy scenarios that consider how energy demands may evolve in the future and what the role of renewable energy in the global energy mix will be. These scenarios use different approaches: some are based on policy considerations; others are based on a least-cost modeling approach, given a portfolio of technology options; others are goal-oriented exercises that place constraints on future scenarios (for example, by setting global emission limits). Scenario analysis also uses different assumptions about many of the essential parameters, including those relating to population and economic development and how these are coupled with energy demand, the availability and costs of technologies, and so on.

Several national and international organizations, such as the IEA, the EIA, the International Institute for Applied Systems Analysis (IIASA), the European Union, and NGOs such as Greenpeace and the World Wide Fund for Nature (WWF), as well as major oil companies, such as BP, Exxon, and Shell, develop and publish projections for global energy demand and supply.

A detailed review of all the relevant modeling exercises is not attempted here, but a short summary of major projections for energy demand and supply in 2030, which highlights the wide range of projections of total final energy consumption and the renewable energy share (from 18 percent to 45 percent), is given in table 4.8.

ORGANIZATION	SCENARIO	TPED (EJ)	RENEWABLES (%)	TFEC (EJ)	RENEWABLES (%)
IEA Statistics 2010	2010 Energy Balances	533	13	324	18
IEA 2012c[a]	NPS 2030	687	17	425	21
	450 ppm 2030	605	23	384	27
	EWS 2030			380	22
IEA 2012[a]	2D	600			
EIA 2011[b]	Reference	684	13.9		
	High oil case	733	13.6		
	Low oil case	655	13.9		
IPCC 2011[c]	ReMind	590	32		
	MINICAM	608	24		
	MESAP/PlaNet	474	39		
IIASA 2012[d]	GEA 1	446	29.8	312	36.7
	GEA 2	458	29.7	321	36.3
	GEA 3	457	27.9	311	34.4
	GEA 4	443	33.3	303	40.7
	GEA 5	456	28.1	324	34.6
	GEA 6	454	34.7	314	40.9
ExxonMobil 2011[e]		618	14	478	24%
BP 2012[f]		683	14		
Shell 2013	Mountains	749	14		
	Oceans	777	17		
Greenpeace/EREC/GWEC 2012	Revolution			340	45%
WWF, Ecofys/OMA 2012				319	42%

TABLE 4.8 **ENERGY DEMAND PROJECTIONS AND RENEWABLE ENERGY SHARE IN MAJOR ENERGY SCENARIOS, 2030**

SOURCE: : IEA 2010, 2011, 2012A, 2012C; IPCC 2011; IIASA 2012; EXXONMOBIL 2012; BP 2012; SHELL 2013; GREENPEACE, EREC, AND GWEC 2012; WWF, ECOFYS, AND OMA 2011.
NOTE: TPED = TOTAL PRIMARY ENERGY DEMAND; TFEC = TOTAL FINAL ENERGY CONSUMPTION.

a. TPED is based on the physical energy content method, which assumes 33 percent efficiency for nuclear; 100 percent efficiency for renewable energy resources like hydro, wind, and solar PV; 50 percent for CSP; and 10 percent for geothermal.

b. TPED is based on the substitution method.

c. In all scenarios, the direct equivalent method is used to measure primary energy demand.

d. TPED is based on the direct equivalent method, assuming 100 percent efficiency for both non-biomass renewables and nuclear.

e. The data are based on interpolations between the data points for 2025 and 2040.

f. The primary energy values of nuclear and hydroelectric power generation, as well as electricity from renewable sources, have been derived by calculating the equivalent amount of fossil fuel required to generate the same volume of electricity in a thermal power station, assuming a conversion efficiency of 38 percent (that is, the average for OECD thermal power generation).

The following subsections summarize the major conclusions of three major modeling exercises: the IPCC analysis described in its Special Report on Renewable Energy; the modeling work carried out in support of the IEA's World Energy Outlook (IEA 2011); and the IIASA's Global Energy Assessment scenario analysis.

United Nations Framework Convention on Climate Change's (UNFCCC's) analysis

The IPCC Special Report on Renewable Energy reviewed a wide range of modeling exercises, covering 164 scenarios from 16 different large-scale integrated models, and drew some general lessons that provide a relevant context for understanding the SE4ALL goal:

- The models differ widely (by a factor of three) in terms of the anticipated growth of overall global energy production and demand.
- Renewable energy deployment plays a substantially higher role in scenarios associated with ambitious GHG emission targets. For scenarios targeting atmospheric carbon dioxide concentrations (CO_2) at levels below 440 ppm, the median deployment level for 2030 is 139 EJ with the highest level of 252 EJ. But these low-emission scenarios exhibit a wide range of renewable energy deployment levels, depending on assumptions about the mix of low-carbon options to be deployed. Where carbon capture and storage (CCS) or nuclear generation is constrained, renewable energy plays a larger role.
- The range of figures for the proportion of renewables in the global energy mix also varies widely. More than half the scenarios show a contribution of over 17 percent, with the highest renewable energy share reaching 43 percent.
- The scenarios show that growth in renewable energy will be worldwide and not constrained to particular regions, although renewable energy will become most significant in emerging and developing economies, where growth in energy demand is likely to be focused. The scenarios also show that the full spectrum of renewable energy technologies will be deployed, with no dominant technology, although modern bioenergy, wind, and solar energy will make the largest contributions.

The IEA's World Energy Outlook scenarios

Table 4.7 shows the primary energy demand today and in 2030 according to the three IEA scenarios developed in the *World Energy Outlook* (IEA 2011). The Current Policies Scenario (CPS) assumes that current policy commitments are maintained. In this scenario, the level of renewables continues to grow sharply. But given the continuing rise of overall energy demand, the proportion of renewables rises only slightly by 2030, to 18.4 percent. The New Policies Scenario (NPS) factors in the impacts of announced policy commitments to improving energy efficiency and deploying low-carbon energy technologies. In this scenario, the modeling indicates that the proportion of renewables would increase more rapidly, reaching 21.1 percent by 2030. This is still significantly below the SE4ALL goal, however, highlighting that current policy commitments are insufficient to promote the type of change that the initiative envisions.

The WEO 450 Scenario sets out an energy pathway that is consistent with a 50 percent chance of meeting the goal to limit the increase in average global temperature to 20C compared with preindustrial levels. It assumes that more vigorous policy action is taken in the years up to 2020 and that, thereafter, OECD and other major economies set economy-wide emissions targets consistent with a trajectory in which greenhouse gas levels are stabilized at a level of 450 ppm of CO_2 equivalent. In this scenario, the overall level of renewables rises to 27 percent, which is still significantly below the 36.1 percent SE4ALL target. The emissions trajectory associated with the WEO 450 Scenario is consistent with the 2°C Scenario (2DS) developed in the context of IEA's Energy Technology Perspectives 2012. In the 2DS, renewables make up around 50 percent of electricity generation in 2030, and their share of total average world electricity generation increases to 57 percent by 2050.

The WEO 450 Scenario foresees a higher share of renewables and increased energy efficiency, and also includes ambitious deployment of CCS technology, assuming around 35 percent of CCS in coal-fired power generation by 2030. Other scenarios use higher levels of renewable power generation instead of CCS technologies to reduce global CO_2 emissions.

The IIASA's Global Energy Assessment scenarios

Within the suite of IIASA's Global Energy Assessment (GEA) scenarios, a number of different energy pathways explore alternative combinations of energy efficiency improvements and supply-side transformations to achieve ambitious targets for sustainable development (table 4.9). These include the goals of:

- Providing almost universal access to affordable clean cooking and electricity for the poor
- Limiting air pollution and health damages from energy use
- Improving energy security throughout the world
- Limiting climate change

The main aim is to provide a better understanding of what is needed to achieve these goals in terms of the combination of measures, time frames, and costs. This involves consideration of the extent to which changes in the demand for energy services together with demand-side efficiency measures can reduce the energy consumed to provide mobility, housing, and industrial services. Alternatively, if there is less emphasis on reducing energy demand, then a more rapid expansion of a broader portfolio of low-carbon supply-side options is needed; the successful implementation of demand-side policies increases the flexibility of supply-side options (and vice versa).

The scenarios are grouped in terms of three levels of differentiation. First, the level of energy demand is considered via three GEA pathway groups, which represent different emphases in terms of demand-side and supply-side changes. Each group varies, in particular, with respect to assumptions about the comprehensiveness of demand-side policies to enhance efficiency, leading to pathways of comparatively low energy demand (GEA-Efficiency), intermediate demand (GEA-Mix), and high demand (GEA-Supply).

The second level of differentiation considers what dominant transportation fuels and technologies might emerge, distinguishing between systems in which conventional liquid fuel systems remain important and those where advanced systems based on electricity/hydrogen take on a major role. For each combination, the diversity of the portfolio of supply-side options is then considered: first, allowing for the unconstrained deployment of the full range of technology options (including renewables, nuclear, and CCS), then looking at a range of ten options where deployment of one or more these technology options is constrained.

The third level of differentiation considers feasible supply-side transitions (for example, use of CCS) as well as demand-side measures.

21%–45%
IS THE RANGE IN THE SHARE OF
RENEWABLE ENERGY IN TFEC BY 2030 ESTIMATED BY LEADING GLOBAL ENERGY MODELS

PATHWAY	CHARACTERISTICS	% RE IN TFEC, 2030
GEA 1	Assumes limited potential of land-based mitigation options, including low potential for biomass; no negative emissions technologies (Bio-CCS) and limited potential for afforestation/reforestation measures. Transportation sector follows an "advanced" trajectory (allowing for rapid expansion of, for example, electric vehicles).	36.7
GEA 2	Assumes the phase-out of nuclear power generation in the medium term, and no CCS. Transportation sector follows an "advanced" trajectory (allowing for rapid expansion of, for example, electric vehicles).	36.3
GEA 3	Assumes limited potential for bioenergy and intermittent renewables (solar and wind). Transportation sector follows a "conventional" trajectory (future vehicles continue to reply predominantly on liquid fuels).	34.4
GEA 4	Assumes limited potential of land-based mitigation options, including low potential for biomass; no negative emissions technologies (Bio-CCS) and limited potential for afforestation/reforestation measures. Transportation sector follows a "conventional" trajectory (future vehicles continue to reply predominantly on liquid fuels).	40.7
GEA 5	Assumes no CCS. Transportation sector follows a "conventional" trajectory (future vehicles continue to reply predominantly on liquid fuels).	34.6
GEA 6	Assumes the phase-out of nuclear power generation in the medium term, and no CCS. Transportation sector follows a "conventional" trajectory (future vehicles continue to reply predominantly on liquid fuels).	40.9

TABLE 4.9 **CHARACTERISTICS OF THE SIX GEA PATHWAYS THAT MEET THE SE4ALL TARGET FOR RENEWABLE ENERGY**

SOURCE: IIASA 2012.
NOTE: CCS CAN ALSO BE USED IN COMBINATION WITH BIOENERGY (BIOCCS) TO PRODUCE NET NEGATIVE CARBON DIOXIDE (CO_2) EMISSIONS. GEA = GLOBAL ENERGY ASSESSMENT; CCS = CARBON CAPTURE AND STORAGE; TFEC = TOTAL FINAL ENERGY CONSUMPTION ALL OF THE SIX PATHWAYS CORRESPOND TO THE EFFICIENCY SCENARIO OF THE GLOBAL ENERGY ASSESSMENT (GEA).

A general conclusion of the analysis is that the role of renewables and other low-carbon supply-side technologies is greater in the scenarios where restricting overall growth in energy demand is less successful, because of added pressure to decarbonize the supply side. The role of renewable technologies (particularly for power generation) will increase substantially, and renewable energy will play a significant role in achieving all the scenarios meeting the GEA sustainability objectives. But the specific SE4ALL renewable energy goal is not achieved in all the scenarios. In the scenarios where the renewable energy proportion equals or exceeds the doubling target, liquid transport fuels are still an important part of the mix (and the most advanced transport technologies are not deployed). This opens up greater opportunities for biofuels, and so increases the overall share of renewable energy.

Conclusions from scenarios

These three exercises indicate several conclusions:

- Current deployment growth rates are not high enough to achieve the SE4ALL target on renewables (see figure 4.19). The level will need to rise by 50 percent–250 percent, depending on trends in overall global energy demand. The scale of the challenge depends equally on the success in stimulating the deployment of renewables and constraining increases in energy demand. As a result, the achievement of this target is intimately linked to success in achieving the complementary SE4ALL energy efficiency goal.

- Exercises show a wide range of potential energy futures, depending on the aims and constraints applied within different models and scenarios. The IPCC 's review of modeling exercises (*Special*

Report on Renewable Energy Sources and Climate Change Mitigation) shows the share of renewables in the global energy mix to range between 17 and 43 percent (in terms of primary rather than final energy consumption).

- Consideration of the IEA's CPS and NPS indicate that neither current policy commitments nor those under consideration will be enough to stimulate sufficient deployment of renewables to meet the SE4ALL goals.

- The six IIASA GEA scenarios concerned with meeting sustainability targets for energy access, limiting air pollution and health damages from energy use, improving energy security, and limiting climate change all include high levels of renewable energy deployment, although the overall level does not reach the SE4ALL goals in every case.

Overall the scenarios show how important renewables are in any future sustainable energy mix, and at the same time highlight their links with energy efficiency and other low-carbon technologies. The SE4ALL target falls within the scope of many scenarios that aim to constrain climate change and meet other sustainability goals (although, as shown in figure 4.19, it falls at the upper end of the spectrum of results from the scenarios).[14] Strong policy action is needed in the short term to stimulate deployment of the technologies and to improve energy efficiency if the goal is to be achieved.

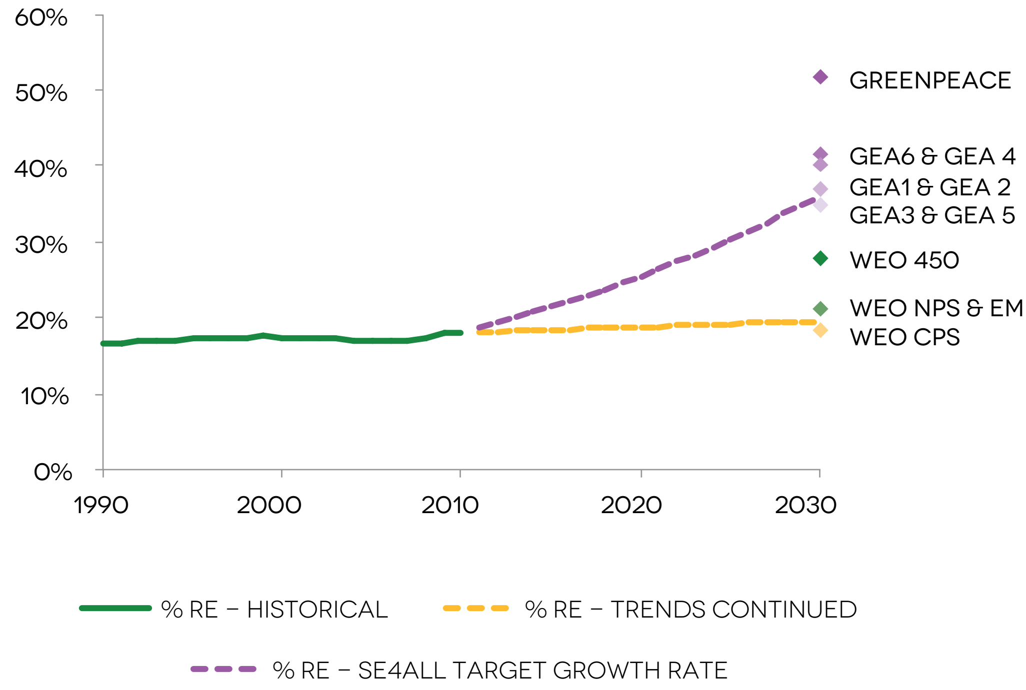


FIGURE 4.19 **SHARE OF RENEWABLE ENERGY IN GLOBAL TOTAL FINAL ENERGY CONSUMPTION: CURRENT TRENDS AND SCENARIOS**

SOURCE: IEA 2012C; EXXONMOBIL 2012; IIASA 2012; GREENPEACE, EREC, AND GWEC 2012.
NOTE: WEO = WORLD ENERGY OUTLOOK; CPS = CURRENT POLICIES SCENARIO; NPS = NEW POLICIES SCENARIO; GEA = GLOBAL ENERGY ASSESSMENT; EM = EXXONMOBIL; RE = RENEWABLE ENERGY.

[14] Based on available data sources (with their associated statistical limitations), the share of renewable energy in TFEC is estimated to be 18 percent as the starting point in 2010. This implies an SE4ALL objective of 36 percent for year 2030. Because the inclusion of sustainability considerations would lower this initial condition and target, they should be regarded as an upper bound.

Barriers and opportunities related to the SE4ALL

This section discusses the main barriers and opportunities for attaining the SE4ALL objective of doubling the share of renewable energy in the global energy mix.

The challenges of achieving SE4ALL targets vary across regions. They are influenced by a number of factors:

- Expected growth in renewable energy production
- Expected growth in overall TFEC
- Expected trends in the use of traditional biomass

Table 4.10 shows historical trends in the share of renewables for different regions around the world, and compares this with the projected data from the WEO 450 Scenario.

Within the OECD the share of renewable energy has been rising due to successful policy efforts and low growth in overall energy demand, as well as the low share of traditional biomass. These trends are expected to continue, and the OECD countries are expected to significantly increase renewables' share of TFEC.

For the non-OECD countries, we can see several observed and expected trends, depending on the patterns of overall energy growth and the opportunities for using renewables and switching away from inefficient biomass use. For regions with a continuing high share of renewables in the power sector (from hydro) and lower use of traditional biomass, we can expect a trend in which the overall share of renewables continues to increase (for example, in the non-OECD Americas). In regions where the use of traditional biomass is widespread (that is, in Africa and Asia), a transition to more efficient biomass fuels does not increase the proportion of renewables even when biomass is used more efficiently, since "raw" fuels determine the statistics. But more efficient uses of biomass potentially free up resources for other applications.

In the WEO 450 Scenario, the Middle East also sees a substantial increase in the share of renewable energy (5.4 percent).

	1990	2000	2010	2030 WEO 450	2030 GEA 1-6	2030 ALL GEA
OECD34	6.9	7.7	10.0	28		
Africa	62.2	63.1	61.7	65		
Non-OECD Americas	38.0	32.7	34.5	47		
Asia excluding China	51.1	43.6	36.7	37		
China (region)	33.2	28.9	19.3	23		
Non-OECD Europe and Eurasia	3.3	4.8	5.4	10		
Middle East	1.0	0.5	0.6	6		
World	16.6	17.4	18.0	28	34–41	23–41

TABLE 4.10 **SHARE OF RENEWABLES IN TOTAL FINAL ENERGY CONSUMPTION BY REGION (AFTER ALLOCATION)**

SOURCE: AUTHORS' ANALYSIS BASED ON IEA 2012D; IEA 2011; AND IIASA (2012).
NOTE: WEO = WORLD ENERGY OUTLOOK; GEA = GLOBAL ENERGY ASSESSMENT; OECD = ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT.

Economic and market opportunities and barriers

The costs of many renewable energy technologies have been a major barrier to their adoption, a problem compounded in many cases by market issues, such as subsidies for competitive energy supply, and by a lack of costing methods to include social and environmental costs such as those related to carbon emissions. Strong growth in renewable deployment has led to significant reductions in the costs of some of the principal technologies. Renewables can now provide a cost-competitive solution in many circumstances.

For mini-grid and off-grid markets, renewable energy technologies are competitive or cheaper than other energy sources in many cases (depending on available sources and fuels). For grid-integrated projects, renewable energy technologies are increasingly competitive in a substantial number of countries. This cycle of increased deployment and reduced costs is likely to continue and will be an important driver for the accelerated renewable energy deployment needed to achieve the target. But in many markets economic barriers still need to be addressed by policy measures that make up for the lack of a level playing field, support market introduction, foster the development of local supply chains and infrastructure, and stimulate the deployment that will lead to further cost reduction and competitiveness.

In addition, there are large market opportunities, especially in growing countries in Asia, Africa, and Latin America. In its CPS, the IEA estimates that 75 percent of total new capacity additions in electricity will be added in non-OECD countries by 2030 (IEA 2012c). This scenario also foresees the addition of 60 percent of total new renewable energy capacity and 88 percent of total new hydroelectric capacity in non-OECD countries (these relative shares are very similar under the IEA's NPS).

$250–400 BILLION IS THE ANNUAL FINANCING REQUIREMENT FOR RENEWABLE ENERGY THROUGH 2030 TO MEET SE4ALL OBJECTIVES.

With regard to biofuels, the IEA estimates in both the CPS and NPS that about 40 percent of the expected incremental consumption projected to 2030 will originate in non-OECD countries.

Noneconomic opportunities and barriers

Section 3 has already discussed a number of important drivers for renewable energy, including energy security, climate change, and local environmental conditions. The prospective analysis using global energy models shows that scenarios aimed at reducing CO2 emissions have higher shares of renewables, although this share depends also on how other low-carbon solutions like CCS are deployed.

On the other hand, several scenarios highlight noneconomic barriers related to:

- Policy uncertainty and risk from ineffective policy design, discontinuity, or insufficient transparency of policies and legislation
- Institutional and administrative issues, including a lack of strong, dedicated institutions; lack of clear responsibilities; and complicated, slow, or nontransparent permitting procedures
- Financial barriers associated with the absence of adequate funding opportunities and financing products for renewable energy technologies
- Infrastructure and integration issues that mainly center on the flexibility of the energy system (for example, the power grid) to integrate/absorb renewable energy technologies
- Lack of knowledge about the availability and performance of renewable energy technologies as well as lack of skilled workers
- Environmental barriers linked to experience with planning regulations and public acceptance of renewable energy technologies

The relative importance of these barriers differs for each technology and market, and the priority changes as a technology matures along the commercialization and deployment path. Also, as one barrier is overcome, others may become apparent.

Policy requirements

Effective policies designed to tackle these barriers are a key requirement to facilitate renewable energy deployment. This is the case even when renewables can provide a cost-competitive energy source, given the nonfinancial regulatory issues that can inhibit deployment.

Policy makers need to be able to deploy policy portfolios that have maximum impact in stimulating deployment and are as cost-effective as possible. Key issues include:

- Establishing a predictable renewable energy policy framework, integrated into an overall energy strategy with clear targets
- Implementing a portfolio of incentives based on technology and market maturity where these are necessary
- Adopting a dynamic policy approach based on monitoring of policy impacts in the context of national and global market trends.

Broadening the geographic base and the need for capacity building

To meet the SE4ALL goal for renewable energy, countries that have already started to deploy renewables need to continue along this path and maintain or accelerate progress. But achieving this challenging goal will depend on a much broader range of countries taking steps to stimulate deployment of renewables as a major component of their overall energy mix. It is likely they can do this in the light of accumulated experience with policy portfolios and technological deployment gained elsewhere. They can also benefit from the significant and continuing cost reductions that are making renewables cost-competitive with other energy sources in a much broader range of circumstances.

But in order to effectively diversify deployment there is a need to build capacity in these new countries in the areas of:

- Awareness of the potential contribution of renewable sources to national energy needs among decision and policy makers
- Awareness of internationally accepted best policy practices
- Development of appropriate regulatory frameworks and institutions
- Information and data gathering (for example, on resource potentials and infrastructure needs)
- Technology skills, supply chain and installation and maintenance capabilities.
- Provision of finance from local and international sources.Public information

Conclusions

In the two decades between 1990 and 2010, the family of renewable energy technologies has matured and established a strong foothold in global energy supply. The range of technologies that can be considered commercially proven has grown, and costs have been reduced significantly. With new pressures on energy supply and security, along with the need to reduce global emissions, the case for deployment is now stronger than ever. Growing energy demand, higher fossil-fuel prices, and the continually diminishing costs of key technologies like wind and solar open up new opportunities for renewables as affordable and sustainable options in each sector (electricity, heat, and transport).

Given the significant scale of the challenge posed by the SE4ALL renewables target, a concerted effort will be needed from governments—both those that have already started along the path of renewable energy deployment and those still exploring the options—to make renewables a key component of their future sustainable energy mix. It will also require a major coordinated effort from a wide range of relevant international organizations to track progress, to identify and promote best practices in policy making and project implementation, and to assist in necessary capacity building to facilitate the diffusion of these technologies into global energy markets.

