Lecture - 13

Energy Efficiency & Conservation

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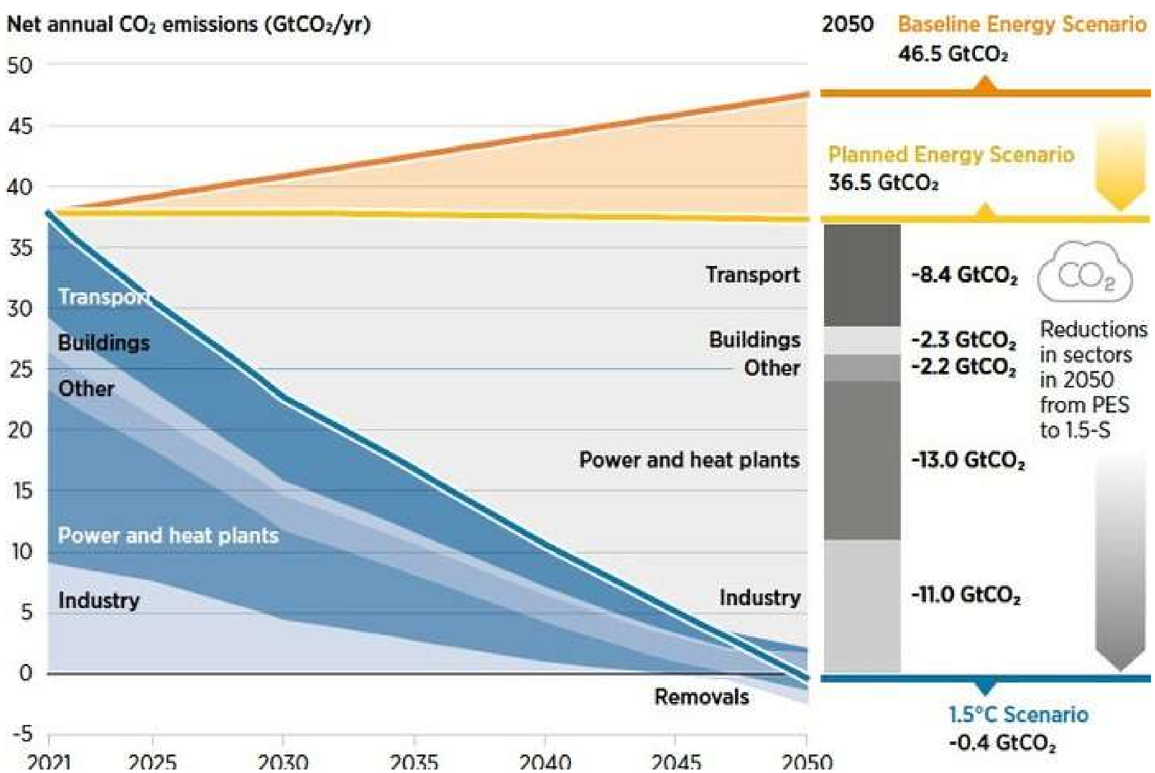
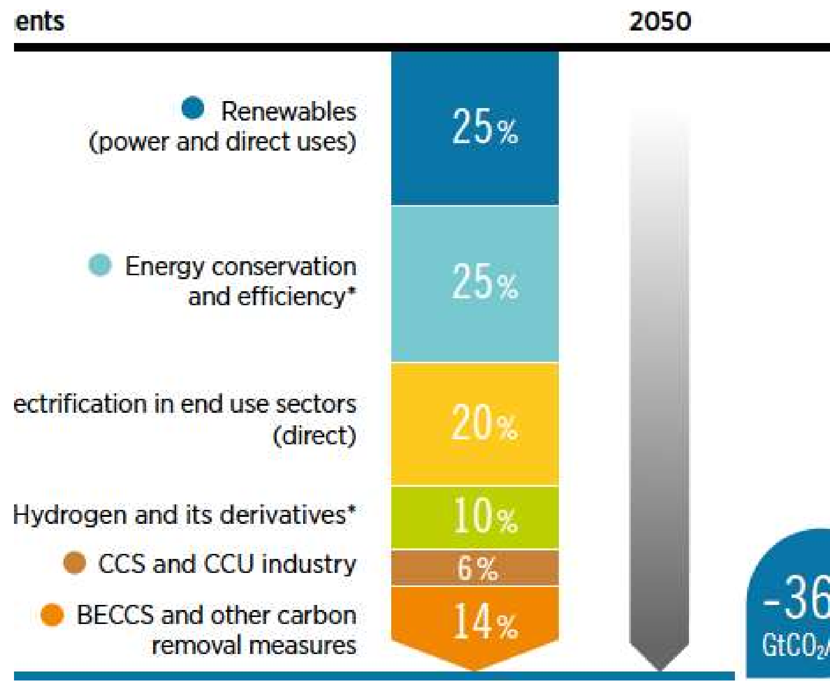
Outline

- Motivation
- Energy efficiency by sector
- EE policies

Motivation

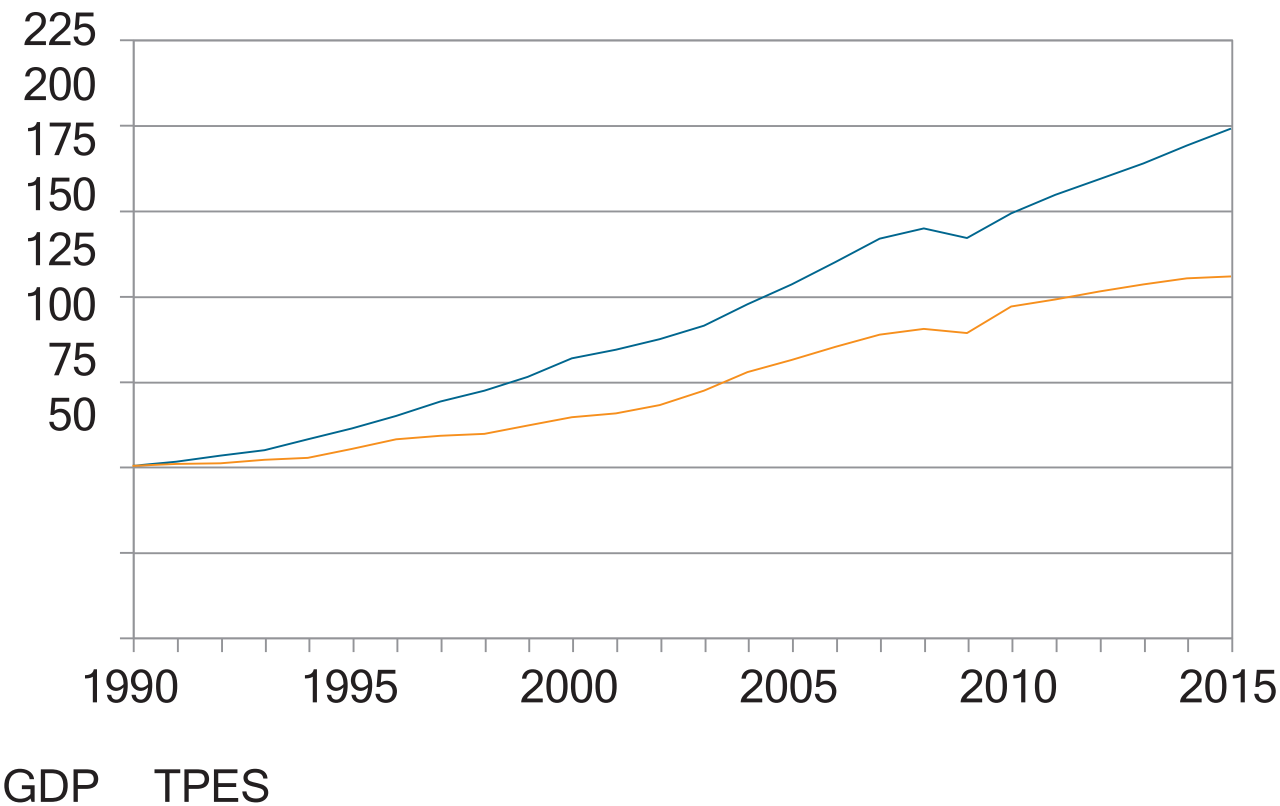
COP 21- NZE for 1.5 °C and abatements





Source: IRENA, 2021

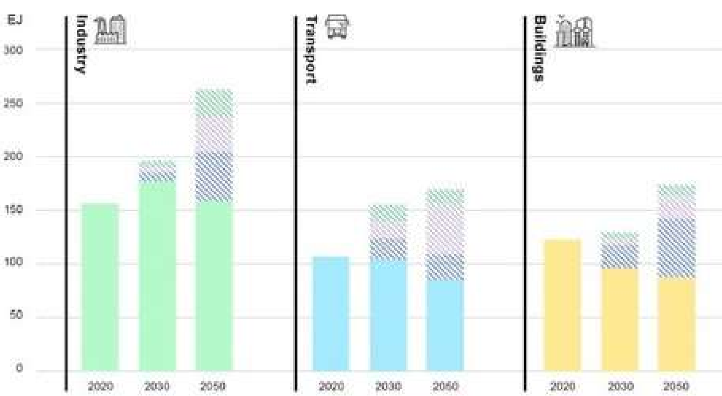
World GDP and TPES trends (1990=100)

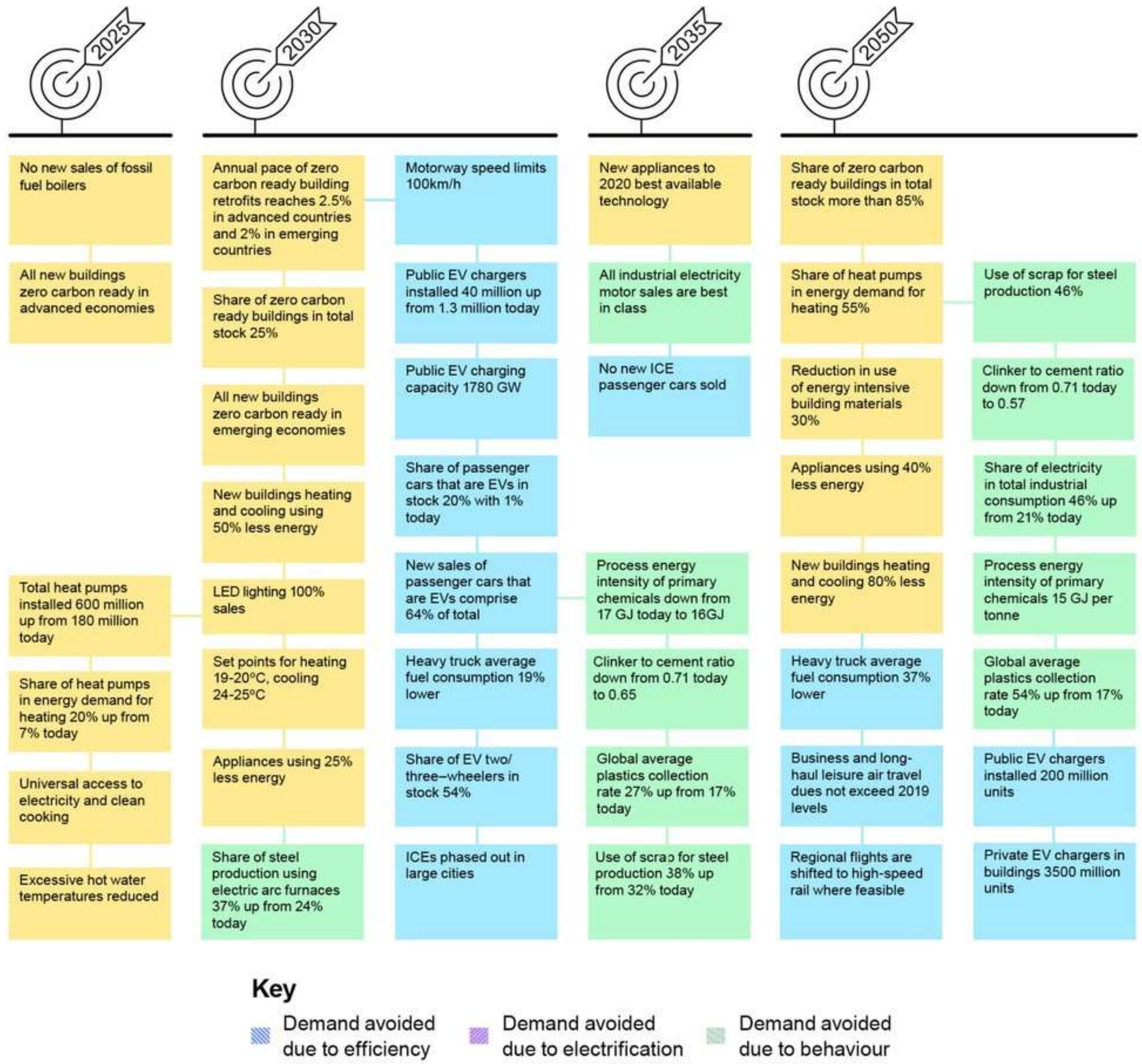


Sources: IEA *World energy balances*, 2017; TPES: total primary energy supply; GDP based on 2010 USD, market exchange rates.

Source: IEA, 2017

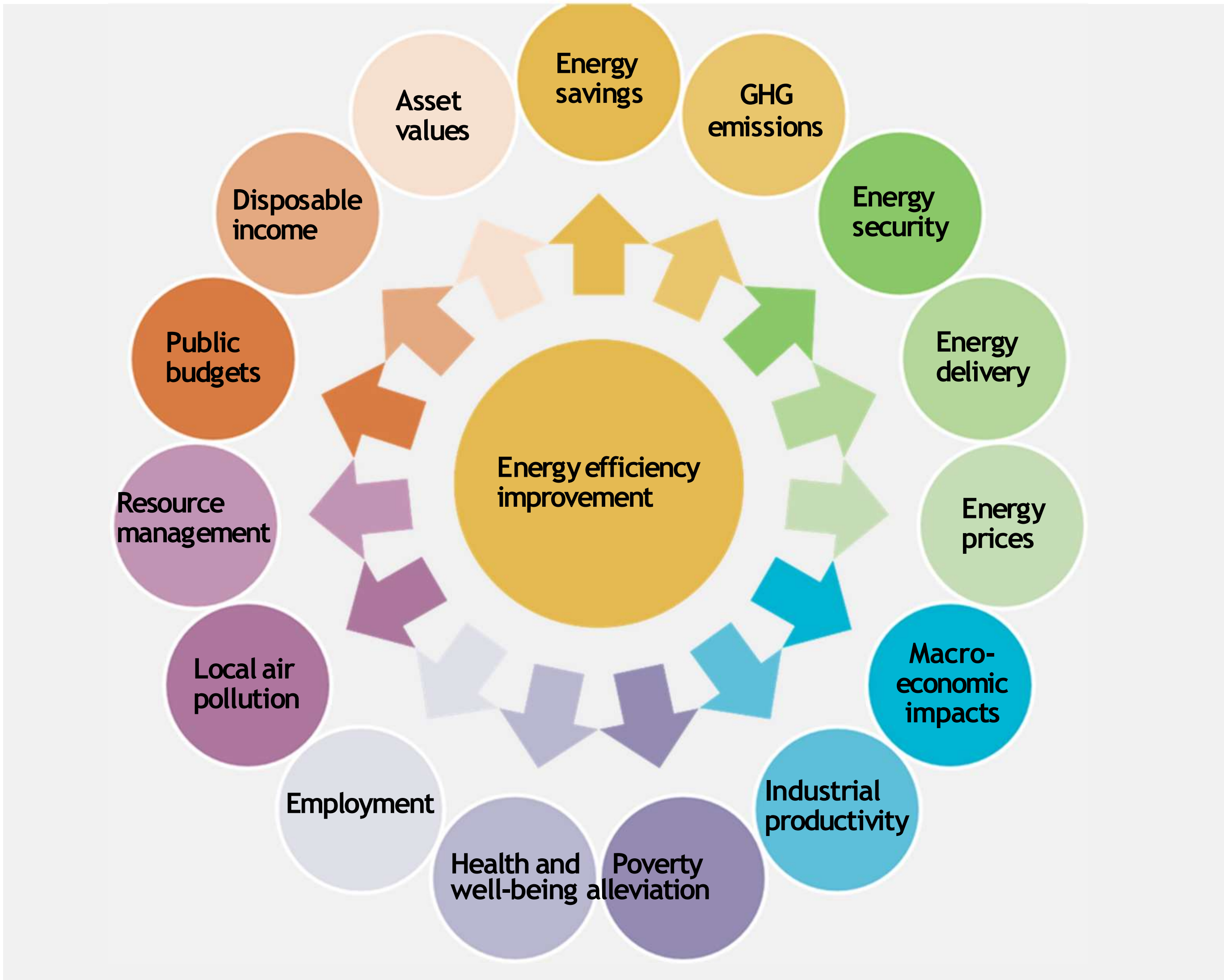
Energy efficiency milestones in the Net Zero Emissions by 2050 Scenario





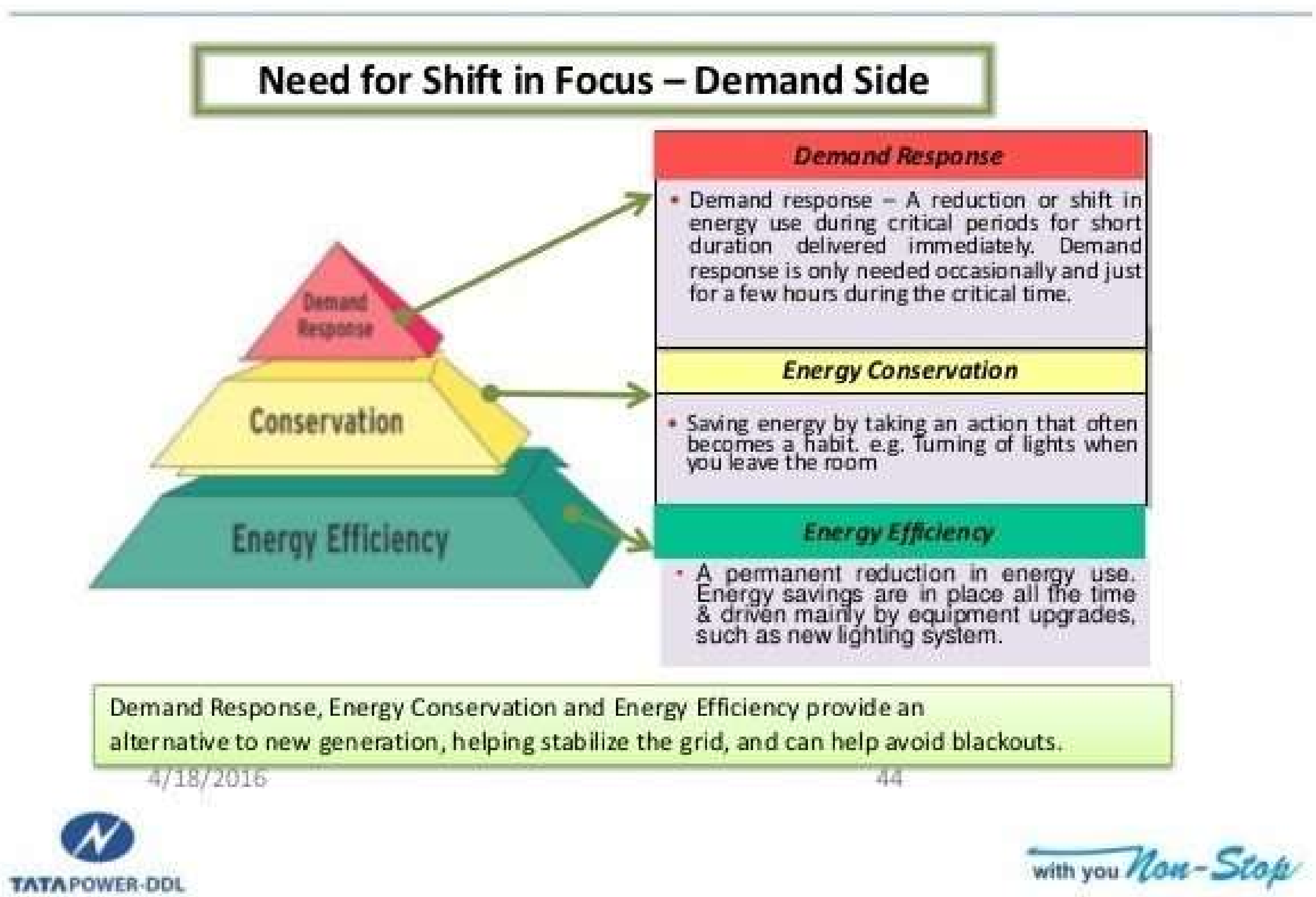
Source: IEA, 2021

The multiple benefits of EE

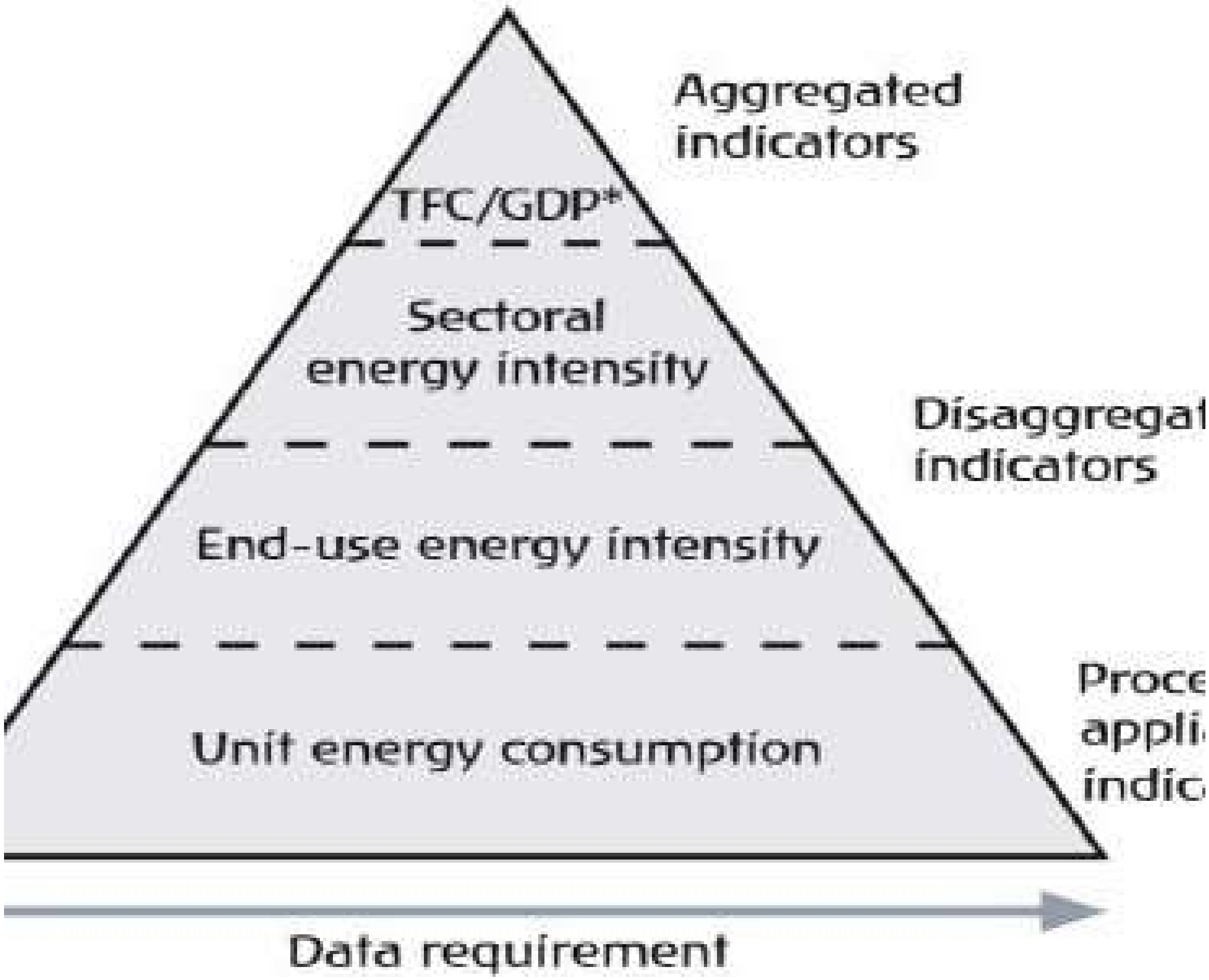


Source: IEA, 2010

Demand side management (DSM)