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ANNEX 1: Concepts, data, and methodology

SOURCE	PRIMARY DATA SOURCE	SOURCE	SECONDARY DATA AND ANALYSIS	REPORTS	COUN-TRIES	TIME SERIES	DATA GAPS
BP			X	Annual Statistical Review of World Energy	67	1965–2011	No gaps
EIA	X		X	International Energy Outlook			
Enerdata Information Services			X	Global Energy and CO2 Database	184	1970–2010	No gaps
FAO	X			Wood fuel data and analysis			
IEA	X	Country surveys		IEA Energy Statistics	138	1960–2010	No gaps
IIASA			X	Annual Global Energy Assessment Report			
IRENA			X	Renewable Energy Country Profiles			
OECD			X	Annual OECD Fact Book			
Platts				Biofuels capacity			
REN 21		Network of over 400 data contribu-tors	X	Annual Global Sta-tus Report			
UN Data	X	Country surveys		UN Data	Over 220	1950–2009	Data gaps in some time series
UN Stats			X	UN Stats Monthly Bulletin of Stats Online			
WEC			X	Annual World Energy Trilemma Report			
WHO	X	Country surveys		WHO Household energy Database			
World Bank			X	World Development Indicators			

TABLE A1.1 **COMPARISON OF ENERGY DATA SOURCES**

SOURCE: AUTHORS'S COMPILATION.

This section provides descriptions of different primary energy accounting methods and an illustration of how primary and final energy are calculated following different methods.

Primary energy accounting

The IEA energy production statistics are based on a physical energy content primary energy accounting method. There are in fact three main ways of presenting the primary energy data, which can affect the overall size of the global energy mix and of the renewable share within it. These are:

- The physical energy content method (used by IEA and Eurostat)
- The partial substitution method (used by EIA)
- The direct equivalent method (used in some IPCC reports)

A description of these methods is found in the table A1.2.

DESCRIPTION	EXAMPLES	USERS
Physical energy content		
Adopts the principle that the primary energy form should be the first energy form used downstream in the production process for which multiple energy uses are practical. This leads to the choice of the following primary energy forms: (a) heat for nuclear, geothermal, and solar energy, and (b) electricity for hydro, tide/wave/ocean and solar PV energy. The method counts the power plant input for fossil fuels (and biomass), but counts power plant output for nuclear, wind, solar, hydro and geothermal. Thus, it uses conversion efficiencies to calculate the primary energy equivalent of renewable energy output.	The primary energy equivalent of hydropower and solar PV assumes 100% conversion efficiency to "primary electricity" (that is, 1 kWh of electricity converts into a gross energy input of 3.6 MJ) The primary energy equivalent of nuclear assumes 33% thermal conversion efficiency (average for nuclear plants in Europe) to "primary electricity" (that is, 1 kWh equals 10.9 MJ of primary energy). For geothermal, the primary energy equivalent is calculated using 10 % conversion efficiency for electricity (in this case, 1 kWh equals 36 MJ) and 50% for geothermal heat.	OECD IEA Eurostat Enerdata
Substitution method		
Reports primary energy from noncombustible sources as if they had been substituted for combustible energy. In other words, it counts the equivalent primary energy of fossil fuels needed to generate a given volume of renewable-source-based electricity. The method uses different conversion factors for different types of renewable energy output. The share of renewables under this method is thus considerably higher than in the "physical energy content" method.	BP applies 38% conversion efficiency to electricity generated from nuclear and hydro. WEC applies 38.6% to electricity from nuclear and all other noncombustible renewable sources.	Used in slightly different variants by: BP US EIA WEC IIASA (GEA)

DESCRIPTION	EXAMPLES	USERS
Direct equivalent method		
Counts one unit of secondary energy provided from noncombustible sources as one unit of primary energy. In this method, secondary energy means at the point of end use; that is, as electricity or heat. It counts all forms of electricity equally regardless of origin and does not use conversion efficiencies.	The primary energy equivalent of noncombustible or renewable-source-based electricity assumes 100% conversion efficiency to "primary electricity" (that is, 1 kWh of electricity converts into 3.6 MJ of primary energy)	UN Statistics IPCC Reports IIASA (IPCC)

TABLE A1.2 **METHODS TO ACCOUNT FOR THE PRIMARY ENERGY OF NONCOMBUSTIBLE SOURCES**

SOURCE: IPCC 2011); REN21 2007.
NOTE: DIFFERENT VARIANTS OF THE SUBSTITUTION METHOD USE DIFFERENT CONVERSION FACTORS.

Table A1.3 shows the figures for total primary energy supply calculated by the three methods for 2010 along with the calculated contribution from renewables to the global energy mix.

	PHYSICAL CONTENT METHOD		DIRECT EQUIVALENT METHOD		SUBSTITUTION METHOD	
	EJ	%	EJ	%	EJ	%
Fossils	433	81%	433	85%	433	79%
Nuclear	30	6%	10	2%	26	5%
Renewables:	69	13%	68	13%	91	17%
Hydro	12	2.32%	12	2.42%	33	5.92%
Wind	1	0.23%	1	0.24%	3	0.59%
Bioenergy	52	9.78%	52	10.21%	52	9.49%
Solar	1	0.14%	1	0.14%	1	0.17%
Geothermal	3	0.51%	1	0.11%	1	0.17%
Ocean	0	0.00%	0	0.00%	0	0.00%
Other	1	0.25%	1	0.26%	1	0.24%
Total	534	100%	511	100%	550	100%

TABLE A1.3 **TOTAL WORLD PRIMARY ENERGY SUPPLY IN 2010 (EJ)**

SOURCE: IEA 2012D.

To illustrate the effect of the different methodologies when renewables play a more significant role in the energy mix, table A1.4 shows the equivalent analysis based on the IEA's WEO 450 Scenario, in which stringent climate goals are met through the application of the full range of low-carbon energy technologies including renewables. In this scenario the proportion of renewables can range between 23 percent and 29 percent, depending on the methodology used, and the ratio between the 2010 and 2030 figures range from 1.70 for the substitution method to 1.78 for the other two methodologies.

The advantage of the primary methodology is that figures are based directly on the physical measurement of energy content for fossil fuels. The disadvantages are that for low-carbon electricity sources the primary energy content has to be calculated and the resulting figures depend on the accounting convention used and are not always directly related to useful energy production.

	PHYSICAL CONTENT METHOD		DIRECT EQUIVALENT METHOD		SUBSTITUTION METHOD	
	EJ	%	EJ	%	EJ	%
Fossils	408	67%	408	73%	408	62%
Nuclear	61	10%	20	4%	53	8%
Renewables:	141	23%	129	23%	192	29%
Hydro	20	3%	20	4%	54	8%
Bioenergy & wastes	86	14%	86	15%	86	13%
Other renewables	34	6%	22	4%	52	8%
Total	610	100%	557	100%	653	100%

TABLE A1.4 **TOTAL WORLD PRIMARY ENERGY SUPPLY IN 2030 IN WEO 450 SCENARIO (EJ)**

SOURCE: IEA 2012D.

Final energy accounting

The data for this methodology come from the total final energy consumption (TFEC) figures within the IEA statistics (these exclude nonenergy uses of fossil fuels such as those for plastics and chemicals). The TFEC figures for power and commercial heat are lower than the figures for their supply because of the energy used within power and heat plants and transmission and distribution losses.

Within the TFEC figures, heat and electricity (secondary energy sources) represent energy commodities ready to be used for energy consumption. Other primary energy sources can be directly used for energy consumption (for example, fossil fuels and bioenergy used for heating in the residential sector), and these are still reported in terms of their fuel content. These sources need to go through further transformation processes (for example, combustion) in order to provide energy services. Such transformation implies losses due to efficiency of conversion. The TFEC level therefore does not represent only useful energy, or energy service, but for direct uses of combustible sources it only represents inputs into a transformation process that will ultimately deliver useful energy. The final energy service is not reported in energy statistics because it is not practical to measure.[15]

In order to establish the contribution of each technology the figures for electricity and commercial heat have to be allocated to the relevant technology. This can be done based on the proportions of production, attributing the losses proportionally (although this penalizes the renewables' share since both internal energy losses and transmission and distribution losses tend to be smaller, at least for distributed renewable sources).

[15] A household will know how much biomass/gas/electricity it used for its heating system but will not measure how much heat the heating system produced. It would be possible to make country/use-specific assumptions on conversions in the final energy sector and estimate useful energy service—but this is a topic for an analytical study, not a statistical assessment.

Table A1.5 shows the breakdown of final consumption figures for 2010, before and after the allocation of electricity and heat, using final energy consumption figures based on the IEA's WEO 450 Scenario.

	TOTAL FINAL CONSUMPTION		TOTAL FINAL ENERGY CONSUMPTION		TOTAL FINAL ENERGY CONSUMPTION AFTER ALLOCATION	
	EJ	%	EJ	%	EJ	%
Fossils	243	66%	209	63%	263	79%
Nuclear	0	0%	0	0%	8	3%
Renewables:	47	13%	47	14%	61	18%
Hydro	0	0.00%	0	0.00%	10	3%
Wind	0	0.00%	0	0.00%	1	0.35%
Bioenergy	46	12.61%	46	13.91%	48	14%
Solar	1	0.17%	1	0.19%	1	0.27%
Geothermal	0	0.08%	0	0.09%	0	0.15%
Ocean	0	0.00%	0	0.00%	0	0.00%
Other renewables	0	0.00%	0	0.00%		0.02%
Electricity	64	18%	64	19%	x	x
Heat	12	3%	12	3%	x	x
Total	366	100%	332	100%	332	100%

TABLE A1.5 **TOTAL FINAL ENERGY CONSUMPTION IN 2010**

SOURCE: IEA 2012D.

The advantage of using the TFEC as the basis for monitoring is that it allows a straight comparison in GWh for electricity-producing renewables/nuclear and for commercial heat and gets closer to measuring the useful energy. But bioenergy and direct use of fossil fuels for heat are still reported in terms of energy inputs, and the useful heat from these sources depends on the conversion efficiency. Non-energy uses are excluded. The disadvantage is that the energy in the electricity and commercial heat sectors has to be allocated to the relevant technology based on the production proportions, and the losses are disproportionally allocated to the renewable technologies.

	TOTAL FINAL ENERGY CONSUMPTION AFTER ALLOCATION	
	EJ	%
Fossils	256	67%
Nuclear	17	5%
Renewables:	109	28%
Hydro	18	5%
Bioenergy & wastes	72	19%
Other renewables	20	5%
Total	382	100%

TABLE A1.6 **TOTAL FINAL ENERGY CONSUMPTION IN 2030 IN WEO 450 SCENARIO**

SOURCE: IEA 2012D.

ANNEX 2. Global trends in renewable energy

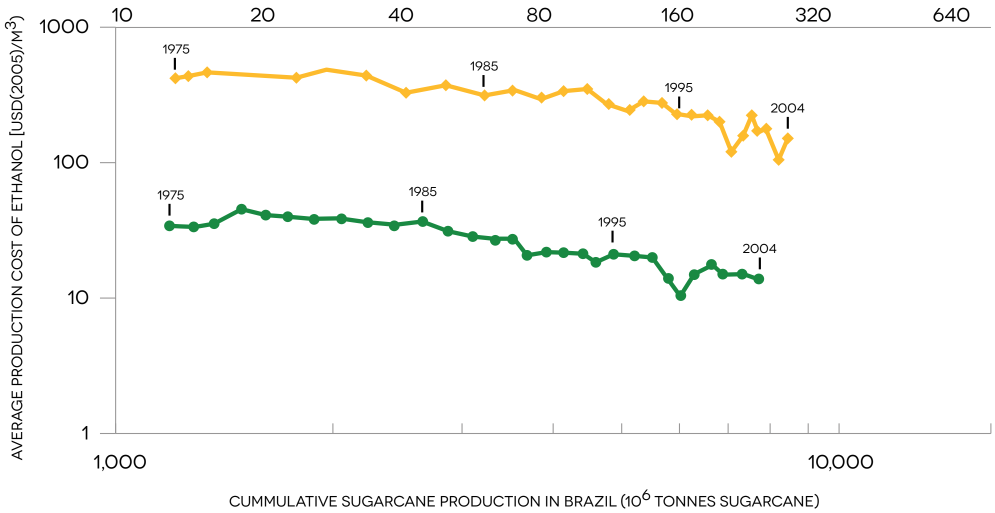


FIGURE A2.1 **LEARNING CURVE FOR SUGARCANE-BASED BIOETHANOL**

SUGARCANE PRODUCTION — ETHANOL: SUGARCANE-BASED PRODUCTION

SOURCE: VAN DEN WALL BAKE. AND OTHERS 2009.

ANNEX 3. Country performance

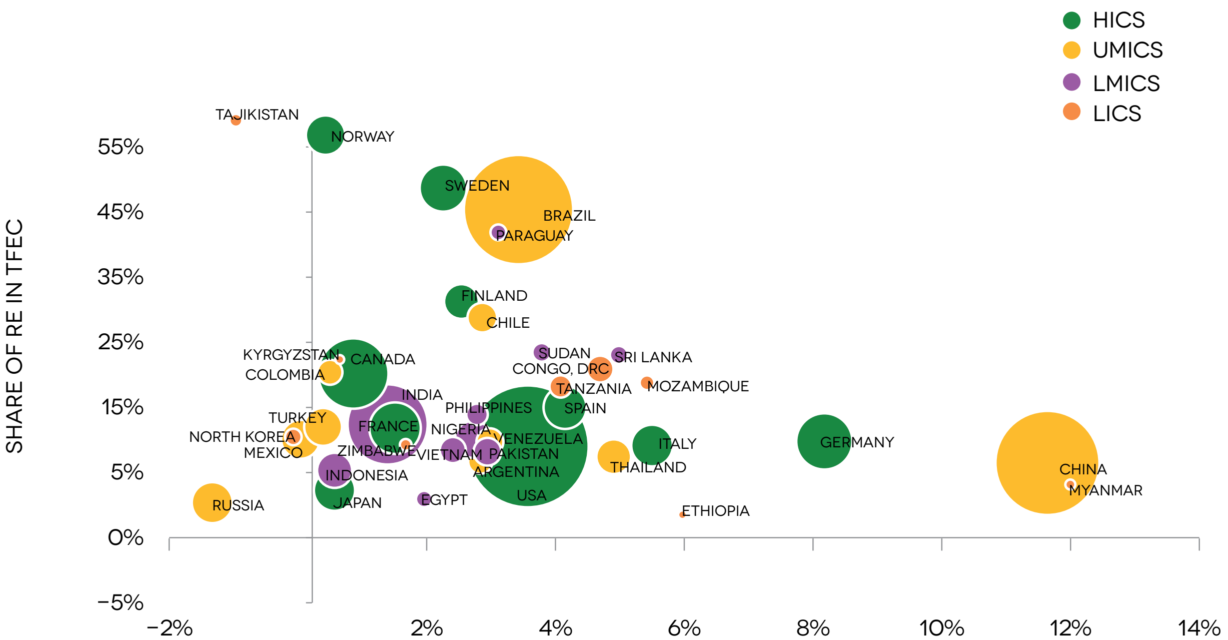


FIGURE A3.1 **SHARE OF RENEWABLE ENERGY (EXCLUDING TRADITIONAL USE OF BIOMASS) IN COUNTRY TFEC AND CAGR, 1990–2010**

SOURCE: AUTHORS' ANALYSIS BASED ON IEA 2012D.

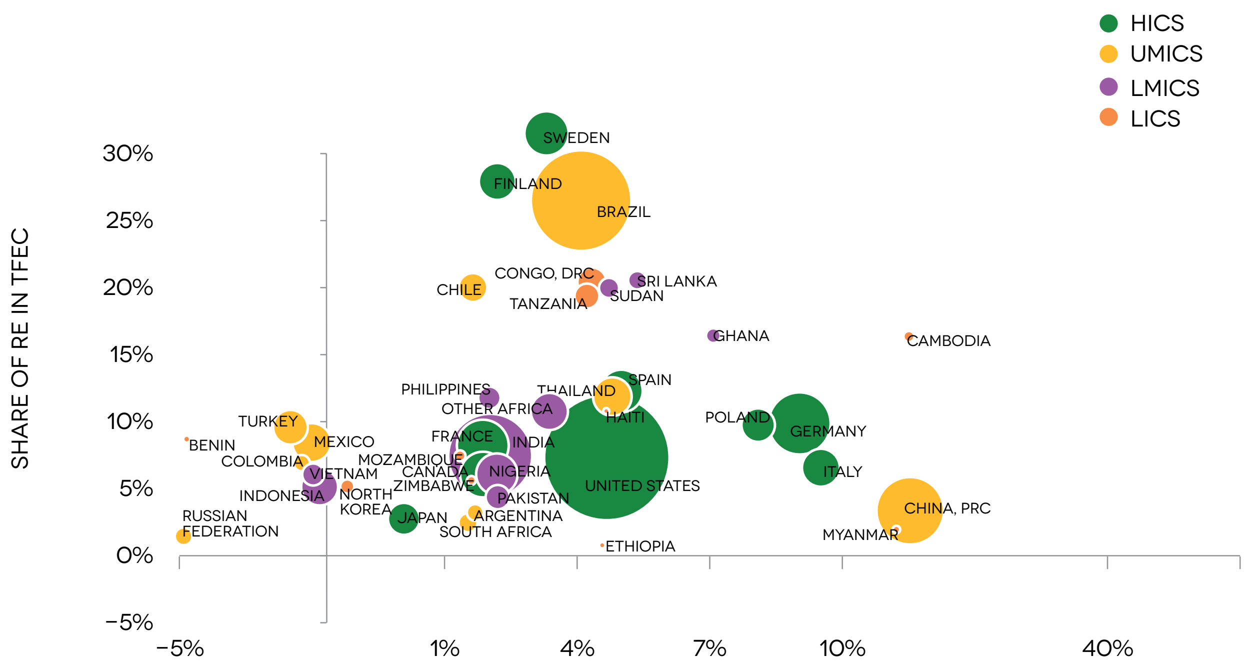


FIGURE A3.2 **SHARE OF RENEWABLE ENERGY (EXCLUDING TRADITIONAL USE OF BIOMASS AND HYDROPOWER) IN COUNTRY TFEC AND CAGR, 1990–2010**

SOURCE: IEA 2012D.

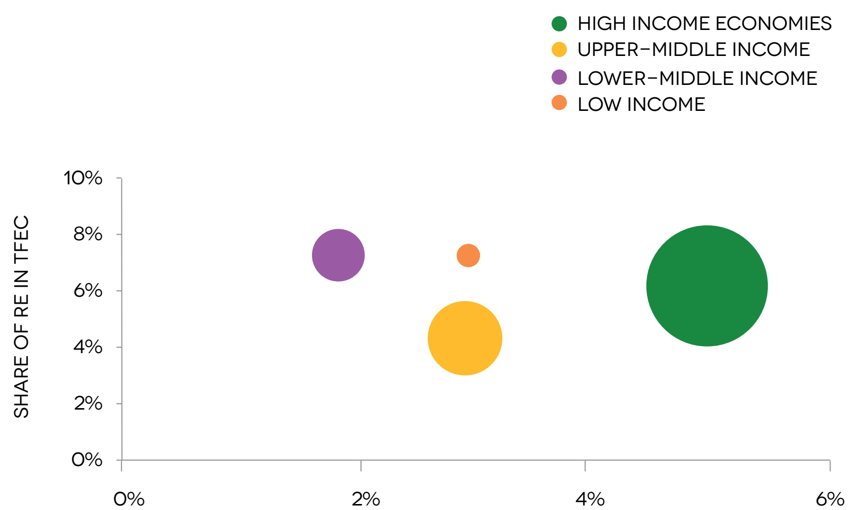
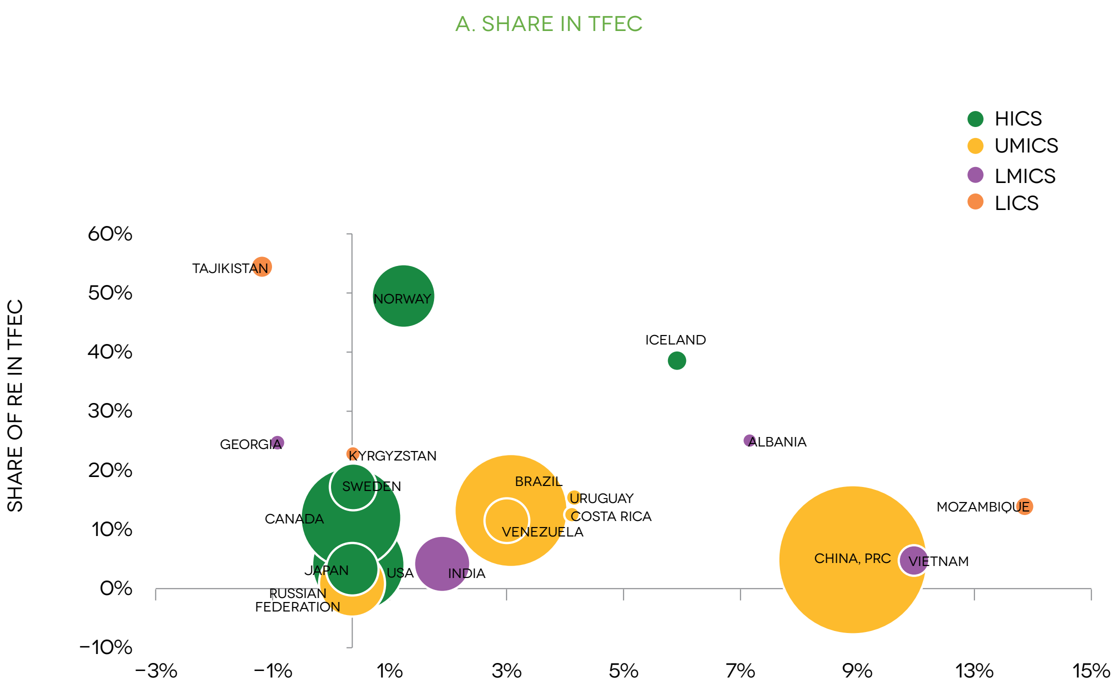


FIGURE A3.3 **SHARE OF NCRE IN TFEC VS. CAGR**

SOURCE: AUTHORS' ANALYSIS BASED ON IEA 2012D.



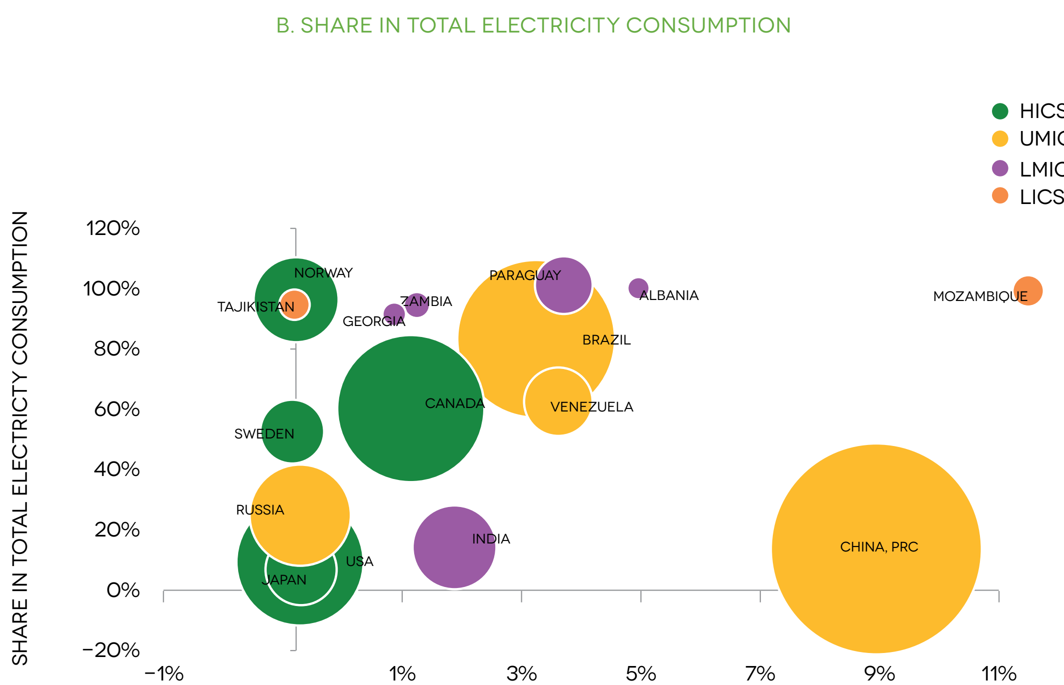


FIGURE A3.4 **SHARE OF HYDRO IN COUNTRY TFEC AND ELECTRICITY CONSUMPTION VS. CAGR, 1990–2010**

SOURCE: AUTHORS' ANALYSIS BASED ON IEA 2012D.