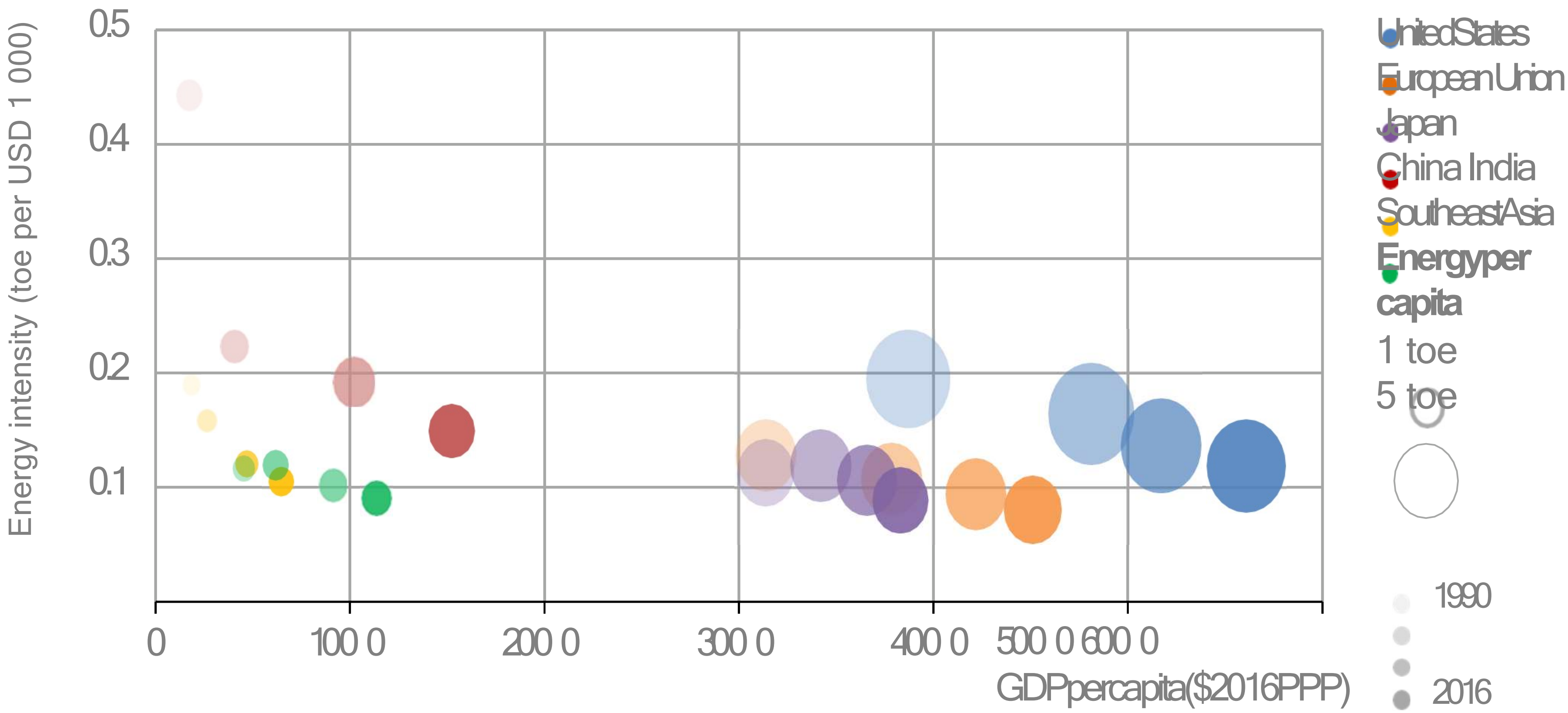


ematic representation of energy indicator



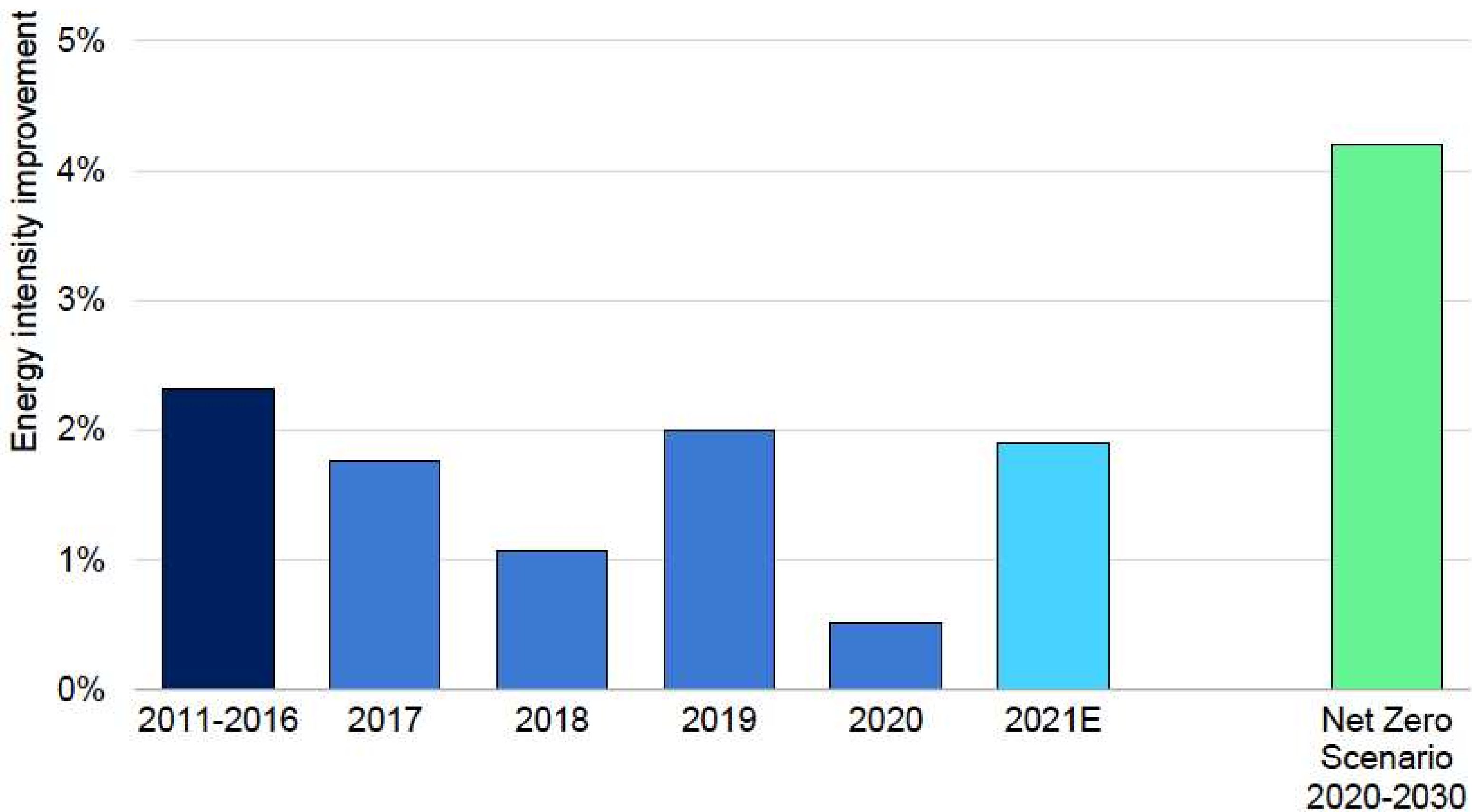
Source: IEA, 2019

Energy intensity trends in selected regions



Note: toe = tonnes of oil equivalent; PPP = purchasing power parity.

Primary energy intensity improvement, 2011-2021



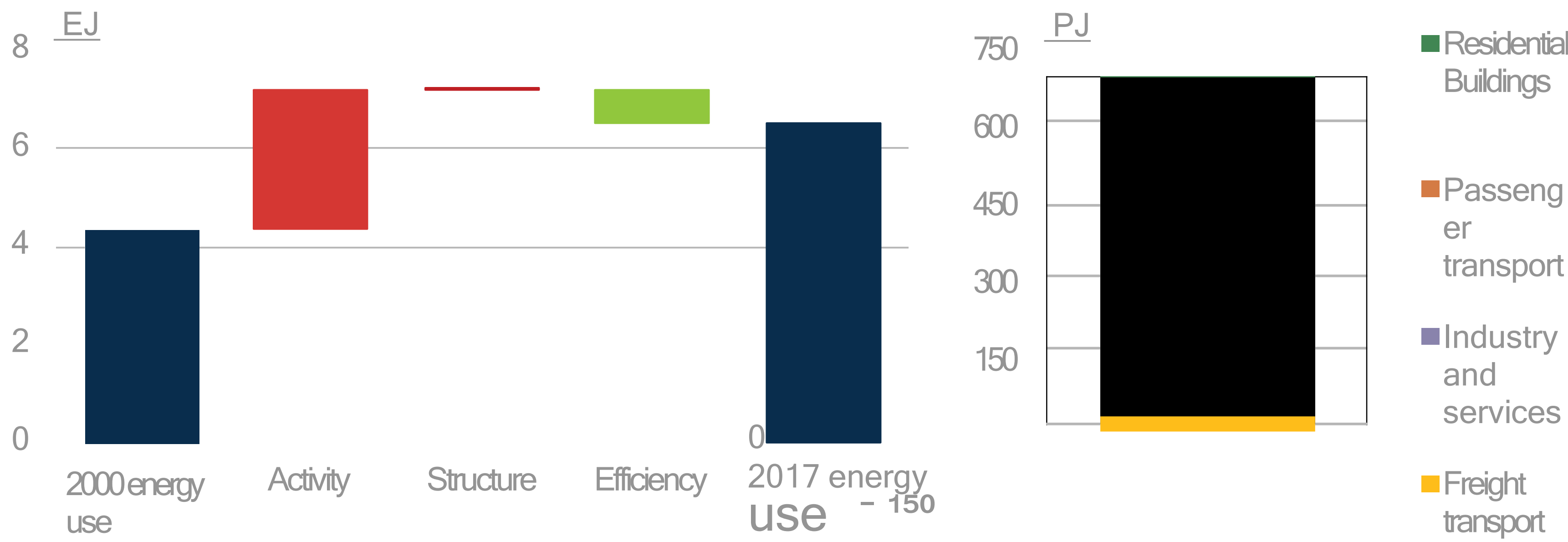
Notes: 2011-2016 five-year average. 2021 estimate based on World Energy Outlook 2021. Net Zero Emissions Scenario = IEA Net Zero Emissions by 2050 Scenario, 2020-2030 intensity improvements, ten year average.

Source: IEA, 2021

Change in global final energy demand and causes, 2018 - 19

Source: IEA, 2019

Decomposition of Indonesian final energy use, 2000 - 17 and sectoral contribution to efficiency gains

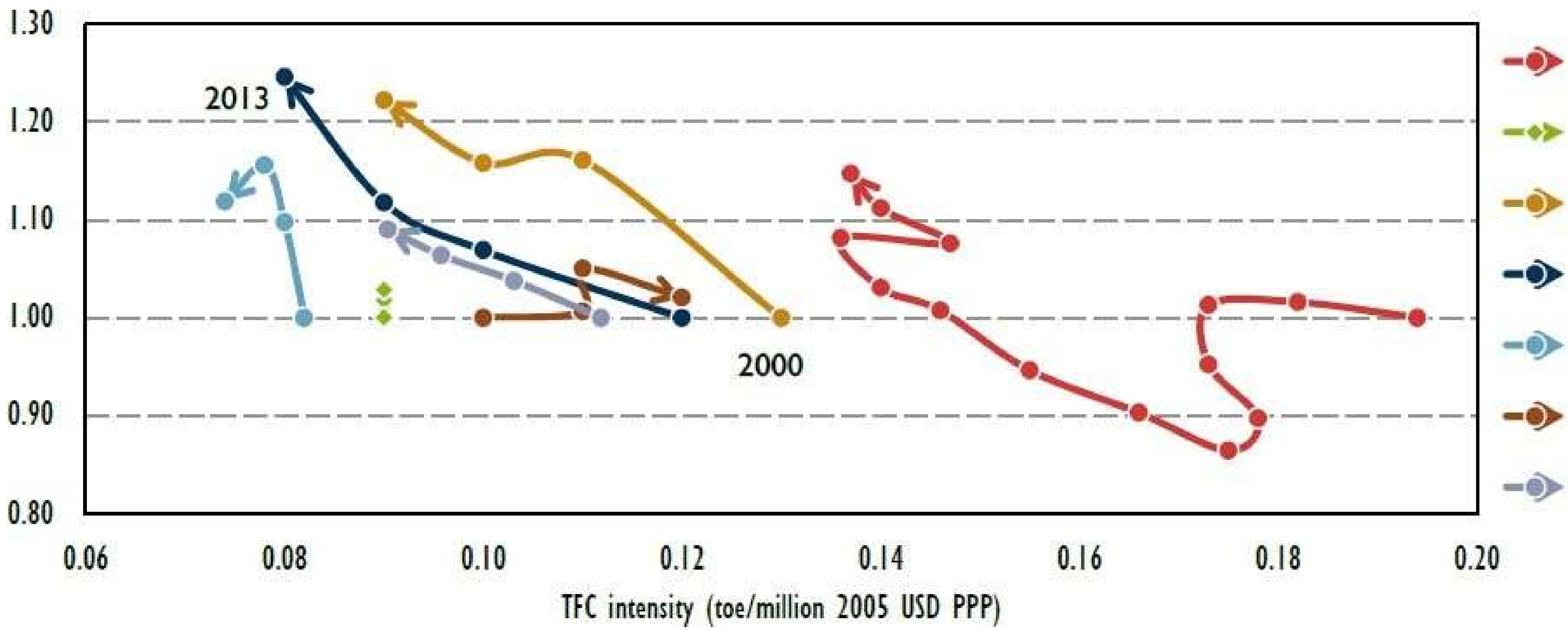


Notes: "Energy use" covers the residential, industry and services, passenger and freight transport sectors. It excludes non-energy use (i.e. feedstocks) and energy supply. Buildings analysis based on IEA *Energy Technology Perspectives* Buildings model (www.iea.org/etp/ etpmodel/buildings/).

Sources: Adapted from IEA (2018a), *World Energy Balances* (database); IEA (2018b), *Mobility Model* (database); Timmer, M. P. et al. (2015), *World Input Output Database* (database); Statistics Indonesia (2018), *Gross Domestic Product* (database).

Source: IEA, 2018

Index of energy efficiency improvement



Source: IEA, 2016

Energy flow and consumption in manufacturing sectors

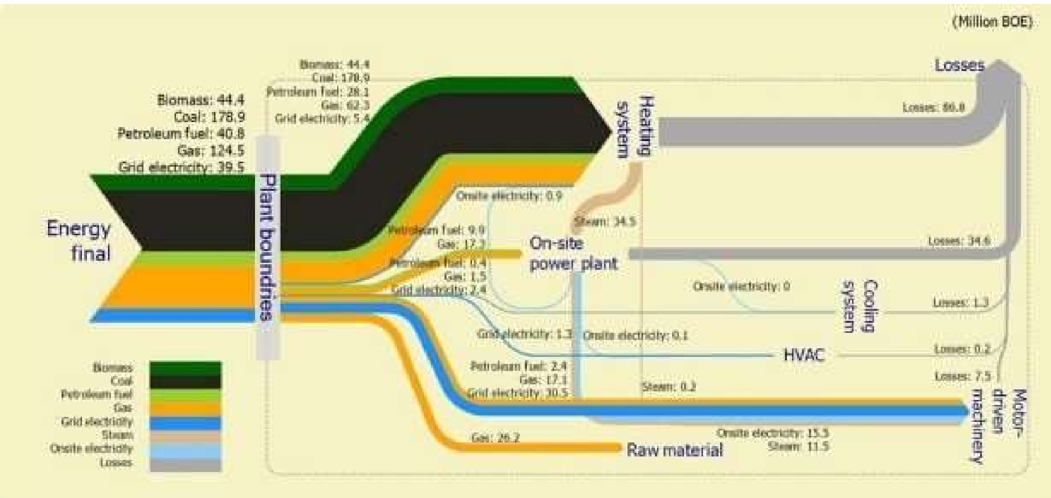


Table 1. Specific energy consumption of the selected industry groups.

Industry group	SEC (BOE/ Tonne)	SEC reference (BOE/Tonne)	References
Pulp	1.21–2.74	1.13–3.16	[16]
Paper	1.63–2.14	1.23–1.79	
Alcohol	1.11	0.78	[17]
Cement	0.67	0.57	[18]
Spinning	1.48–3.65	0.57–0.59	
Weaving	0.83–8.6	0.82–7.03	
Finishing	8.35	7.8	
Basic Metal and Steel	0.67–0.86	0.46–0.50	
Sugar processing	5.98	4.75	[19]

Source: Yales et al, 2016

Disaggregation of total final energy consumption into sectors

- Total final consumption
  - Residential
    - Space heating
    - Space cooling
    - Water heating
    - Lighting
    - Cooking
    - Appliances
    - Other energy use
  - Services
    - Space heating
    - Space cooling
    - Water heating
    - Lighting
    - Other equipment
    - Other energy use
  - Industry
    - Iron and steel
    - Chemical and petrochemical
    - Non-ferrous metals
    - Non-metallic minerals
    - Transport equipment
    - Food and tobacco
    - Wood and wood products
    - Paper, pulp & print
    - Textile and leather
    - Not elsewhere specified
  - Transport
    - Passenger
      - Road: Passenger light-duty vehicles
      - Powered 2- and 3-wheelers
      - Buses
      - Rail: Passenger trains
      - Air: Passenger airplanes
      - Water: Passenger ships
    - Freight
      - Road: Freight light-duty vehicles
      - Heavy duty vehicles
      - Rail: Freight trains
      - Air: Freight airplanes
      - Water: Freight ships
  - Other
    - Mining and quarrying
    - Construction
    - Water supply/waste management
    - Agriculture/ forestry
    - Fishing
    - Pipeline transport
    - Non-specific other sectors
    - Non-energy use

Source: IEA, 2014

Energy demand forecasting models

- Econometric models. Projections based on price and income factors and their relationship to energy demand
  - *elasticity*
- End-use models is (engineering oriented). Projections based on the technological structure of energy consumption and relate the energy consumption to factors describing the level of economic activity in each sector (drivers) – *intensity, SEC*

Econometric model

ased on the COBB-DOUGLAS production functic

$$E = a\frac{Y^{\alpha}}{P^{\beta}}$$

Energy Demand
Income (GDP per capita)
Energy Price
coefficient

α: Income Elasticity of Energy Demand

$$\alpha = \frac{\Delta E / E}{\Delta Y / Y} = \frac{\%\ change\ in\ E}{\%\ change\ in\ Y}$$

β: Price Elasticity of Energy Demand

$$\beta = \frac{\Delta E / E}{\Delta P / P} = \frac{\%\ change\ in\ E}{\%\ change\ in\ P}$$

April, 7 '05

End-use (engineering) model

Energy Demand for each activity results from the product of two factors: *LEVEL OF ACTIVITY* (ener service) and *ENERGY INTENSITY* (energy use pe unit of service)

$$Energy\ use = \sum_{i=1}^{n} Q_i \cdot I_i$$

: Quantity of energy service *i*

Intensity of energy use for energy service *i*

$$Q_i = N_i \cdot P_i \cdot M_i$$

N_i: Number of eligible customers for end-use *i*

P_i: Penetration (total units/total customers) of end-use service *i* (can be >100%)

M_i: Magnitude of extent of end-use service *i*

generic energy efficiency indicator (energy intensity) = $\frac{\text{Energy end-use}}{\text{activity}}$

Activity data for transport
- Vehicle stocks
- Passenger-kilometres
- Tonne-kilometres


Vehicle stock

Distance travelled


Load


Occupancy

Activity data for residential
- Population
- Number of occupied dwellings
- Residential floor area
- Appliances stock and diffusion