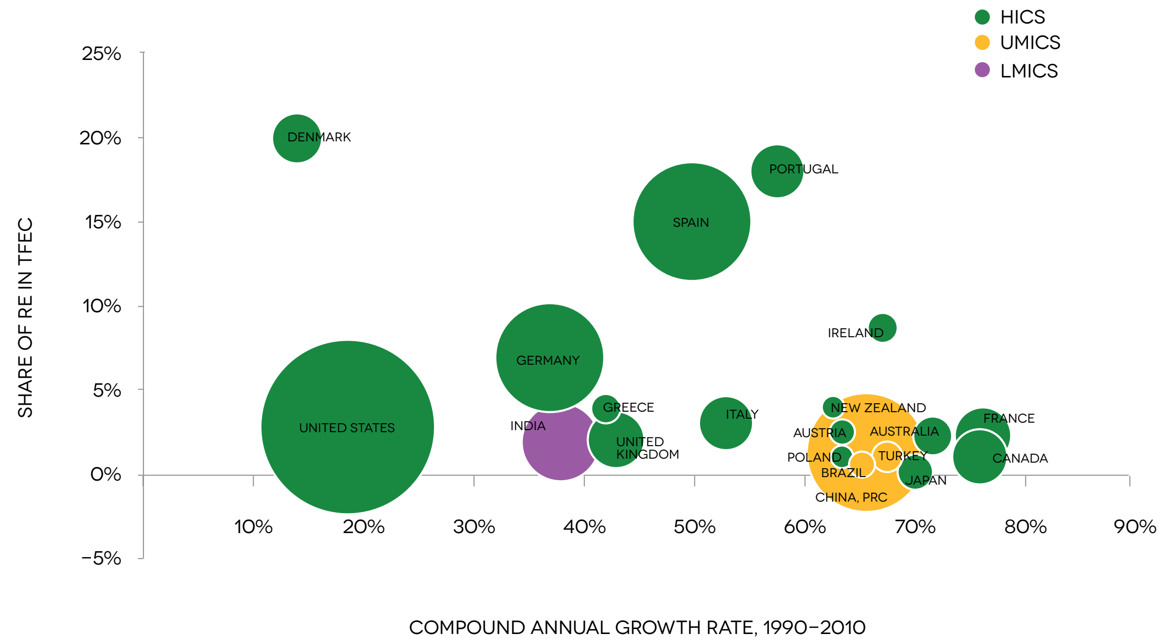


FIGURE A3.5 **SHARE OF WIND IN ELECTRICITY CONSUMPTION VS. CAGR, 1990—2010**

SOURCE: AUTHORS' ANALYSIS BASED ON IEA 2012D.

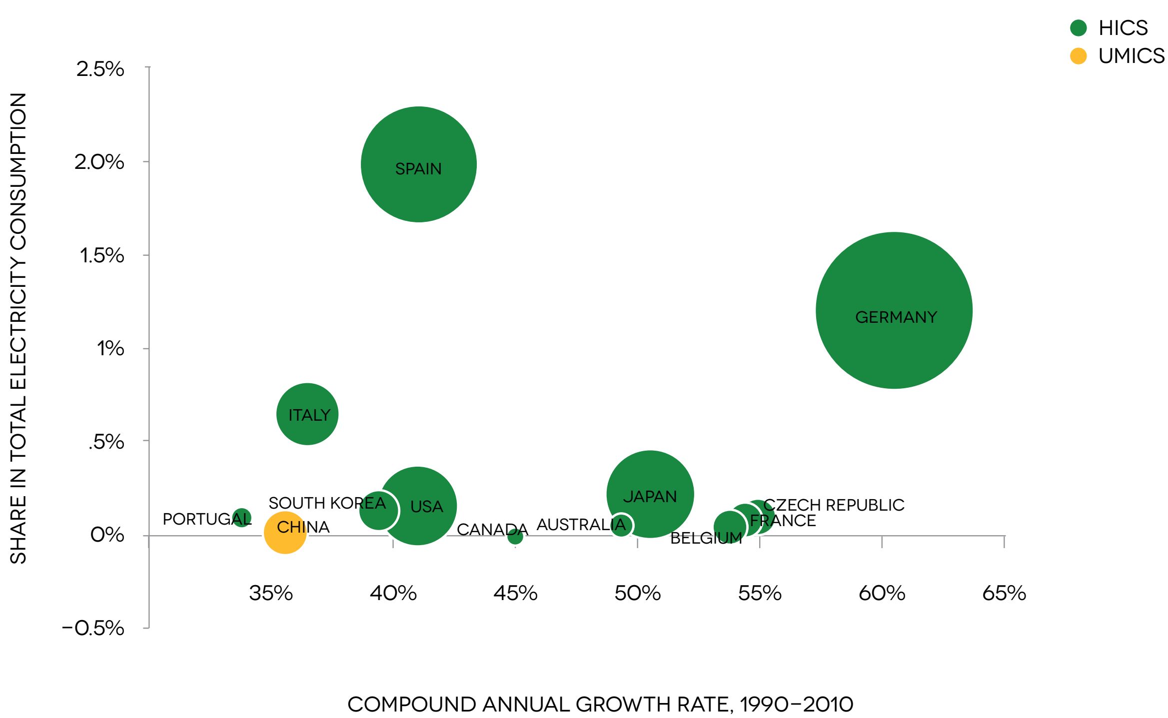


FIGURE A3.6 **SHARE OF SOLAR PV IN ELECTRICITY CONSUMPTION VS. CAGR, 1990—2010**

SOURCE: AUTHORS' ANALYSIS BASED ON IEA 2012D.

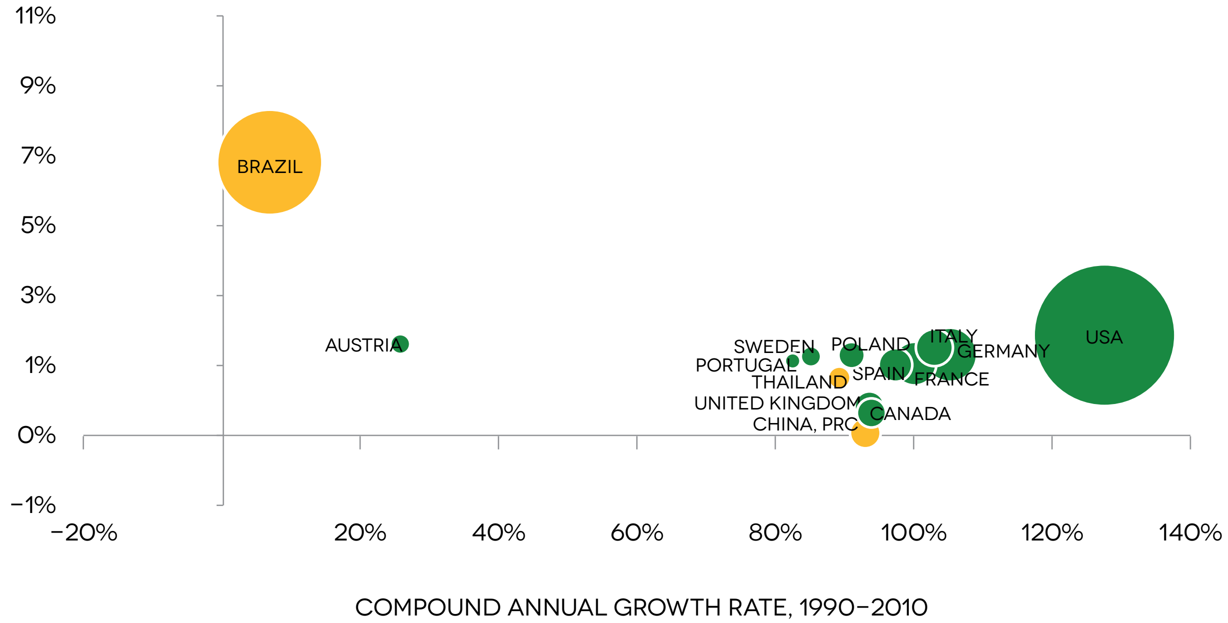


FIGURE A3.7 **SHARE OF BIOFUELS IN ELECTRICITY CONSUMPTION VS. CAGR, 1990–2010**

SOURCE: AUTHORS' ANALYSIS BASED ON IEA 2012D.

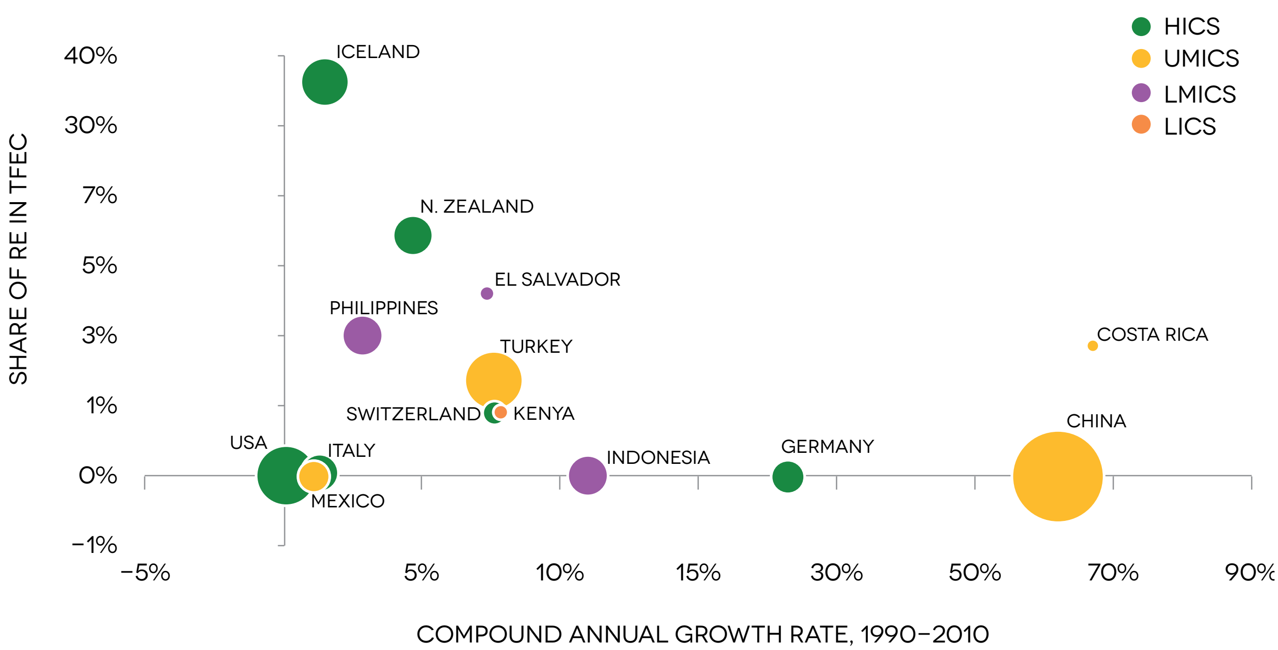
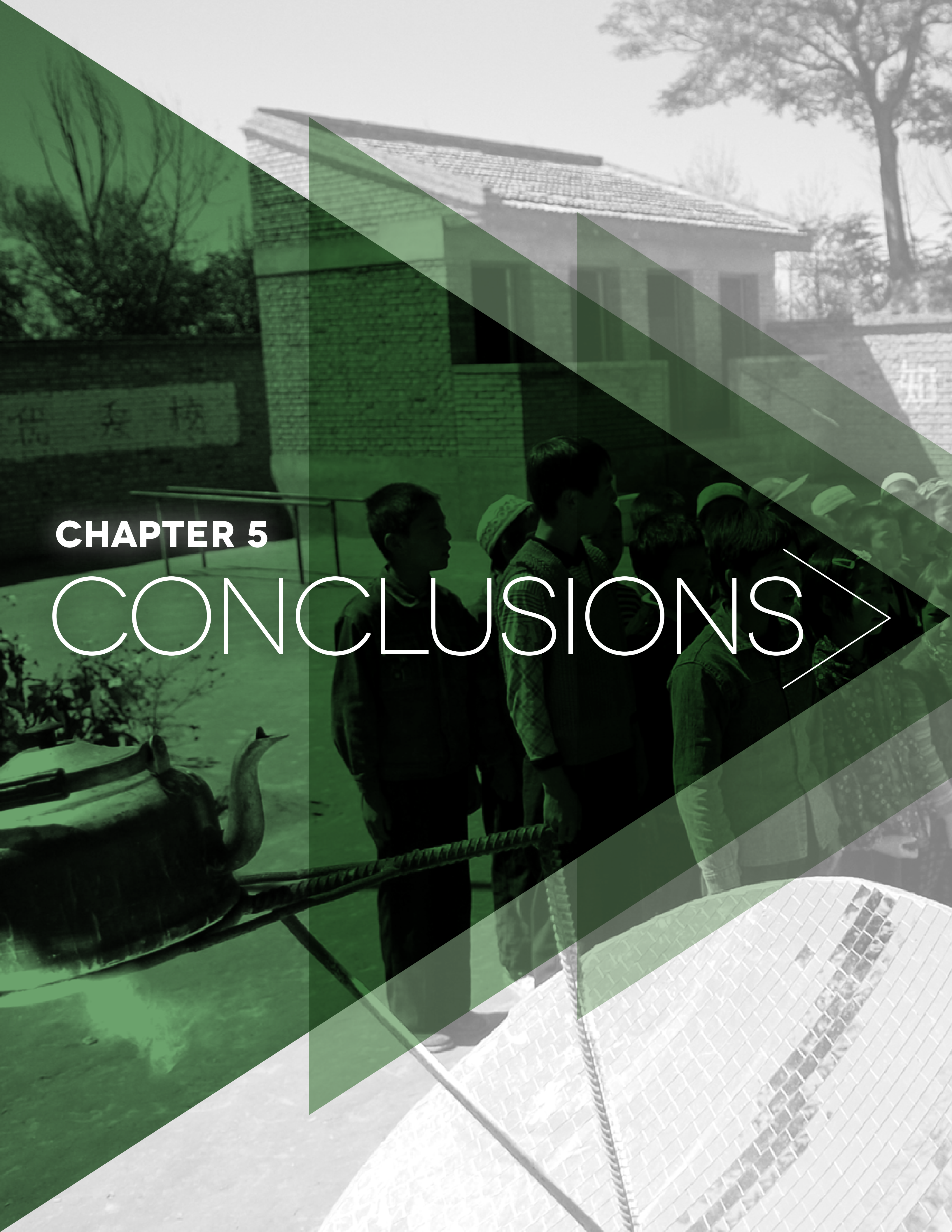


FIGURE A3.8 **SHARE OF GEOTHERMAL ENERGY IN COUNTRY TFEC VS. CAGR, 1990–2010**

SOURCE: AUTHORS' ANALYSIS BASED ON IEA 2012D.
NOTE: BUBBLE SIZE REPRESENTS VOLUME OF FINAL RENEWABLE ENERGY CONSUMPTION IN 2010. TFEC = TOTAL FINAL ENERGY CONSUMPTION; CAGR = COMPOUNT ANNUAL GROWTH RATE.

CHAPTER 5
CONCLUSIONS



SECTION 1. METHODICAL CONCLUSIONS

The Global Tracking Framework has built a robust data platform capable of monitoring global progress toward the SE4ALL objectives (table 5.1). This framework draws primarily on household surveys for data on energy access and on national energy balances for data on renewable energy and energy efficiency. Based on a comprehensive review of sources, it has been possible to cover between 126 and 181 countries depending on the indicator, which is equivalent to between 96 and 98 percent of the world's population.

CATEGORY	DATA SOURCES	COUNTRY COVERAGE (% OF GLOBAL POPULATION)
Electrification	Global networks of household surveys plus some censuses	212 (100)
Cooking fuels	Global networks of household surveys plus some censuses	193 (99)
Energy intensity	IEA and UN for energy balances WDI for GDP and sectoral value added	181 (98)
Renewable energy	IEA and UN for energy balances REN 21, IRENA, and BNEF for complementary indicators	181 (98)

TABLE 5.1 **OVERVIEW OF DATA SOURCES AND COUNTRY COVERAGE UNDER GLOBAL TRACKING**

NOTE: IEA = INTERNATIONAL ENERGY AGENCY; UN = UNITED NATIONS; REN 21 = RENEWABLE ENERGY NETWORK FOR THE 21ST CENTURY; IRENA = INTERNATIONAL RENEWABLE ENERGY AGENCY; BNEF = BLOOMBERG NEW ENERGY FINANCE; WDI = WORLD DEVELOPMENT INDICATORS (WORLD BANK); GDP= GROSS DOMESTIC PRODUCT.

Looking ahead, the Global Tracking Framework will be updated on a biannual basis to provide the international community with a regular report on the status of progress toward the SE4ALL objectives.

While the methodology here developed provides an adequate basis for basic global tracking, there are a number of significant information improvements that would be desirable to implement in the medium term (table 5.2). To effectively monitor progress through 2030 incremental investments in energy data systems will be essential over the next five years, both at the global and national levels. These represent relatively cost-effective high-impact improvements, whose implementation would be contingent on the availability of financial resources.

With regard to energy access, the first task will be to introduce the capability for medium-term global tracking using a simplified two-threshold framework. This would require modifying energy-related questions in the major global household survey networks to gather specific and unambiguous information about the use of electric lighting and the presence or absence of an electricity connection, as well as sharpening questions about the cooking fuels and cookstoves used in the household, in part to determine whether the latter may be considered "improved" even where solid fuels continue to be used. This work will require dialogue and close coordination with the International Household Survey Network among others. Second, the full multi-tier frameworks for access to electricity and cooking solutions described in chapter 2 need to be piloted in a number of SE4ALL opt-in countries to validate them for wider application. The pilot process would require preparation of survey questionnaires capable of capturing the attributes necessary for classifying households within the multi-tier frameworks. Third, upon validation of the multi-tier methodology, the survey questionnaires could potentially be administered at the national level by all opt-in countries.

	RECOMMENDED TARGETING OF EFFORT OVER NEXT FIVE YEARS
Energy access	Work to improve energy questionnaires for global networks of household surveys. Pilot country-level surveys to provide more precise and informative multi-tier measures of access to electricity and clean cooking Develop suitable access measures for heating.
Energy efficiency	Integrate data systems on energy use and associated output measures. Strengthen country capacity to collect data on sectoral (and ideally subsectoral process) intensities. Improve data on physical activity drivers (traffic volumes, number of households, floor space, etc.). Improve data on energy efficiency targets, policies, and investments.
Renewable energy	Improve data and definitions for bio-energy and sustainability. Capture renewable energy used in distributed generation. Capture renewable energy used off-grid and in micro-grids. Promote a more harmonized approach to target-setting.

TABLE 5.2 **MEDIUM-TERM AGENDA FOR THE IMPROVEMENT OF GLOBAL ENERGY DATABASES**

SOURCE: AUTHORS.

Thereafter, the feasibility of applying such a multi-tier energy access survey at the global level could be addressed. One way to address this challenge would be to commission a globally active survey agency to conduct the survey across all relevant countries. Another would be to enlist the support of various development agencies in conducting the standardized survey as a part of their operations in countries where they have significant engagement. It would be best to explore both possibilities at this stage. In addition, new methodologies would need to be developed and piloted to measure access to energy for community and productive uses, and for heating purposes. Funding would be needed to implement the pilots, to carry out regular energy surveys in opt-in countries, to develop new methodologies, and to prepare periodic tracking reports.

With regard to energy efficiency, the main concern is to strengthen countries' capacity to produce more disaggregated data on sectoral, subsectoral, and process energy use, as well as the associated output measures. This will entail ensuring consistency in sectoral definitions and methodologies to facilitate country comparisons and regional aggregations. Moving from value-based to physical-based indicators will permit a better tracking of improvements in energy efficiency. Such a move will require data on drivers of physical activity such as passenger and freight traffic volumes, residential and commercial floor space, and production volumes of energy-intensive products, which at present are available for only a few countries. These technical indicators will need to be complemented with other indicators more relevant to policy makers, including national energy efficiency targets, policies, and investments.

With regard to renewable energy, the first task will be to conduct assessments for the purpose of devising definitions and methods that will permit energy statistics to capture more accurately the full spectrum of existing renewable energy sources and applications. These assessments would cover the following areas: small, distributed, grid-connected electricity generation; off-grid and mini-grid power generation systems; direct production of heat and net energy from heat pumps; waste fuels; and renewable energy production in general. In a second stage, the new definitions, categories, and methodologies will have to be integrated into the questionnaires and procedures used to collect and report energy statistics at the country level. This exercise will necessarily involve the commitment and participation of the international organizations that maintain the primary data repositories in energy—notably the International Energy Agency, the International Renewable Energy Agency, the United Nations, and the World Health Organization.

In parallel, a review of methodological approaches—including definitions, indicators, and criteria—for assessing the sustainability of the main renewable energy technologies, and in particular modern and traditional uses of biomass, will have to be carried out and used as the basis for internationally accepted standards. Implementing the new methodologies and procedures will require capacity building efforts and should be preceded by piloting at the country level.

Finally, while many countries have already set national targets for renewable energy, these are expressed in such a wide range of units that they do not permit ready aggregation or comparison across countries. Going forward, it is proposed that countries express their renewable energy targets as a percentage of their total final energy consumption for consistency with the global tracking framework.

SECTION 2. SUBSTANTITIVE CONCLUSIONS

The Global Tracking Framework presented in this report has made it possible to establish the following starting points against which progress will be measured under the SE4ALL initiative (table 5.3). The rate of access to electricity and primary non-solid fuel will have to increase from 83 and 59 percent, respectively, in 2010 to 100 percent by 2030. The rate of improvement of energy intensity will have to double from –1.3 percent for 1990–2010 to –2.6 percent for 2010–30. The share of renewable energy in the global energy mix will have to double from an estimated starting point of at most 18 percent in 2010, implying an objective of up to 36 percent by 2030.

Global progress toward the achievement of each of the three SE4ALL objectives depends critically on the efforts of some 20 *high-impact countries* that have a particularly large weight in aggregate global performance. Overlapping groups of 20 high-impact countries in Asia and Africa account for about two-thirds of the global electrification deficit and four-fifths of the global deficit in access to non-solid fuels (figure 5.1). Meeting the universal access objective globally will depend critically on the progress that can be made in these countries. A third group of 20 high-income and emerging economies accounts for four-fifths of global energy consumption. The efforts of this group of countries to develop renewable energy and accelerate improvements in energy efficiency will ultimately determine the global achievement of the corresponding targets.

	OBJECTIVE 1		OBJECTIVE 2	OBJECTIVE 3
	Universal access to modern energy services		Doubling global rate of improvement of energy efficiency	Doubling share of renewable energy in global energy mix
Proxy indicator	Percentage of population with electricity access	Percentage of population with primary reliance on non-solid fuels	Rate of improvement in energy intensity*	Renewable energy share in TFEC
Historic reference 1990	76	47	–1.3	16.6
Starting point 2010	83	59		18.0
Objective for 2030	100	100	–2.6	36.0

TABLE 5.3 **SE4ALL HISTORIC REFERENCES, STARTING POINTS, AND GLOBAL OBJECTIVES (%)**

SOURCE: AUTHORS.
NOTE: TFEC = TOTAL FINAL ENERGY CONSUMPTION
*Measured in primary energy terms and GDP at purchasing power parity

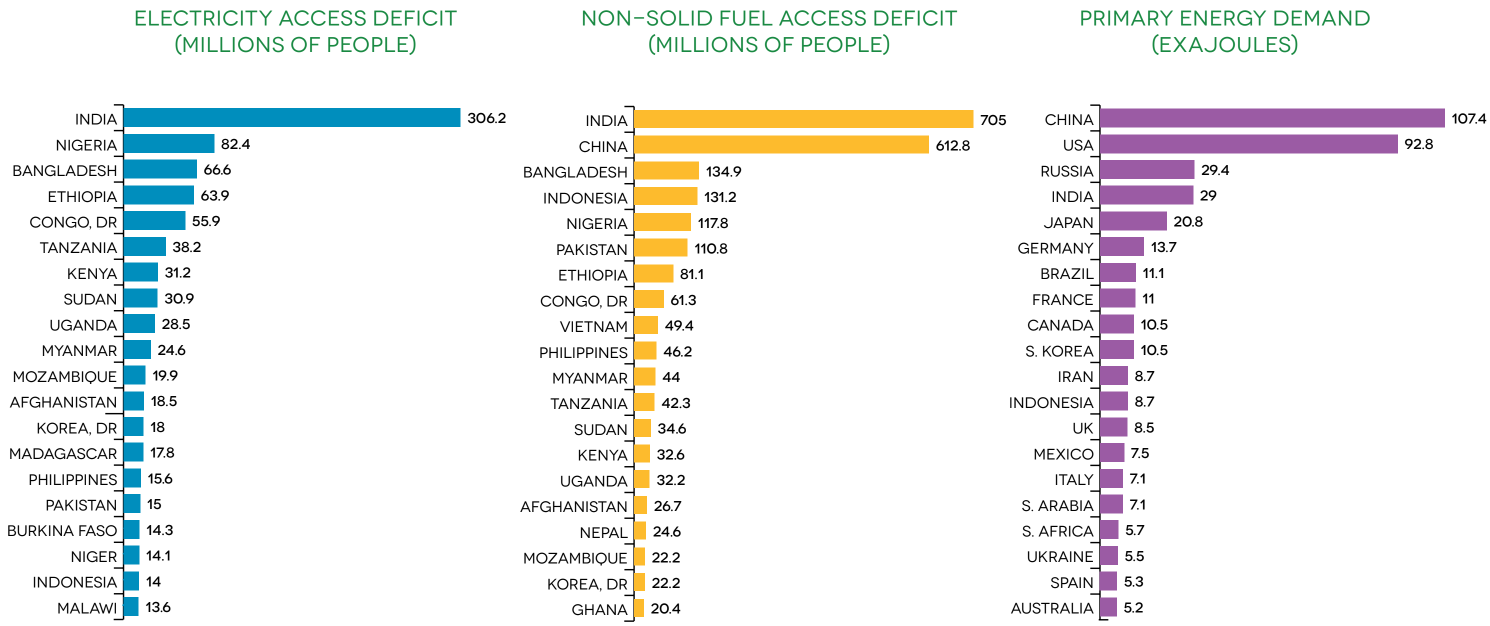


FIGURE 5.1 **OVERVIEW OF HIGH-IMPACT COUNTRIES**

SOURCE: IEA, WB GLOBAL ELECTRIFICATION DATABASE, WHO GLOBAL HOUSEHOLD ENERGY DATABASE.
NOTE: DR = "DEMOCRATIC REPUBLIC OF."

In charting a course toward the achievement of the SE4ALL objectives, it will also be important to learn from the experience of *fast-moving countries* that made particularly rapid progress on the three energy indicators between 1990 and 2010 (figure 5.2). In the case of electrification and cooking, even the fastest-moving countries have not been able to expand access by more than 3–4 percentage points annually. In the case of energy efficiency, the most rapid improvements in energy intensity, amounting to a compound annual growth rate of 4–8 percent, have been achieved in countries that began with high levels of energy intensity, where efficiency gains were relatively easy to make. In the case of renewable energy, the fastest-moving countries have experienced compound annual growth rates of 10–15 percent (excluding traditional biomass).

On all three aspects of energy sector development, China and India, stand out as being both high-impact *and* fast-moving countries.

Global energy model scenarios that gauge the scale of the global challenge implied by the achievement of these three objectives make it plain that business as usual will not remotely suffice to deliver the three SE4ALL objectives (table 5.4). With regard to universal access, business as usual would leave 12–16 percent and 31–36 percent of the world's population in 2030 without electricity and modern cooking solutions, respectively. With regard to energy efficiency, implementing all currently available measures with reasonable payback periods would be enough to meet or even exceed the SE4ALL objective. However, barriers prevent wider adoption of many of those measures, with the result that their current uptake ranges from around 20 percent for power generation and building construction to around 40 percent for manufacturing and transportation. With regard to renewable energy, few scenarios point to renewable energy shares above 30 percent by 2030.

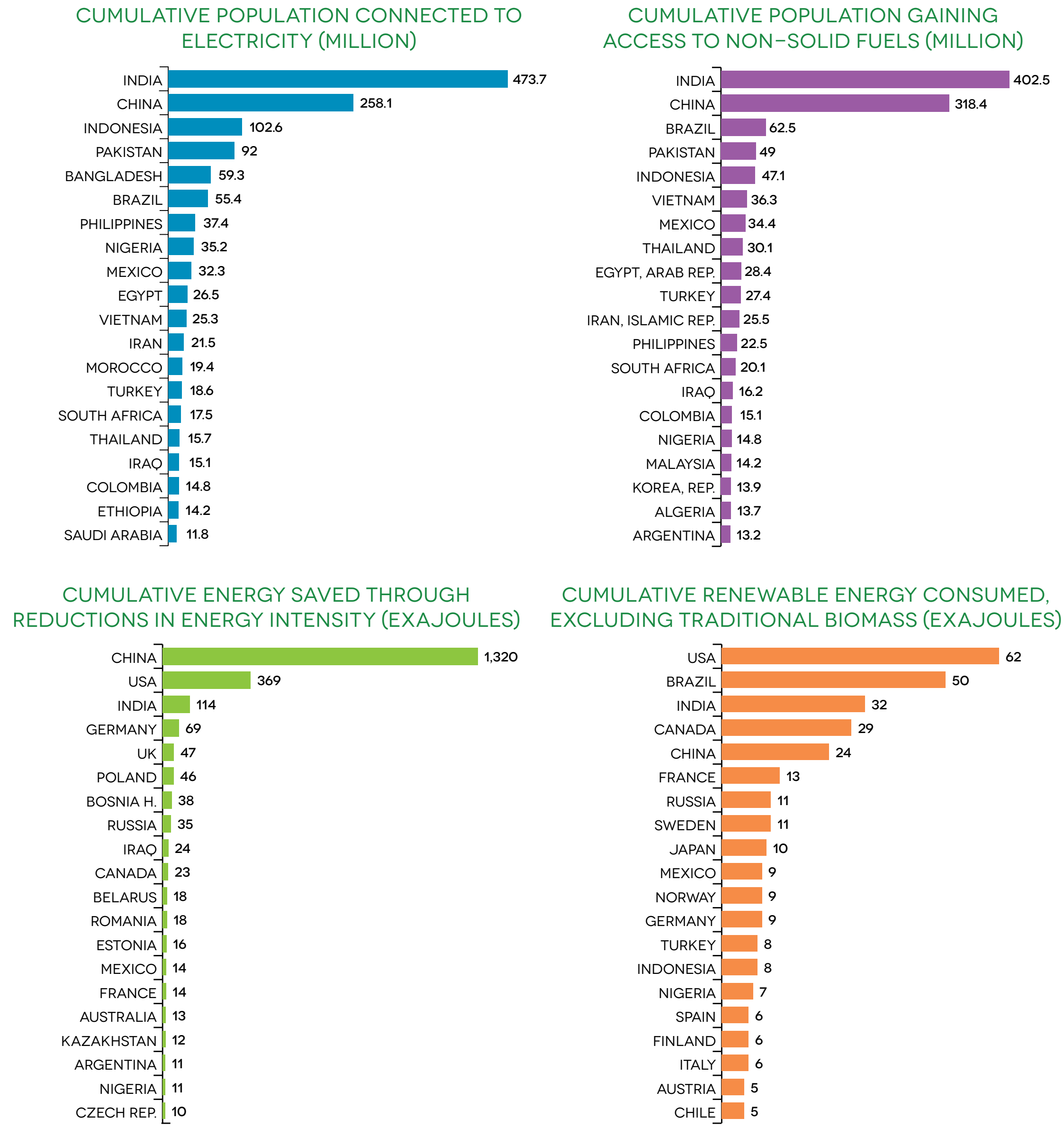


FIGURE 5.2 **OVERVIEW OF FAST MOVING COUNTRIES (1990–2010)**

SOURCE: IEA, UN, WB GLOBAL ELECTRIFICATION DATABASE, WHO GLOBAL HOUSEHOLD ENERGY DATABASE.
NOTE: BOSNIA H. = BOSNIA AND HERZEGOVINA.

Actual global investment in the areas covered by the three SE4ALL objectives has been estimated at around $400 billion in 2010 (table 5.5). The *additional* investments required to *achieve* the three objectives are tentatively estimated to be at least $600–800 billion per year, entailing a doubling or tripling of direct financial flows over current levels. The bulk of those investments are associated with the energy efficiency and renewable energy objectives, with access-related expenditures representing a relatively small percentage of the incremental costs (10–20 percent).

The global energy models also help to clarify the kinds of policy measures that would be needed to reach the three sustainable energy objectives. The IEA's *World Energy Outlook* (WEO) and the *Global Energy Assessment* (GEA) of the International Institute for Applied Systems Analysis (IIASA) coincide in highlighting the importance of phasing out fossil fuel subsidies, adopting measures to provide transparent price signals for carbon, embracing stringent and consistent technology standards for energy efficiency, and carefully designing targeted subsidies to increase access to electricity and clean cooking fuels.

Global models also serve to clarify the likely pattern of efforts across geographical regions toward the achievement of the three objectives, based on their starting points, their potential for improvement, and their comparative advantage. On energy access, greatest efforts are needed in Sub-Saharan Africa and South Asia. For energy efficiency, the highest rates of improvement—around –4 percent annually—are projected for Asia (particularly China) and the countries of the former Soviet Union. For renewable energy, Sub-Saharan Africa and Latin America emerge as the regions projected to reach the highest share of renewable energy in 2030—in excess of 50 percent, while much of the rest of the world falls in the 20–40 percent range (table 5.6).

	OBJECTIVE 1		OBJECTIVE 2	OBJECTIVE 3
	Universal access to modern energy services		Doubling global rate of improvement of energy efficiency	Doubling share of renewable energy in global mix
Percentage in 2030	Population with electricity access	Population with primary reliance on non-solid fuels	Global rate of improvement in energy intensity*	Renewable energy share in total final energy consumption
IEA scenarios				
New policies	88	69	–2.3	20
Efficient world	88	69	–2.8	22
450	n.a.	n.a.	–2.9	27
GEA scenarios				
Baseline	84	64	–1.0	12
GEA Pathways	100	100	–3.0 to –3.2	34 to 41
2^{0} Celsius	n.a.	n.a.	–1.8 to –3.2	23 to 41

TABLE 5.4 **OVERVIEW OF PROJECTED OUTCOMES FOR 2030 FROM IEA WORLD ENERGY OUTLOOK AND IIASA GLOBAL ENERGY ASSESSMENT**

SOURCE: IEA (2012) AND IIASA (2012).
n.a. = NOT APPLICABLE.

* IEA scenarios are presented in primary energy terms while GEA scenarios in final energy terms (GDP at purchasing power parity in both cases)

	OBJECTIVE 1		OBJECTIVE 2	OBJECTIVE 3	
Average annual investment 2010–30 (US$ billion)	Universal access to modern energy services		Doubling global rate of improvement of energy efficiency	Doubling share of renewable energy in global mix	Total
	Electrification	Cooking	Energy efficiency	Renewable energy	
Actual for 2010	9.0	0.1	180	228	417.1
Additional from WEO	45.0	4.4	393	>>174	>>616.4*
Additional from GEA	15.0	71.0	259–365	259–406	604–858**

TABLE 5.5 **OVERVIEW OF PROJECTED ANNUAL INVESTMENT NEEDS FOR 2010–2030 FROM WORLD ENERGY OUTLOOK AND GLOBAL ENERGY ASSESSMENT**

SOURCE: IEA (2012) AND IIASA (2012).

* WEO estimates are taken to be those closest to the corresponding SE4ALL objective: the Energy for All Scenario in the case of universal access, the Efficient World Scenario in the case of energy efficiency, and the 450 Scenario in the case of renewable energy. The 450 Scenario corresponds to a 27 percent renewable energy share, which is significantly below the SE4ALL objective. The Efficient World Scenario corresponds to a –2.8 percent CAGR for global energy intensity, which is significantly above the SE4ALL objective.

** GEA estimates that a further $716–910 billion would be needed annually for complementary infrastructure and broader energy sector investments not directly associated with the three objectives.

	OBJECTIVE 1				OBJECTIVE 2		OBJECTIVE 3	
	Universal access to modern energy services				Doubling global rate of improvement of energy efficiency		Doubling share of renewable energy in global mix	
	Percentage of population with electricity access		Percentage of population with primary reliance on non-solid fuels		Rate of improvement in energy intensity*		Renewable energy share in total final energy consumption	
	2010	SE4ALL	2010	SE4ALL	1990–2010	SE4ALL	2010	SE4ALL
Sub-Saharan Africa	32	100	19	100	1.1	2.2–2.4	56	60–73
Centrally Planned Asia	98	100	54	100	5.2	3.6–3.9	17	27–31
Central and Eastern Europe	100	100	90	100	3.1	2.6–3.0	8	28–36
Former Soviet Union	100	100	95	100	2.4	3.7–4.3	6	27–48
Latin America and Caribbean	95	100	86	100	0.7	2.6–3.0	25	49–57
Middle East and North Africa	95	100	99	100	-0.9	1.8–2.1	3	13–17
North America	100	100	100	100	1.7	2.4–2.6	8	26–34
Pacific OECD	100	100	100	100	0.7	2.9–3.4	6	30–41
Other Pacific Asia	89	100	57	100	1.2	3.6–4.0	18	30–37
South Asia	74	100	38	100	2.9	2.7–2.9	47	25–32
Western Europe	100	100	100	100	1.1	3.2–3.5	11	27–43
World	83	100	59	100	1.5	3.0–3.2	17	34–41

TABLE 5.6 **GLOBAL ENERGY ASSESSMENT: REGIONAL PROJECTIONS UNDER SE4ALL SCENARIOS**

SOURCE: IIASA (2012). ACCESS TO ELECTRICITY FOR 2010 IS FROM WB GLOBAL ELECTRIFICATION DATABASE, 2012. ACCESS TO NON-SOLID FUEL FOR 2010 IS FROM WHO GLOBAL HOUSEHOLD ENERGY DATABASE, 2012.

* Measured in final energy terms and GDP at purchasing power parity

Moreover, the global energy models clarify how the three SE4ALL objectives interact with each other and contribute to addressing global concerns such as climate change. The IEA finds that neither energy efficiency nor renewable energy measures *alone* will be sufficient to contain global warming to two degrees Celsius, but that the two, in tandem, take us much closer to the target. Achieving universal access to modern energy would have a negligible effect on global carbon dioxide emissions, adding only 0.6 percent. The GEA estimates that the probability of limiting global warming to two degrees Celsius increases to between 66 and 90 percent when the SE4ALL objectives for renewable energy and energy efficiency are *simultaneously* met—higher than if either objective were met individually (Rogelj and others 2013). The achievement of the universal access objective for modern cooking, which would increase reliance on typically fossil-based non-solid fuels for cooking, would have a small offsetting effect, reducing the share of renewable energy in the global mix by some two percentage points, with a negligible impact on the probability of achieving the two degree Celsius target.

In conclusion, the Global Tracking Framework has constructed a robust data platform capable of monitoring global progress toward the SE4ALL objectives. Looking ahead, the consortium of agencies that has produced this report recommends a biannual update on the status of the three SE4ALL objectives that will build on this framework.

The methodology of the SE4ALL Global Tracking Framework provides an adequate basis for basic global tracking, but that tracking effort could be vastly improved if several measures were implemented over the next five years. These cost-effective, high-impact improvements to global energy databases will be contingent on the availability of financial resources. For energy access, the focus will be to move beyond binary measures of energy access to a multi-tier framework that better captures the quantity and quality of electricity supplied, as well as the efficiency, safety and convenience of household cookstoves, including those that make use of biomass. For energy efficiency, the main concern is to strengthen countries' capacity to produce disaggregated data on sectoral and subsectoral energy consumption that are fully integrated with measures of the output of those same sectors. In the case of renewable energy, the main priority will be to improve the ability to gauge the sustainability of different forms of renewable energy, particularly traditional biomass.

Finally, given the scale of the challenge of meeting the three SE4ALL objectives for energy, it is apparent that bold policy measures, combined with a regulatory and institutional environment that supports innovation and encourages investment, will be required to produce the requisite increases in the energy sector's capacity to widen access, boost the output derived from a given unit of energy, and raise the share of renewable energy in the overall energy mix. A detailed analysis of the policy environment at the country level lies beyond the immediate scope of this Global Tracking Framework, which has focused on the monitoring of global progress toward the stated SE4ALL objectives. However, it will be an important focus for future work in support of the critical social, economic, and environmental goals that the SE4ALL initiative addresses.

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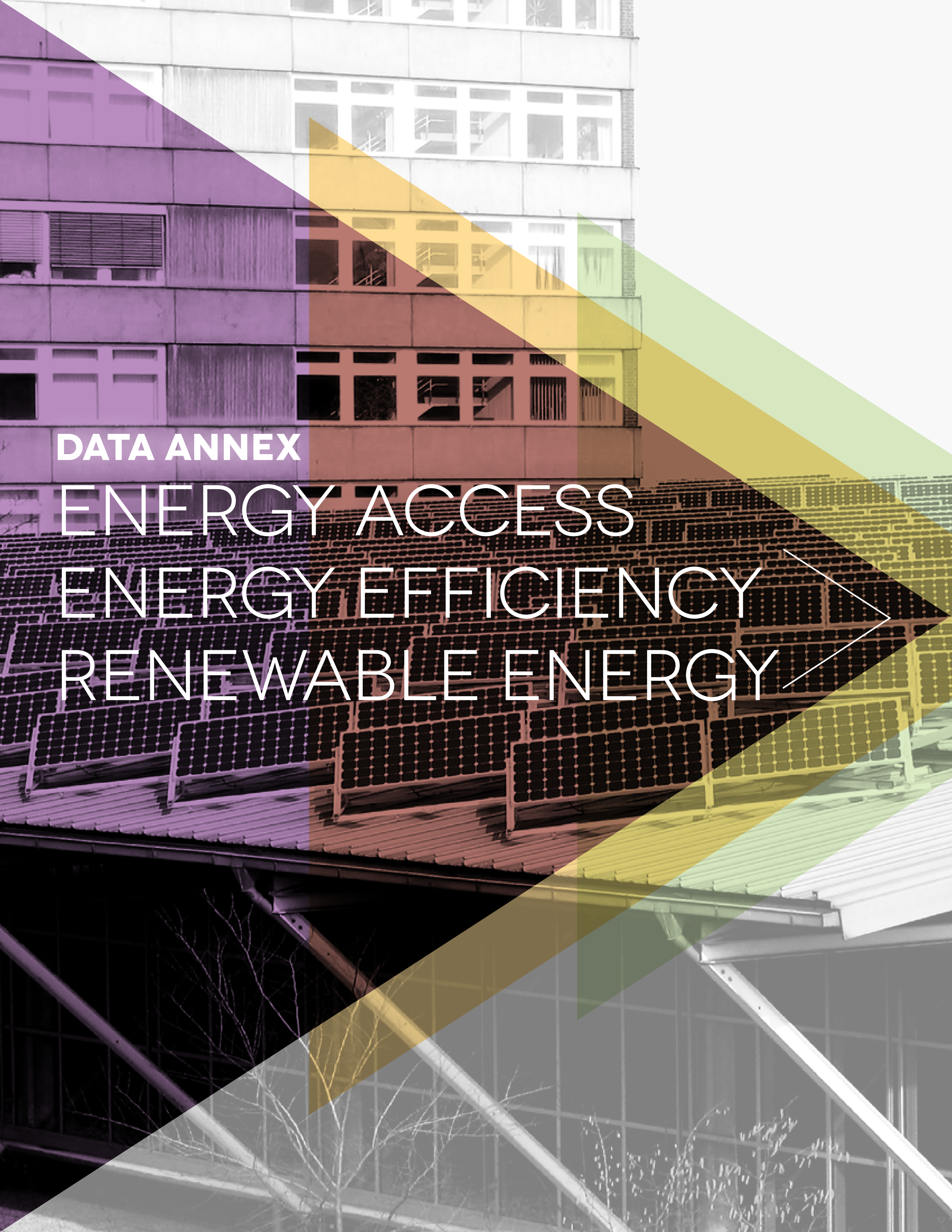
DATA ANNEX

ENERGY ACCESS
ENERGY EFFICIENCY
RENEWABLE ENERGY



DATA ANNEX: ENERGY ACCESS

		ACCESS TO ELECTRICITY (% OF POPULATION)						ACCESS TO NON-SOLID FUEL (% OF POPULATION)					
		TOTAL			RURAL	URBAN		TOTAL			RURAL	URBAN	
Region	**Country**	**1990**	**2000**	**2010**	**2010**	**2010**	**Latest available Source/year**	**1990**	**2000**	**2010**	**2010**	**2010**	**Latest available Source/year**
SA	Afghanistan	35	37	41	29	81	NRVA 2007/08	< 5	9	15	5	66	Other2007
DEV	Albania	100	100	100	100	100	DHS 2008	36	50	61	49	89	DHS2008
NA	Algeria	94	98	99	98	100	COMELEC 2007	86	> 95	> 95	> 95	> 95	MICS2006
Oceania	American Samoa	49	53	56	43	57	Estimate						
DEV	Andorra	100	100	100	100	100	Assumption	> 95	> 95	> 95	> 95	> 95	Assumption
SSA	Angola	28	31	35	6	55	DHS 2011	< 5	16	45	11	84	DHS2006
LAC	Antigua and Barbuda	81	85	88	74	100	Estimate	86	> 95	> 95	> 95	> 95	Other2007
LAC	Argentina	81	85	88	74	89	Estimate	83	94	> 95	> 95	> 95	Other2001
CCA	Armenia	94	98	100	100	100	DHS 2005	15	50	81	51	> 95	NatSur2008
LAC	Aruba	81	85	88	74	100	Estimate						
DEV	Australia	100	100	100	100	100	Assumption	> 95	> 95	> 95	> 95	> 95	Assumption
DEV	Austria	100	100	100	100	100	Assumption	> 95	> 95	> 95	> 95	> 95	Assumption
CCA	Azerbaijan	93	96	100	99	100	DHS 2006	48	72	93	81	> 95	DHS2006
LAC	Bahamas	81	85	88	74	91	Estimate	> 95	> 95	> 95	> 95	> 95	Estimate
WA	Bahrain	87	91	94	90	95	Estimate	> 95	> 95	> 95	> 95	> 95	Estimate
SA	Bangladesh	22	32	55	43	88	HIES 2010	9	11	9	5	37	DHS2007
LAC	Barbados	81	85	88	74	100	Estimate	> 95	> 95	> 95	> 95	> 95	NatCen2000
DEV	Belarus	100	100	100	100	100	HBS 2009	81	92	> 95	94	> 95	MICS2005
DEV	Belgium	100	100	100	100	100	Assumption	> 95	> 95	> 95	> 95	> 95	Assumption
LAC	Belize	81	85	88	74	100	Estimate	71	81	88	82	> 95	NatCen2010
SSA	Benin	22	25	28	9	52	DHS 2006	< 5	6	9	5	14	DHS2006
DEV	Bermuda	100	100	100	100	100	Assumption						
SA	Bhutan	66	68	72	50	100	DHS 2007	22	42	60	45	> 95	MICS2010
LAC	Bolivia, Plurinational State of	74	77	80	55	93	DHS 2008	55	64	71	27	94	DHS2008
DEV	Bosnia and Herzegovina	94	99	100	98	100	HBS 2007	42	50	55	31	83	MICS2005
SSA	Botswana	37	40	43	43	43	BAIS III 2008	35	50	63	38	90	NatSur2007
LAC	Brazil	92	97	99	94	100	NatCen2009	81	89	94	64	> 95	WHS2003
SEA	Brunei Darussalam	66	69	73	64	75	Estimate	> 95	> 95	> 95	> 95	> 95	Estimate
DEV	Bulgaria	100	100	100	100	100	HIS 2007	77	87	93			Estimate