# of people


# of dwellings


Surface


# of appliances

Activity data for industry
- Value added
- Physical production

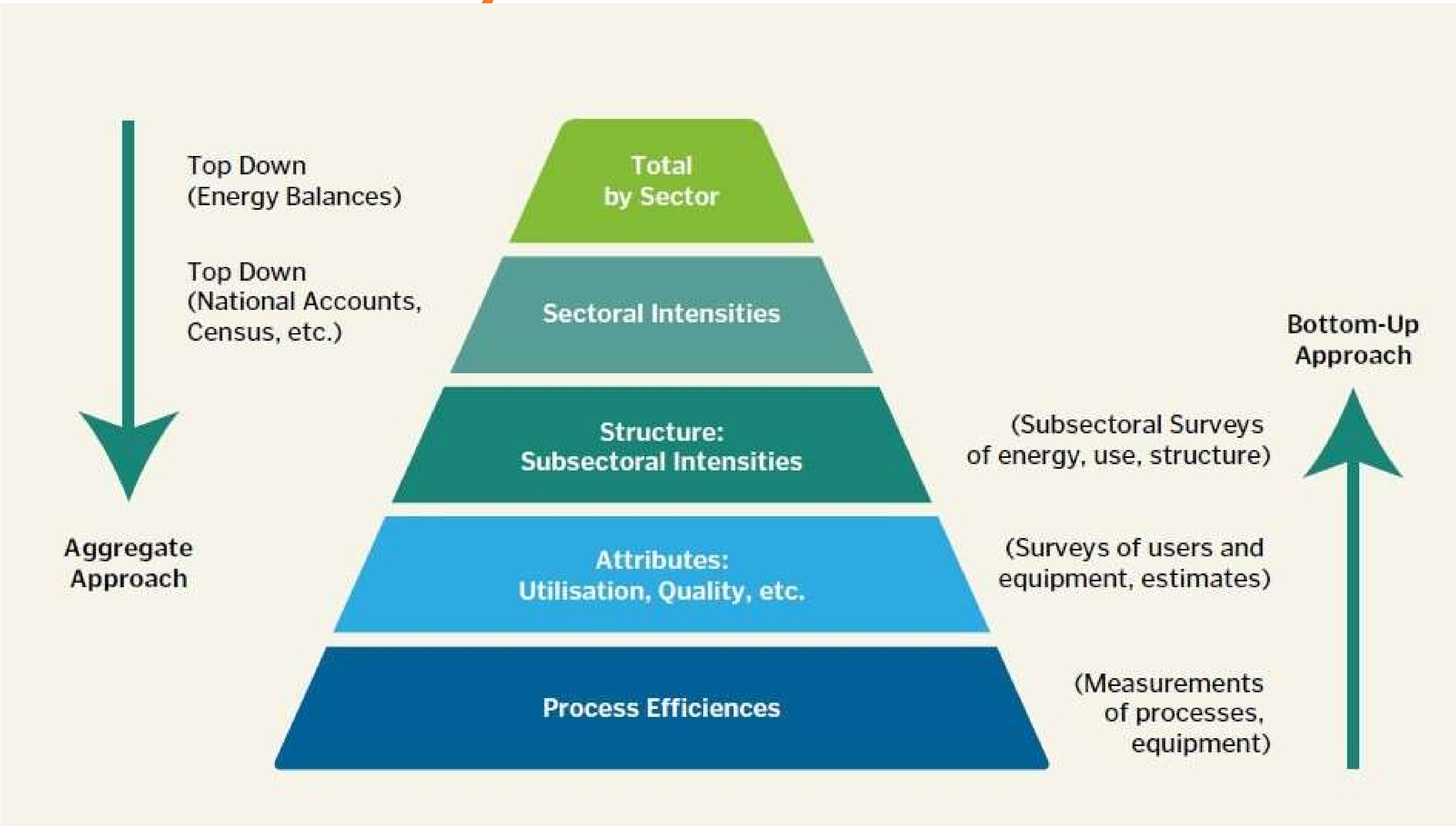

Value added


Volume

Source:IEA

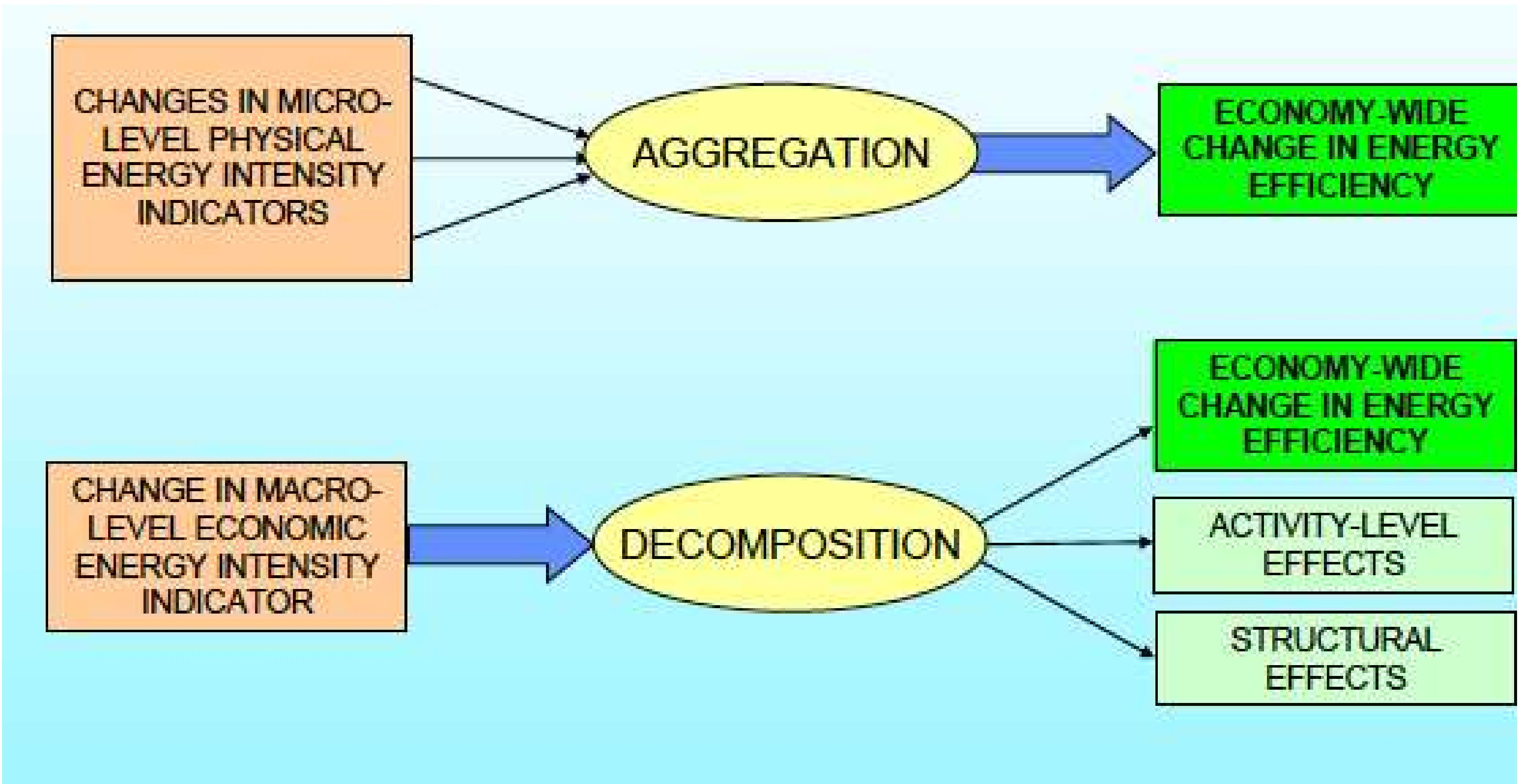
Energy Efficiency

Hierarchy of Energy Efficiency Indicators



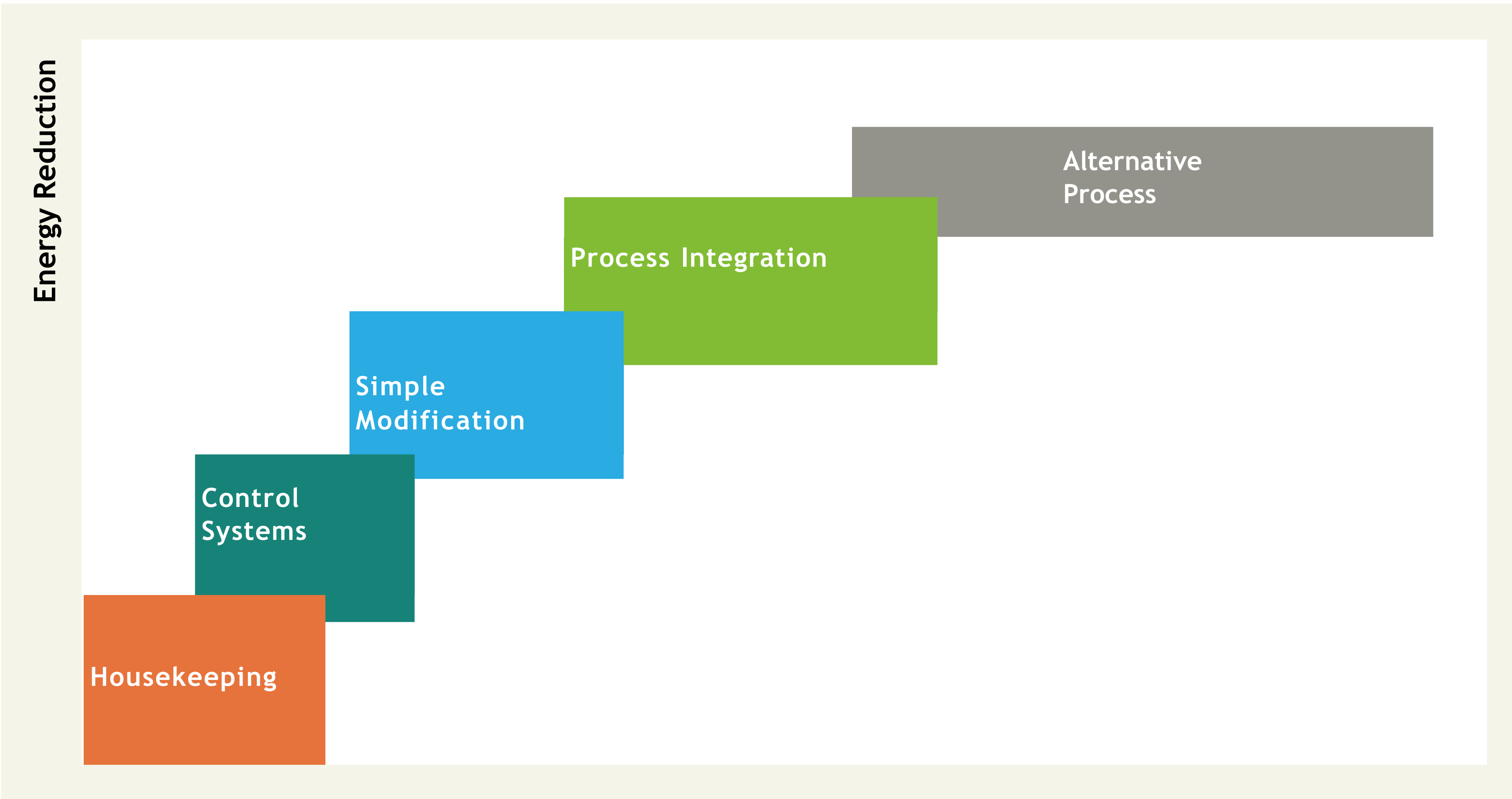
Source: UNEP,

Bottom-up versus top-down



Source: Househam

A Structured Approach of Energy Management



Source: UNEP,

How can we improve energy efficiency?

- **Through technology:**
  - design of houses, equipment & appliances etc.
- **Through behavior:**
  - how we shop
  - how we use energy: energy conservation
  - how we organise processes: energy management

Source: IEA, 2010

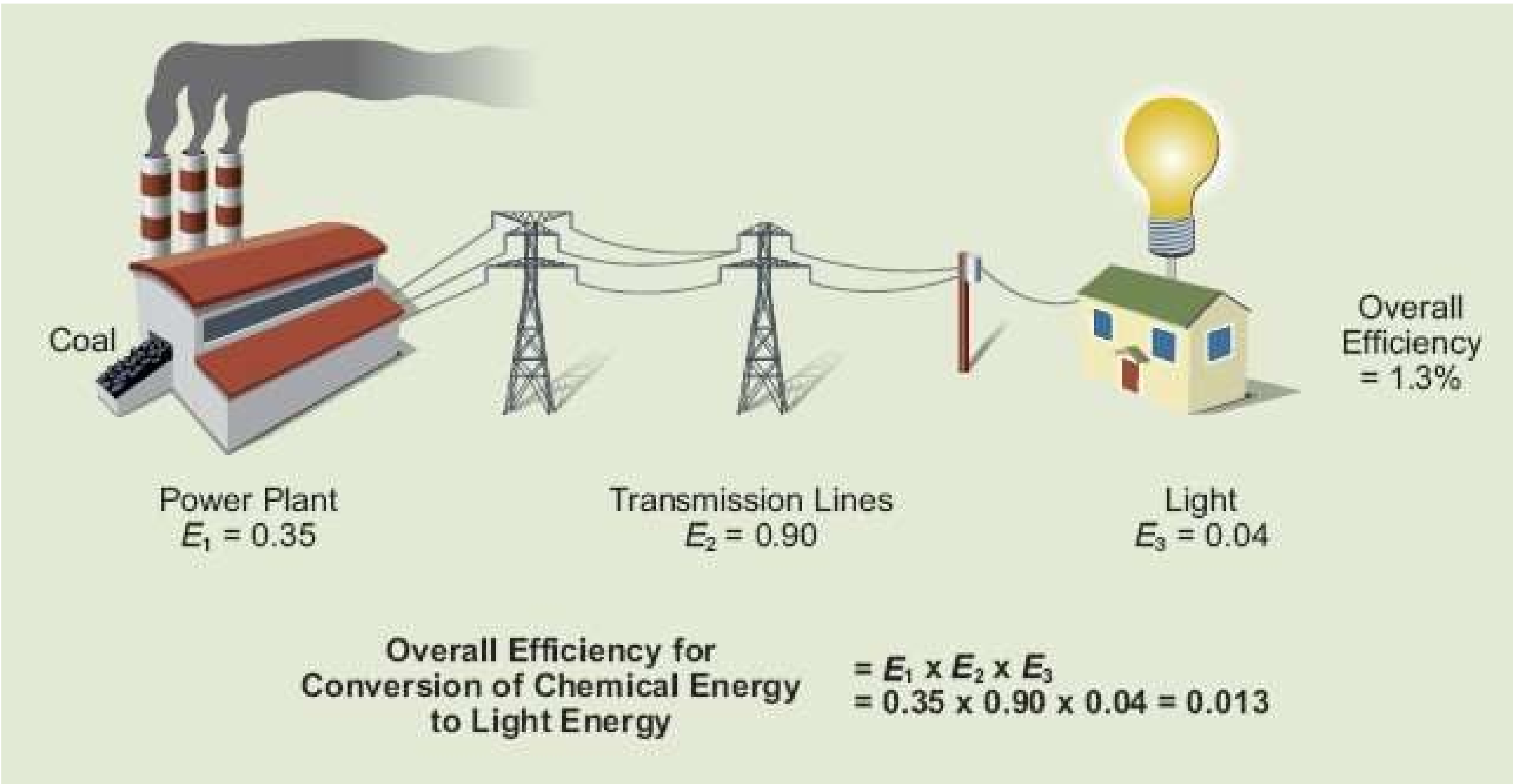
Conservation vs. Efficiency

- Improving Energy Conservation
  - – Behavioral changes that reduce energy use; cooler showers, adjusting the thermostat

Source: AP

- Improving Energy Efficiency
  - – Changes in equipment and behavior that result in increased energy services per unit of energy consumed

Layers of Inefficiency Currently



Source: Brown, 2012

What is energy intensity?

Box 1.1 What is energy intensity and how does it relate to energy efficiency?

Energy intensity is a measure of the amount of energy used to produce a unit of output. The energy intensity indicator used in this report is primary energy demand per unit of global GDP, i.e. the amount of energy the global economy uses (before it is converted into end-use fuels such as electricity and gasoline) to produce one unit of economic output.

Changes in global primary energy intensity are not solely an indication of energy efficiency improvements. They are also influenced by factors such as the movement of economic activity away from energy-intensive heavy industries towards less energy-intensive service sectors. Decomposition analysis, as detailed later in this chapter, is used to determine changes in energy efficiency more accurately.

Source: IEA, 2018

Top down approach

- Drivers of energy consumption: 3 main effects

- **Activity effect**
  - Change in the **overall level** of the activity / level of action that drives energy consumption.

- **Structure effect (Activity mix)**
  - Change in the **mix of activities** within a sector

- **Energy efficiency effect (Intensity)**
  - Changes in **sub-sectoral energy intensities** (i.e. energy used per unit of activity)

- There are **different methods** – the IEA uses the LMDI

LMDI = Logarithmic Mean Divisia Index

Three main factors affect yearly changes in final energy use

- *Activity effects*: whether factors that drive energy-using activities, such as industry value-added, tonne or passenger kilometres travelled and population, increased or decreased, many of which are linked to changes in economic output.
- *Structural effects*: whether there were changes in the type of energy-using activities, such as the share of activity across various economic sectors, appliance ownership, number of buildings and floor area, and the share of different transport modes.
- *Efficiency effects*: whether the energy used per unit of activity increased or decreased.

Source: IEA, 2016

Decomposition to analyse energy efficiency

Table 1.1 Sectors and indicators included in the IEA decomposition analysis

Sector	Service/sub-sector	Activity	Structure	Efficiency effect
Residential	Space heating	Population	Floor area/ population	Space heating energy*/ floor area
	Water heating	Population	Occupied dwellings/ population	Water heating energy/occupied dwellings
	Cooking	Population	Occupied dwellings/ population	Cooking energy/ occupied dwellings
	Space cooling	Population	Floor area/ population	Space cooling energy*/floor area
	Lighting	Population	Floor area/ population	Lighting energy/floor area
	Appliances	Population	Appliance stock/ population	Appliances energy/ appliance stock
Passenger transport	Car; bus; rail; domestic aviation	Passenger kilometre	Share of passenger kilometres by mode and persons per vehicle	Energy/vehicle kilometre
Freight transport	Truck; rail; domestic shipping	Tonne kilometre	Share of tonne kilometres by mode and tonnes per vehicle	Energy/vehicle kilometre
Manufacturing	Food, beverages and tobacco; paper, pulp and printing; chemicals; non-metallic minerals; primary metals; metal products and equipment; other manufacturing	Value-added	Share of value added	Energy/value-added
Services	Services	Value-added	Share of value added	Energy/value-added
Other industries**	Agriculture and fishing; construction	Value-added	Share of value added	Energy/value-added

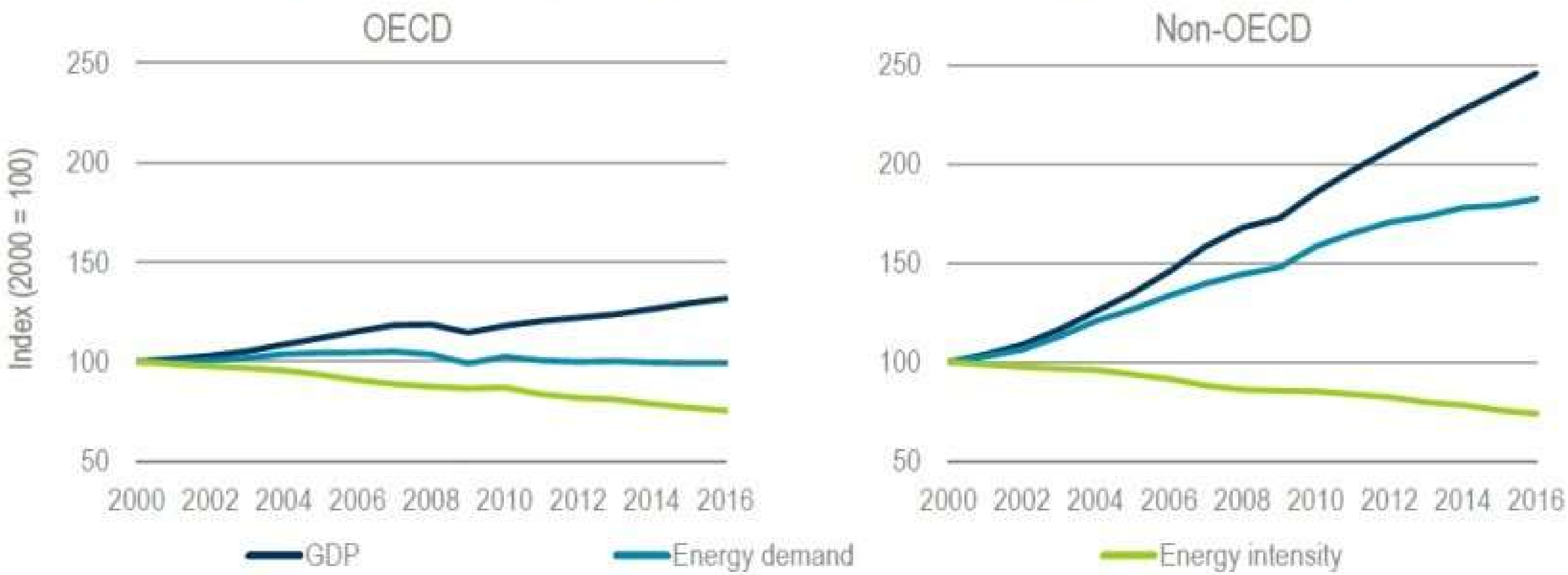
* Adjusted for climate variation using heating degree-days.

** Because they are energy producing sectors and outside the scope of this analysis, the following sectors are not included: mining and quarrying; fuel processing; and electricity, gas and water supply. 'Other industries' are analysed only to a very limited extent.

Source: IEA, 2016

Energy demand, GDP and energy intensity

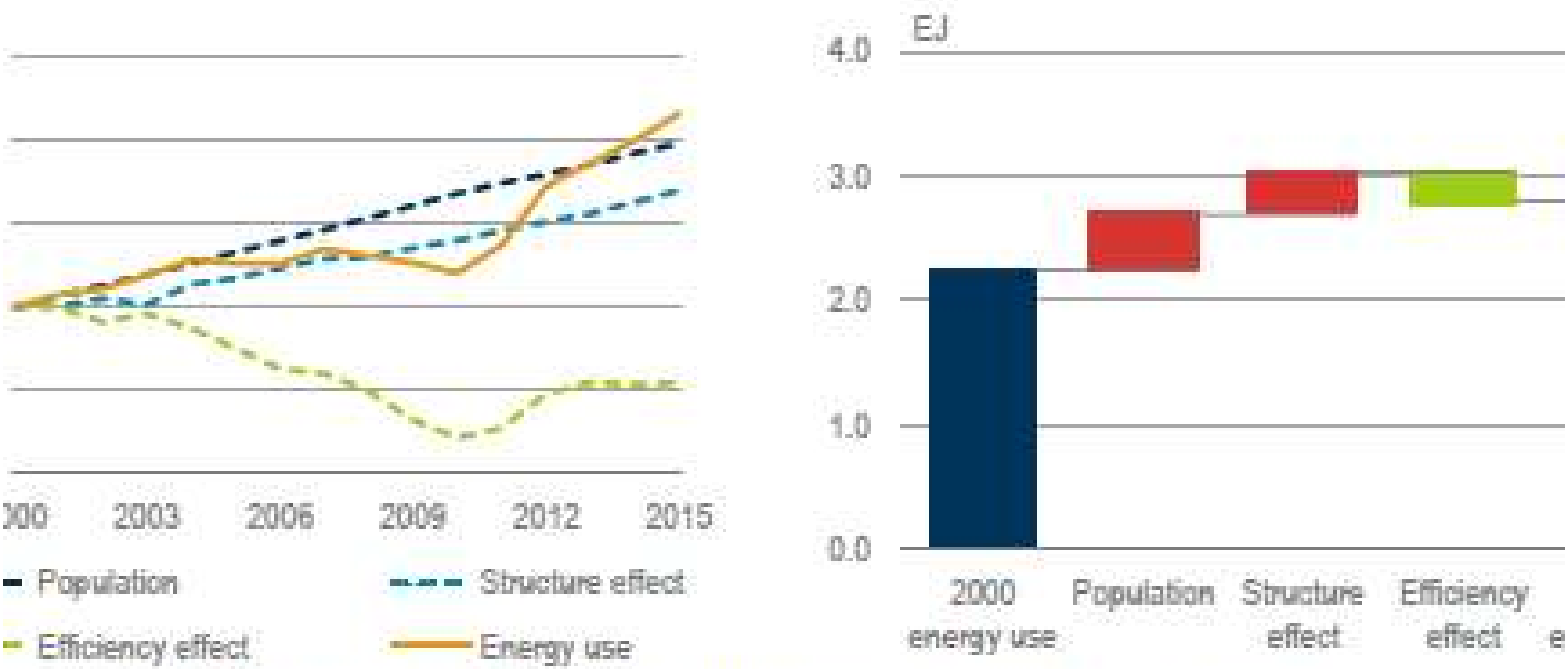
Figure 1.3 Primary energy demand, GDP and energy intensity by region



Sources: Adapted from IEA (2016a) *World Energy Outlook 2016*; and IEA (2017a), *World Energy Statistics and Balances 2017* (database), www.iea.org/statistics.

Source: IEA, 2017

Figure 5.2 Decomposition of Indonesian residential sector final energy use, 200

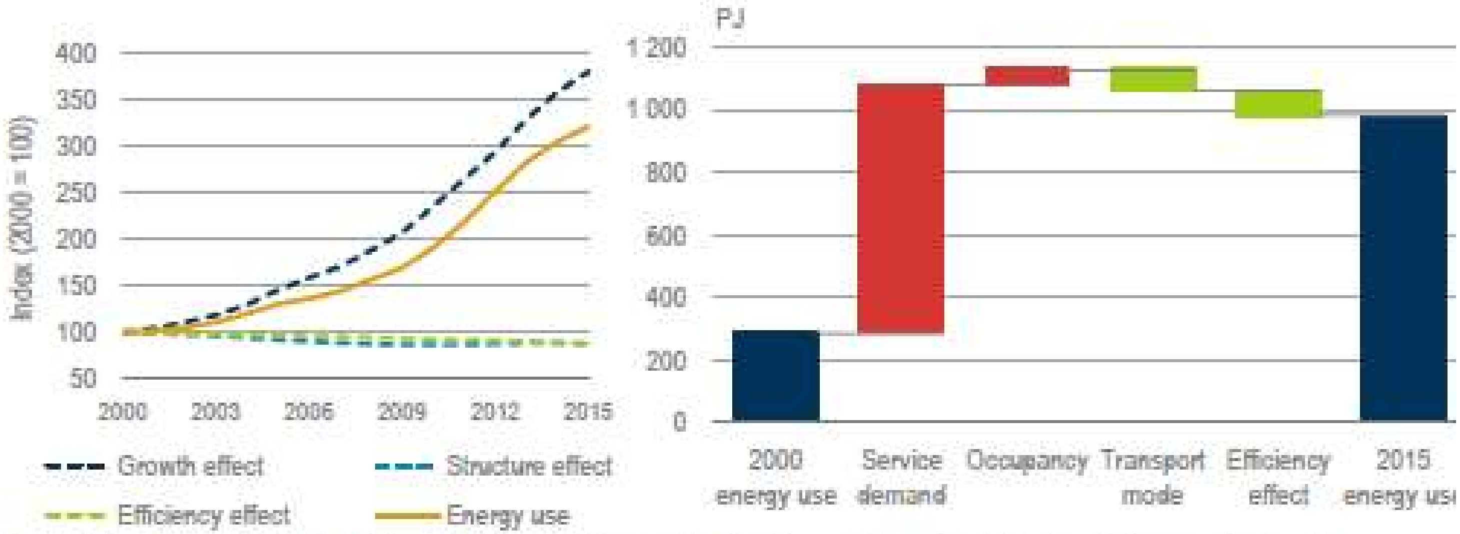


icture effect includes number of dwellings, residential floor area and appliance ownership per capita.

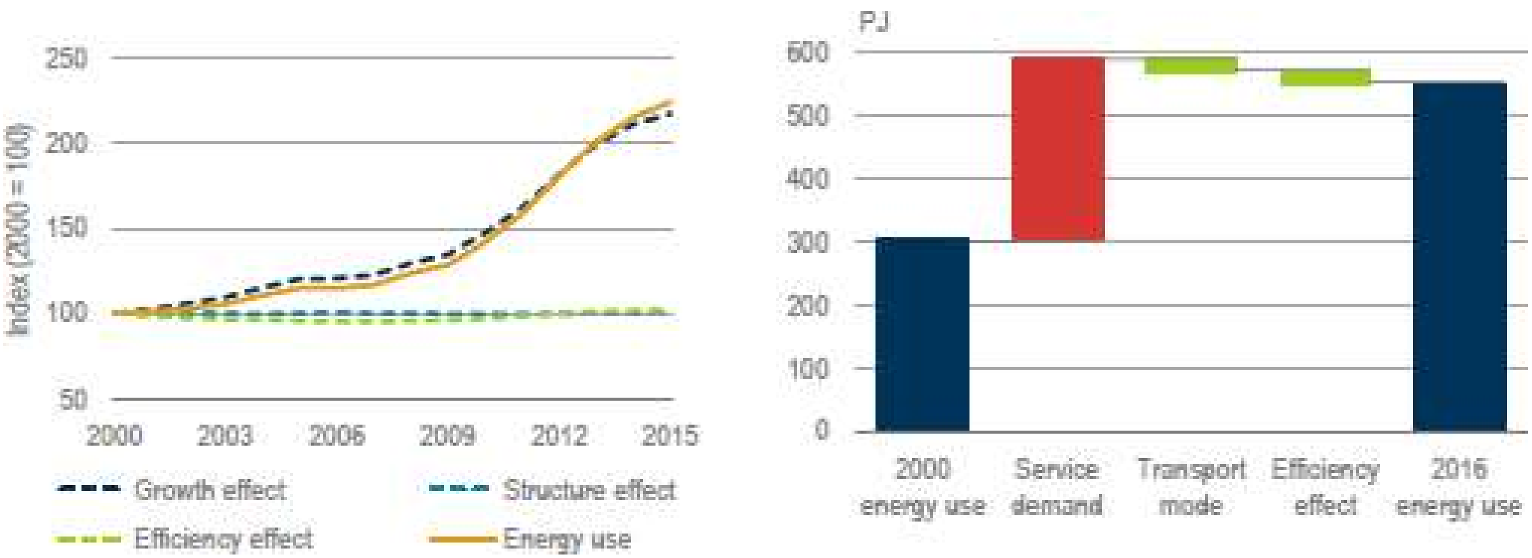
dapted from IEA (2017a), *Energy Efficiency Indicators* (database), www.iea.org/statistics/topics/energyefficiency/.

Source: IEA, 2017

Figure 5.7 Decomposition of Indonesian passenger transport final energy use, 2000-15



Source: Adapted from IEA (2017a), *Energy Efficiency Indicators* (database), www.iea.org/statistics/topics/energyefficiency/.



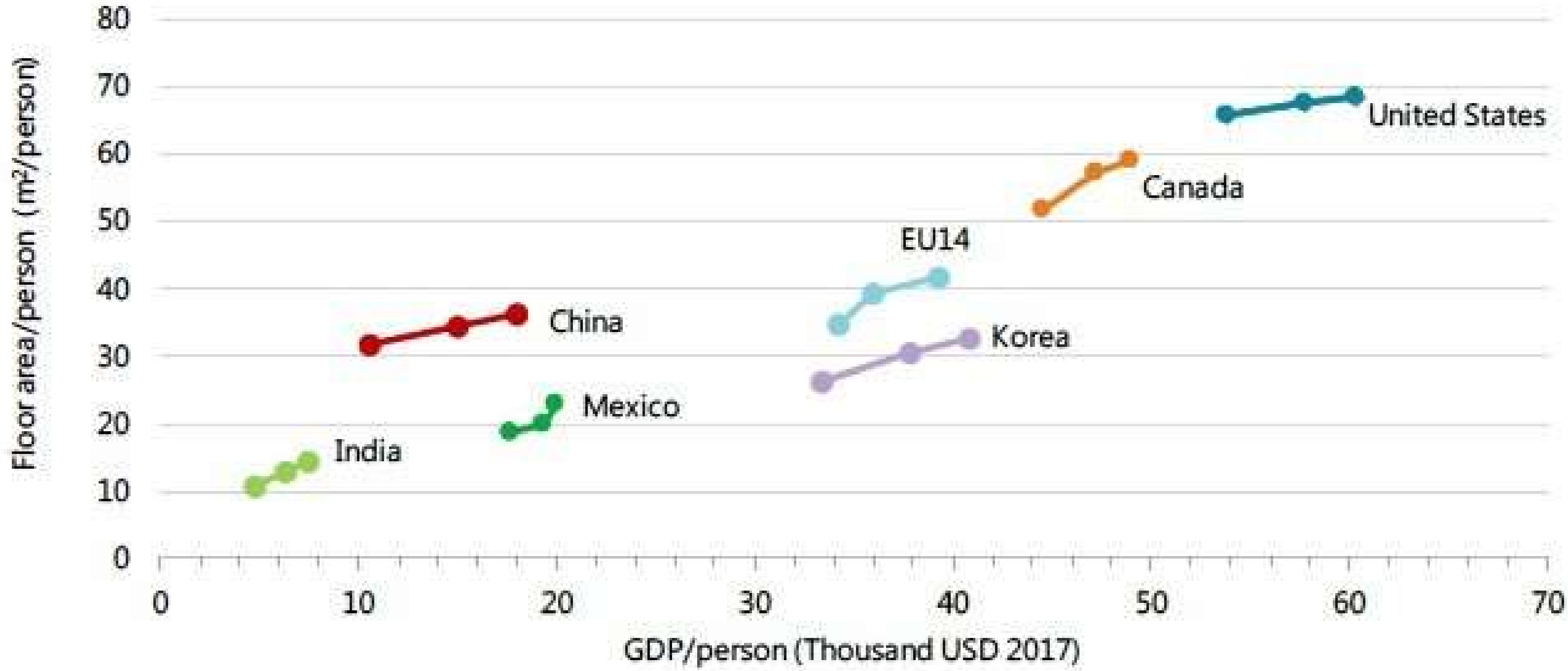
Source: IEA, 2017

Residential/Building Sector

Indicator	Coverage	Energy data	Activity data	Code	[illegible] or
Space heating energy consumption per capita	Overall	Total space heating energy consumption	Total population	H2a	
Space heating energy consumption per dwelling	Overall	Total space heating energy consumption	Total number of dwellings	H2b	
Space heating energy consumption per floor area (idem per floor area heated)	Overall	Total space heating energy consumption	Total floor area	H2c	ſ
	By dwelling type	Space heating energy consumption of dwellings type A	Floor area of dwellings type A	H3a	
	By heating system	Space heating energy consumption of dwellings with system α	Floor area of dwellings with heating system α	H3b	
	By energy source	Space heating energy consumption of dwellings with energy source Z	Floor area of dwellings with energy source Z	H3c	
Space cooling energy consumption per dwelling with air conditioning (A/C)	Overall	Total space cooling energy consumption	Total number of dwellings with A/C	C2a	
Space cooling energy consumption per floor area of dwellings with A/C	Overall	Total space cooling energy consumption	Total floor area cooled	C2b	ſ
	By dwelling type	Space cooling energy consumption of dwellings type A	Floor area cooled of dwell- ings type A with A/C	C3a	
	By type of cooling system	Space cooling energy consumption of dwellings with A/C system α	Floor area cooled of dwell- ings with A/C system α	C3b	
	By energy source	Space cooling energy consumption of dwellings with A/C system energy source Z	Floor area cooled of dwellings with A/C energy source Z	C3c	
Water heating energy consumption per capita	Overall	Total water heating energy consumption	Total population	W2a	
Water heating energy consumption per dwelling	Overall	Total water heating energy consumption	Total number of dwellings	W2b	ſ
	By type of water heating system	Water heating energy consumption for dwellings with water heating system α	Total number of dwellings with water heating system α	W3a	
	By type of energy source	Water heating energy consumption for water heating systems with energy source Z	Total number of dwellings with systems with energy source Z	W3b	
Lighting energy consumption per capita	Overall	Total lighting energy consumption	Total population	L2a	
Lighting energy consumption per dwelling	Overall	Total lighting energy consumption	Total number of dwellings	L2b	ſ
	By dwelling type	Lighting energy consumption of dwellings of type A	Number of dwellings of type A	L3a	
Lighting energy consumption per floor area	Overall	Total lighting energy consumption	Total floor area	L2c	
	By dwelling type	Lighting energy consumption of dwellings of type A	Total floor area of dwellings type A	L3b	
Cooking energy consumption per capita	Overall	Total cooking energy consumption	Total population	K2a	
Cooking energy consumption per dwelling	Overall	Total cooking energy consumption	Total number of dwellings	K2b	ſ
	By energy source	Cooking energy consumption with cooking energy source Z	Number of dwellings with cooking energy source Z	K3a	
Appliances energy consumption per capita	Overall	Total appliances energy consumption	Total population	A2a	
Appliances energy consumption per dwelling	Overall	Total appliances energy consumption	Total number of dwellings	A2b	
Energy consumption per appliance unit	By appliance type	Energy consumption for all appliances of type A	Number of appliances of type A	A3a	ſ

Heating Cooling Water heating Lighting Cooking Appliances

Average residential per capita floor area versus GDP in selected countries, 2010-15- 18

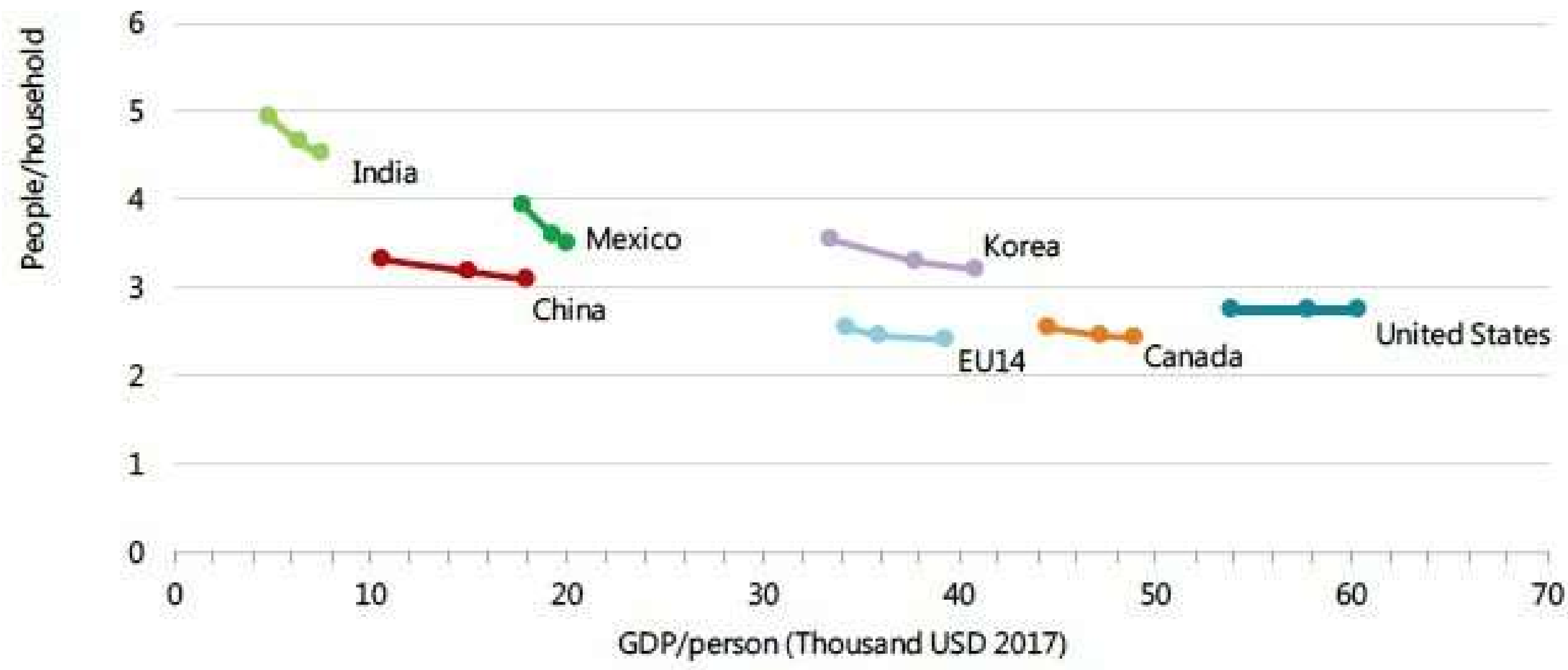


Notes: The country label shows the 2018 value. GDP is based on 2017 USD and purchasing power parity. EU14 refers to Austria, Belgium, Denmark, Finland, France, Germany, Greece, Republic of Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, and Sweden.

Source: Adapted from IEA (2019c), *Energy Technology Perspectives* (buildings model)

Source: IEA, 2019

Average household size versus GDP in selected countries, 2010-15-18

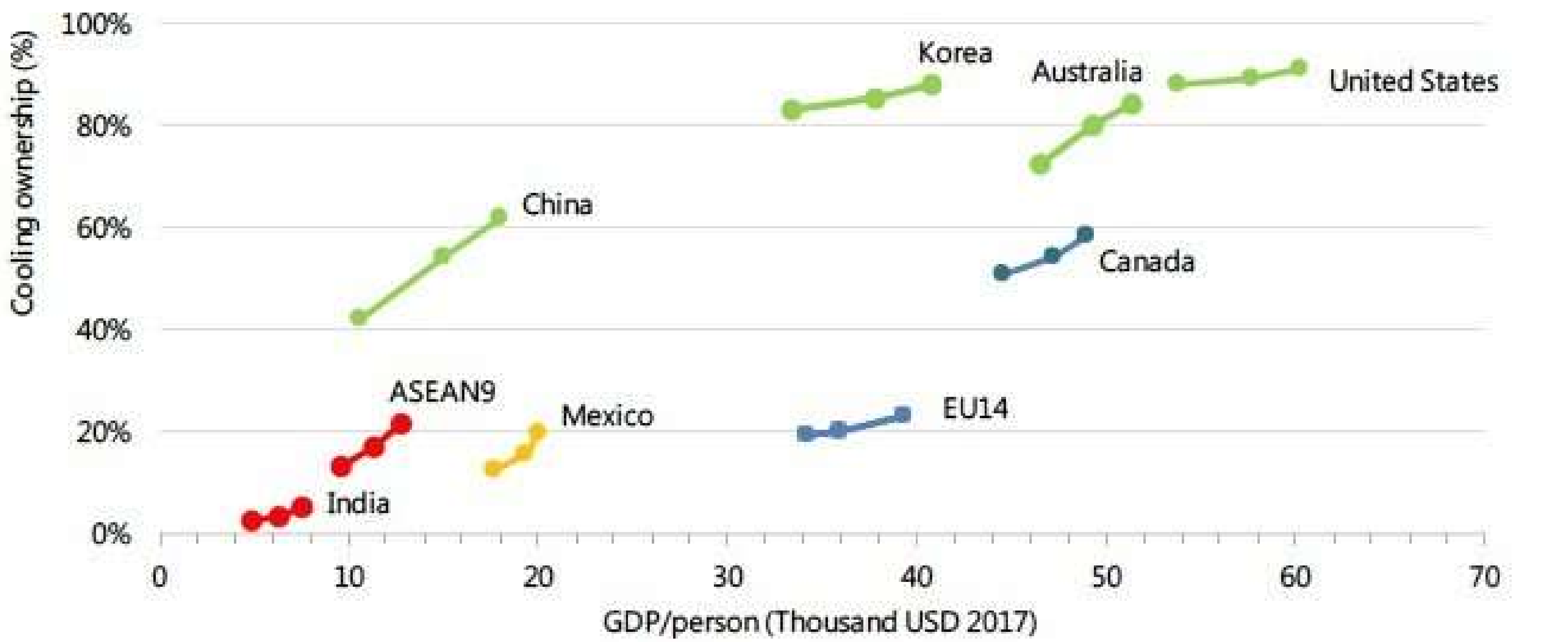


Notes: The country label shows the 2018 value. GDP is based on 2017 USD and purchasing power parity. EU14 refers to Austria, Belgium, Denmark, Finland, France, Germany, Greece, Republic of Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, and Sweden.

Source: Adapted from IEA (2019c), *Energy Technology Perspectives* (buildings model).

Source: IEA, 2019

Ownership of cooling devices and GDP per capita in selected countries 2010-15-18

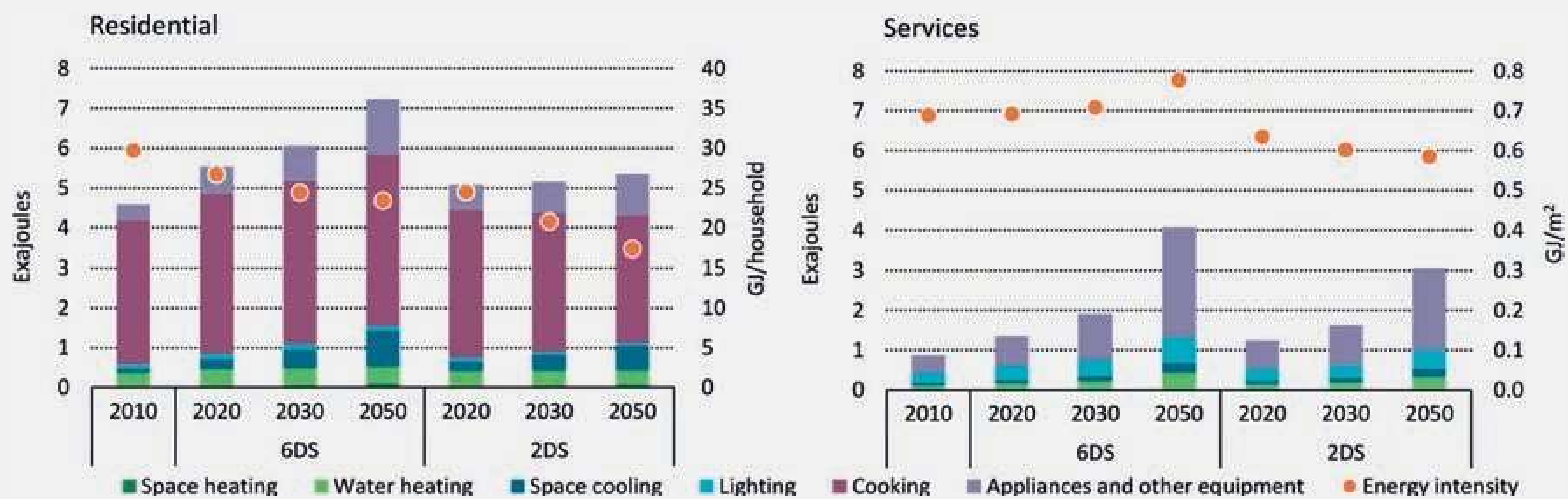


Notes: Blue = cold (<75 days above 20C), green = mild (75-199), orange = hot (200-299), red = very hot (>300). GDP is based on 2017 USD and purchasing power parity. *Ownership* means household ownership of at least one cooling device. EU14 refers to Austria, Belgium, Denmark, Finland, France, Germany, Greece, Republic of Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, and Sweden.

Source: Adapted from IEA (2019c) *Energy Technology Perspectives* (buildings model).

Source: IEA, 2019

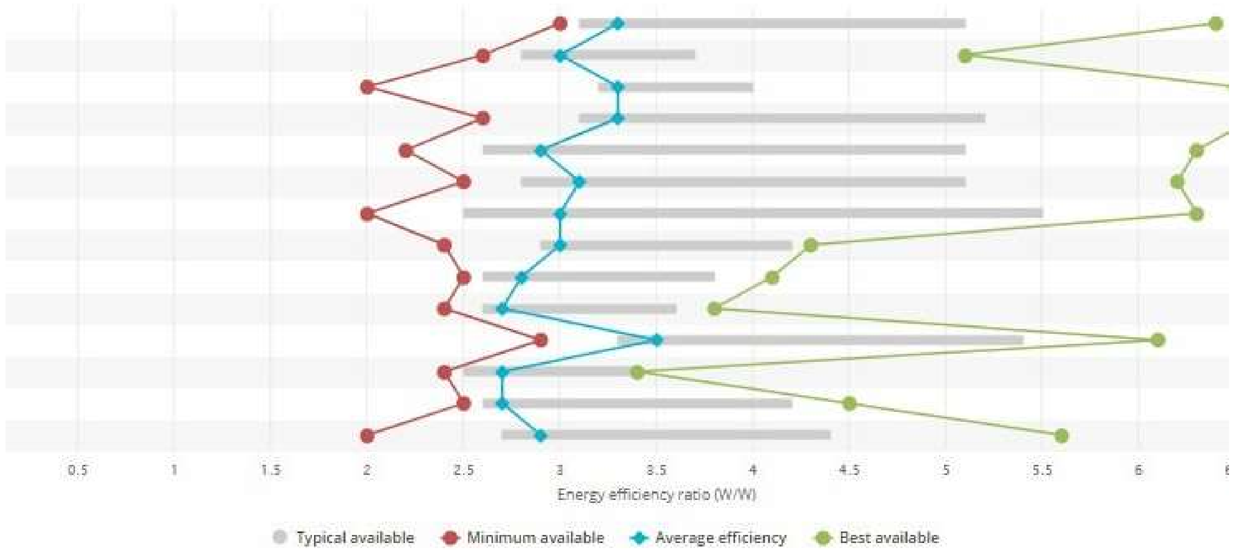
Figure 2.1.4 ASEAN residential and services sub-sectors energy consumption and intensities



Notes: GJ = gigajoule. m² = square metre. For the services sub-sector, cooking is reported under the category "appliances and other equipment".