		ACCESS TO ELECTRICITY (% OF POPULATION)						ACCESS TO NON-SOLID FUEL (% OF POPULATION)					
		TOTAL			RURAL	URBAN		TOTAL			RURAL	URBAN	
Region	Country	1990	2000	2010	2010	2010	Latest available Source/year	1990	2000	2010	2010	2010	Latest available Source/year
SSA	Burkina Faso	6	7	13	1	47	DHS 2010	< 5	< 5	8	5	23	NatSur2007
SSA	Burundi	0	4	5	1	41	DHS 2010	< 5	< 5	< 5	< 5	5	MICS2005
SEA	Cambodia	19	17	31	19	81	DHS 2010	< 5	6	11	5	45	DHS2010
SSA	Cameroon	29	46	49	14	82	NatCen2006	6	17	25	5	41	MICS2005
DEV	Canada	100	100	100	100	100	Assumption	> 95	> 95	> 95	> 95	> 95	Assumption
SSA	Cape Verde	58	59	67	44	81	DHS 2005	51	61	68	33	90	NatSur2007
LAC	Cayman Islands	81	85	88	74	88	Estimate						
SSA	Central African Republic	3	6	9	5	16	Estimate	< 5	< 5	< 5	< 5	5	MICS2006
SSA	Chad	0	2	4	0	15	DHS 2004	< 5	< 5	12	6	27	Other2005
DEV	Channel Islands	100	100	100	100	100	Assumption						
LAC	Chile	95	98	100	98	100	ENEMDU 2010	76	86	94	53	> 95	N atCen2002
EA	China	94	98	100	98	100	Electric Company 2010	36	47	54	19	70	NatCen2005
EA	China, Hong Kong SAR	100	100	100	100	100	Estimate						
EA	China, Macau SAR	86	90	93	90	93	Estimate						
LAC	Colombia	90	93	97	91	99	NatCen2010	74	81	86	49	> 95	DHS2010
SSA	Comoros	42	45	48	37	77	Estimate	11	21	29	15	58	Other2004
SSA	Congo	24	21	37	9	53	DHS 2009	< 5	14	23	5	33	DHS2009
SSA	Congo, Dem. Rep. of the	6	7	15	3	39	DHS 2007	< 5	< 5	7	5	14	DHS2007
LAC	Costa Rica	93	95	99	98	100	ENCOVI 2010	77	87	94	86	> 95	NatSur2009
SSA	Cote d'Ivoire	37	51	59	37	80	DHS 2005	13	19	22	5	35	MICS2005
DEV	Croatia	100	100	100	100	100	Assumption	73	84	92	82	> 95	WHS2003
LAC	Cuba	94	97	100	93	100	Estimate	93	94	91	77	94	Other2008
LAC	Curacao	81	85	88	74	88	Estimate						
DEV	Cyprus	96	100	100	100	100	Assumption	> 95	> 95	> 95			Assumption
DEV	Czech Republic	100	100	100	100	100	HBS 2009	82	94	> 95	> 95	> 95	WHS2003
DEV	Denmark	100	100	100	100	100	Assumption	> 95	> 95	> 95			Assumption
SSA	Djibouti	43	46	50	10	61	PRSP 2004	84	87	87	21	90	NatSur2006
LAC	Dominica	85	88	91	100	87	Estimate	58	80	> 95	> 95	> 95	NatCen2001

		ACCESS TO ELECTRICITY (% OF POPULATION)						ACCESS TO NON-SOLID FUEL (% OF POPULATION)					
		TOTAL			RURAL	URBAN		TOTAL			RURAL	URBAN	
Region	Country	1990	2000	2010	2010	2010	Latest available Source/year	1990	2000	2010	2010	2010	Latest available Source/year
LAC	Dominican Republic	78	92	98	94	100	NatCen2010	63	80	93	85	> 95	DHS2007
SEA	East Timor	32	34	38	24	74	DHS 2010	< 5	8	8	< 5	21	DHS2009
LAC	Ecuador	90	93	97	93	100	NatCen2010	73	87	> 95	87	> 95	NatCen2006
NA	Egypt	96	98	100	99	100	DHS 2008	93	> 95	> 95	> 95	> 95	DHS2005
LAC	El Salvador	77	88	92	82	97	INE 2010	50	65	78	49	93	NatSur2007
SSA	Equatorial Guinea	22	26	29	14	52	Estimate	18	21	23			Estimate
SSA	Eritrea	23	32	33	9	79	Estimate	14	28	40	15	73	DHS2002
DEV	Estonia	100	100	100	100	100	Assumption	72	82	89	69	> 95	WHS2003
SSA	Ethiopia	10	13	23	5	85	DHS 2011	7	6	< 5	< 5	27	DHS2005
DEV	Faeroe Islands	100	100	100	100	100	Assumption						
Oceania	Fiji	49	53	56	43	68	Estimate	45	56	63			Other1996
DEV	Finland	100	100	100	100	100	Assumption	> 95	> 95	> 95	> 95	> 95	Assumption
DEV	France	100	100	100	100	100	Assumption	> 95	> 95	> 95	> 95	> 95	Assumption
Oceania	French Polynesia	49	53	56	43	68	Estimate						
SSA	Gabon	73	74	82	35	89	CWIQ 2005	50	64	74	25	86	Other2006
SSA	Gambia	18	34	31	23	37	Estimate	< 5	< 5	9	5	12	MICS2005
CCA	Georgia	97	100	100	100	100	HBS 2009	45	51	54	15	88	MICS2005
DEV	Germany	100	100	100	100	100	Assumption	> 95	> 95	> 95	> 95	> 95	Assumption
SSA	Ghana	31	45	61	38	82	DHS 2008	< 5	9	16	5	28	DHS2008
DEV	Greece	100	100	100	100	100	Assumption	> 95	> 95	> 95	> 95	> 95	Assumption
DEV	Greenland	100	100	100	100	100	Assumption						
LAC	Grenada	81	85	88	74	100	Estimate	69	89	100	100	100	NatCen2001
Oceania	Guam	49	53	56	43	57	Estimate						
LAC	Guatemala	76	79	82	68	96	NatCen2006	36	41	43	18	73	WHS2003
SSA	Guinea	14	16	20	3	53	DHS 2005	< 5	< 5	< 5	< 5	< 5	DHS2005
SSA	Guinea-Bissau	51	54	57	19	100	Estimate	< 5	< 5	< 5	< 5	< 5	MICS2006
LAC	Guyana	72	75	78	72	91	DHS 2009	74	85	93	91	> 95	DHS2009
LAC	Haiti	31	31	34	12	54	DHS 2006	< 5	6	9	5	16	DHS2005
LAC	Honduras	75	77	81	64	97	NatCen2010	32	42	49	14	81	DHS2005

		ACCESS TO ELECTRICITY (% OF POPULATION)						ACCESS TO NON-SOLID FUEL (% OF POPULATION)					
		TOTAL			RURAL	URBAN		TOTAL			RURAL	URBAN	
Region	**Country**	**1990**	**2000**	**2010**	**2010**	**2010**	**Latest available Source/year**	**1990**	**2000**	**2010**	**2010**	**2010**	**Latest available Source/year**
DEV	Hungary	100	100	100	100	100	HBS 2007	> 95	> 95	> 95	> 95	> 95	Assumption
DEV	Iceland	100	100	100	100	100	Assumption	> 95	> 95	> 95	> 95	> 95	Assumption
SA	India	51	62	75	67	93	NSSO 2009	13	29	42	14	77	NatSur2006
SEA	Indonesia	67	88	94	89	99	DHS12 2010	33	41	45	23	80	DHS2007
SA	Iran, Islamic Republic of	94	98	98	95	100	Ministry of Energy 2006	88	> 95	> 95	> 95	> 95	Natcen2006
WA	Iraq	92	94	98	94	100	IAU Iraq / UN Factsheet 2011	89	> 95	> 95	91	> 95	MICS2005
DEV	Ireland	100	100	100	100	100	Assumption	> 95	> 95	> 95	> 95	> 95	Assumption
DEV	Isle of Man	100	100	100	100	100	Assumption						
DEV	Israel	96	100	100	100	100	Assumption	> 95	> 95	> 95	> 95	> 95	Assumption
DEV	Italy	100	100	100	100	100	Assumption	> 95	> 95	> 95	> 95	> 95	Assumption
LAC	Jamaica	70	87	92	84	99	Ministry of Energy, 2008;	62	77	89			NatCen2001
DEV	Japan	100	100	100	100	100	Assumption	> 95	> 95	> 95	> 95	> 95	Assumption
WA	Jordan	95	100	99	99	100	DHS 2009	88	> 95	> 95	> 95	> 95	DHS2009
CCA	Kazakhstan	94	97	100	98	100	HBS 2008	71	83	91	77	> 95	MICS2005
SSA	Kenya	11	15	23	8	71	DHS 2008	18	20	20	5	61	DHS2010
Oceania	Kiribati	49	53	56	43	73	Estimate	34	45	54			Estimate
EA	Korea, Dem. People's Rep. of	20	22	26	10	37	Fund for Peace 2008; IEA est	< 5	7	9	5	11	NatCen2008
EA	Korea, Republic of	86	90	93	90	94	Estimate	80	> 95	> 95	> 95	> 95	Other1998
DEV	Kosovo	100	100	100	100	100	HBS 2009						
WA	Kuwait	87	91	94	90	94	Estimate	> 95	> 95	> 95	> 95	> 95	Estimate
CCA	Kyrgyzstan	97	100	100	100	100	HBS 2008	49	59	66	47	90	MICS2005
SEA	Lao People's Dem. Rep.	52	46	66	52	94	LECS4 2008	< 5	5	< 5	< 5	11	NatSur2007
DEV	Latvia	100	100	100	100	100	Assumption	77	87	95	78	> 95	WHS2003
WA	Lebanon	93	95	100	99	100	Other	92	> 95	> 95	> 95	> 95	Other1996
SSA	Lesotho	6	5	17	7	43	DHS 2009	37	39	39	20	94	DHS2009
SSA	Liberia	0	1	4	1	7	DHS 2011	< 5	< 5	< 5	< 5	5	DHS2009

		ACCESS TO ELECTRICITY (% OF POPULATION)						ACCESS TO NON-SOLID FUEL (% OF POPULATION)					
		TOTAL			RURAL	URBAN		TOTAL			RURAL	URBAN	
Region	**Country**	**1990**	**2000**	**2010**	**2010**	**2010**	**Latest available Source/year**	**1990**	**2000**	**2010**	**2010**	**2010**	**Latest available Source/year**
NA	Libya	97	100	100	99	100	Estimate	89	> 95	> 95	> 95	> 95	Estimate
DEV	Liechtenstein	100	100	100	100	100	Assumption						
DEV	Lithuania	100	100	100	100	100	HBS 2008	77	87	93			Assumption
DEV	Luxembourg	100	100	100	100	100	Assumption	> 95	> 95	> 95	> 95	> 95	Assumption
DEV	Macedonia, Former Yugoslav Rep. of	93	95	99	98	100	HBS 2006	52	61	67	48	78	MICS2005
SSA	Madagascar	9	11	14	9	25	DHS 2011	< 5	< 5	< 5	< 5	5	NatCen2009
SSA	Malawi	3	5	9	4	37	DHS 2010	< 5	< 5	< 5	< 5	11	DHS2010
SEA	Malaysia	93	96	99	98	100	HIS/BA 2009	78	92	> 95	> 95	> 95	WHS2003
SA	Maldives	94	96	100	100	100	DHS 2009	36	65	92	91	> 95	DHS2009
SSA	Mali	12	17	17	3	42	DHS 2006	< 5	< 5	< 5	< 5	5	DHS2006
DEV	Malta	100	100	100	100	100	Assumption	> 95	> 95	> 95	> 95	> 95	Assumption
Oceania	Marshall Islands	49	53	56	43	61	Estimate	80	76	68	8	92	Other2007
SSA	Mauritania	12	15	18	2	42	EPCV 2005	20	32	42	21	66	MICS2007
SSA	Mauritius	97	99	100	100	100	Estimate	81	93	> 95	> 95	> 95	NatSur2004
LAC	Mexico	95	98	99	98	100	NatCen2010	75	82	86	61	> 95	NatCen2010
Oceania	Micronesia, Federated States of	49	53	56	43	100	Estimate	45	53	59			NatCen2005
DEV	Moldova, Republic of	92	95	99	98	99	DHS 2005	72	82	89	79	> 95	DHS2005
DEV	Monaco	100	100	100	100	100	Assumption	> 95	> 95	> 95	> 95	> 95	Assumption
EA	Mongolia	80	83	86	67	100	LSMS 2005	19	25	28	5	43	MICS2005
DEV	Montenegro	100	100	100	100	100	Assumption	56	65	72	46	85	MICS2005
NA	Morocco	49	71	99	97	100	DHS 2003	81	91	> 95	87	> 95	DHS2004
SSA	Mozambique	6	7	15	2	45	DHS 2009	< 5	< 5	5	5	10	MICS2008
SEA	Myanmar	43	47	49	28	92	IHLCA 2010	< 5	< 5	8	5	17	Other2004
SSA	Namibia	26	37	44	15	92	DHS 2006	26	37	45	14	83	DHS2006
SA	Nepal	70	73	76	72	100	DHS 2011	26	23	18	10	67	DHS2006
DEV	Netherlands	100	100	100	100	100	Assumption	> 95	> 95	> 95	> 95	> 95	Assumption
Oceania	New Caledonia	49	53	56	43	64	Estimate						
DEV	New Zealand	100	100	100	100	100	Assumption	> 95	> 95	> 95	> 95	> 95	Assumption
LAC	Nicaragua	72	73	74	43	96	ENAHO 3 2005	23	36	46	9	71	NatSur2006

		ACCESS TO ELECTRICITY (% OF POPULATION)						ACCESS TO NON-SOLID FUEL (% OF POPULATION)					
		TOTAL			RURAL	URBAN		TOTAL			RURAL	URBAN	
Region	Country	1990	2000	2010	2010	2010	Latest available Source/year	1990	2000	2010	2010	2010	Latest available Source/year
SSA	Niger	6	7	9	2	46	DHS 2006	< 5	< 5	< 5	< 5	6	DHS2006
SSA	Nigeria	42	45	48	35	62	DHS 2010	26	28	26	10	54	DHS2008
DEV	Norway	100	100	100	100	100	Assumption	> 95	> 95	> 95	> 95	> 95	Assumption
WA	Oman	87	91	94	90	96	Estimate	> 95	> 95	> 95	> 95	> 95	Estimate
SA	Pakistan	60	80	91	88	98	PSLM 2010-11	12	26	36	11	71	NatSur2006
Oceania	Palau	49	53	56	43	58	Estimate	90	> 95	> 95			Other1997
LAC	Panama	81	85	88	74	93	Estimate	75	80	82	73	> 95	LSMS2008
Oceania	Papua New Guinea	8	11	15	8	63	LSMS 2006	5	17	27	11	72	LSMS1996
LAC	Paraguay	90	92	97	94	99	NatCen2010	46	50	51	20	68	NatSur2009
LAC	Peru	69	72	85	60	93	NatCen2010	38	52	64	25	92	NatSur2010
SEA	Philippines	65	71	83	73	94	DHS 2008	40	47	50	34	76	DHS2008
DEV	Poland	100	100	100	100	100	Assumption	> 95	> 95	> 95	> 95	> 95	Assumption
DEV	Portugal	100	100	100	100	100	Assumption	> 95	> 95	> 95	> 95	> 95	Assumption
LAC	Puerto Rico	81	85	88	74	88	Estimate						
WA	Qatar	87	91	94	90	94	Estimate	92	> 95	> 95	> 95	> 95	NatCen2010
DEV	Romania	100	100	100	100	100	HBS 2009	65	75	83	63	> 95	Other2002
DEV	Russian Federation	100	100	100	100	100	HBS 2009	91	> 95	> 95	92	> 95	MICS2005
SSA	Rwanda	2	6	11	4	40	EICV 3 2011	< 5	< 5	< 5	< 5	5	NatSur2007
LAC	Saint Lucia	81	85	88	74	100	Estimate	63	86	100	100	100	Estimate
Oceania	Samoa	80	89	100	90	100	Estimate	30	40	47	25	73	DHS2009
DEV	San Marino	100	100	100	100	100	Assumption	> 95	> 95	> 95	> 95	> 95	Assumption
SSA	Sao Tome and Principe	50	53	57	44	65	DHS 2008	9	20	29	15	42	DHS2008
WA	Saudi Arabia	87	91	94	90	95	Estimate	> 95	> 95	> 95	> 95	> 95	Estimate
SSA	Senegal	26	37	57	27	97	DHS 2011	19	35	49	17	86	NatSur2008
DEV	Serbia	100	100	100	100	100	Estimate	49	60	68	41	89	MICS2005
SSA	Seychelles	22	26	29	14	42	Estimate	80	93	> 95	> 95	> 95	Other2002
SSA	Sierra Leone	6	9	12	1	29	DHS 2008	7	5	< 5	< 5	5	DHS2008
SEA	Singapore	66	69	73	64	73	Estimate	> 95	> 95	> 95	> 95	> 95	Estimate
DEV	Slovak Republic	100	100	100	100	100	Assumption	81	93	> 95	> 95	> 95	WHS2003

		ACCESS TO ELECTRICITY (% OF POPULATION)						ACCESS TO NON-SOLID FUEL (% OF POPULATION)					
		TOTAL			RURAL	URBAN		TOTAL			RURAL	URBAN	
Region	**Country**	**1990**	**2000**	**2010**	**2010**	**2010**	**Latest available Source/year**	**1990**	**2000**	**2010**	**2010**	**2010**	**Latest available Source/year**
DEV	Slovenia	100	100	100	100	100	Assumption	76	88	> 95	> 95	> 95	WHS2003
Oceania	Solomon Islands	13	16	19	10	57	Estimate	10	12	10	5	43	NatSur2007
SSA	Somalia	22	26	29	14	54	Estimate	< 5	< 5	< 5	< 5	5	MICS2005
SSA	South Africa	65	66	83	64	94	GHS 2011	61	75	85	63	94	NatSur2010
SSA	South Sudan	0	0	2	1	5	NatCen2010						
DEV	Spain	100	100	100	100	100	Assumption	> 95	> 95	> 95	> 95	> 95	WHS2003
SA	Sri Lanka	78	81	85	83	96	HIES 2009	11	20	25	15	66	NatSur2009
LAC	St. Kitts and Nevis	81	85	88	74	100	Estimate	73	81	86			Estimate
LAC	St. Martin (French part)	81	85	88	74	100	Estimate						
LAC	St. Vincent and the Grenadines	67	70	73	29	100	Estimate	31	65	> 95	> 95	> 95	NatSur2007
SSA	Sudan	23	25	29	15	57	Other HH 2010	< 5	7	21	13	24	NatCen2008
LAC	Suriname	97	100	100	100	100	Estimate	70	81	88			MiCS2006
SSA	Swaziland	29	32	35	22	85	DHS 2006	22	35	45	25	87	DHS2006
DEV	Sweden	100	100	100	100	100	Assumption	> 95	> 95	> 95	> 95	> 95	Assumption
DEV	Switzerland	100	100	100	100	100	Assumption	> 95	> 95	> 95	> 95	> 95	Assumption
WA	Syrian Arab Republic	85	87	93	78	100	Other HH 2010	84	> 95	> 95	> 95	> 95	MICS2005
CCA	Tajikistan	95	99	100	99	100	LSMS 2003	14	41	66	53	94	MICS2005
SSA	Tanzania, United Republic of	7	9	15	4	46	DHS 2010	< 5	< 5	6	5	16	DHS2010
SEA	Thailand	93	96	100	97	100	Household Energy Consumption Survey 2010	37	57	74	57	90	MICS2005
SSA	Togo	10	17	28	6	64	QUIBB 2006	< 5	< 5	6	5	7	NatSur2006
Oceania	Tonga	80	86	92	80	100	Estimate	28	44	57	53	92	NatCen2006
LAC	Trinidad and Tobago	93	95	99	98	100	Other HH 2009	81	93	> 95	> 95	> 95	MICS2006
NA	Tunisia	93	95	100	99	100	COMELEC 2007	82	94	> 95	> 95	> 95	MICS2006
WA	Turkey	100	100	100	100	100	HBS 2009	79	90	> 95	> 95	> 95	Other1999
CCA	Turkmenistan	95	100	100	100	100	HBS 2009	86	> 95	> 95	> 95	> 95	DHS2000
LAC	Turks and Caicos Islands	81	85	88	74	89	Estimate						
Oceania	Tuvalu	35	37	41	29	53	Estimate	33	58	81			Other2002

		ACCESS TO ELECTRICITY (% OF POPULATION)						ACCESS TO NON-SOLID FUEL (% OF POPULATION)					
		TOTAL			RURAL	URBAN		TOTAL			RURAL	URBAN	
Region	**Country**	**1990**	**2000**	**2010**	**2010**	**2010**	**Latest available Source/year**	**1990**	**2000**	**2010**	**2010**	**2010**	**Latest available Source/year**
SSA	Uganda	7	9	15	5	67	DHS 2011	< 5	< 5	< 5	< 5	11	DHS2009
DEV	Ukraine	93	96	100	100	100	DHS 2007	79	90	> 95	89	> 95	DHS2007
WA	United Arab Emirates	87	91	94	90	95	Estimate	86	> 95	> 95	> 95	> 95	WHS2003
DEV	United Kingdom of Great Britain and Northern Ireland	100	100	100	100	100	Assumption	> 95	> 95	> 95	> 95	> 95	Assumption
DEV	United States of America	100	100	100	100	100	Assumption	> 95	> 95	> 95	> 95	> 95	Assumption
LAC	Uruguay	92	96	99	93	100	SEDLAC 2009	89	> 95	> 95	87	> 95	NatSur2006
CCA	Uzbekistan	97	100	100	100	100	Estimate	69	80	89	80	> 95	MICS2005
Oceania	Vanuatu	18	19	24	15	50	Estimate	17	18	16	6	49	MICS2007
LAC	Venezuela, Bolivarian Rep. of	99	100	100	100	100	SEDLAC 2010	85	> 95	> 95	> 95	> 95	NatCen2001
SEA	Vietnam	88	89	96	95	99	LSMS 2006	< 5	24	44	29	78	NatCen2009
LAC	Virgin Islands (U.S.)	81	85	88	74	89	Estimate						
WA	West Bank and Gaza	87	91	94	90	96	Estimate						
WA	Yemen	38	41	45	31	75	Estimate	52	61	67	49	> 95	MICS2006
SSA	Zambia	13	17	19	3	43	DHS 2007	5	13	17	5	39	DHS2007
SSA	Zimbabwe	28	34	37	13	75	DHS 2011	32	34	34	6	84	DHS2006

AGGREGATED BY INCOME LEVEL		ACCESS TO ELECTRICITY (% OF POPULATION)						ACCESS TO NON-SOLID FUEL (% OF POPULATION)					
		TOTAL			RURAL	URBAN		TOTAL			RURAL	URBAN	
Region	**Country**	**1990**	**2000**	**2010**	**2010**	**2010**	**Latest available Source/year**	**1990**	**2000**	**2010**	**2010**	**2010**	**Latest available Source/year**
	High income: non-OECD	88	90	92	89	93		71	74	81	77	86	
	High income: OECD	99	100	100	100	100		99	100	100	99	100	
	Low income	20	24	32	19	64		7	9	9	6	25	
	Lower middle income	58	68	77	69	91		25	37	46	21	75	
	Upper middle income	93	96	98	96	99		53	64	71	36	85	

AGGREGATED BY REGION		ACCESS TO ELECTRICITY (% OF POPULATION)						ACCESS TO NON-SOLID FUEL (% OF POPULATION)					
		TOTAL			RURAL	URBAN		TOTAL			RURAL	URBAN	
Region	Country	1990	2000	2010	2010	2010	Latest available Source/year	1990	2000	2010	2010	2010	Latest available Source/year
CCA	Caucasus and Central Asia	95	99	100	99	100		58	73	85	74	98	
DEV	Developed Countries	100	100	100	100	100		95	98	99	96	100	
EA	Eastern Asia	93	96	98	97	98		37	48	55	35	76	
LAC	Latin America and Caribbean	88	92	95	84	98		73	81	86	57	94	
NA	Northern Africa	85	92	99	99	100		88	96	100	99	100	
Oceania	Oceania	21	23	25	14	65		14	24	31	21	73	
SA	Southern Asia	52	63	75	67	94		16	30	40	23	78	
SEA	Southeastern Asia	71	81	88	80	97		29	40	48	27	77	
SSA	Sub-Saharan Africa	23	26	32	14	63		14	17	19	6	42	
WA	Western Asia	89	89	91	78	97		83	90	95	86	99	
	WORLD	76	79	83	70	95		47	54	59	35	84	

NOTE: THE SOURCE FIELD GIVES EITHER (A) THE NAME AND DATE OF THE HOUSEHOLD SURVEY FROM WHICH THE FIGURE IS TAKEN; OR (B) INDICATES THAT THE FIGURE IS AN ESTIMATE BASED ON THE STATISTICAL MODEL DESCRIBED IN ANNEX 2 OF CHAPTER 2; OR (C) IS BASED ON THE ASSUMPTION OF UNIVERSAL ACCESS IN COUNTRIES CLASSIFIED BY THE UNITED NATIONS AS DEVELOPED.