Key point *Cooking in the residential sub-sector continues to dominate energy use, although reduced use of biomass and overall energy efficiency improvements lead to significant intensity reductions in buildings.*

Residential & commercial AC - energy efficiency ratio



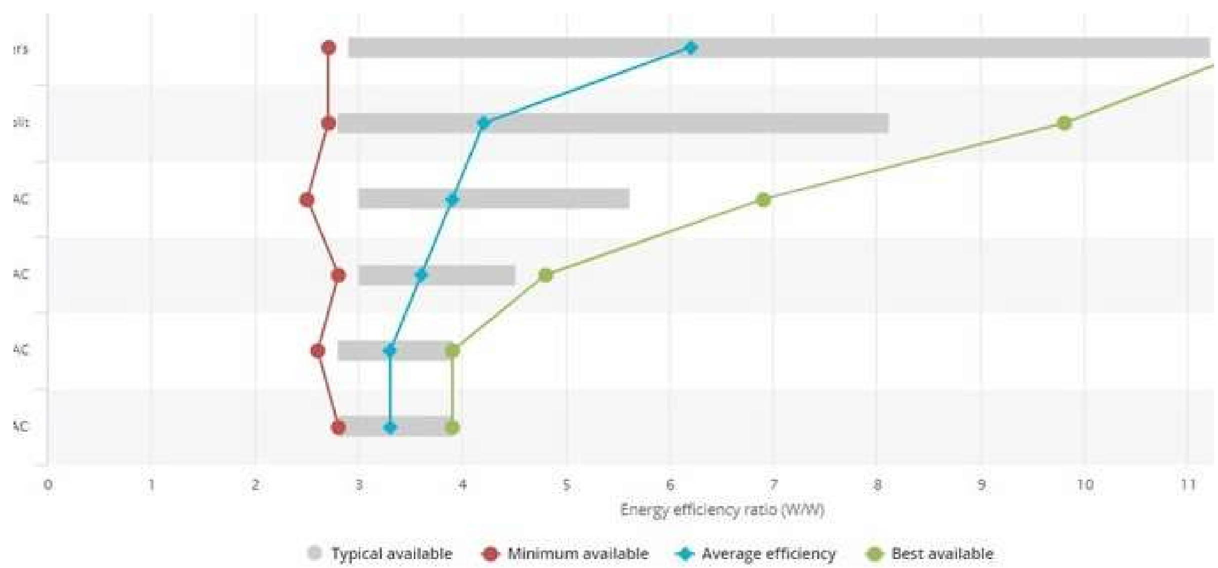
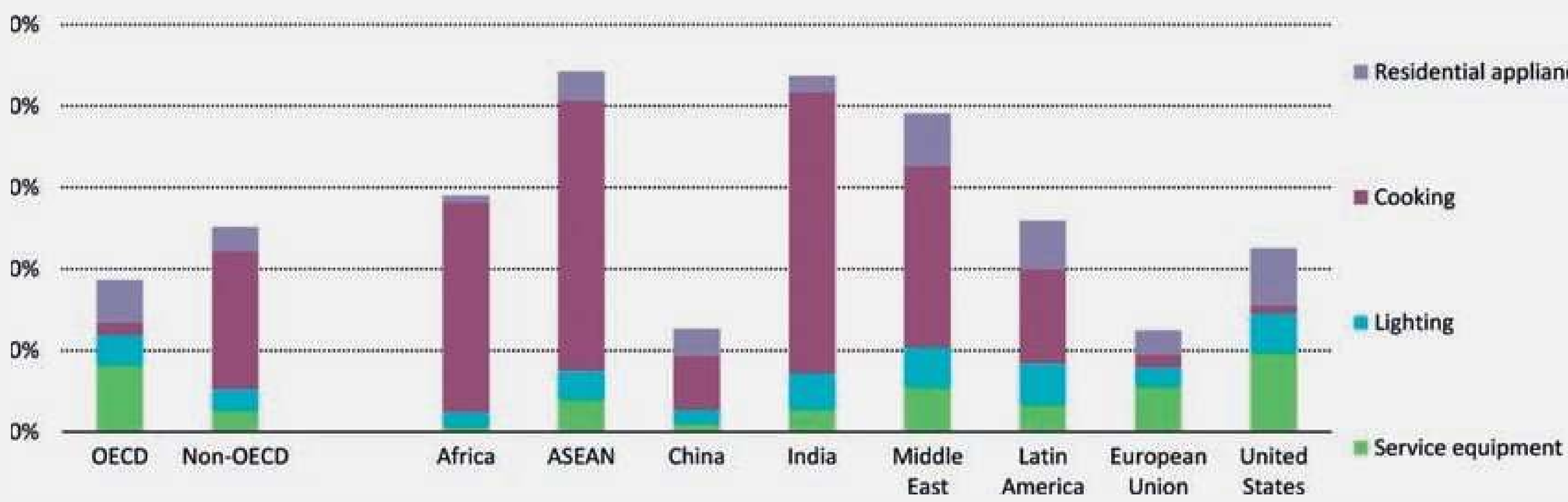


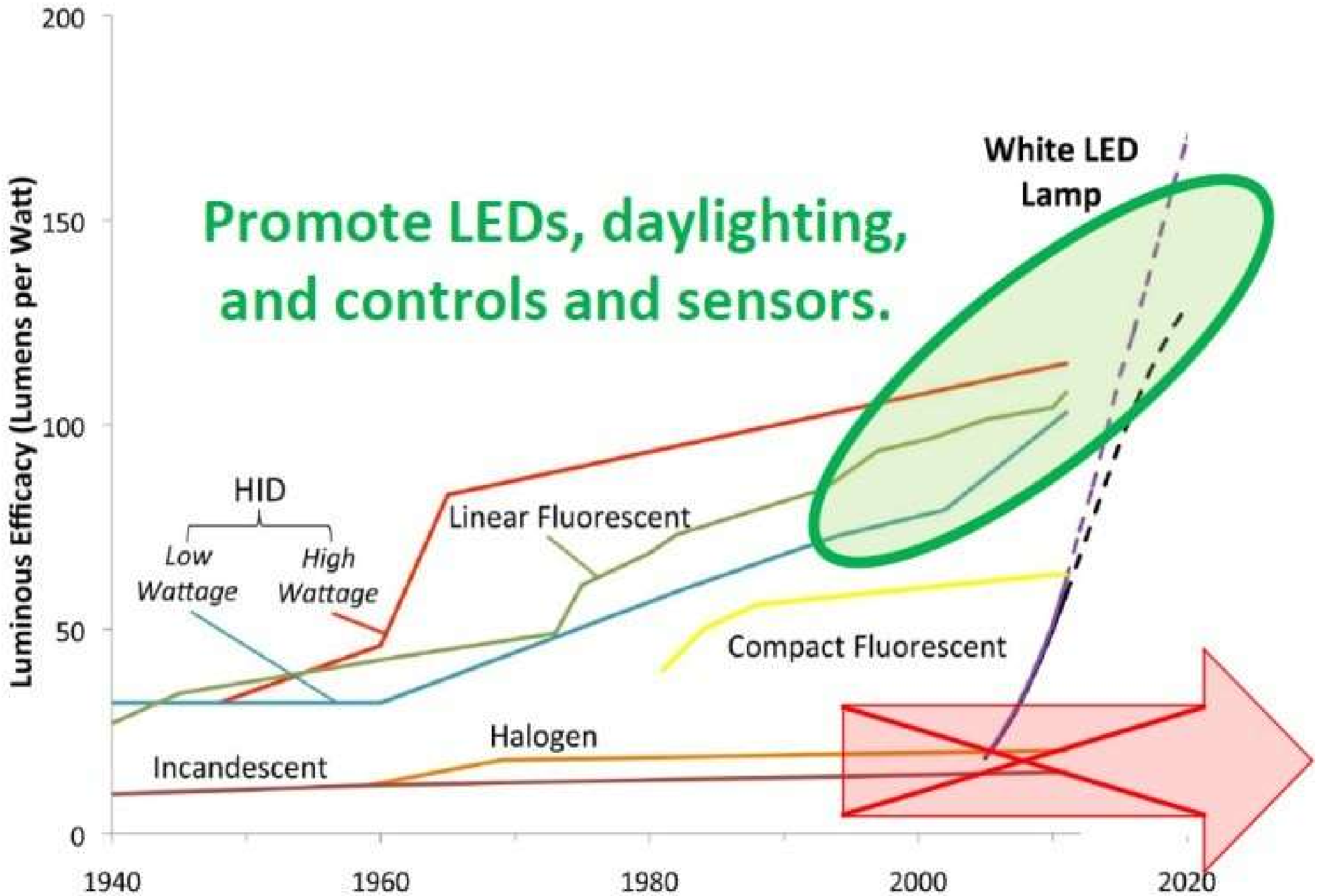
Figure 5.1 Lighting, cooking and appliances as a percentage of total energy consumption in buildings for selected regions in 2010



Source: unless otherwise noted, all tables and figures in this chapter are derived form IEA data and analysis.

Key point *Appliances and service equipment account for roughly 25% of buildings energy use in OECD countries, while cooking in non-OECD countries accounts for nearly 35%.*

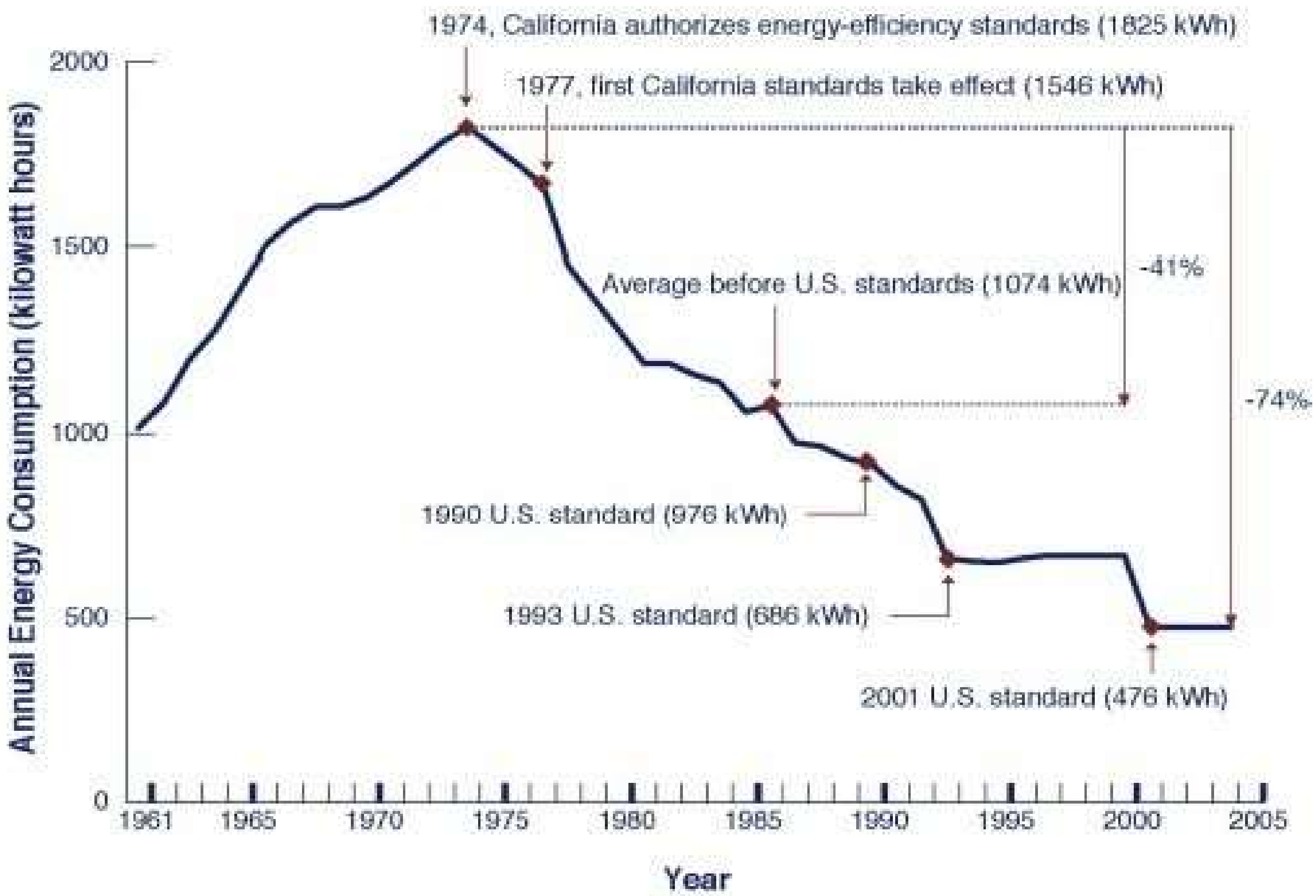
Energy efficiency technologies lighting: Large savings potential



Ban all incandescent bulbs, including halogens.

Source: IEA, 2016

US domestic refrigerator average efficiency improvement, 1960-2005



Source: Lawrence Berkley National Laboratory.

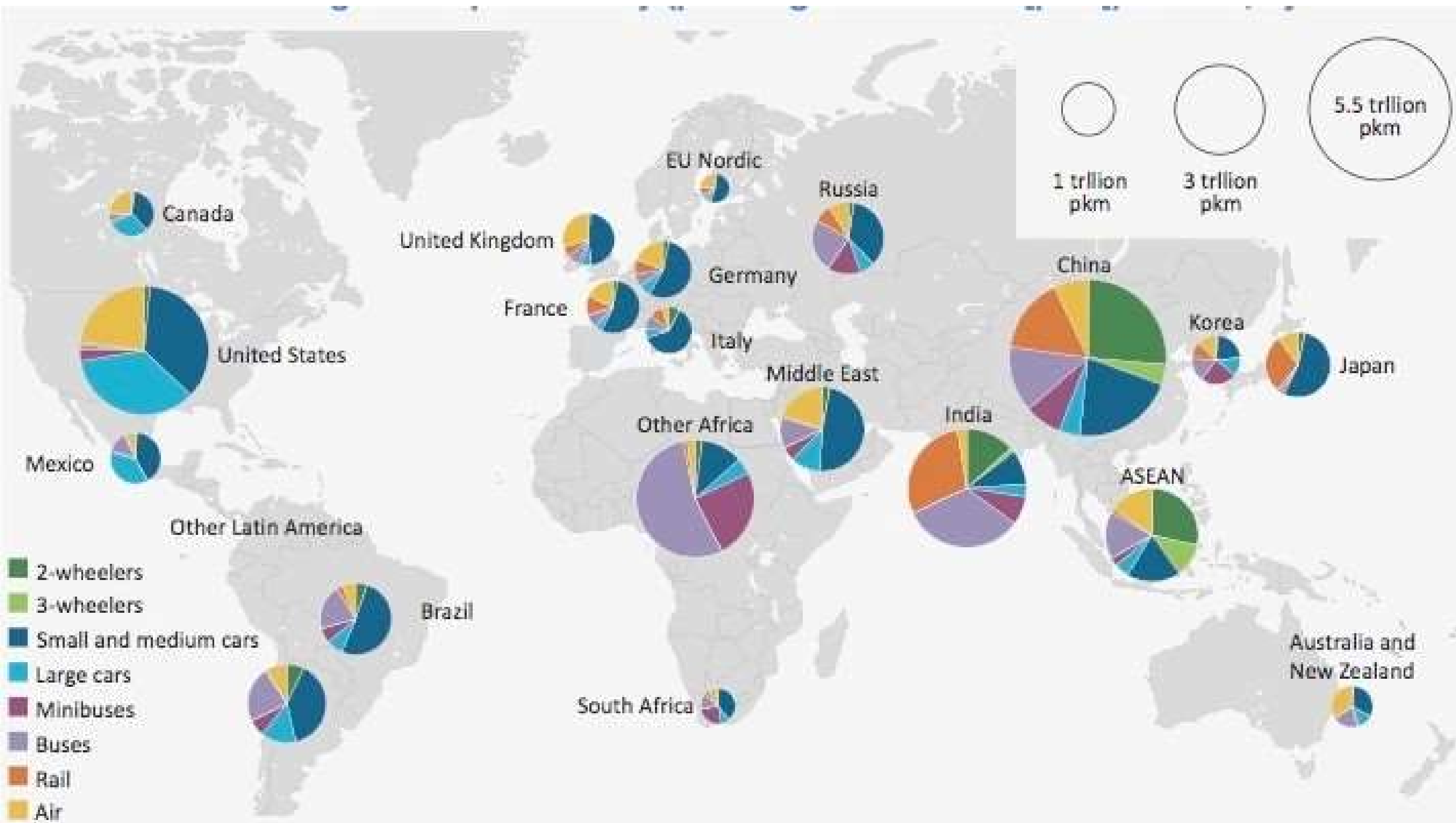
Table ES.1 Regional priorities in the buildings sector

Technology	ASEAN[4]	Brazil	China	European Union	India	Mexico	Russia	South Africa	United States
Advanced envelope – cold climate (highly insulating windows, air sealing and insulation)			● red	● gold			● red		● red
Reduced cooling loads – hot climates (reflective technologies and advanced cooling equipment)	● gold	● gold				● gold			
Heat pumps (water heating and/or space heating and/or space cooling)			● gold	● red			● gold		● gold
Solar thermal (water heating and/or space heating)		● red			● gold	● red		● red	
More efficient use of biomass (more efficient cooking and water heating and leading to modern biogas)	● red				● red			● gold	
Policy									
Building codes with supporting infrastructure (education, product ratings, and implementation to pursue holistic approach with advanced envelopes)	● gold	● gold	● gold		● red	● gold	● gold	● gold	
Appliance and equipment standard (promoting advanced appliances, lighting, heat pumps, heat pump water heater, gas condensing boilers,	● red	● red	● red		● gold	● red		● red	
Deep renovation of existing buildings (mjsictelmlsareqpuspreaectrwictatllcodadvas,nedefdcieimvtecodpeing)				● red			● red		● red
Zero-energy new buildings (advanced holistic building design with integrated renewable energy and high-performance equipment)				● gold					● gold

Notes: red indicates immediate priority, while gold indicates second priority. This is not intended to be an exhaustive list, but intentionally shows the immediate priority for technology and policy, along with a second goal, to help highlight which technologies and policies will have the largest impact in the country or region. Most of the technology and policy categories could be applicable to all countries.

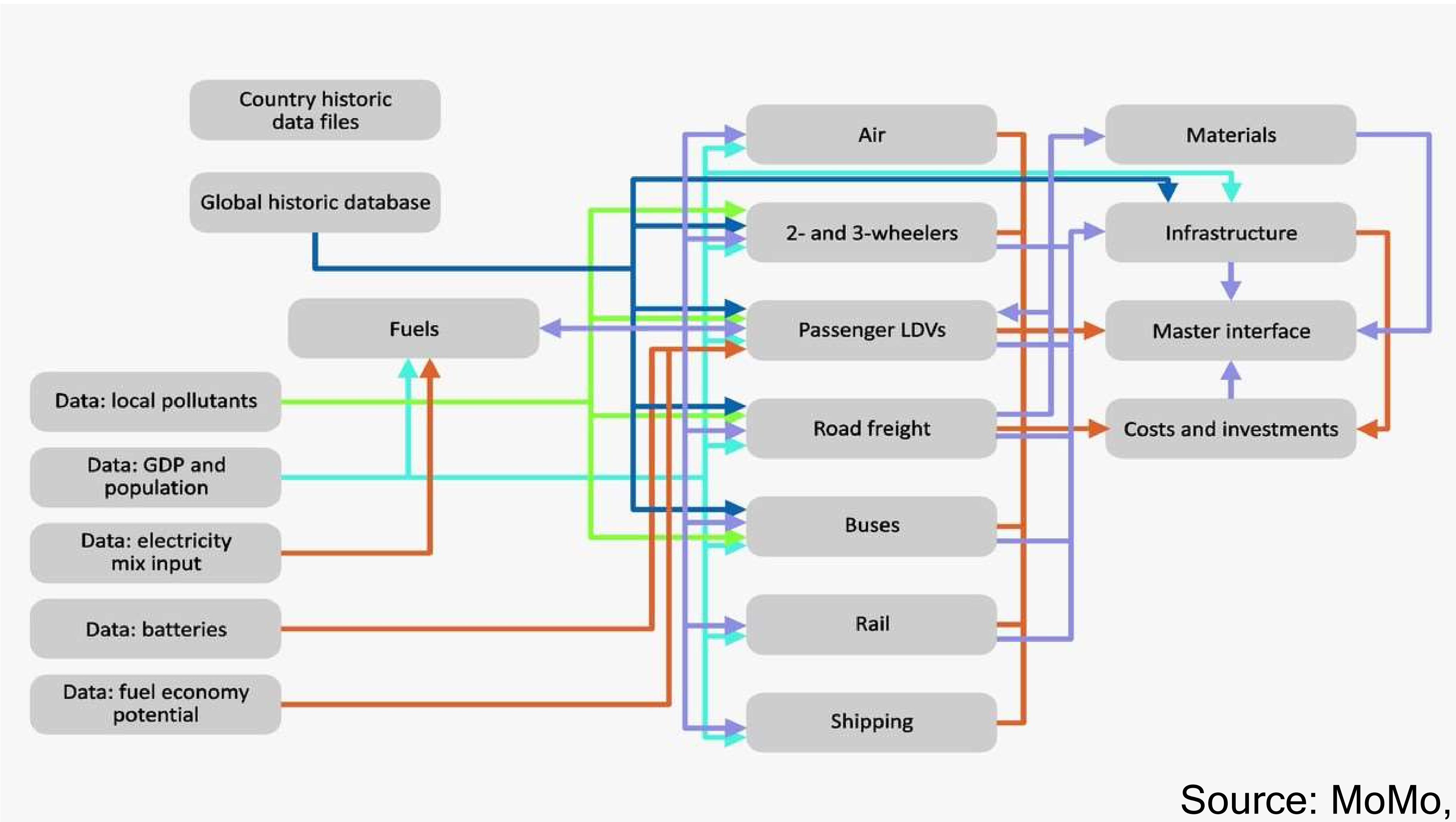
Transport Sector

Passenger transport activity (passenger kilometres/pkm) in 2015, by mode



Source: *Energy Technology Perspectives 2016*, IEA 2016.

Modelling of the transport sector in the Mobility Model (MoMo)



Source: MoMo, IEA

ASIF approach

- Vehicle ***A**ctivity*
- the ***S**tructure* of the organization of vehicle across services, modes, vehicle classes and powertrain groups
- the *energy **I**ntensity* of each of the vehicles in this structure

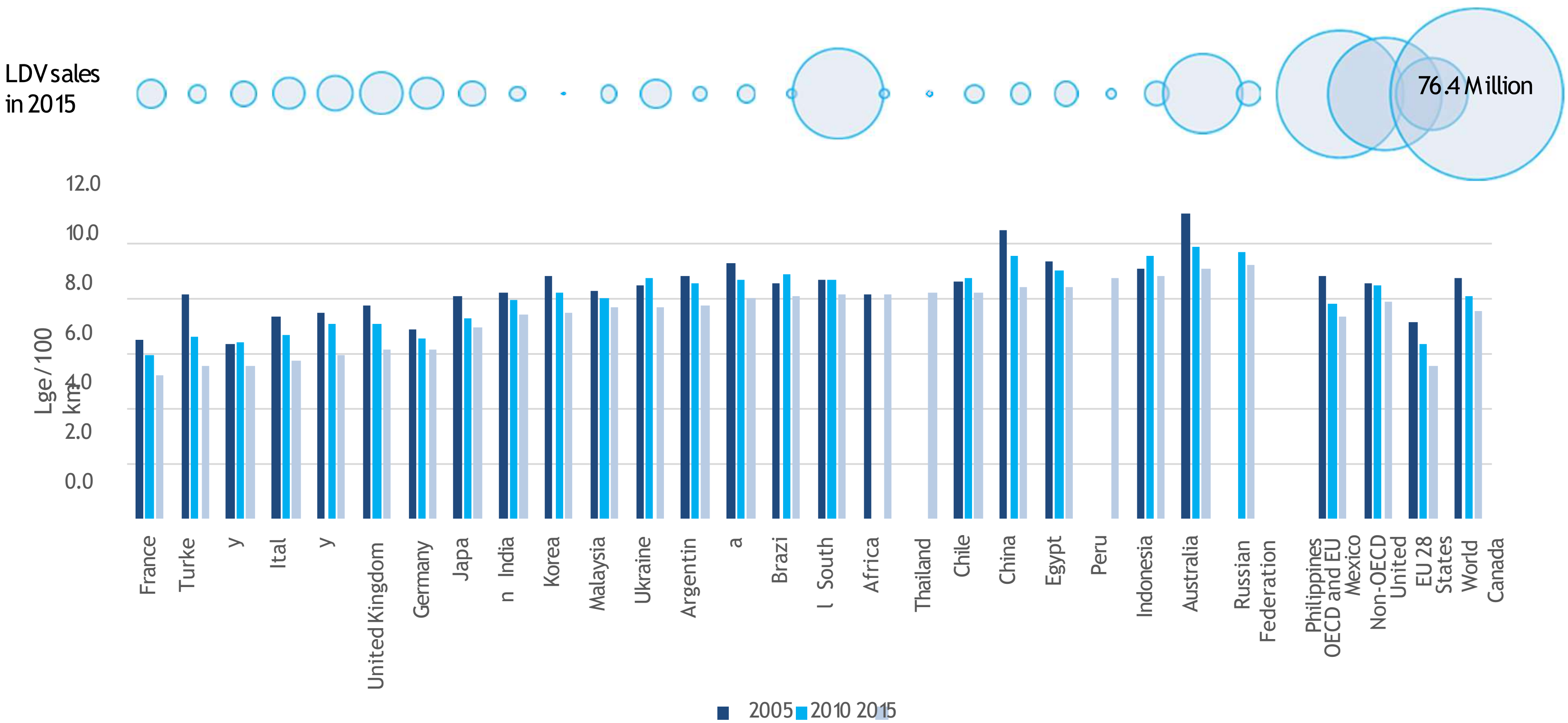
... allow to calculate ***F**uel consumption*

The calculation is based on Laspeyres identities

$$F = \sum_i F_i = A \sum_i \left(\frac{A_i}{A}\right)\left(\frac{F_i}{A_i}\right) = \boxed{A \sum_i S_i I_i = F}$$

F	total ***F**uel use*
A	vehicle ***A**ctivity* (expressed in *vkm*)
F_i	fuel used by vehicles with a given set of characteristics (***i***) (e.g. segments by service, mode, vehicle and powertrain)
$A_i/A = S_i$	sectoral ***S**tructure* (same disaggregation level)
$F_i/A_i = I_i$	energy ***I**ntensity*, i.e. the average fuel consumption per *vkm* (same disaggregation level)

Figure 1• Average new LDV fuel economy by country, normalised to the WLTC, 2005-15

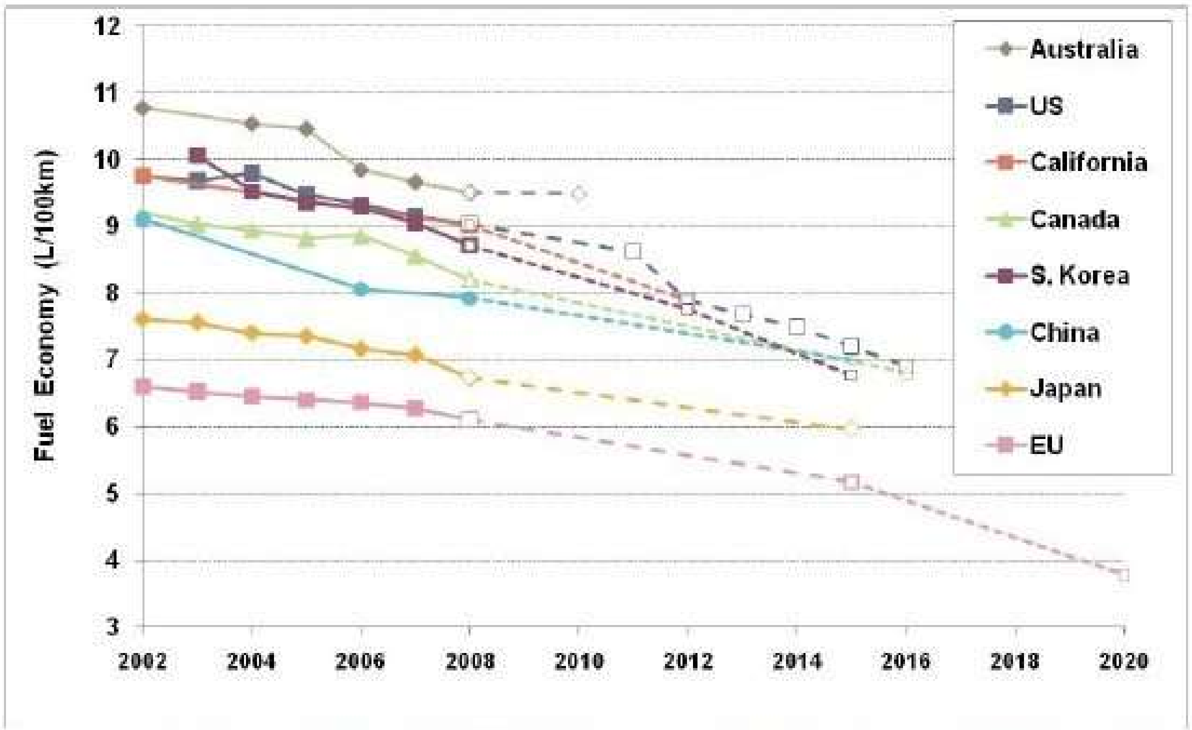


Notes: Lge/100 km = litres of gasoline equivalent per 100 kilometres; OECD and EU = member states of the European Union and specified member countries of the Organisation for Economic Co-operation and Development (Australia, Canada, Chile, Japan, Korea, Mexico, Turkey and United States); Non-OECD = specified non-OECD countries (Argentina, Brazil, China, Egypt, India, Indonesia, Malaysia, Peru, Philippines, Russian Federation, South Africa, Thailand and Ukraine); **WLTC** = Worldwide harmonised Light Vehicle Test Cycle.

Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Source: IEA, 2017

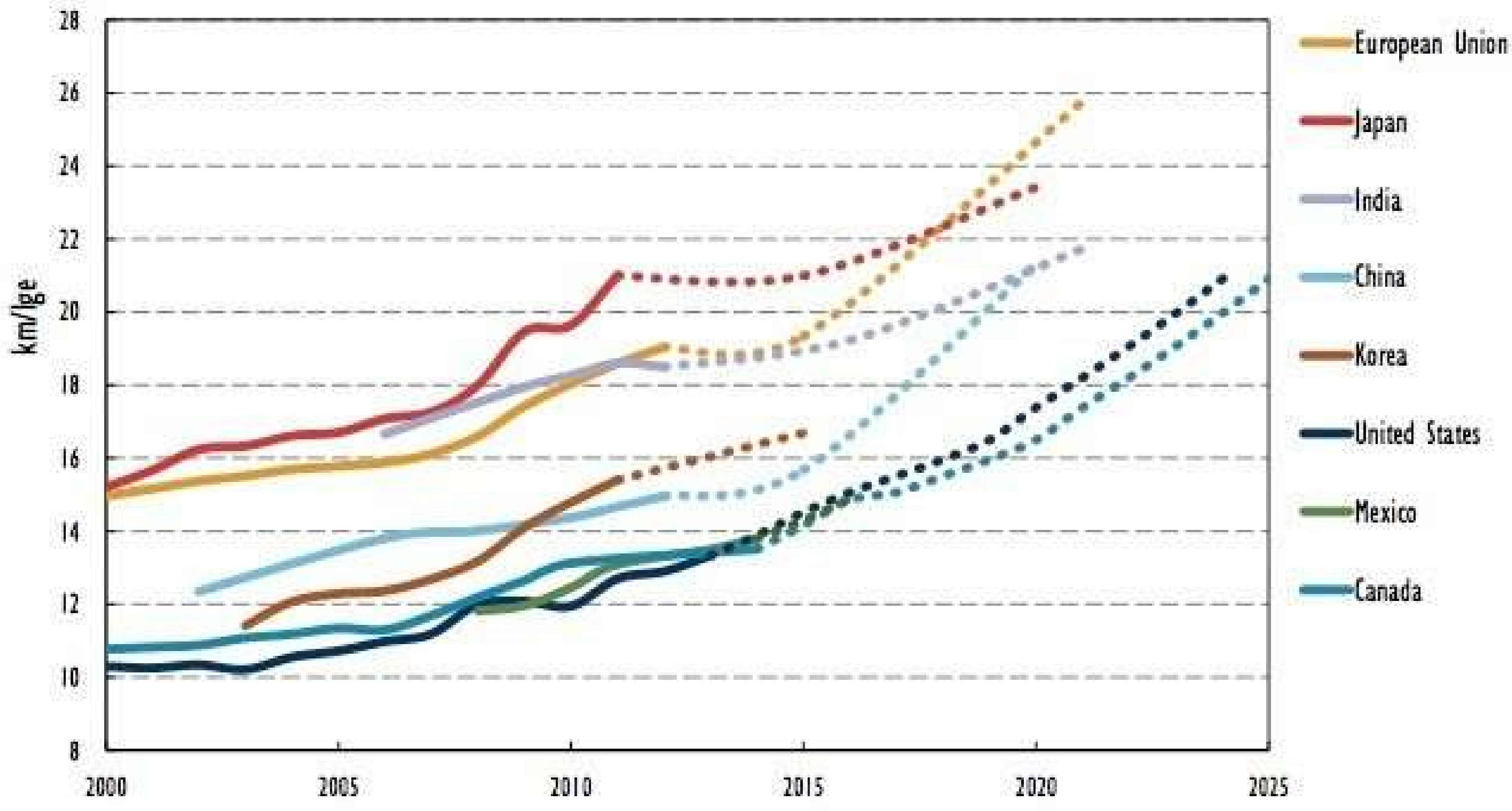
Light-duty vehicle fuel economy trends in selected countries



Note: Fuel economy figures reflect each country's own test procedures. Solid lines show historical patterns; dashed lines show enacted standards; and dotted lines show proposed standards.
Source: ICCT, 2010.

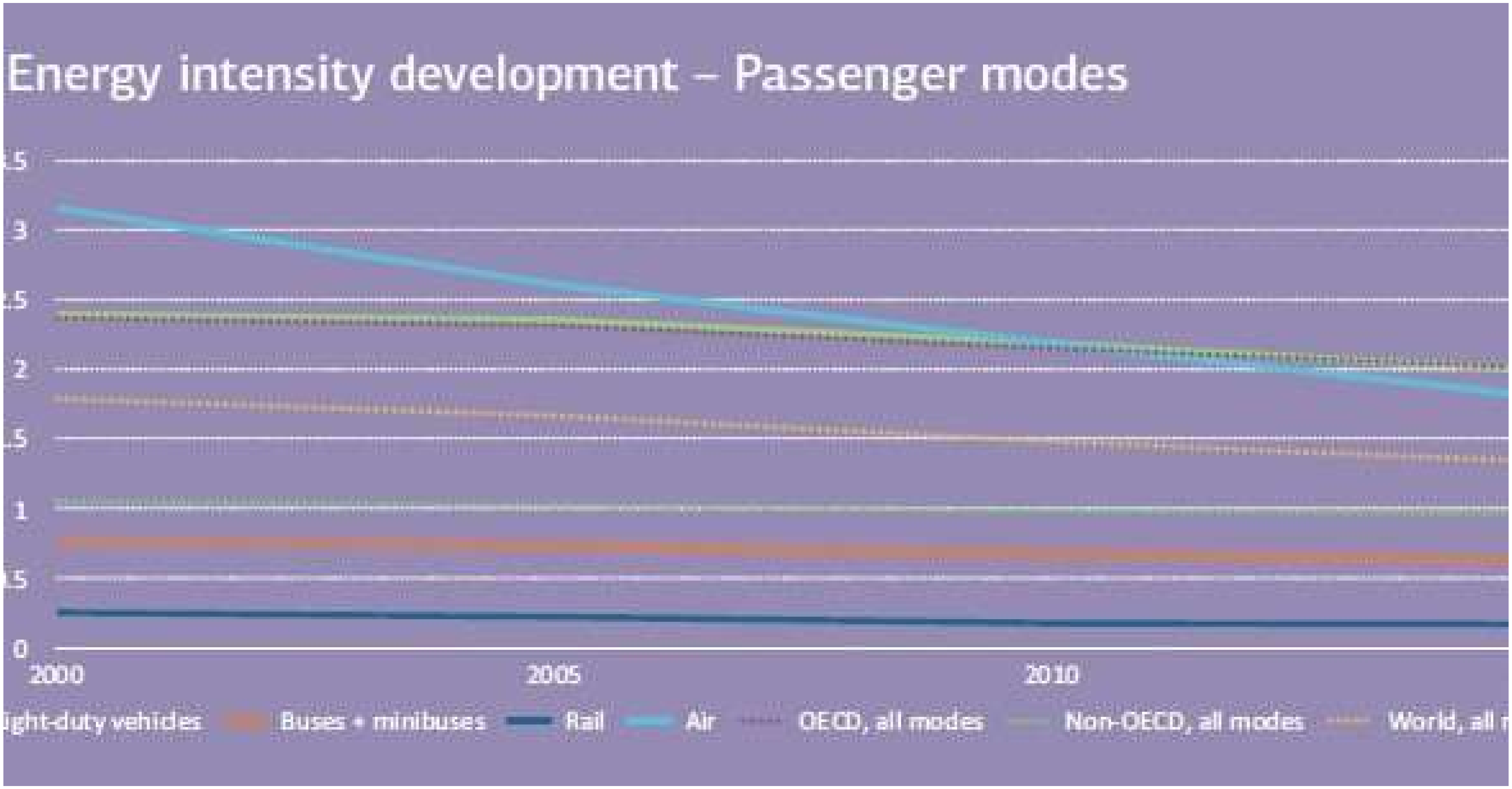
Source; IEA, 2010

Enacted Light Duty Vehicle Fuel Economy Standards



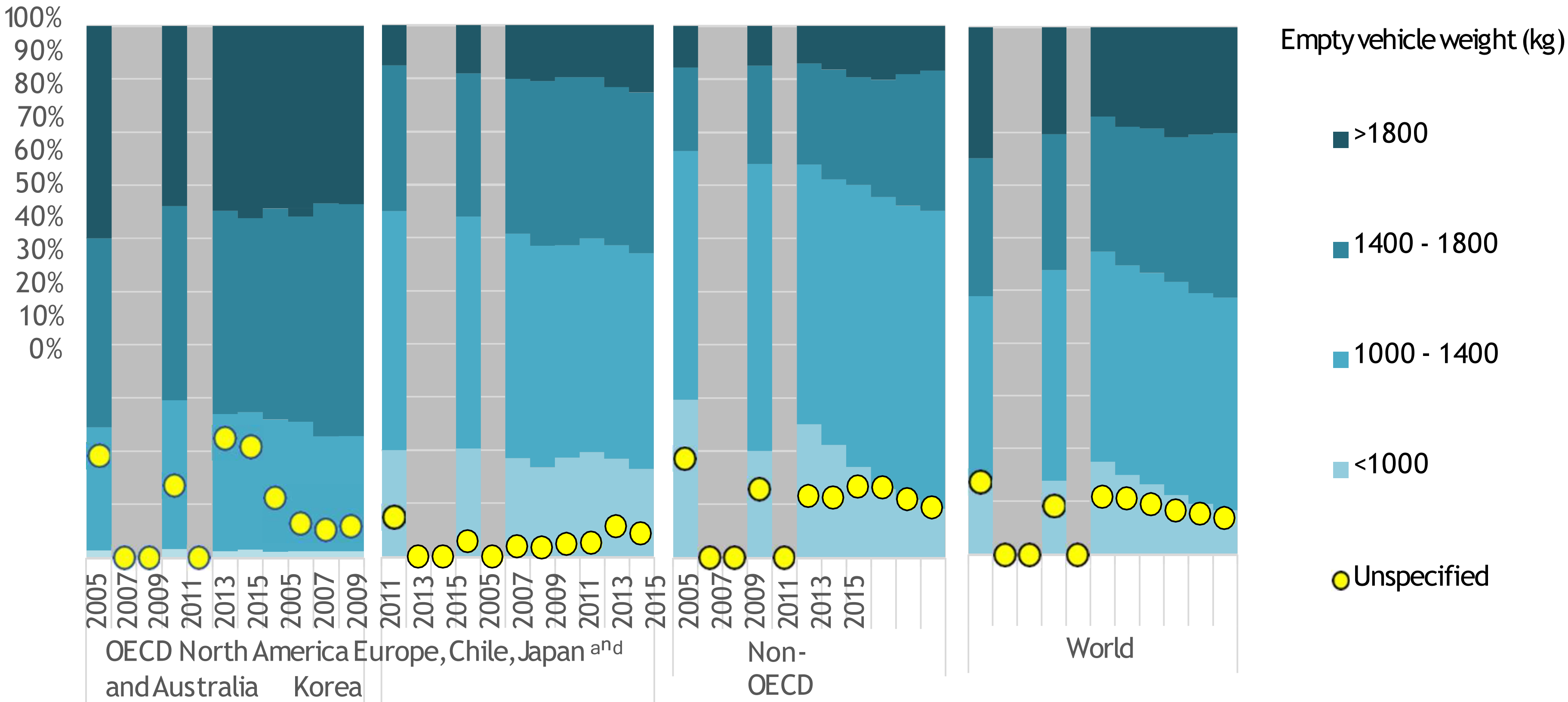
Source: *ICCT (2014).*

Source: IEA, 2017



Source: IEA, 2017

Figure 18 • Vehicle weight evolution for OECD and non-OECD, 2005-15



Source: IEA elaboration and enhancement for broader coverage of IHS Markit database.

Source: IEA, 2017

Table 2.5 • OEM announcements related to electric cars

OEM	2018	2019	2020	2021	2022	2023	2024	2025	2030
BMW	0.14							15-25%, 25	
BAIC			0.8						
BYD			0.6						
Dongfeng Motor Co					30%				
Ford					40				
Geely			1						
GM		2				20			
Honda									15%
Hyundai-Kia			12						
Mahindra & Mahindra			0.036						
Maruti Suzuki			1						
Mazda			1						
Mercedes-Benz								15-25%, 10	
Other Chinese OEMs			7						
PSA					0.9	27			
Renault-Nissan					1, 12, 20%				
Tesla	100%, 0.5		1, 1						
Toyota			10						1
Volkswagen			0.4					25%, 2.5, 80	
Volvo		1		5					

Number of sales millions % of electric sales

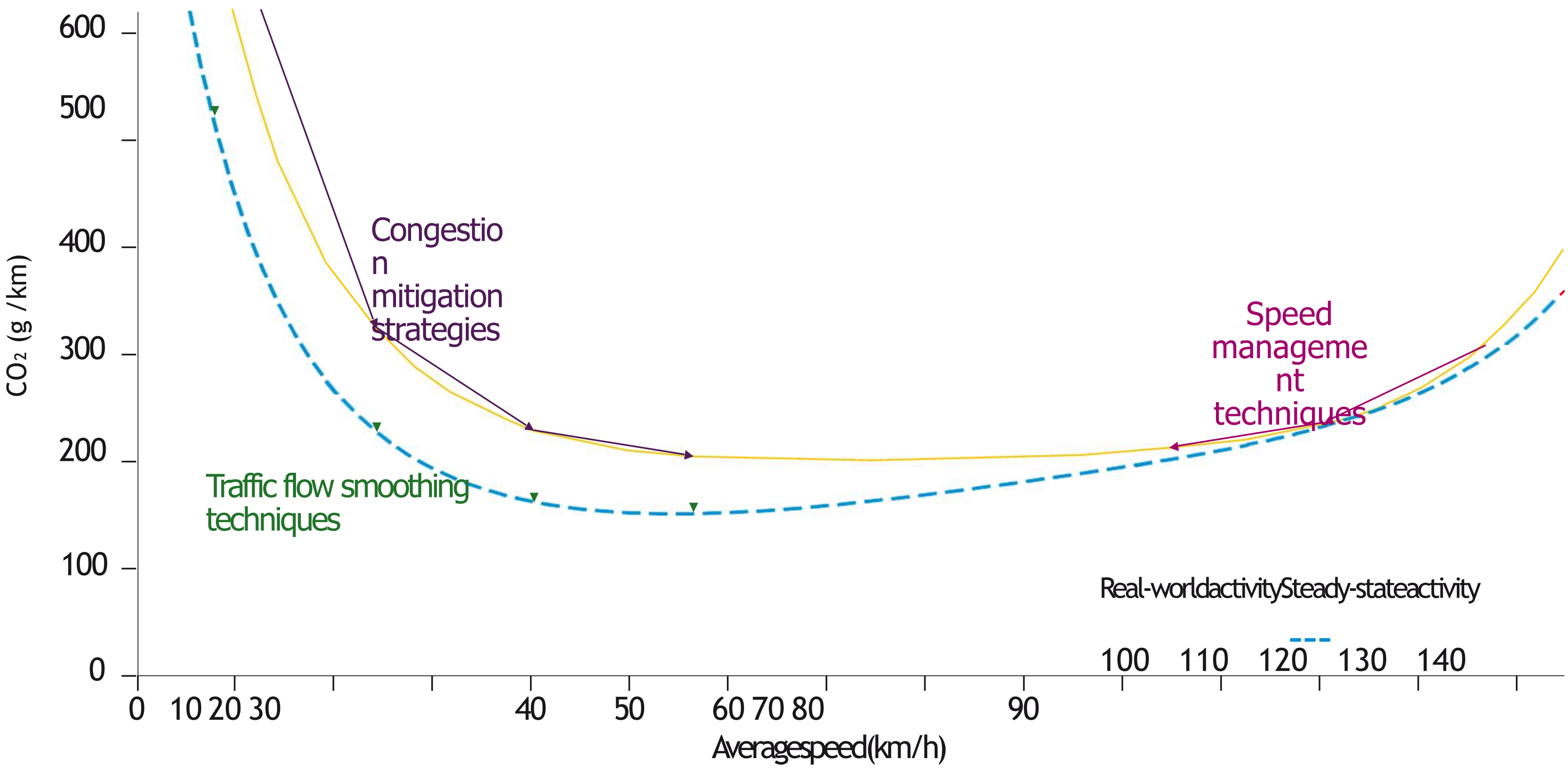
Number of new EV models Share of models with an electric version

Notes: This table presents an overview based on the IEA's understanding of companies' announcements and may not be complete. It intends to present announcements only related to electric cars (PHEVs and BEVs), therefore other announcements by OEMs that also include HEVs and give no specific indication regarding the PHEVs/BEV share are not included in this table. Instead, they are highlighted in these notes. Audi, part of the Volkswagen Group, announced that three new electric car models will be released in 2020 (Audi, 2017). Toyota announced an objective of 4.5 million sales of HEVs and PHEVs in 2030 (Toyota, 2017). Jaguar Land Rover announced that an electrified version of all new models will be available as from 2020 (BEV, PHEV or HEV) (Jaguar Land Rover, 2017). Renault Nissan announced an aim of 20% of its sales to be zero- emission vehicles in 2022 and 30% of sales to be either PHEVs or HEVs (Groupe Renault, 2017a). Volvo aims for 1 million combined sales of HEVs, PHEVs and BEVs by 2025. Honda is striving for two-thirds of sales to be FCEVs, HEVs or electric cars by 2030 (Honda, 2017). The number of sales presented in the table for China's OEMs such as BJEV-BAIC, BYD, Geely and others represents the production capacity targets rather than sales targets. Other Chinese OEMs include: Daimler-BAIC, JAC Motors, SAIC Motor, Great Wall Motor, Chery New Energy, Changan Automobile, GAC Group, Jiangling Motors, Lifan Auto, MIN AN Auto, Wanxiang Group, YUDO Auto, Chongqing Sokon Industrial Group, ZTE, National Electric Vehicle, LeSEE, NextEV, Chehejia, SINGULATO Motors, Ai Chi Yi We, WM Motor, Future Mobility Corporation, LEAPMOTOR, Sinomach, Youxia, Hanteng Autos, Yongyuan, Xiaopeng Zhaoqing, Yujie and Zhengdao Shantou.

Sources: Electric Cars Report (2018) for BMW; BMW Group (2017) for BMW; Mitchell (2017) for BMW; Tabeta (2018) for Dongfeng Motor Co; General Motors (2017) for GM; Carey and White (2018) for Ford; Healey (2016) for Honda; Jin (2017) for Hyundai-Kia; The Economic Times (2018) for Mahindra & Mahindra; Charged Electric Vehicles Magazine (2017) for Mazda; Liu (2018) for Other Chinese OEMs; Daimler (2018c) for Mercedes-Benz; Reuters (2016) for Mercedes-Benz; Welch (2018); Nussbaum (2017); Cobb (2015); Voelcker (2017); Marklines (2018) for Tesla; Sheehan (2017) for Tesla; Reuters (2017c) for Volkswagen; Volkswagen (2016) for Volkswagen; Volkswagen (2017); Autocar (2018); Tesla (2018b); Maruti Suzuki (2018); Korosec (2017) for Volvo; Volvo Car Group, (2017) for Volvo; China Economic Net (2018) for Volkswagen; Xinhua (2018) for Geely; The Beijing News (2017) for BAIC; NBD (2018) for Geely; Groupe Renault (2017a) for Renault-Nissan; Toyota (2017) for Toyota; (China Economic Net, 2018) Groupe Renault (2017a 2017b) for Renault-Nissan; Reuters (2017d) and InsideEVs (2017) for PSA; Tabeta (2018) for Dongfeng Motor Co.

Key point: Several OEMs have announced increased EV production and development of new EV models.