NOTE: DEVELOPED COUNTRIES (DEV) ARE CONSIDERED TO HAVE ACCESS RATES OF 100 PERCENT. CCA = CAUCASUS AND CENTRAL ASIA; EA = EASTERN ASIA; LAC = LATIN AMERICA AND CARIBBEAN; NA = NORTHERN AFRICA; SA = SOUTHERN ASIA; SEA = SOUTH-EASTERN ASIA; SSA = SUB-SAHARAN AFRICA; WA = WESTERN ASIA; BAIS=BOTSWANA AIDS IMPACT SURVEY III; COMELEC= MAGHREB ASSOCIATION OF THE ELECTRICITY SECTOR; CWIQ= CORE WELFARE INDICATORS QUESTIONNAIRE SURVEY; DHS = DEMOGRAPHIC AND HEALTH SURVEY; EICV=INTEGRATED HOUSEHOLD LIVING CONDITIONS SURVEY IN RWANDA; EPCV=PERMANENT LIVING CONDITIONS; GHS=GENERAL HOUSEHOLD SURVEY; HBS = HOUSEHOLD BUDGET SURVEY; IES = INTEGRATED EXPENDITURE SURVEY; HIES=HOUSEHOLD INCOME AND EXPENDITURE SURVEYS; HIS = INTEGRATED HOUSEHOLD SURVEY; HIS/BA= HOUSEHOLD INCOME AND BASIC AMENITIES SURVEY REPORT; LECS=LAO EXPENDITURE AND CONSUMPTION SURVEY; LSMS = LIVING STANDARD MEASUREMENT SURVEY; MICS=MULTIPLE INDICATORS CLUSTER SURVEY; NRVA=NATIONAL RISK AND VULNERABILITY ASSESSMENT; NSSO=NATIONAL SAMPLE SURVEY ORGANIZATION; QUIBB=QUESTIONNAIRE DES INDICATEURS DE BASE DU BIENETRE; WHS=WORLD HEALTH SURVEY.

DATA ANNEX: ENERGY EFFICIENCY

COUNTRY	DATA SOURCE[a]	RATE OF PRIMARY ENERGY INTENSITY IMPROVEMENT, CAGR (%)			LEVEL OF PRIMARY ENERGY INTENSITY, (MJ/$2005 PPP)		DECOMPOSITION ANALYSIS, CAGR (%)	RATE OF FINAL ENERGY INTENSITY IMPROVEMENT, CAGR (%)	FINAL TO PRIMARY ENERGY RATIO		CUMULATIVE ENERGY SAVINGS (PJ)
		1990–2000	2000–2010	1990–2010	1990	2010	1990–2010	1990–2010	1990	2010	1990–2010
Afghanistan	UN/WDI	–15.81	3.12	–6.83	11.8	2.9	8.93**	–2.04	—	—	2,993
Albania	IEA/WDI	–5.28	–3.49	–4.39	8.7	3.5	-2.88*	–3.84	84.0	94.2	1,227
Algeria	IEA/WDI	0.30	0.34	0.32	5.9	6.3	—	1.10	57.4	67.0	–909
Angola	IEA/WDI	1.68	–4.41	–1.41	7.7	5.8	-0.29	–1.23	77.0	79.9	184
Antigua and Barbuda	UN/WDI	–1.49	3.44	0.94	2.8	3.4	—	–2.83	—	—	6
Argentina	IEA/WDI	–1.63	–2.19	–1.91	7.9	5.4	-1.83	–1.43	65.3	72.0	11,171
Armenia	IEA/WDI	–9.13	–5.49	–7.33	30.9	6.8	-11.22	–7.97	84.0	73.1	3,756
Aruba	UN/WDI	—	—	—	—	—	—	—	—	—	—
Australia	IEA/WDI	–1.07	–1.56	–1.32	8.9	6.8	-1.27	–1.73	65.6	60.4	13,162
Austria	IEA/WDI	–1.25	0.16	–0.55	5.3	4.8	-0.36	–0.40	79.4	81.7	1,774
Azerbaijan	IEA/WDI	–2.93	–12.70	–7.95	32.2	6.1	-8.47*	–8.22	61.2	57.6	10,415
Bahamas	UN/WDI	–2.75	3.78	0.46	3.4	3.7	—	8.38	—	—	66
Bahrain	IEA/WDI	–2.38	–0.64	–1.51	20.6	15.2	—	–1.51	54.5	54.6	1,535
Bangladesh	IEA/WDI	–0.89	–0.54	–0.71	6.8	5.9	-1.36	–1.48	86.2	73.8	1,558
Barbados	UN/WDI	–1.10	2.36	0.61	3.6	4.1	0.59	–3.36	—	—	11
Belarus	IEA/WDI	–4.80	–5.80	–5.30	29.1	9.8	-4.63	–5.55	75.7	71.9	17,682
Belgium	IEA/WDI	–0.28	–0.98	–0.63	8.1	7.1	-0.84	–0.48	66.4	68.5	2,489
Belize	UN/WDI	0.49	–6.34	–2.98	9.7	5.3	—	–3.17	—	—	78
Benin	IEA/WDI	–2.87	2.22	–0.36	13.0	12.1	—	–0.28	86.4	87.8	282
Bermuda	UN/WDI	—	—	—	—	—	—	—	—	—	—
Bhutan	UN/WDI	–2.66	–5.83	–4.26	38.3	16.0	—	0.04	—	—	528
Bolivia, Plurinational State of	IEA/WDI	–0.11	3.00	1.43	5.3	7.1	—	1.19	82.6	78.7	–371
Bosnia and Herzegovina	IEA/WDI	–22.25	–0.12	–11.87	119.7	9.6	-0.80**	–13.37	69.7	49.6	37,653
Botswana	IEA/WDI	–1.79	–1.90	–1.84	5.5	3.8	-2.13	–1.14	71.4	82.4	426
Brazil	IEA/WDI	0.39	–0.06	0.17	5.5	5.7	0.42	0.15	79.5	79.3	–4,973
British Virgin Islands	UN/WDI	—	—	—	—	—	—	—	—	—	—
Brunei Darussalam	IEA/WDI	1.10	1.67	1.38	5.8	7.6	—	6.29	19.9	51.3	–257
Bulgaria	IEA/WDI	–2.99	–4.35	–3.67	18.2	8.6	-3.81	–4.55	61.0	50.8	7,280

COUNTRY	DATA SOURCE[a]	RATE OF PRIMARY ENERGY INTENSITY IMPROVEMENT, CAGR (%)			LEVEL OF PRIMARY ENERGY INTENSITY, (MJ/$2005 PPP)		DECOMPOSITION ANALYSIS, CAGR (%)	RATE OF FINAL ENERGY INTENSITY IMPROVEMENT, CAGR (%)	FINAL TO PRIMARY ENERGY RATIO		CUMULATIVE ENERGY SAVINGS (PJ)
		1990–2000	2000–2010	1990–2010	1990	2010	1990–2010	1990–2010	1990	2010	1990–2010
Burkina Faso	UN/WDI	–5.54	0.47	–2.58	21.2	12.6	-3.35*	–3.01	—	—	1,738
Burundi	UN/WDI	2.15	2.30	2.23	21.4	33.3	—	8.81	—	—	–652
Cambodia	IEA/WDI	–2.97	–3.75	–3.43	13.7	7.6	—	–4.20	0.0	84.8	–2,635
Cameroon	IEA/WDI	1.01	–2.07	–0.54	8.2	7.4	-2.30**	–1.30	95.4	81.9	–189
Canada	IEA/WDI	–1.00	–1.82	–1.41	11.7	8.8	-1.15	–1.31	76.3	77.8	23,448
Cape Verde	UN/WDI	1.62	0.16	0.88	3.7	4.4	—	–0.56	—	—	–16
Cayman Islands	UN/WDI	—	—	—	—	—	—	—	—	—	—
Central African Republic	UN/WDI	–4.09	–0.11	–2.12	18.3	11.9	—	–3.57	—	—	218
Chad	UN/WDI	0.89	–5.70	–2.46	12.9	7.9	—	5.90	—	—	488
Chile	IEA/WDI	–0.34	–1.73	–1.04	6.4	5.2	-1.10	–1.18	79.2	77.0	2,391
China	IEA/WDI	–7.07	–2.18	–4.65	30.5	11.8	-6.48	–5.64	76.0	61.6	1,319,738
China, Hong Kong SAR	IEA/WDI	0.52	–3.59	–1.56	2.7	2.0	—	–1.54	60.1	60.3	773
China, Macao SAR	UN/WDI	2.83	–8.56	–3.04	1.8	1.0	—	–4.13	—	—	71
Colombia	IEA/WDI	–1.97	–1.76	–1.86	5.0	3.4	-2.50	–2.43	78.1	69.5	5,746
Comoros	UN/WDI	2.45	2.50	2.47	2.9	4.7	—	7.69	—	—	–9
Congo	IEA/WDI	–0.92	1.38	0.22	3.8	4.0	—	–0.04	77.8	73.9	16
Congo, Dem. Rep. of the	IEA/WDI	9.66	–1.26	4.06	21.5	47.6	—	4.38	89.8	95.6	–7,220
Cook Islands	UN/WDI	—	—	—	—	—	—	—	—	—	—
Costa Rica	IEA/WDI	–1.31	0.29	–0.51	4.4	4.0	-1.55	–1.41	89.2	74.5	254
Cote d'Ivoire	IEA/WDI	2.18	2.47	2.32	7.6	12.0	1.90	1.33	66.6	54.8	–1,645
Croatia	IEA/WDI	0.10	–1.68	–0.80	5.9	5.0	-0.32	–0.23	72.1	80.7	138
Cuba	IEA/WDI	—	—	—	—	—	—	—	79.7	56.7	—
Cyprus	IEA/WDI	0.43	–1.44	–0.51	5.4	4.9	0.01	–0.04	64.2	70.5	–5
Czech Republic	IEA/WDI	–2.30	–2.57	–2.44	12.2	7.4	-3.05	–3.02	69.2	61.3	10,499
Denmark	IEA/WDI	–1.84	–0.24	–1.04	5.6	4.5	-0.83	–0.92	75.9	77.7	1,919
Djibouti	UN/WDI	2.81	–0.26	1.26	5.2	6.7	—	4.03	—	—	–42
Dominica	UN/WDI	3.96	–0.02	1.95	1.8	2.6	—	–0.18	—	—	–8
Dominican Republic	IEA/WDI	0.55	–4.40	–1.96	6.2	4.2	-5.53**	–1.80	65.8	68.0	462

COUNTRY	DATA SOURCE[a]	RATE OF PRIMARY ENERGY INTENSITY IMPROVEMENT, CAGR (%)			LEVEL OF PRIMARY ENERGY INTENSITY, (MJ/$2005 PPP)		DECOMPOSITION ANALYSIS, CAGR (%)	RATE OF FINAL ENERGY INTENSITY IMPROVEMENT, CAGR (%)	FINAL TO PRIMARY ENERGY RATIO		CUMULATIVE ENERGY SAVINGS (PJ)
		1990–2000	2000–2010	1990–2010	1990	2010	1990–2010	1990–2010	1990	2010	1990–2010
Ecuador	IEA/WDI	1.10	–0.40	0.35	4.5	4.9	-0.29	–0.18	87.5	78.8	–591
Egypt	IEA/WDI	–1.89	1.16	–0.38	7.4	6.8	-0.33*	–0.61	70.8	67.6	1,860
El Salvador	IEA/WDI	0.24	–1.31	–0.54	5.3	4.7	-3.27	–1.97	82.1	61.3	–8
Equatorial Guinea	UN/WDI	–11.08	6.53	–2.67	11.0	6.4	—	–11.87	—	—	808
Eritrea	IEA/WDI	–7.26	–1.45	–4.08	25.6	12.1	—	–4.30	0.0	69.2	–640
Estonia	IEA/WDI	–14.62	–1.77	–8.42	60.8	10.5	-9.26	–9.10	60.6	52.3	15,850
Ethiopia	IEA/WDI	–0.45	–2.25	–1.36	23.6	18.0	-2.68	–1.39	95.1	94.3	1,668
Falkland Islands (Malvinas)	UN/WDI	—	—	—	—	—	—	—	—	—	—
Fiji	UN/WDI	–1.04	–3.67	–2.36	7.9	4.9	—	–1.13	—	—	52
Finland	IEA/WDI	–0.76	–0.55	–0.66	10.3	9.0	-1.04	–0.99	78.4	73.3	1,178
France	IEA/WDI	–0.77	–0.70	–0.73	6.6	5.7	-0.74	–0.87	63.9	62.1	13,508
French Guiana	UN/WDI	—	—	—	—	—	—	—	—	—	—
French Polynesia	UN/WDI	—	—	—	—	—	—	—	—	—	—
Gabon	IEA/WDI	0.49	1.54	1.02	3.6	4.4	-0.13*	1.17	85.4	88.0	–136
Gambia	UN/WDI	0.65	–0.03	0.31	6.5	7.0	—	0.80	—	—	–8
Georgia	IEA/WDI	–4.73	–5.08	–4.91	17.6	6.4	-4.82	–4.20	72.3	83.9	1,552
Germany	IEA/WDI	–2.32	–1.20	–1.76	7.2	5.0	-1.81	–1.71	68.6	69.3	69,126
Ghana	IEA/WDI	–0.41	–3.74	–2.09	16.5	10.8	-3.17	–2.18	81.7	80.2	1,003
Gibraltar	IEA/WDI	—	—	—	—	—	—	—	78.1	83.8	—
Greece	IEA/WDI	0.02	–1.90	–0.94	5.1	4.2	—	–0.73	67.6	70.5	1,431
Grenada	UN/WDI	1.68	2.20	1.94	2.5	3.6	-0.29**	–1.48	—	—	–12
Guadeloupe	UN/WDI	—	—	—	—	—	—	—	—	—	—
Guatemala	IEA/WDI	0.65	0.46	0.55	6.2	6.9	-0.33	0.05	91.4	82.7	–94
Guinea	UN/WDI	–1.74	–4.20	–2.98	40.6	22.2	—	–3.31	—	—	1,645
Guinea-Bissau	UN/WDI	–0.68	1.37	0.34	8.6	9.2	—	1.73	—	—	1
Guyana	UN/WDI	–1.18	–2.10	–1.64	22.7	16.3	0.49	–2.45	—	—	137
Haiti	IEA/WDI	2.94	1.21	2.07	6.4	9.7	—	2.77	79.1	90.6	–556
Honduras	IEA/WDI	–0.95	0.25	–0.35	7.7	7.2	—	–1.22	98.1	82.2	106

COUNTRY	DATA SOURCE[a]	RATE OF PRIMARY ENERGY INTENSITY IMPROVEMENT, CAGR (%)			LEVEL OF PRIMARY ENERGY INTENSITY, (MJ/$2005 PPP)		DECOM-POSITION ANALYSIS, CAGR (%)	RATE OF FINAL ENERGY INTENSITY IMPROVEMENT, CAGR (%)	FINAL TO PRIMARY ENERGY RATIO		CUMULATIVE ENERGY SAVINGS (PJ)
		1990–2000	2000–2010	1990–2010	1990	2010	1990–2010	1990–2010	1990	2010	1990–2010
Hungary	IEA/WDI	–1.64	–1.67	–1.65	8.8	6.3	-1.85	–1.74	71.8	70.6	3,906
Iceland	IEA/WDI	1.44	3.41	2.42	13.4	21.6	0.57	0.58	78.6	54.7	–450
India	IEA/WDI	–1.72	–2.98	–2.35	12.5	7.8	-4.09	–3.25	79.5	66.0	114,220
Indonesia	IEA/WDI	0.40	–2.15	–0.88	11.2	9.3	-1.73	–1.24	80.9	75.3	9,891
Iran, Islamic Rep. of	IEA/WDI	2.10	0.96	1.53	8.5	11.6	1.63	1.30	78.9	75.4	–22,350
Iraq	IEA/WDI	–10.76	4.80	–3.29	30.2	15.5	—	–4.81	75.7	55.2	23,829
Ireland	IEA/WDI	–1.16	–1.87	–1.52	5.1	3.7	-0.93	–1.25	74.0	78.1	2,155
Israel	IEA/WDI	–1.60	–0.14	–0.88	5.8	4.8	—	–0.57	60.7	64.6	1,963
Italy	IEA/WDI	–0.01	–0.45	–0.23	4.6	4.4	-0.14	–0.37	78.4	76.2	1,220
Jamaica	IEA/WDI	1.42	–3.05	–0.84	8.0	6.8	-0.62	–0.97	70.3	68.5	–90
Japan	IEA/WDI	0.55	–1.17	–0.31	5.6	5.3	-0.45	–0.54	68.3	65.3	–2,328
Jordan	IEA/WDI	–1.04	–2.16	–1.60	13.1	9.5	-2.27	–2.13	71.1	64.0	714
Kazakhstan	IEA/WDI	–3.51	–0.52	–2.02	26.5	17.6	-3.26*	–3.63	81.2	58.3	12,434
Kenya	IEA/WDI	0.66	–0.48	0.09	13.4	13.6	-0.82	–0.23	70.2	65.8	–424
Kiribati	UN/WDI	1.54	3.49	2.51	2.2	3.6	—	12.22	—	—	–1
Korea, Dem. People's Rep. of	IEA/WDI	—	—	—	—	—	—	—	82.3	86.6	—
Korea, Republic of	IEA/WDI	1.14	–1.22	–0.05	8.0	7.9	-1.36	–0.55	69.7	63.0	–5,171
Kuwait	IEA/WDI	5.46	0.57	2.99	6.2	11.2	—	2.56	43.4	39.9	–5,800
Kyrgyzstan	IEA/WDI	–7.04	–1.97	–4.54	28.3	11.2	—	–4.69	92.2	89.4	2,131
Lao People's Dem. Rep.	UN/WDI	–3.20	–5.12	–4.16	13.4	5.7	-4.95	–5.83	—	—	814
Latvia	IEA/WDI	–4.56	–1.85	–3.21	12.3	6.4	-2.87	–2.45	81.6	95.4	1,853
Lebanon	IEA/WDI	2.78	–2.26	0.23	4.8	5.1	—	0.46	58.2	61.0	–598
Lesotho	UN/WDI	1.28	–2.59	–0.67	12.2	10.6	—	–3.58	—	—	10
Liberia	UN/WDI	0.42	–2.40	–1.00	73.1	59.8	—	0.97	—	—	–125
Libya	IEA/WDI	3.10	–2.82	0.09	7.7	7.9	—	0.92	48.5	57.1	–2,712
Lithuania	IEA/WDI	–4.73	–4.46	–4.60	14.6	5.7	-4.75	–3.69	64.8	78.2	3,839
Luxembourg	IEA/WDI	–5.04	–0.28	–2.69	8.8	5.1	-1.86	–2.13	82.1	92.0	1,533
Macedonia, Former Yugoslav Rep. of	IEA/WDI	1.66	–1.62	0.01	6.4	6.4	0.65	0.16	60.9	62.9	–361

COUNTRY	DATA SOURCE[a]	RATE OF PRIMARY ENERGY INTENSITY IMPROVEMENT, CAGR (%)			LEVEL OF PRIMARY ENERGY INTENSITY, (MJ/$2005 PPP)		DECOM-POSITION ANALYSIS, CAGR (%)	RATE OF FINAL ENERGY INTENSITY IMPROVEMENT, CAGR (%)	FINAL TO PRIMARY ENERGY RATIO		CUMULATIVE ENERGY SAVINGS (PJ)
		1990–2000	2000–2010	1990–2010	1990	2010	1990–2010	1990–2010	1990	2010	1990–2010
Madagascar	UN/WDI	2.31	0.55	1.43	10.3	13.7	—	0.54	—	—	–721
Malawi	UN/WDI	–2.03	–2.43	–2.23	16.8	10.7	—	–2.96	—	—	536
Malaysia	IEA/WDI	0.96	–0.18	0.39	7.5	8.1	-1.12*	–0.02	64.7	59.6	–4,062
Maldives	UN/WDI	8.17	4.64	6.39	2.7	9.3	—	5.53	—	—	–132
Mali	UN/WDI	–1.25	–3.41	–2.34	10.6	6.6	—	–3.48	—	—	445
Malta	IEA/WDI	–5.30	0.64	–2.38	6.0	3.7	—	–1.82	38.4	43.0	262
Martinique	UN/WDI	—	—	—	—	—	—	—	—	—	—
Mauritania	UN/WDI	–7.19	–0.35	–3.83	20.3	9.3	-1.99*	–1.77	—	—	839
Mauritius	UN/WDI	–0.37	–0.79	–0.58	7.3	6.5	-2.40	–1.95	—	—	81
Mexico	IEA/WDI	–1.70	0.30	–0.71	6.1	5.3	-0.58	–1.08	68.7	63.7	13,954
Moldova, Republic of	IEA/WDI	–3.33	–4.52	–3.92	24.4	11.0	-4.13	–3.72	67.4	70.4	893
Mongolia	IEA/WDI	–3.46	–3.10	–3.28	26.8	13.7	-5.21	–4.34	87.0	69.7	1,020
Montenegro	IEA/WDI	n.a	–1.30	–1.30	5.7	5.4	—	–4.18	0.0	53.8	–193
Montserrat	UN/WDI	—	—	—	—	—	—	—	—	—	—
Morocco	IEA/WDI	1.56	–0.04	0.76	4.3	5.0	0.92	1.01	71.9	75.6	–1,076
Mozambique	IEA/WDI	–3.33	–3.88	–3.61	46.3	22.2	-3.51	–3.59	80.3	80.6	3,587
Myanmar	IEA/WDI	—	—	—	—	—	-5.60*	—	88.0	92.1	—
Namibia	IEA/WDI	1.08	0.40	0.74	4.3	5.0	-0.67*	0.55	98.3	94.5	–116
Nepal	IEA/WDI	–1.49	–1.52	–1.50	17.9	13.2	-2.49	–1.52	99.5	99.1	1,315
Netherlands	IEA/WDI	–2.01	–0.06	–1.04	7.0	5.7	-1.07	–0.85	74.8	77.6	10,284
Netherlands Antilles	IEA/WDI	—	—	—	—	—	—	—	42.9	48.4	—
New Caledonia	UN/WDI	—	—	—	—	—	—	—	—	—	—
New Zealand	IEA/WDI	–0.05	–1.65	–0.85	8.3	7.0	-1.18	–1.34	77.4	70.2	1,236
Nicaragua	IEA/WDI	–0.71	–1.44	–1.08	11.3	9.1	-1.21	–1.27	73.8	71.0	139
Niger	UN/WDI	1.57	–8.58	–3.64	16.6	7.9	0.21**	–3.65	—	—	394
Nigeria	IEA/WDI	–0.24	–3.92	–2.10	21.4	14.0	—	–1.92	89.1	92.4	11,078
Norway	IEA/WDI	–1.46	0.69	–0.39	6.4	5.9	-1.08	–1.53	83.0	65.9	3,339
Oman	IEA/WDI	2.01	4.53	3.26	6.4	12.3	—	2.53	44.5	38.6	–2,035

COUNTRY	DATA SOURCE[a]	RATE OF PRIMARY ENERGY INTENSITY IMPROVEMENT, CAGR (%)			LEVEL OF PRIMARY ENERGY INTENSITY, (MJ/$2005 PPP)		DECOM-POSITION ANALYSIS, CAGR (%)	RATE OF FINAL ENERGY INTENSITY IMPROVEMENT, CAGR (%)	FINAL TO PRIMARY ENERGY RATIO		CUMULATIVE ENERGY SAVINGS (PJ)
		1990–2000	2000–2010	1990–2010	1990	2010	1990–2010	1990–2010	1990	2010	1990–2010
Pakistan	IEA/WDI	0.11	–1.62	–0.76	9.9	8.5	-1.09	–0.90	84.8	82.6	2,196
Palau	UN/WDI	2.14	4.98	3.55	5.9	11.8	—	4.58	—	—	–16
Panama	IEA/WDI	0.54	–2.31	–0.90	4.3	3.6	-2.52**	–1.05	82.5	80.0	88
Papua New Guinea	UN/WDI	–2.17	–2.66	–2.42	11.4	7.0	-2.01	–4.02	—	—	585
Paraguay	IEA/WDI	0.49	–1.72	–0.62	7.6	6.7	—	–0.91	95.3	89.9	0
Peru	IEA/WDI	–1.61	–0.89	–1.25	4.2	3.3	-1.76	–1.92	87.9	76.8	2,749
Philippines	IEA/WDI	0.50	–4.40	–1.98	7.6	5.1	-2.98	–2.77	69.2	58.8	3,660
Poland	IEA/WDI	–5.04	–2.49	–3.77	13.8	6.4	-3.17	–3.09	59.6	68.7	46,298
Portugal	IEA/WDI	0.96	–1.10	–0.07	4.3	4.3	0.57	–0.02	79.7	80.5	–1,178
Puerto Rico	UN/WDI	—	—	—	—	—	—	—	—	—	—
Qatar	IEA/WDI	3.79	–0.99	1.37	7.9	10.3	—	1.25	54.1	52.8	–3,106
Reunion	UN/WDI	—	—	—	—	—	—	—	—	—	—
Romania	IEA/WDI	–3.63	–4.46	–4.05	14.3	6.3	-4.04	–4.18	69.3	67.5	17,593
Russian Federation	IEA/WDI	0.46	–3.39	–1.49	19.7	14.6	-2.12	–2.04	71.1	63.5	34,769
Rwanda	UN/WDI	4.50	–6.04	–0.91	10.3	8.6	—	–1.18	—	—	–364
Saint Kitts and Nevis	UN/WDI	–1.66	5.82	2.01	3.5	5.1	—	–1.34	—	—	–9
Saint Lucia	UN/WDI	4.31	1.14	2.71	2.3	3.9	—	–3.61	—	—	–29
Saint Pierre and Miquelon	UN/WDI	—	—	—	—	—	—	—	—	—	—
Saint Vincent and the Grenadines	UN/WDI	3.09	0.40	1.74	2.0	2.9	—	–2.84	—	—	–12
Samoa	UN/WDI	–0.85	–1.70	–1.27	5.7	4.4	—	15.76	—	—	9
Sao Tome and Principe	UN/WDI	–9.71	–1.96	–5.92	55.2	16.3	—	–4.78	—	—	120
Saudi Arabia	IEA/WDI	2.63	1.90	2.27	8.0	12.6	1.93	2.45	60.1	62.2	–27,204
Senegal	IEA/WDI	0.48	–0.54	–0.03	6.6	6.6	0.05	0.16	64.1	66.6	–9
Serbia	IEA/WDI	2.17	–1.98	0.07	9.2	9.3	-0.15	–0.03	62.7	61.4	–2,344
Seychelles	UN/WDI	12.83	1.44	6.99	2.3	9.0	—	10.06	—	—	–139
Sierra Leone	UN/WDI	6.72	–5.61	0.37	24.8	26.7	—	0.03	—	—	–1,071
Singapore	IEA/WDI	–2.02	0.13	–0.95	6.3	5.2	-1.49	1.61	43.5	72.4	1,790
Slovakia	IEA/WDI	–2.01	–4.51	–3.27	13.3	6.8	-3.72	–3.95	73.9	64.1	5,047