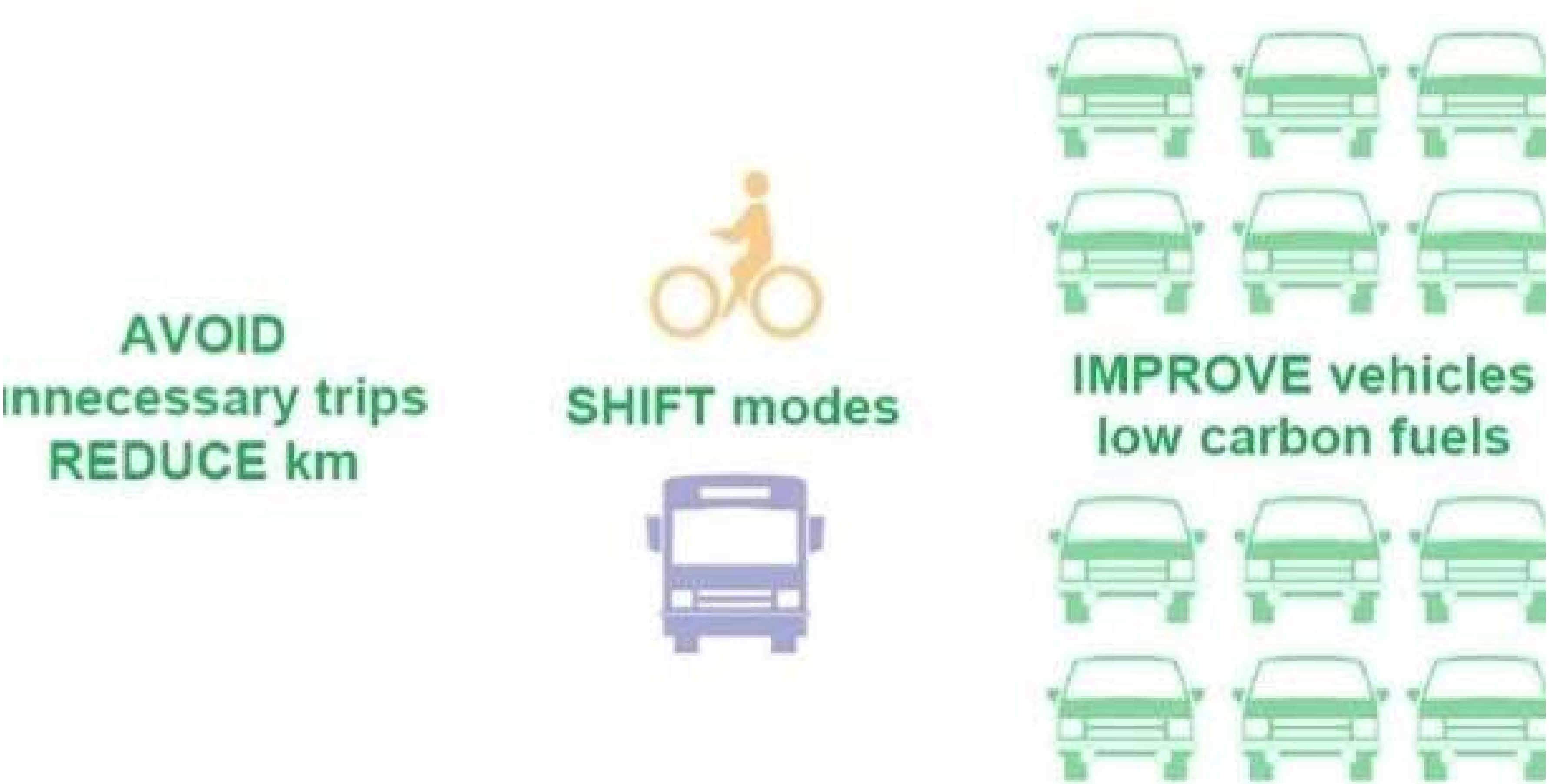
Possible use of traffic operation strategies in improving on-road fuel economy



Source: Barth and Boriboonsomsin, 2008.

Source: IEA, 2012

Transport Demand Management



Source: IEA, 2016

Policy implementation of transport energy efficiency

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Source: Updated from IEA (2009b)

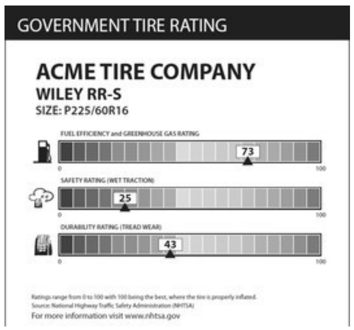
Announcements by car manufacturers related to curbing or halting production of ICE cars

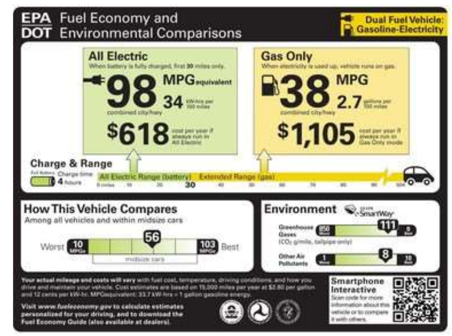
Manufacturer	2017 sales (millions)	Planned policies
Toyota	8.0	Stop selling diesel cars in Europe by the end of 2018.
Fiat Chrysler	4.1	Phase out diesel across its model line-up as of 2022.
Honda	3.7	Discontinue production and sales of a flagship diesel-powered vehicle in Europe.
Peugeot (PSA)	3.2	All vehicles are electrified with HEV and PHEV in 2025 for global market.
Chongqing Changan	2.6	All vehicles are electrified with HEV and PHEV in 2025 for Chinese market.
Beijing Automotive Industry Holding (BAIC)	2.0	All vehicles are electrified with HEV and PHEV in 2025 for Chinese market.
Mazda	1.1	All vehicles are electrified with HEV, PHEV and BEV in 2030.
Subaru	1.0	Withdraw diesel car production and sales by FY 2020.
Jaguar Land Rover	0.6	All vehicles are electrified with HEV and PHEV in 2020 for global market.
Volvo	0.5	Stop developing diesel engine, all vehicles are electrified with HEV and PHEV in 2025 for global market.
Porsche	0.2	No diesel units in production; focus on optimised gasoline, HEVs, PHEVs and BEVs.

Sources: Campbell (2018) for Fiat Chrysler; Nikkei (2017a) for Honda; Porsche (2018) for Porsche; Nikkei (2017b) for Subaru; Toyota Europe (2018) for Toyota; Reuters (2017a) for Volvo; Reuters (2017b) for BAIC, Reuters (2017c) for Chongqing Changan, Jaguar Land Rover (2017) for Jaguar Land Rover; Automotive News (2018) for PSA; CNET (2018) for Mazda; New registrations (sales) from IHS Markit (2018).

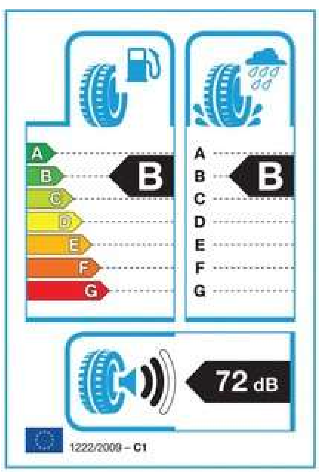
Source: IEA, 2018

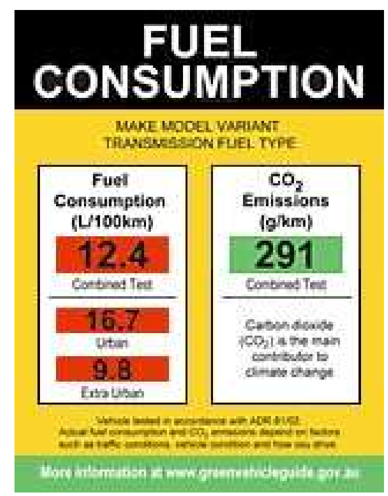
Transport labelling





Source:NHTSA and EPA (2010b)





Global average well-to-wheel greenhouse gas emissions intensity, 2019 and 2030

Powertrain	CO_2-eq per kilometre 2019 STEPS	CO_2-eq per kilometre 2030 APS
Gasoline internal combustion engine vehicle	205	130
Diesel internal combustion engine vehicle	180	130
Compressed natural gas internal combustion engine vehicle	180	140
Hybrid electric vehicle	135	100
Plug-in hybrid electric vehicle	105	40
Powertrain	CO_2-eq per kilometre 2019 STEPS	CO_2-eq per kilometre 2030 APS
Battery-electric vehicle	70	30
Fuel cell electric vehicle	130	40

Notes: 2019 based on IEA *World Energy Outlook* Stated Policies Scenario (STEPS), 2030 based on Announced Pledges Scenario (APS). Ranges are based on the WLTC rated performance. Well-to-wheel greenhouse gas carbon intensity across all passenger light-duty vehicles, values rounded for simplicity. Carbon intensity values for fuel cell vehicles reported here are a range between values using electrolytic hydrogen and natural gas steam methane reforming pathways. Carbon intensity values for internal combustion engine vehicles, hybrids and plug-in hybrids include biofuel blending.

Sources: IEA analysis based on IEA (2021), Global Fuel Economy Initiative.

Source: IEA, 2021

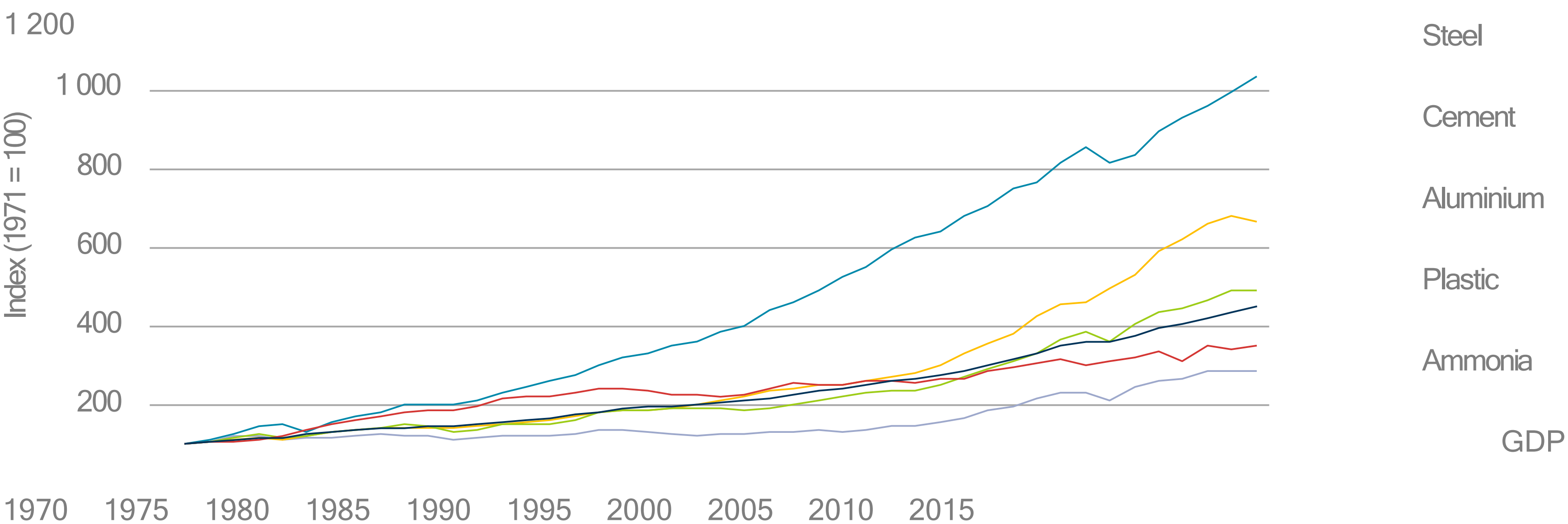
Industrial Sector

Table 1: Key indicators for the global cement industry in the 2DS by 2030

	2DS low-variability case	
	2014	***2030***
Clinker to cement ratio	0.65	0.64
Thermal energy intensity of clinker (gigajoule per tonne of clinker [GJ/t clinker])	3.5	3.3
Electricity intensity of cement (kilowatt hour per tonne of cement [kWh/t cement])	91	87
Alternative fuel use (percentage of thermal energy)	5.6	17.5
CO_2 captured and stored (million tonne of carbon dioxide per year [$MtCO_2/yr$])	-	14
Direct CO_2 intensity of cement (tonne of carbon dioxide per tonne of cement [tCO_2/t cement])	0.54	0.52

Notes: Thermal energy intensity of clinker does not include any impact related to other carbon mitigation levers beyond improving energy efficiency (e.g. carbon capture). Electricity intensity of cement production does not include reduction in purchased electricity demand from the use of EHR equipment or any impact related to other carbon mitigation levers beyond improving energy efficiency (e.g. carbon capture). Alternative fuel use includes biomass, and biogenic and non-biogenic wastes. Direct CO_2 intensity refers to gross direct CO_2 emissions, after carbon capture.

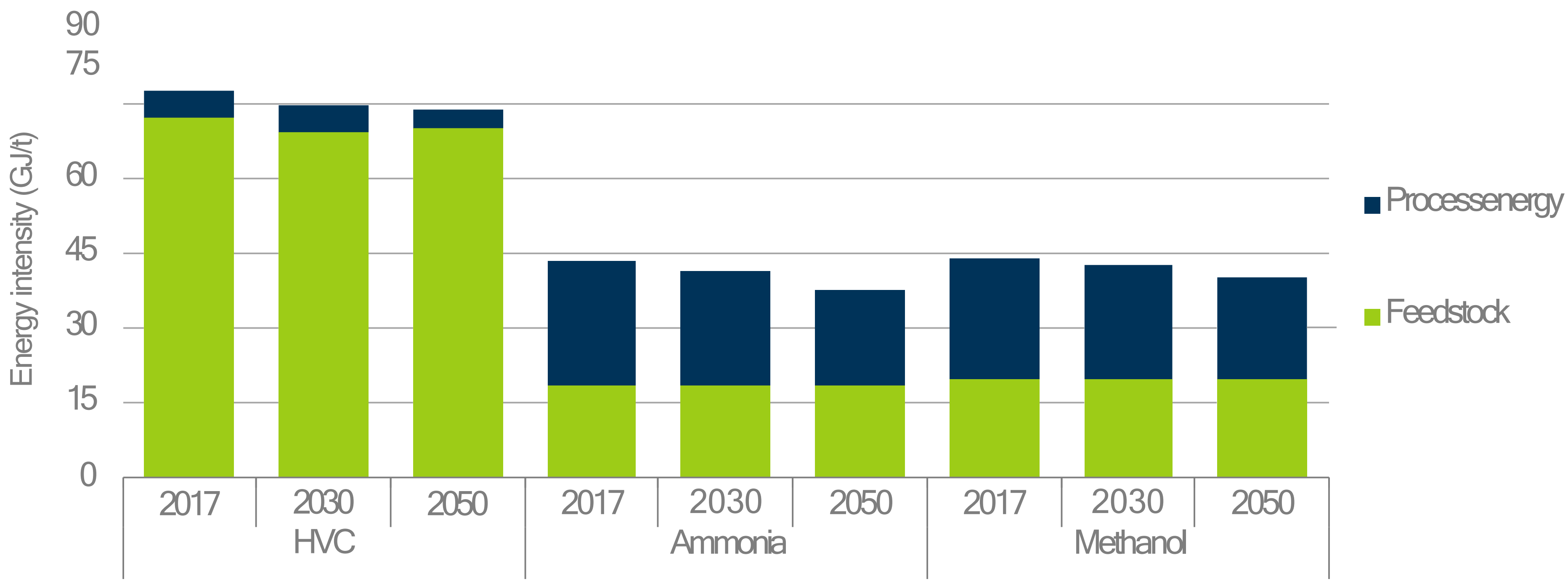
Figure 1.3 • Production growth for selected bulk materials and GDP



Notes: Outputs of different industrial sectors are displayed on an indexed basis referred to 1971 levels. *Aluminium* refers to primary aluminium production only. *Steel* refers to crude steel production. *Plastics* includes a subset of the main thermoplastic resins.

Sources: Geyer, R., J.R. Jambeck and K.L. Law (2017), "Production, use, and fate of all plastics ever made", https://doi.org/10.1126/sciadv.1700782; Worldsteel (2017), *Steel Statistical Yearbook 2017*, www.worldsteel.org/en/dam/jcr:3e275c73-6f11-4e7f-a5d8-23d9bc5c508f/Steel+Statistical+Yearbook+2017.pdf; IMF (2018), *World Economic Outlook Database*, www.imf.org/external/pubs/ft/weo/2018/01/weodata/index.aspx; USGS (2018a), *2018 Minerals Yearbook: Aluminium*, https://minerals.usgs.gov/minerals/pubs/commodity/aluminum/myb1-2015-alumi.pdf; USGS (2018b), *2018 Minerals Yearbook: Cement*, https://minerals.usgs.gov/minerals/pubs/commodity/cement/myb1-2014-cemen.pdf; USGS (2018c), *2018 Minerals Yearbook: Nitrogen*, https://minerals.usgs.gov/minerals/pubs/commodity/nitrogen/myb1-2015-nitro.pdf. Levi, P.G. and J.M. Cullen (2018), "Mapping global flows of chemicals: From fossil fuel feedstocks to chemical products", https://doi.org/10.1021/acs.est.7b04573.

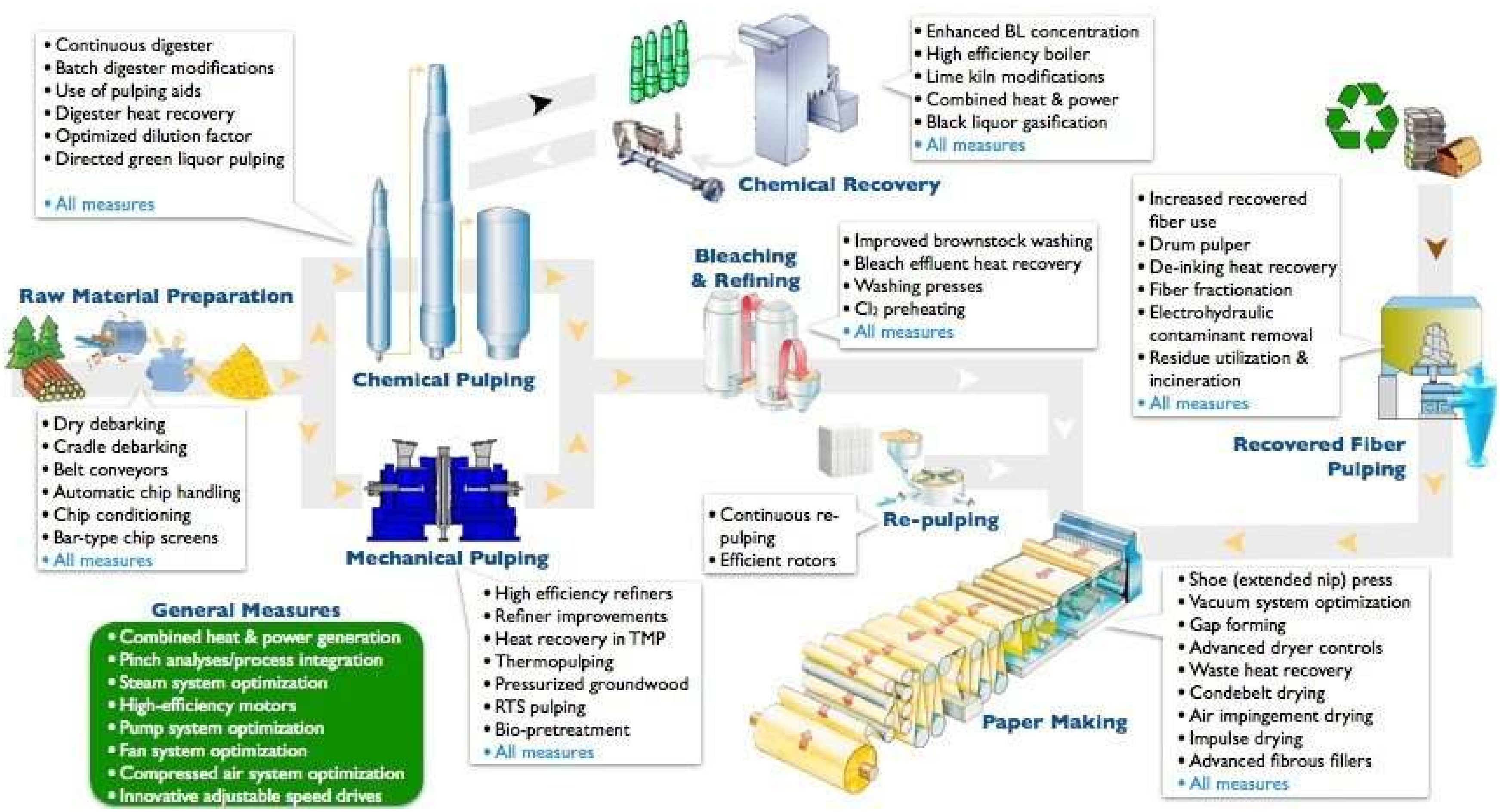
Figure 4.10 • Average energy intensity by primary chemical in the RTS



Notes: Net process energy intensities are depicted for feedstock. In steam crackers, the conversion of feedstock to chemicals results by-product off-gases, which can be used to provide process energy. When utilised, this reduces the quantities of process energy required. The same is true for both ammonia and methanol, but to a much lesser extent because lower quantities of calorific gases are generated from the conversion of the feedstock.

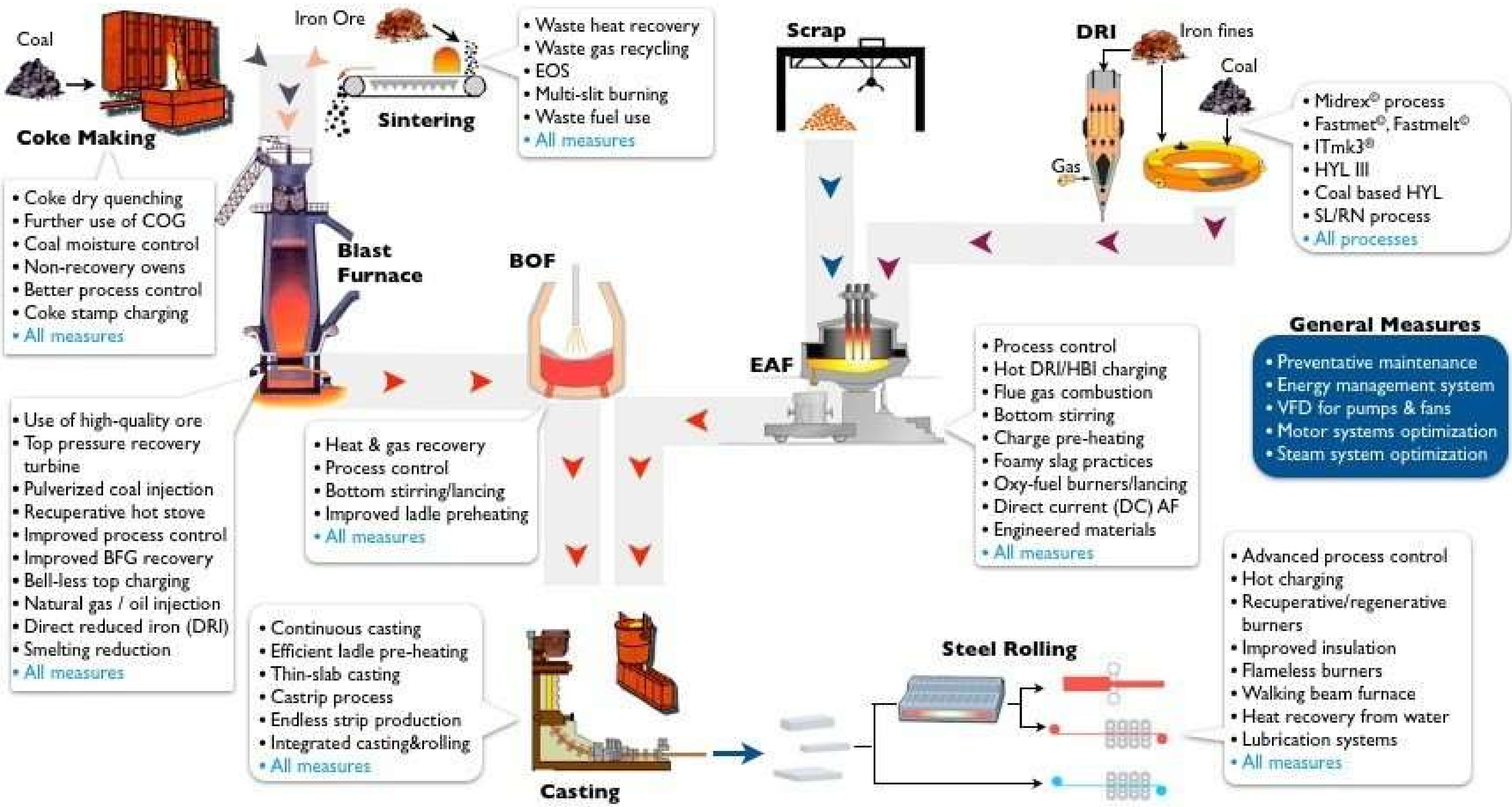
Key message • Feedstock intensity remains steady, while process energy intensity declines.