COUNTRY	DATA SOURCE[a]	RATE OF PRIMARY ENERGY INTENSITY IMPROVEMENT, CAGR (%)			LEVEL OF PRIMARY ENERGY INTENSITY, (MJ/$2005 PPP)		DECOM-POSITION ANALYSIS, CAGR (%)	RATE OF FINAL ENERGY INTENSITY IMPROVEMENT, CAGR (%)	FINAL TO PRIMARY ENERGY RATIO		CUMULATIVE ENERGY SAVINGS (PJ)
		1990–2000	2000–2010	1990–2010	1990	2010	1990–2010	1990–2010	1990	2010	1990–2010
Slovenia	IEA/WDI	–0.62	–1.48	–1.05	7.3	5.9	-2.05*	–0.57	64.7	71.3	365
Solomon Islands	UN/WDI	–1.82	–2.65	–2.24	4.7	3.0	—	–3.46	—	—	24
Somalia	UN/WDI	—	—	—	—	—	—	—	—	—	—
South Africa	IEA/WDI	0.03	–1.19	–0.58	13.6	12.1	-1.43	–1.69	56.1	44.9	229
Spain	IEA/WDI	0.27	–1.57	–0.65	4.9	4.3	0.01	–0.23	67.3	73.3	1,031
Sri Lanka	IEA/WDI	–0.96	–3.28	–2.13	6.7	4.3	-3.02*	–2.43	96.1	90.4	1,529
Sudan	IEA/WDI	–3.28	–4.12	–3.70	16.3	7.7	-2.26	–3.00	57.1	66.1	5,749
Suriname	UN/WDI	0.44	–2.74	–1.17	13.3	10.5	4.54	0.64	—	—	14
Swaziland	UN/WDI	7.43	–1.09	3.08	8.7	15.9	-4.12	1.75	—	—	–442
Sweden	IEA/WDI	–1.97	–1.33	–1.65	9.4	6.7	-1.78	–1.61	68.0	68.7	6,984
Switzerland	IEA/WDI	–0.78	–1.18	–0.98	4.5	3.7	-0.71	–0.75	76.7	80.3	1,413
Syrian Arab Republic	IEA/WDI	–0.86	–1.57	–1.21	12.0	9.4	-1.71	–1.94	72.7	62.7	2,033
Tajikistan	IEA/WDI	0.61	–7.04	–3.29	14.2	7.2	-3.14	–3.35	88.2	87.1	250
Thailand	IEA/WDI	1.09	0.62	0.85	7.8	9.3	0.08	1.08	68.8	72.0	–6,918
Timor-Leste	UN/WDI	n.a	–6.29	–6.29	7.9	4.7	—	–5.08	—	—	–61
Togo	IEA/WDI	3.02	0.33	1.66	15.0	20.8	—	1.26	67.0	61.9	–414
Tonga	UN/WDI	2.35	2.55	2.45	3.6	5.9	—	1.32	—	—	–11
Trinidad and Tobago	IEA/WDI	2.70	1.46	2.08	19.1	28.8	—	3.00	62.0	74.2	–2,185
Tunisia	IEA/WDI	–0.70	–1.57	–1.14	5.6	4.5	-1.41	–1.11	73.6	74.1	744
Turkey	IEA/WDI	0.13	–0.60	–0.23	5.0	4.8	-0.68	–0.38	76.0	73.8	2,360
Turkmenistan	IEA/WDI	0.64	–8.35	–3.96	53.5	23.8	-4.52	–4.93	70.2	57.3	5,128
Turks and Caicos Islands	UN/WDI	—	—	—	—	—	—	—	—	—	—
Uganda	UN/WDI	–3.64	–4.11	–3.87	40.1	18.2	-5.55**	–4.00	—	—	6,622
Ukraine	IEA/WDI	2.04	–4.34	–1.20	25.2	19.8	-0.94	–1.47	59.6	56.5	–3,410
United Arab Emirates	IEA/WDI	0.53	1.89	1.21	6.4	8.2	—	0.77	79.3	72.7	–3,685
United Kingdom of Great Britain and Northern Ireland	IEA/WDI	–2.06	–2.59	–2.32	6.7	4.2	-1.99	–2.24	66.9	68.1	47,052
United Republic of Tanzania	IEA/WDI	0.19	–2.64	–1.24	19.2	14.9	—	–1.40	89.8	86.8	837

COUNTRY	DATA SOURCE[a]	RATE OF PRIMARY ENERGY INTENSITY IMPROVEMENT, CAGR (%)			LEVEL OF PRIMARY ENERGY INTENSITY, (MJ/$2005 PPP)		DECOM-POSITION ANALYSIS, CAGR (%)	RATE OF FINAL ENERGY INTENSITY IMPROVEMENT, CAGR (%)	FINAL TO PRIMARY ENERGY RATIO		CUMULATIVE ENERGY SAVINGS (PJ)
		1990–2000	2000–2010	1990–2010	1990	2010	1990–2010	1990–2010	1990	2010	1990–2010
United States of America	IEA/WDI	–1.65	–1.78	–1.71	10.1	7.1	-1.67	–1.70	67.5	67.7	368,527
Uruguay	IEA/WDI	–0.17	0.07	–0.05	4.2	4.1	0.21	–0.01	85.8	86.6	78
Uzbekistan	IEA/WDI	1.11	–7.85	–3.47	47.3	23.3	-3.91	–3.76	75.4	71.0	3,859
Vanuatu	UN/WDI	2.27	–0.51	0.87	2.3	2.7	—	7.96	—	—	–2
Venezuela, Bolivarian Rep. of	IEA/WDI	0.53	–0.04	0.25	9.7	10.2	0.78*	–0.12	63.2	58.7	–799
Viet Nam	IEA/WDI	–2.52	0.22	–1.16	12.5	9.9	-2.39	–1.61	89.9	81.9	7,495
Western Sahara	UN/WDI	—	—	—	—	—	—	—	—	—	—
Yemen	IEA/WDI	0.84	–0.05	0.39	4.9	5.3	0.47*	0.41	72.1	72.2	–470
Zambia	IEA/WDI	0.79	–2.80	–1.02	23.0	18.8	-1.67	–1.18	79.5	76.9	5
Zimbabwe	IEA/WDI	—	—	—	—	—	—	—	85.7	87.8	—

AGGREGATED BY REGION	DATA SOURCE	RATE OF PRIMARY ENERGY INTENSITY IMPROVEMENT, CAGR (%)			LEVEL OF PRIMARY ENERGY INTENSITY, (MJ/$2005 PPP)		DECOM-POSITION ANALYSIS, CAGR (%)	RATE OF FINAL ENERGY INTENSITY IMPROVEMENT, CAGR (%)	FINAL TO PRIMARY ENERGY RATIO		CUMULATIVE ENERGY SAVINGS (PJ)
		1990–2000	2000–2010	1990–2010	1990	2010	1990–2010	1990–2010	1990	2010	1990–2010
Northern America	IEA/WDI	–1.59	–1.78	–1.68	10.2	7.3	–1.62	–1.66	68.4	68.7	391,975
Europe	IEA/WDI	–1.41	–1.10	–1.25	6.5	5.0	–1.12	–1.21	69.6	70.2	223,096
Eastern Europe	IEA/WDI	–1.26	–3.34	–2.30	18.7	11.8	–2.65	–2.65	68.2	63.4	140,558
Caucasian and Central Asia	IEA/WDI	–0.84	–5.59	–3.24	30.3	15.7	–3.55	–4.15	76.3	63.2	39,526
Western Asia	IEA/WDI	0.55	1.00	0.77	7.1	8.3	0.41	0.42	67.1	62.6	–10,469
Eastern Asia	IEA/WDI	–1.84	–0.35	–1.10	11.8	9.5	–2.11	–1.89	73.2	62.3	1,314,102
South Eastern Asia	IEA/WDI	0.17	–1.16	–0.50	9.1	8.2	–1.48	–0.66	74.2	71.8	9,718
Southern Asia	IEA/WDI	–0.86	–2.11	–1.49	11.1	8.2	–2.71	–2.16	80.3	70.1	101,857
Oceania	IEA/WDI	–0.95	–1.60	–1.27	8.8	6.8	–1.33	–1.73	68.5	62.4	15,038
Latin America and Caribbean	IEA/WDI	–0.52	–0.38	–0.45	6.1	5.6	–0.44	–0.56	73.6	72.1	27,714
Northern Africa	IEA/WDI	–0.18	0.07	–0.06	6.4	6.4	–0.46	0.20	64.0	67.4	–2,093
Sub-Saharan Africa	IEA/WDI	0.03	–2.19	–1.08	15.5	12.4	–1.36	–1.18	76.8	75.4	24,624
World	IEA/WDI	–1.61	–0.99	–1.30	10.0	7.7	–1.63	–1.53	71.7	68.0	2,275,646

AGGREGATED BY INCOME LEVEL	DATA SOURCE	RATE OF PRIMARY ENERGY INTENSITY IMPROVEMENT, CAGR (%)			LEVEL OF PRIMARY ENERGY INTENSITY, (MJ/$2005 PPP)		DECOM-POSITION ANALYSIS, CAGR (%)	RATE OF FINAL ENERGY INTENSITY IMPROVEMENT, CAGR (%)	FINAL TO PRIMARY ENERGY RATIO		CUMULATIVE ENERGY SAVINGS (PJ)
		1990–2000	2000–2010	1990–2010	1990	2010	1990–2010	1990–2010	1990	2010	1990–2010
High income	IEA/WDI	–1.03	–1.25	–1.14	7.9	6.3	–0.61	–1.18	68.4	67.8	608,778
Upper middle income	IEA/WDI	–2.59	–1.13	–1.86	14.1	9.7	–2.62	–2.47	72.5	64.1	1,462,534
Lower middle income	IEA/WDI	–1.92	–2.70	–2.31	14.0	8.8	–3.15	–2.62	75.0	70.3	191,629
Low income	IEA/WDI	–0.79	–1.97	–1.38	16.2	12.2	–2.50	–1.40	89.0	88.6	12,706

SOURCE: IEA WORLD ENERGY STATISTICS AND BALANCE (2012); UN ENERGY STATISTICS (2012); WORLD DEVELOPMENT INDICATORS (2012).

[a.] THE IEA WORLD ENERGY STATISTICS AND BALANCES PROVIDES COUNTRY LEVEL DATA FOR 138 COUNTRIES THAT ACCOUNT FOR MORE THAN 99 PERCENT OF GLOBAL ENERGY CONSUMPTION. THE REST OF THE COUNTRIES ARE LUMPED TOGETHER IN THREE REGIONAL GROUPS AND REPORTED IN AN AGGREGATED MANNER. TO INCREASE THE COUNTRY-LEVEL COVERAGE, UN ENERGY STATISTICS ARE USED FOR THE 68 COUNTRIES NOT REPORTED SEPARATELY BY THE IEA. HOWEVER, A NUMBER OF DIFFERENCES BETWEEN THE TWO DATA SOURCES —NAMELY, THE APPLICATION OF DIFFERENT METHODOLOGIES TO ESTIMATE THE USE OF PRIMARY SOLID BIOFUELS (BIOMASS) AND THE FACT THAT THE UN DATA WERE AVAILABLE ONLY THROUGH 2009, AT THE LATEST—CALLED FOR AN ADJUSTMENT OF THE UN DATA TO ALLOW FOR A FAIR COMPARISON OF ENERGY INTENSITY LEVELS AMONG COUNTRIES.

FOR SOME COUNTRIES FOR WHICH ENERGY DATA WERE AVAILABLE BUT GDP DATA WERE NOT, NO ENERGY INTENSITY FIGURE IS SHOWN. (ENERGY INTENSITY IS A DERIVATIVE OF BOTH ENERGY CONSUMPTION AND GDP.)

FIRST AVAILABLE DATA WERE USED FOR SOME COUNTRIES FOR WHICH 1990 WERE NOT AVAILABLE: CAMBODIA (1995), ERITREA (1992), MONTENEGRO (2005), AND TIMOR-LESTE (2002). GDP DATA WERE ESTIMATED TO FILL GAPS IN TIME SERIES FOR THE FOLLOWING COUNTRIES: AFGHANISTAN, BARBADOS, BOSNIA AND HERZEGOVINA, DJIBOUTI, ESTONIA, HAITI, IRAQ, IRAN (ISLAMIC REPUBLIC OF), IRELAND, KUWAIT, LIBYA, MALDIVES, PALAU, QATAR, AND SAO TOME AND PRINCIPE.

* Country has less than 20 years of historical data available. Caution should be used when comparing CAGRs of decomposition analysis and energy intensity for country.

** Country has less than 10 years of historical data available. Caution should be used when comparing CAGRs of decomposition analysis and energy intensity for country.

DATA ANNEX: RENEWABLE ENERGY

COUNTRY	DATA SOURCE	SHARE (%) OF RE IN TFEC			SHARE (%) IN TFEC IN 2010								RE SHARE (%) IN 2010 OF:		TOTAL FINAL ENERGY CONSUMPTION (PJ) IN 2010
		1990	2000	2010	Traditional biomass	Modern biomass	Hydro	Liquid biofuels	Wind	Solar	Geothermal	Other	Electricity capacity	Electricity generation	
Afghanistan	UN	42.4	56.5	19.3	12.2	—	7.0	—	—	—	—	—	76.5	87.2	72
Albania	IEA	24.9	41.0	37.9	9.7	1.4	26.4	—	—	0.4	—	—	90.1	100.0	77
Algeria	IEA	0.2	0.6	0.3	0.3	0.0	0.0	—	—	—	—	—	2.5	0.4	1,044
Angola	IEA	72.3	75.5	54.9	51.3	1.3	2.4	—	—	—	—	—	43.1	67.3	451
Antigua and Barbuda	UN	—	—	—	—	—	—	—	—	—	—	—	—	—	4
Argentina	IEA	8.9	11.0	9.0	0.6	2.0	5.3	1.1	0.0	—	—	—	27.8	28.6	2,052
Armenia	IEA	1.9	6.2	9.0	—	0.1	8.9	—	0.0	—	—	—	33.5	39.5	74
Aruba	UN	0.8	0.1	0.1	0.1	—	—	—	—	—	—	—	11.3	—	6
Australia	IEA	8.0	8.4	7.3	—	4.6	1.3	0.4	0.5	0.4	—	0.1	18.7	8.9	2,940
Austria	IEA	25.2	26.5	30.6	—	15.1	11.5	2.0	0.6	0.7	0.1	0.6	72.9	66.4	1,083
Azerbaijan	IEA	0.3	1.6	3.1	—	—	3.1	—	0.0	—	—	—	15.5	18.4	263
Bahamas	UN	—	—	0.9	—	0.9	—	—	—	—	—	—	—	—	29
Bahrain	IEA	—	—	—	—	—	—	—	—	—	—	—	0.0	—	221
Bangladesh	IEA	72.0	59.5	42.0	41.4	0.0	0.6	—	—	—	—	—	4.0	3.9	883
Barbados	UN	18.9	13.6	9.8	0.7	9.1	—	—	—	—	—	—	—	—	13
Belarus	IEA	0.8	4.9	7.0	2.9	3.9	0.0	0.2	0.0	—	—	0.0	0.3	0.4	719
Belgium	IEA	1.3	1.5	5.3	—	3.2	0.1	1.2	0.3	0.2	0.0	0.4	16.9	6.9	1,425
Belize	UN	37.0	24.1	35.6	—	20.1	15.5	—	—	—	—	—	48.9	92.3	9
Benin	IEA	93.7	70.3	51.5	42.9	8.7	—	—	—	—	—	—	1.6	0.7	134
Bermuda	UN	—	—	—	—	—	—	—	—	—	—	—	—	—	9
Bhutan	UN	96.5	95.2	91.7	81.3	0.4	10.0	—	—	—	—	—	98.9	100.0	54
Bolivia, Plurinational State of	IEA	37.4	29.1	31.7	13.1	15.8	2.9	—	—	0.0	—	—	30.1	34.0	240
Bosnia and Herzegovina	IEA	7.3	19.4	19.9	5.9	0.1	13.9	—	—	—	—	—	49.2	46.9	126
Botswana	IEA	47.1	35.7	26.4	26.4	0.0	—	—	—	0.0	—	—	—	—	77
Brazil	IEA	49.8	42.8	47.0	4.0	20.3	15.2	7.3	0.1	0.2	—	—	78.7	84.8	8,108
British Virgin Islands	UN	100.0	1.6	1.1	1.1	—	—	—	—	—	—	—	—	—	1
Brunei Darussalam	IEA	0.7	—	—	—	—	—	—	—	—	—	—	—	—	70
Bulgaria	IEA	1.9	8.3	14.4	8.3	2.0	3.0	0.2	0.4	0.1	0.4	0.0	26.7	12.6	360

COUNTRY	DATA SOURCE	SHARE (%) OF RE IN TFEC			SHARE (%) IN TFEC IN 2010								RE SHARE (%) IN 2010 OF:		TOTAL FINAL ENERGY CONSUMPTION (PJ) IN 2010
		1990	2000	2010	Traditional biomass	Modern biomass	Hydro	Liquid biofuels	Wind	Solar	Geothermal	Other	Electricity capacity	Electricity generation	
Burkina Faso	UN	92.4	86.5	85.3	84.1	0.8	0.4	—	—	—	—	—	12.7	18.9	125
Burundi	UN	82.6	93.2	96.8	95.7	0.4	0.7	—	—	—	—	—	98.1	98.4	84
Cambodia	IEA	82.5	81.1	73.3	57.6	15.6	0.1	—	—	0.0	—	—	5.2	4.9	178
Cameroon	IEA	81.6	84.5	78.6	66.7	6.7	5.2	—	—	—	—	—	72.2	73.2	243
Canada	IEA	20.6	20.5	19.9	—	5.3	13.5	0.6	0.4	0.0	—	0.1	58.9	60.9	7,266
Cape Verde	UN	—	1.7	1.5	1.0	—	—	—	0.5	—	—	—	3.1	1.7	3
Cayman Islands	UN	—	—	—	—	—	—	—	—	—	—	—	—	—	4
Central African Republic	UN	93.9	86.0	81.0	47.1	31.2	2.6	—	—	—	—	—	56.8	99.9	17
Chad	UN	95.1	97.9	92.3	91.1	1.2	—	—	—	—	—	—	—	—	82
Chile	IEA	34.0	31.4	27.0	—	19.4	7.4	—	0.1	—	—	—	38.0	40.2	954
China	IEA	32.3	27.7	18.8	13.5	0.0	3.6	0.1	0.2	0.6	0.3	0.5	25.1	17.5	59,740
China, Hong Kong SAR	IEA	1.1	0.6	0.7	0.7	0.0	—	—	0.0	—	—	—	0.0	0.0	338
China, Macao SAR	UN	0.7	0.2	0.2	—	0.2	—	—	—	—	—	—	—	—	17
Colombia	IEA	38.3	28.0	28.6	8.2	6.6	13.7	0.1	0.0	—	—	—	67.1	72.1	894
Comoros	UN	1.0	1.0	1.3	—	—	1.3	—	—	—	—	—	16.7	11.6	1
Congo	IEA	66.7	72.7	50.6	47.5	0.0	3.1	—	—	—	—	—	80.4	76.9	45
Congo, Dem. Rep. of the	IEA	92.0	97.2	96.2	74.1	19.7	2.4	—	—	—	—	—	98.6	99.6	950
Cook Islands	UN	—	—	—	—	—	—	—	—	—	—	—	1.1	—	0
Costa Rica	IEA	55.7	32.7	41.9	9.0	13.1	16.3	—	0.8	—	2.6	—	67.6	93.3	144
Cote d'Ivoire	IEA	80.2	64.7	75.4	65.7	7.8	1.9	—	—	—	—	—	49.4	28.8	218
Croatia	IEA	13.5	17.5	19.4	0.1	5.9	12.9	0.0	0.2	0.1	0.1	0.1	47.0	60.7	263
Cuba	IEA	44.3	35.7	16.3	0.8	11.5	0.1	3.9	—	0.0	—	—	1.3	3.2	252
Cyprus	IEA	0.5	3.1	6.4	0.5	0.9	—	0.9	0.1	3.7	0.0	0.2	5.8	1.3	69
Czech Republic	IEA	2.7	4.9	9.5	—	7.0	0.7	1.0	0.1	0.2	—	0.6	10.4	6.9	1,019
Denmark	IEA	7.3	10.9	21.4	—	14.4	0.0	0.2	3.8	0.1	0.0	2.9	37.0	32.1	615
Djibouti	UN	—	—	—	—	—	—	—	—	—	—	—	—	—	5
Dominica	UN	23.6	11.3	9.1	4.2	—	4.9	—	—	—	—	—	80.4	25.0	1
Dominican Republic	IEA	34.3	22.3	25.9	16.1	7.5	2.4	—	—	—	—	—	9.4	11.4	237

COUNTRY	DATA SOURCE	SHARE (%) OF RE IN TFEC			SHARE (%) IN TFEC IN 2010								RE SHARE (%) IN 2010 OF:		TOTAL FINAL ENERGY CONSUMPTION (PJ) IN 2010
		1990	2000	2010	Traditional biomass	Modern biomass	Hydro	Liquid biofuels	Wind	Solar	Geothermal	Other	Electricity capacity	Electricity generation	
Ecuador	IEA	23.2	19.6	12.4	4.0	1.8	6.6	—	0.0	—	—	—	44.7	51.6	372
Egypt	IEA	8.6	8.2	6.1	1.8	1.9	2.2	—	0.3	—	—	—	12.4	9.9	1,792
El Salvador	IEA	67.1	50.9	34.8	16.0	8.7	5.9	—	—	—	4.3	—	47.4	65.1	107
Equatorial Guinea	UN	82.0	53.2	15.4	15.2	—	0.2	—	—	—	—	—	2.6	7.0	10
Eritrea	IEA	88.3	71.2	77.2	73.8	3.3	—	—	—	0.0	—	—	1.3	0.6	21
Estonia	IEA	3.3	19.9	25.1	—	24.5	0.0	—	0.4	—	—	0.1	6.6	8.1	120
Ethiopia	IEA	95.6	94.3	94.5	92.7	0.7	1.0	—	—	—	0.0	—	90.1	99.4	1,310
Falkland Islands (Malvinas)	UN	—	—	—	—	—	—	—	—	—	—	—	10.0	—	1
Fiji	UN	16.4	13.0	15.5	2.6	—	12.8	—	—	—	—	—	51.0	57.4	12
Finland	IEA	24.6	31.7	33.5	—	27.6	4.6	0.6	0.1	0.0	—	0.6	31.5	30.1	1,051
France	IEA	10.4	9.3	12.3	—	6.7	2.8	1.6	0.4	0.1	0.1	0.6	21.5	13.8	6,314
French Guiana	UN	12.5	8.0	34.4	7.9	2.1	24.3	—	—	—	—	—	90.1	90.1	9
French Polynesia	UN	100.0	9.2	8.6	0.5	—	8.1	—	—	—	—	—	25.3	28.7	9
Gabon	IEA	78.3	74.5	63.0	48.4	11.8	2.8	—	—	—	—	—	41.0	44.2	78
Gambia	UN	58.9	50.3	41.0	41.0	—	—	—	—	—	—	—	—	—	10
Georgia	IEA	12.8	47.3	39.9	12.6	1.9	23.5	—	—	—	1.9	0.0	62.8	92.5	103
Germany	IEA	2.1	3.8	10.8	—	4.6	0.7	1.8	1.4	0.6	0.2	1.4	36.3	16.7	8,504
Ghana	IEA	80.6	74.7	66.5	44.1	15.7	6.7	—	—	—	—	—	59.4	83.6	311
Gibraltar	IEA	—	—	—	—	—	—	—	—	—	—	—	—	—	5
Greece	IEA	7.8	7.5	11.1	—	4.7	3.2	0.7	1.2	1.1	0.1	0.1	26.7	18.3	769
Grenada	UN	6.4	7.0	8.8	8.1	0.7	—	—	—	—	—	—	1.4	—	3
Guadeloupe	UN	7.8	0.6	5.5	0.5	—	1.0	—	3.7	0.3	—	—	11.0	15.0	18
Guatemala	IEA	75.0	62.7	67.0	59.7	4.1	3.0	—	—	—	0.2	—	43.5	66.9	354
Guinea	UN	92.6	89.6	88.9	87.3	0.5	1.1	—	—	—	—	—	31.6	52.4	114
Guinea-Bissau	UN	70.8	50.1	37.4	7.1	30.3	—	—	—	—	—	—	—	—	6
Guyana	UN	28.1	41.5	46.7	26.6	20.1	—	—	—	—	—	—	4.0	—	31
Haiti	IEA	81.1	76.0	70.5	60.2	10.0	0.3	—	—	—	—	—	20.7	30.2	87
Honduras	IEA	70.1	55.1	49.8	41.7	3.0	5.1	—	—	—	—	—	36.3	46.1	157

COUNTRY	DATA SOURCE	SHARE (%) OF RE IN TFEC			SHARE (%) IN TFEC IN 2010								RE SHARE (%) IN 2010 OF:		TOTAL FINAL ENERGY CONSUMPTION (PJ) IN 2010
		1990	2000	2010	Traditional biomass	Modern biomass	Hydro	Liquid biofuels	Wind	Solar	Geothermal	Other	Electricity capacity	Electricity generation	
Hungary	IEA	3.9	5.2	9.1	—	6.7	0.1	1.1	0.3	0.0	0.6	0.3	9.8	8.1	674
Iceland	IEA	62.2	66.1	76.7	—	—	38.5	—	—	—	38.2	0.0	95.3	100.0	108
India	IEA	57.5	52.6	42.4	31.7	8.5	1.7	0.0	0.3	0.1	—	—	27.0	14.2	17,569
Indonesia	IEA	58.7	44.7	37.4	31.6	4.4	0.9	0.0	—	—	0.5	—	17.8	16.0	6,177
Iran, Islamic Republic of	IEA	1.3	0.4	0.7	0.0	0.2	0.5	—	0.0	—	—	0.0	13.8	4.2	5,983
Iraq	IEA	1.6	0.3	1.6	—	0.1	1.5	—	—	—	—	—	24.9	9.5	855
Ireland	IEA	2.3	2.0	5.2	—	1.7	0.4	0.8	2.0	0.1	—	0.3	20.2	13.1	460
Israel	IEA	5.8	6.0	8.5	—	0.1	0.0	0.0	0.0	8.4	—	0.0	1.9	0.2	562
Italy	IEA	3.8	5.1	10.0	—	3.2	3.7	1.5	0.7	0.2	0.5	0.3	24.7	25.8	5,033
Jamaica	IEA	7.6	11.5	12.1	8.4	3.0	0.5	—	0.2	—	—	—	5.2	6.4	86
Japan	IEA	4.4	3.9	4.2	—	1.3	2.2	—	0.1	0.2	0.1	0.1	10.6	10.1	11,915
Jordan	IEA	2.8	2.1	3.0	0.1	0.0	0.1	—	0.0	2.8	—	0.0	0.6	0.5	188
Kazakhstan	IEA	1.4	2.5	1.2	0.1	0.0	1.1	—	—	—	—	—	11.8	9.7	1,816
Kenya	IEA	77.7	81.8	77.1	74.2	0.2	1.9	—	0.0	—	0.8	—	58.1	69.5	529
Kiribati	UN	39.5	30.9	1.1	1.1	—	—	—	—	—	—	—	—	—	1
Korea, Dem. People's Rep. of	IEA	7.7	9.8	12.0	—	6.6	5.4	—	—	—	—	—	52.6	61.9	672
Korea, Republic of	IEA	1.6	0.7	1.3	—	0.2	0.2	0.3	0.1	0.1	0.0	0.4	3.4	1.2	4,982
Kuwait	IEA	0.2	—	—	—	—	—	—	—	—	—	—	—	—	513
Kyrgyzstan	IEA	7.9	37.3	22.5	—	0.1	22.3	—	—	—	—	—	79.9	91.0	106
Lao People's Dem. Rep.	UN	96.7	91.3	90.1	80.6	—	9.0	—	—	0.5	—	—	97.4	92.3	66
Latvia	IEA	17.6	35.8	35.3	17.7	9.7	6.9	0.6	0.1	—	—	0.2	72.8	54.9	173
Lebanon	IEA	11.5	5.0	5.0	2.6	0.2	1.8	—	—	0.4	—	—	12.1	5.3	161
Lesotho	UN	—	100.0	100.0	—	—	100.0	—	—	—	—	—	100.0	100.0	1
Liberia	UN	95.4	90.5	92.5	92.5	—	—	—	—	—	—	—	—	—	74
Libya	IEA	3.1	2.1	2.1	2.1	0.0	—	—	—	—	—	—	—	—	347
Lithuania	IEA	3.1	17.6	22.6	12.7	6.2	1.7	1.0	0.7	—	0.0	0.2	8.2	19.2	189
Luxembourg	IEA	1.7	6.8	3.7	—	1.2	0.5	1.1	0.2	0.1	—	0.5	7.8	8.3	162
Macedonia, Former Yugoslav Rep. of	IEA	2.4	19.4	23.0	10.1	1.0	11.0	0.3	—	—	0.6	—	35.9	33.5	75

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		1990	2000	2010	Traditional biomass	Modern biomass	Hydro	Liquid biofuels	Wind	Solar	Geothermal	Other	Electricity capacity	Electricity generation	
Madagascar	UN	86.4	78.5	82.8	53.5	27.6	1.8	—	—	0.0	—	—	34.4	58.2	114
Malawi	UN	86.1	76.9	81.3	38.5	36.4	6.4	—	—	—	—	—	99.7	85.5	59
Malaysia	IEA	14.0	8.6	6.2	4.6	0.3	1.3	0.0	—	—	—	0.0	8.3	6.2	1,557
Maldives	UN	—	—	—	—	—	—	—	—	—	—	—	0.1	—	2
Mali	UN	91.6	88.9	88.3	85.4	1.4	1.5	—	—	—	—	—	51.6	55.2	62
Malta	IEA	—	—	0.3	—	—	—	—	—	0.3	—	—	0.3	—	15
Martinique	UN	2.3	1.6	1.6	0.2	0.8	—	—	0.0	0.6	—	—	0.3	2.8	23
Mauritania	UN	40.9	42.6	35.1	35.1	—	—	—	—	—	—	—	36.9	—	33
Mauritius	UN	51.9	14.6	6.9	0.5	5.4	1.1	—	0.0	—	—	—	24.3	4.8	33
Mexico	IEA	14.3	12.5	10.0	—	7.0	2.3	—	0.1	0.1	0.4	0.0	21.6	17.6	4,408
Moldova, Republic of	IEA	0.8	4.6	4.3	—	4.0	0.3	—	—	—	—	—	11.6	2.2	75
Mongolia	IEA	1.8	4.9	3.7	2.6	1.1	—	—	—	—	—	—	0.1	—	96
Montenegro	IEA	n.a.	n.a.	48.9	5.6	0.4	42.9	—	—	—	—	—	75.8	66.0	18
Montserrat	UN	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Morocco	IEA	8.5	6.7	7.2	3.4	0.6	2.7	—	0.5	—	—	—	23.7	18.5	500
Mozambique	IEA	93.1	92.5	89.6	71.2	7.8	10.7	—	—	—	—	—	89.7	99.9	344
Myanmar	IEA	90.9	80.2	84.9	79.5	2.6	2.8	—	—	—	—	—	46.7	67.7	535
Namibia	IEA	38.9	38.2	30.2	13.8	0.0	16.4	—	—	0.0	—	—	63.4	84.9	63
Nepal	IEA	95.1	88.3	88.3	84.3	1.0	2.3	—	—	—	—	0.6	92.1	99.9	424
Netherlands	IEA	1.2	1.5	3.6	—	1.5	0.0	0.5	0.6	0.1	0.0	0.8	14.5	9.5	2,064
Netherlands Antilles	IEA	—	—	—	—	—	—	—	—	—	—	—	9.4	—	29
New Caledonia	UN	40.2	15.9	8.0	0.2	0.0	7.0	—	0.7	—	—	—	23.2	23.1	19
New Zealand	IEA	29.2	28.9	31.5	—	8.8	15.7	0.0	1.0	0.1	5.6	0.2	68.3	73.4	497
Nicaragua	IEA	70.4	62.4	53.8	44.4	6.9	1.3	—	0.4	—	0.8	—	31.6	37.0	92
Niger	UN	86.8	93.9	73.7	71.0	2.8	—	—	—	0.0	—	—	—	0.0	39
Nigeria	IEA	88.4	86.9	88.8	79.6	8.8	0.4	—	—	—	—	—	32.9	24.4	4,373
Norway	IEA	59.3	60.3	56.9	—	6.2	49.2	0.6	0.4	—	—	0.5	93.6	95.8	796
Oman	IEA	—	—	—	—	—	—	—	—	—	—	—	—	—	265

COUNTRY	DATA SOURCE	SHARE (%) OF RE IN TFEC			SHARE (%) IN TFEC IN 2010								RE SHARE (%) IN 2010 OF:		TOTAL FINAL ENERGY CONSUMPTION (PJ) IN 2010
		1990	2000	2010	Traditional biomass	Modern biomass	Hydro	Liquid biofuels	Wind	Solar	Geo-thermal	Other	Electricity capacity	Electricity generation	
Pakistan	IEA	57.5	51.1	46.0	37.9	4.7	3.4	—	—	—	—	—	29.6	33.7	2,777
Palau	UN	—	—	6.8	—	—	6.8	—	—	—	—	—	n.a.	11.8	1
Panama	IEA	43.7	34.4	24.1	11.3	2.9	10.0	—	—	—	—	—	47.4	57.0	126
Papua New Guinea	UN	70.4	66.4	66.7	56.9	6.6	3.3	—	—	—	—	—	38.9	27.3	89
Paraguay	IEA	78.5	70.4	64.1	23.1	25.9	13.8	1.2	—	—	—	—	99.9	100.0	179
Peru	IEA	39.4	32.2	30.2	17.7	1.5	10.4	0.6	0.0	0.0	—	—	39.9	57.9	610
Philippines	IEA	51.0	34.9	28.8	15.1	7.5	2.3	0.9	0.0	0.0	3.0	—	33.1	26.3	988
Poland	IEA	2.5	6.9	9.5	—	7.5	0.3	1.4	0.2	0.0	0.0	0.1	6.5	6.9	2,718
Portugal	IEA	27.1	20.0	27.9	—	13.5	7.5	1.9	4.3	0.4	0.2	0.2	45.5	52.8	722
Puerto Rico	UN	1.8	0.7	0.7	—	—	0.7	—	—	—	—	—	2.8	0.7	67
Qatar	IEA	—	—	—	—	—	—	—	—	—	—	—	—	—	397
Reunion	UN	38.9	16.5	17.6	1.1	10.8	5.1	—	0.7	—	—	—	38.7	40.0	41
Romania	IEA	3.4	16.5	24.0	16.2	1.9	5.3	0.5	0.1	0.0	0.1	0.0	30.9	33.1	914
Russian Federation	IEA	3.8	3.5	3.3	0.3	0.4	2.6	—	0.0	—	0.0	—	20.5	16.1	16,133
Rwanda	UN	84.4	89.4	87.9	86.8	0.5	0.6	—	—	0.0	—	—	47.6	40.0	51
Saint Kitts and Nevis	UN	67.4	23.3	—	—	—	—	—	—	—	—	—	—	—	2
Saint Lucia	UN	—	—	—	—	—	—	—	—	—	—	—	—	—	3
Saint Pierre and Miquelon	UN	—	—	1.7	—	—	—	—	1.7	—	—	—	2.3	3.5	0
Saint Vincent and the Grenadines	UN	18.0	10.6	7.9	3.1	—	4.8	—	—	—	—	—	14.9	17.1	2
Samoa	UN	100.0	49.6	44.5	32.5	3.1	8.9	—	—	—	—	—	—	45.1	2
Sao Tome and Principe	UN	62.2	35.7	35.4	33.5	—	1.9	—	—	—	—	—	42.9	35.7	2
Saudi Arabia	IEA	0.0	0.0	0.0	0.0	0.0	—	—	—	—	—	—	—	—	3,005
Senegal	IEA	55.6	47.7	42.5	41.5	0.2	0.8	—	—	0.0	—	—	0.3	10.4	91
Serbia	IEA	15.5	23.5	20.3	11.0	0.7	8.6	—	—	—	0.1	—	26.6	31.8	367
Seychelles	UN	—	—	—	—	—	—	—	—	—	—	—	—	—	8
Sierra Leone	UN	95.6	90.6	71.2	52.2	18.9	0.1	—	—	—	—	—	52.9	31.8	58
Singapore	IEA	0.2	0.3	0.4	—	—	—	—	—	—	—	0.4	0.2	1.3	532
Slovakia	IEA	2.2	3.7	10.9	—	5.2	3.8	1.6	0.0	0.0	0.0	0.2	23.0	21.6	433

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		1990	2000	2010	Traditional biomass	Modern biomass	Hydro	Liquid biofuels	Wind	Solar	Geothermal	Other	Electricity capacity	Electricity generation	
Slovenia	IEA	12.4	15.9	18.8	—	11.2	5.8	0.9	—	0.1	0.5	0.3	35.5	29.2	207
Solomon Islands	UN	68.4	87.0	75.3	75.3	—	—	—	—	—	—	—	—	—	4
Somalia	UN	100.0	96.3	94.8	67.0	27.8	—	—	—	—	—	—	—	—	89
South Africa	IEA	16.6	18.2	18.7	15.1	3.2	0.3	—	0.0	0.1	—	—	2.0	1.0	2,405
Spain	IEA	10.5	8.0	14.8	—	4.7	3.6	1.7	3.8	0.8	0.0	0.2	38.8	32.5	3,628
Sri Lanka	IEA	78.1	64.2	62.0	36.9	20.4	4.7	—	0.0	0.0	—	—	52.0	52.5	370
Sudan	IEA	73.3	81.6	66.6	43.3	20.8	2.5	—	—	—	—	—	69.3	49.0	437
Suriname	UN	36.0	17.1	18.3	6.4	0.6	11.2	—	—	—	—	—	46.1	53.9	25
Swaziland	UN	84.3	46.8	35.7	24.6	6.4	4.7	—	—	—	—	—	40.3	47.3	35
Sweden	IEA	34.1	40.9	47.4	—	27.3	15.4	1.7	0.8	0.0	—	2.1	62.1	55.3	1,368
Switzerland	IEA	16.9	18.5	21.2	—	4.4	13.7	0.0	0.0	0.2	1.3	1.6	68.9	56.7	858
Syrian Arab Republic	IEA	2.4	1.9	1.4	—	0.0	1.3	—	—	—	—	—	10.8	5.6	505
Tajikistan	IEA	29.6	62.4	57.3	—	—	57.3	—	—	—	—	—	91.2	96.6	84
Tanzania, United Republic of	IEA	94.8	94.3	90.7	70.6	19.0	1.1	—	—	—	—	—	66.8	58.0	729
Thailand	IEA	33.6	22.0	22.8	10.2	10.9	0.7	1.0	—	0.0	0.0	0.0	8.9	5.6	2,780
Timor-Leste	UN	n.a.	n.a.	43.1	43.1	—	—	—	—	—	—	—	—	—	3
Togo	IEA	78.7	77.1	76.1	64.3	9.2	2.6	—	—	—	—	—	78.8	76.2	69
Tonga	UN	—	0.4	2.0	2.0	—	—	—	—	—	—	—	—	—	2
Trinidad and Tobago	IEA	1.2	0.5	0.2	0.2	0.0	—	—	—	—	—	—	0.3	—	232
Tunisia	IEA	14.5	14.2	14.6	13.9	0.4	0.1	—	0.1	—	—	—	3.2	1.2	291
Turkey	IEA	24.6	17.3	14.2	—	6.3	5.1	0.0	0.3	0.4	2.0	0.0	35.1	26.4	2,948
Turkmenistan	IEA	0.3	0.0	0.0	—	—	0.0	—	—	—	—	—	0.0	0.0	511
Turks and Caicos Islands	UN	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Uganda	UN	96.1	94.6	88.8	85.5	2.6	0.7	—	—	—	—	—	68.5	58.6	390
Ukraine	IEA	0.7	1.3	2.9	1.4	0.4	1.2	—	0.0	—	—	—	10.1	7.2	2,856
United Arab Emirates	IEA	—	0.1	0.1	—	0.1	—	—	—	—	—	—	0.0	—	1,799
United Kingdom of Great Britain and Northern Ireland	IEA	0.7	1.0	3.2	—	0.9	0.2	0.9	0.6	0.1	0.0	0.6	10.0	6.8	5,435

COUNTRY	DATA SOURCE	SHARE (%) OF RE IN TFEC			SHARE (%) IN TFEC IN 2010								RE SHARE (%) IN 2010 OF:		TOTAL FINAL ENERGY CONSUMPTION (PJ) IN 2010
		1990	2000	2010	Traditional biomass	Modern biomass	Hydro	Liquid biofuels	Wind	Solar	Geo-thermal	Other	Electricity capacity	Electricity generation	
United States of America	IEA	4.2	5.4	7.6	—	3.2	1.4	1.9	0.5	0.1	0.1	0.3	12.9	10.1	57,173
Uruguay	IEA	44.8	38.8	52.3	8.3	26.3	17.7	—	0.1	—	—	—	60.2	89.0	148
Uzbekistan	IEA	1.3	1.2	2.6	—	0.0	2.6	—	—	—	—	—	14.9	21.0	1,226
Vanuatu	UN	100.0	68.9	41.6	39.7	—	1.1	—	0.8	—	—	—	10.7	19.0	2
Venezuela, Bolivarian Rep. of	IEA	11.8	14.1	12.5	1.1	1.0	10.5	—	—	—	—	—	61.5	64.9	1,853
Viet Nam	IEA	76.1	58.0	34.8	24.5	5.6	4.7	—	—	—	—	—	36.4	29.1	1,924
Western Sahara	UN	—	—	—	—	—	—	—	—	—	—	—	—	—	2
Yemen	IEA	2.1	1.2	1.0	—	1.0	—	—	—	—	—	—	—	—	211
Zambia	IEA	82.9	89.9	90.7	68.0	12.0	10.8	—	—	—	—	—	99.6	99.7	260
Zimbabwe	IEA	64.1	70.2	80.8	69.2	5.2	6.4	—	—	—	—	—	33.4	50.2	352

AGGREGATED BY REGION	DATA SOURCE	SHARE (%) OF RE IN TFEC			SHARE (%) IN TFEC IN 2010								RE SHARE (%) IN 2010 OF:		TOTAL FINAL ENERGY CONSUMPTION (PJ) IN 2010
		1990	2000	2010	Traditional biomass	Modern biomass	Hydro	Liquid biofuels	Wind	Solar	Geo-thermal	Other	Electricity capacity	Electricity generation	
Northern America	IEA	6.0	7.1	9.0	—	3.4	2.8	1.7	0.5	0.1	0.1	0.3	18.2	16.3	64,439
Europe	IEA	8.1	9.4	14.1	0.3	6.0	4.1	1.3	1.1	0.3	0.3	0.8	33.6	26.0	42,078
Eastern Europe	IEA	3.0	4.2	5.4	1.1	1.8	2.1	0.3	0.0	0.0	0.0	0.0	17.5	13.8	25,902
Caucasian and Central Asia	IEA	3.1	5.2	4.4	0.4	0.1	3.9	—	0.0	—	0.0	0.0	28.6	28.2	4,184
Western Asia	IEA	8.2	5.8	4.3	0.0	1.6	1.5	0.0	0.1	0.6	0.5	0.0	11.4	7.4	11,697
Eastern Asia	IEA	22.2	19.1	15.3	10.4	0.3	3.2	0.1	0.2	0.5	0.2	0.4	20.8	14.8	77,743
South Eastern Asia	IEA	52.2	37.9	31.1	23.4	5.5	1.5	0.3	0.0	0.0	0.4	0.0	15.9	14.1	14,741
Southern Asia	IEA	50.9	43.4	34.8	26.7	6.1	1.6	0.0	0.2	0.0	—	0.0	24.4	14.0	28,007
Oceania	IEA	15.0	15.6	15.1	4.3	4.8	4.0	0.3	0.5	0.3	0.7	0.1	24.2	22.2	3,867
Latin America and Caribbean	IEA	32.3	28.2	29.0	5.1	11.5	9.3	2.9	0.1	0.1	0.1	0.0	52.5	56.5	22,000
Northern Africa	IEA	6.5	6.2	5.0	2.5	1.0	1.4	—	0.2	—	—	—	9.6	7.2	3,974
Sub-Saharan Africa	IEA	72.5	74.6	75.4	65.3	8.5	1.6	—	0.0	0.0	0.0	—	26.0	22.7	16,368
World	IEA	16.6	17.4	18.0	9.6	3.7	3.1	0.8	0.3	0.2	0.2	0.3	23.9	19.4	329,834

AGGREGATED BY INCOME LEVEL	DATA SOURCE	SHARE (%) OF RE IN TFEC			SHARE (%) IN TFEC IN 2010								RE SHARE (%) IN 2010 OF:		TOTAL FINAL ENERGY CONSUMPTION (PJ) IN 2010
		1990	2000	2010	Traditional biomass	Modern biomass	Hydro	Liquid biofuels	Wind	Solar	Geo-thermal	Other	Electricity capacity	Electricity generation	
High income	IEA	6.2	7.0	9.3	0.0	3.9	2.8	1.3	0.6	0.2	0.2	0.4	20.7	16.6	138,623
Upper middle income	IEA	18.8	19.6	16.7	8.4	2.6	4.1	0.6	0.1	0.3	0.2	0.2	27.0	22.1	120,299
Lower middle income	IEA	45.1	47.6	43.2	34.2	6.7	2.0	0.0	0.1	0.0	0.1	0.0	26.5	20.7	48,666
Low income	IEA	61.9	73.7	74.2	63.9	6.7	3.4	—	0.0	0.0	0.1	0.0	56.3	59.1	7,410

SOURCES: IEA WORLD ENERGY STATISTICS AND BALANCES (2012), UN ENERGY STATISTICS.

NOTE: OWING TO UNAVAILABILITY OF DATA FOR 1990, THE FIRST AVAILABLE DATA WERE USED FOR THE FOLLOWING COUNTRIES: CAMBODIA (1995), ERITREA (1992), KOSOVO (2000), MONTENEGRO (2005), AND NAMIBIA (1991). THE LATEST AVAILABLE UN DATA ARE FOR 2009. WORLD IS GREATER THAN THE SUM OF COUNTRIES BECAUSE WORLD INCLUDES MARINE AND AVIATION BUNKERS.

— = DATA NOT AVAILABLE.

The report's framework for data collection and analysis will enable us to monitor progress on the SE4ALL objectives from now to 2030. It is methodologically sound and credible. It produces findings that are conclusive and actionable. In many respects, what you measure determines what you get. That is why it is critical to get measurement right and to collect the right data, which is what this report has done. It has charted a map for our achievement of sustainable energy for all and a way to track progress. Let the journey begin!

—Kandeh Yumkella
Secretary General's Special Representative for Sustainable Energy for All

SUSTAINABLE
ENERGY FOR ALL

The SE4ALL Global Tracking Framework full report, overview paper, executive summary and associated datasets can be downloaded from the following website:

www.worldbank.org/se4all

COORDINATORS