General measures of pulp and paper industry



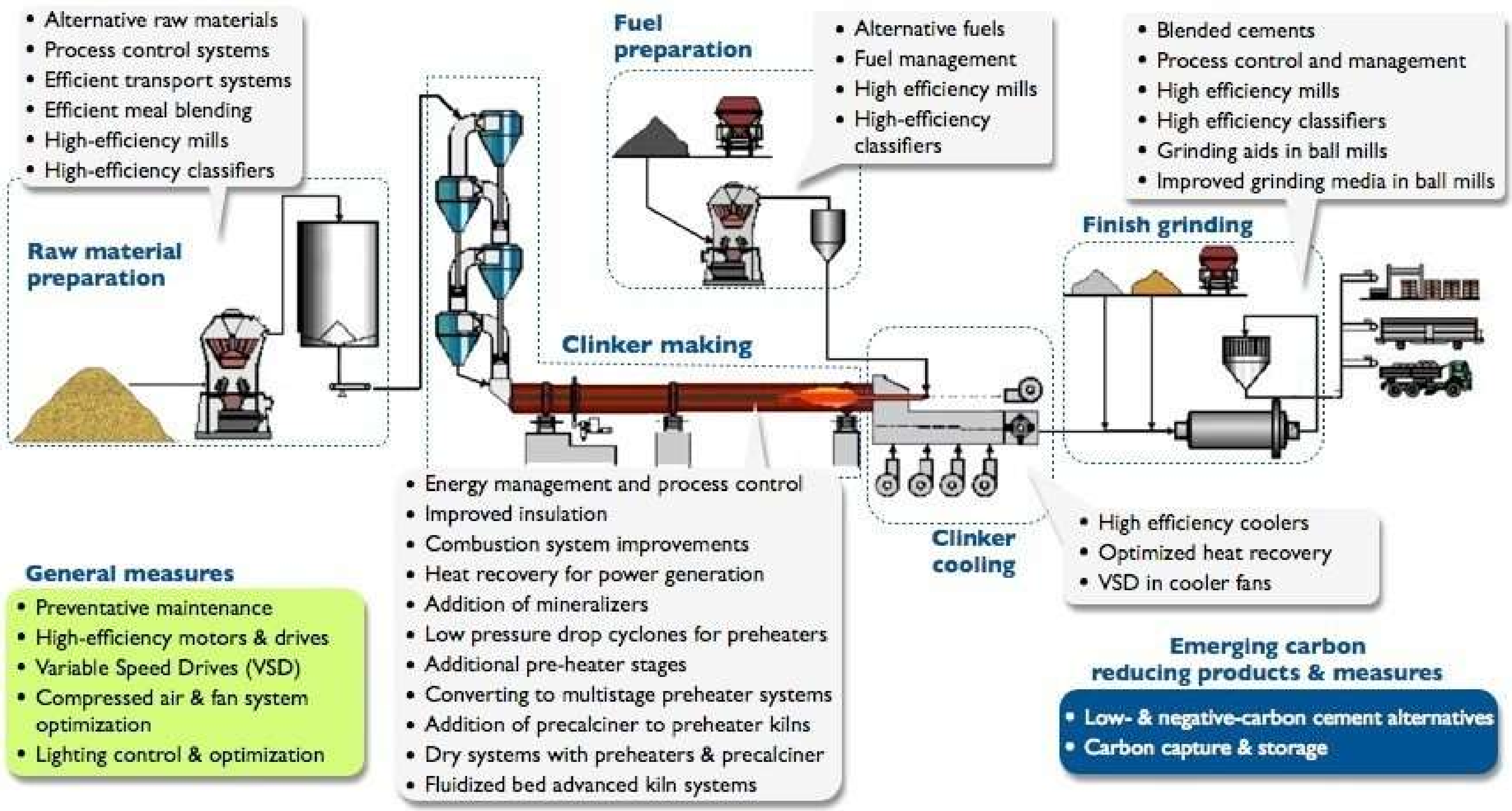
Source: ietd

General measures of iron and steel



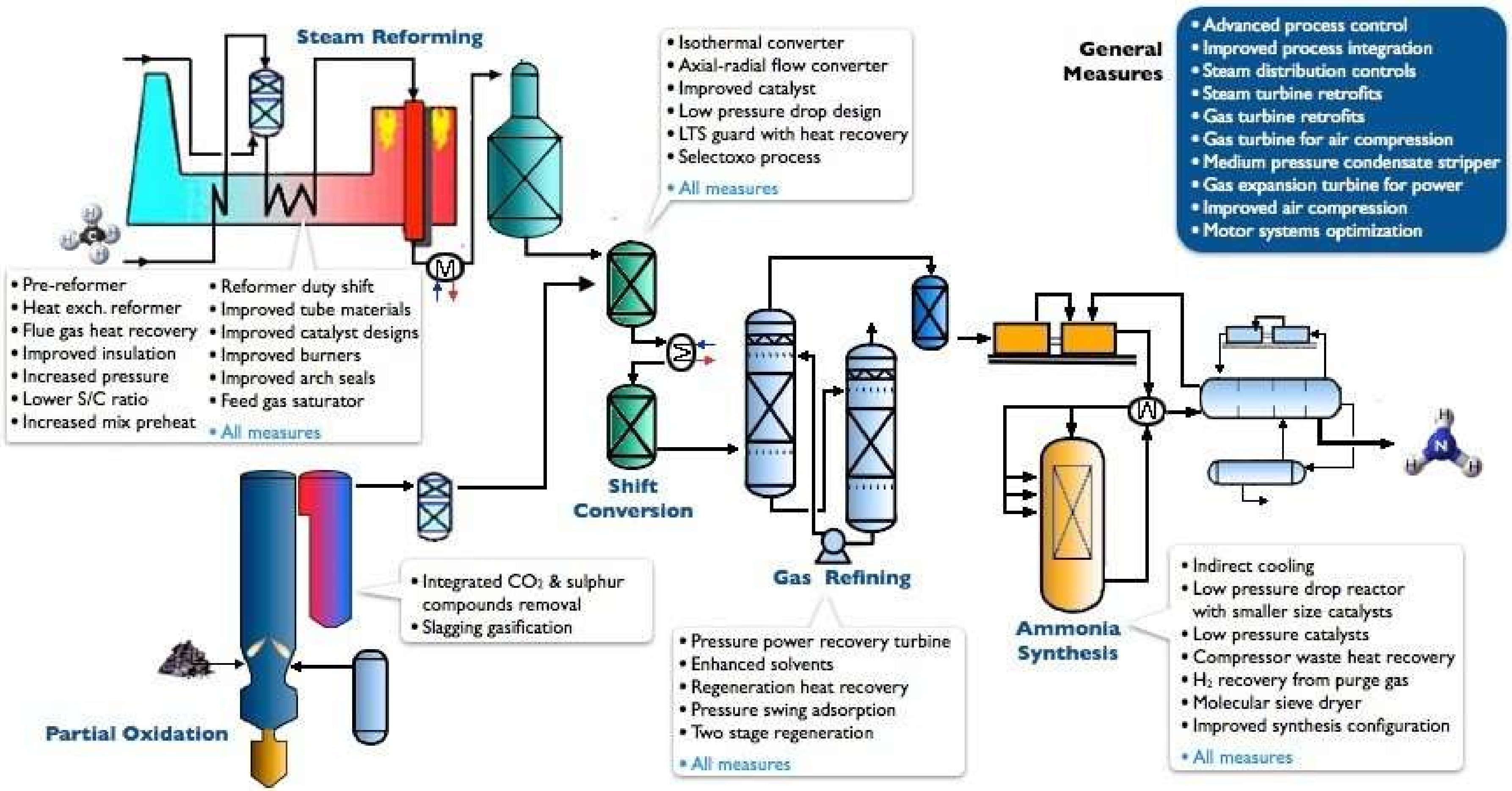
Source: ietd

General measures of cement industry



Source: ietd

General measures of ammonia industry



Source: ietd

Table 4. Selected industry energy benchmark data
Source: UNIDO, 2010

Sectors	Units	Developed Countries	Developing Countries	Global Average	Lowest Found	BAT
Petroleum refineries	EEI	0.7 - 0.8	1.3 - 3.8	1.25	-	1.0
High value chemicals	GJ/t	12.6 - 18.3	17.1 - 18.3	16.9	12.5	10.6
Ammonia	GJ/t	33.2 - 36.2	35.9 - 46.5	41.0	31.5	23.5
Methanol	GJ/t	33.7 - 35.8	33.6 - 40.2	35.1	30.0	28.8
Alumina production	GJ/t	10.9 - 15.5	10.5 - 24.5	16.0	7.8	7.4
Aluminium smelting	MWh/t	14.8 - 15.8	14.6 - 15.0	15.5	14.2	13.4
Copper	GJ/t	-	-	13.8	7.4	6.3
Zinc	GJ/t	15.2 - 19.7	16.7 - 37.2	23.6	15.2	-
Iron and steel	EEI	1.2 - 1.4	1.4 - 2.2	1.5	1.16	1.0
Clinker	GJ/t	3.3 - 4.2	3.1 - 6.2	3.5	3.0	2.9
Cement	kWh/t	109 - 134	92 - 121	109	88	56
Lime	GJ/t	3.6 - 13.0	5.0 - 13.0	-	3.2	-
Glass	GJ/t	4.0 - 10.0	6.8 - 7.8	6.5	3.6	3.4
Brick making	MJ/kg	1.5 - 3.0	0.8 - 11.0	-	0.8	-
Tiles	GJ/t	1.9 - 7.3	3.1 - 8.3	-	1.9	-
Sanitaryware	GJ/t	4.2 - 11.3	4.4 - 20.0	-	4.2	-
Pulp and paper	EEI	0.9 - 1.7	0.4 - 2.3	1.3	-	1.0
Textile spinning	GJ/t	3.5 - 3.6	3.5 - 3.6	-	3.4	-
Textile weaving	GJ/t	11.0 - 65.0	5.0 - 43.0	-	-	-
Brewery	MJ/hl	-	-	229	156	-
Cheese	GJ/t	4.3 - 35.2	-	-	1.8	-
Fluid milk	GJ/t	3.1 - 6.5	-	-	0.3	-

Source: UNEP, 2016

Table 8. Shortlist of sector specific energy efficiency opportunities – cement industry
Source: Adapted from Worrell and Galitsky, 2008

Sector	Energy efficiency opportunities	
Cement production – raw materials preparation	• Efficient transport systems (dry process) • Slurry blending and homogenisation (wet process) • Raw meal blending systems (dry process) • Conversion to closed circuit wash mill (wet process)	• High-efficiency roller mills (dry process) • High-efficiency classifiers (dry process) • Fuel Preparation: Roller mills
Clinker production (wet)	• Energy management and process control • Seal replacement • Kiln combustion system improvements • Kiln shell heat loss reduction • Use of waste fuels • Conversion to modern grate cooler • Refractories	• Optimize grate coolers • Conversion to pre-heater, pre-calciner kilns • Conversion to semi-dry kiln (slurry drier) • Conversion to semi-wet kiln • Efficient kiln drives • Oxygen enrichment
Clinker production (dry)	• Energy management and process control • Seal replacement • Kiln combustion system improvements • Kiln shell heat loss reduction • Use of waste fuels • Conversion to modern grate cooler • Refractories • Heat recovery for power generation • Low pressure drop cyclones for suspension	• pre-heaters • Optimise grate coolers • Addition of pre-calciner to pre-heater kiln • Long dry kiln conversion to multi-stage • pre-heater kiln • Long dry kiln conversion to multi-stage • pre-heater, pre-calciner kiln • Efficient kiln drives • Oxygen enrichment
Cement production – finish grinding	• Energy management and process control • Improved grinding media (ball mills) • High-pressure roller press • High efficiency classifiers • General Measures • Preventative maintenance (insulation, compressed air system, maintenance) • High efficiency motors • Efficient fans with variable speed drives	• Optimisation of compressed air systems • Efficient lighting • Product & Feedstock Changes • Blended Cements • Limestone cement • Low Alkali cement • Use of steel slag in kiln • Reducing fineness of cement for selected uses

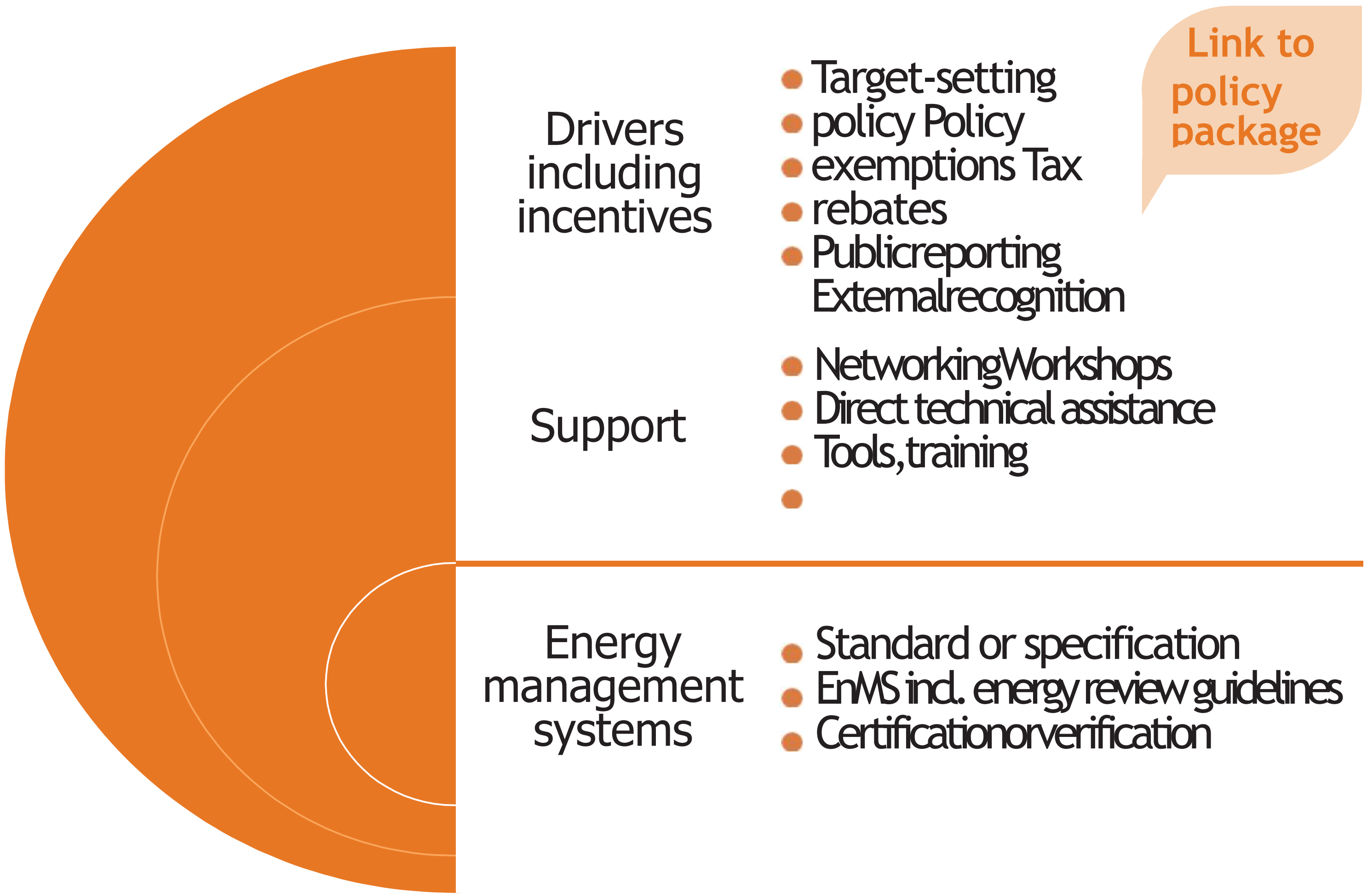
Table 10. Shortlist of sector specific energy efficiency opportunities – vehicle assembly
Source: Adapted from Galitsky et al., 2008

Sector	Energy efficiency opportunities	
Vehicle assembly – painting	• Minimise stabilisation periods • Reduce air flow in pain booths • Utilise heat recovery • Efficient ventilation system • Efficient oven type • Infrared paint curing • UV paint curing • Microwave heating	• Wet on wet paint • New paint - powders • New paint - powder slurry coats • Ultrafiltration / reverse osmosis for waste water cleaning • Carbon filters and other volatile carbon organic removers • High pressure water jet system
Vehicle assembly – body weld	• Computer control • High efficiency welding / inverter technology • Multi-welding units	• Frequency modulated DC welding machine • Hydroforming • Electric robots
Vehicle assembly – stamping	• Variable voltage controls • Air actuators	

Table 11. Shortlist of sector specific energy efficiency opportunities – pharmaceuticals
Source: Adapted from Galitsky et al., 2008

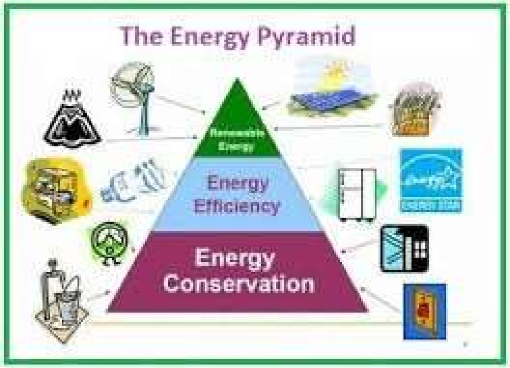
Sector	Energy efficiency opportunities	
Pharmaceutical – R&D	• Fume cupboard controls • Variable speed driven fans • Energy efficient clean rooms	
Pharmaceutical – Primary manufacturing	• Close-system sterilisation • Variable flow control for process air • Energy efficient agitation	
Pharmaceutical – Secondary manufacturing	• Variable speed driven fans • Variable speed driven vacuum • Multiple effect evaporation	• Optimise the operation of pharmaceutical water generation • Recover and reuse water from water treatment plant for other applications

Figure 1 Elements of energy management programmes

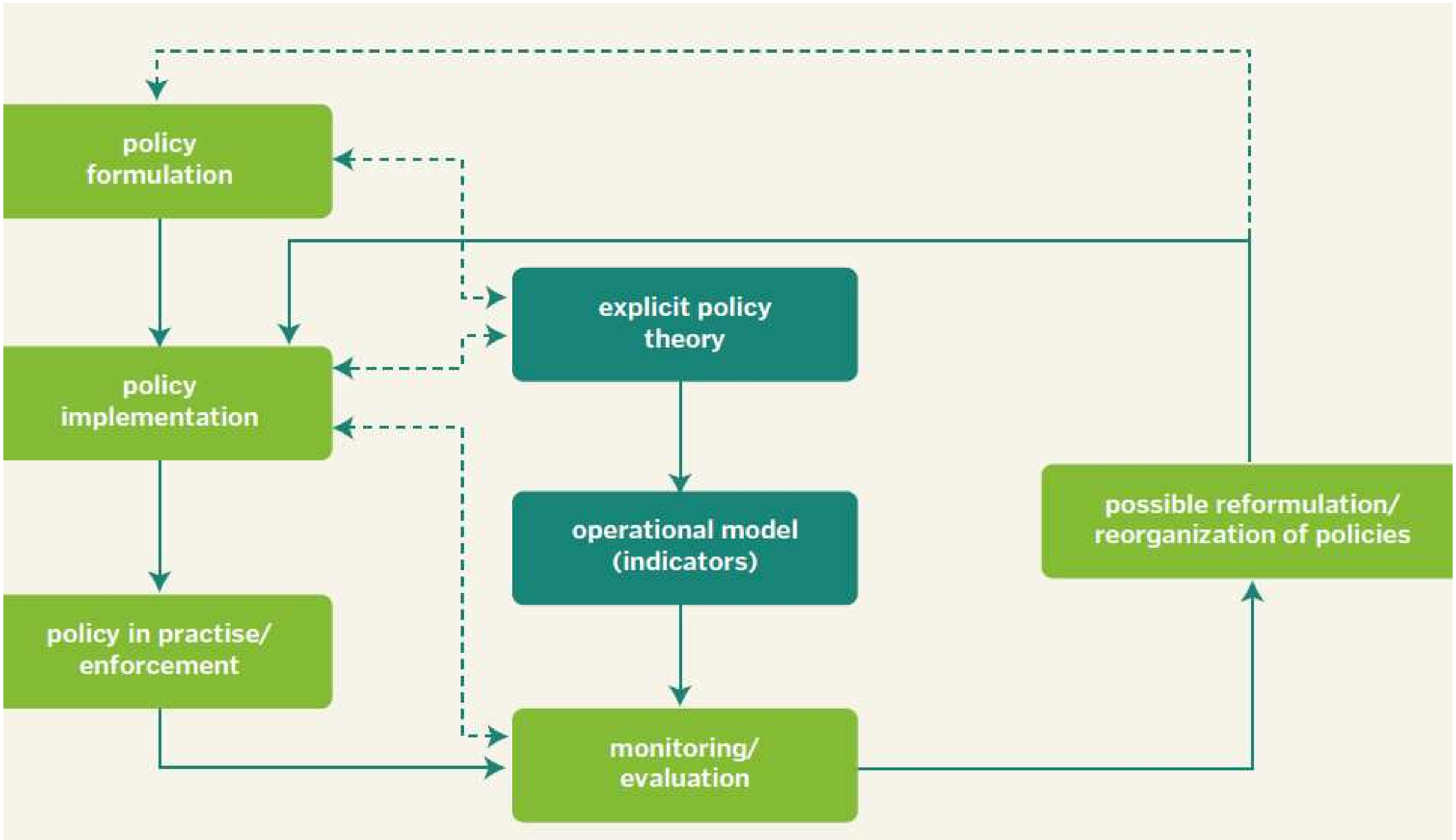


Source: Reinaud, Goldberg and Rozite, 2012.

EE&C policy

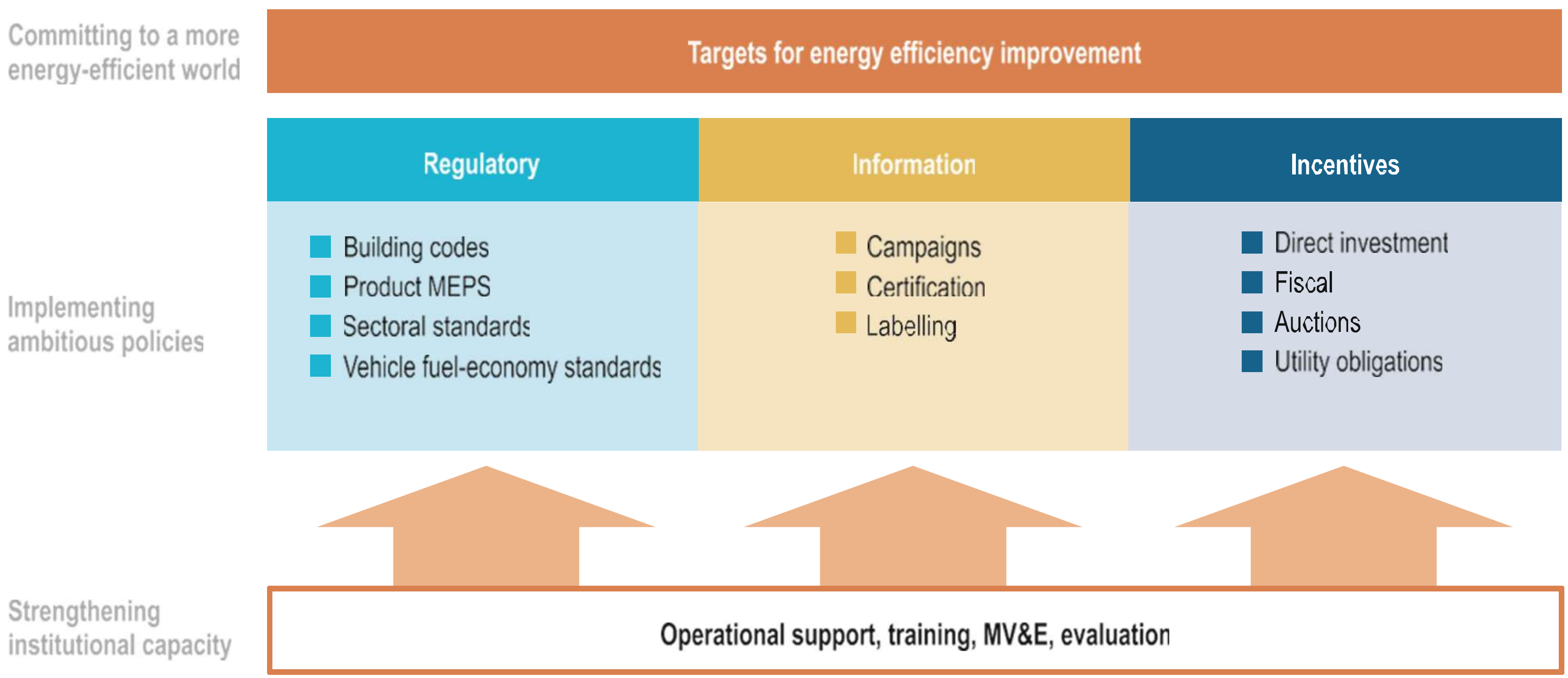

The Energy Pyramid
Renewable Energy
Energy Efficiency
Energy Conservation

The policy formulation cycle



Source: UNEP, 2016

Measures contributing to a policy strategy to increase energy efficiency

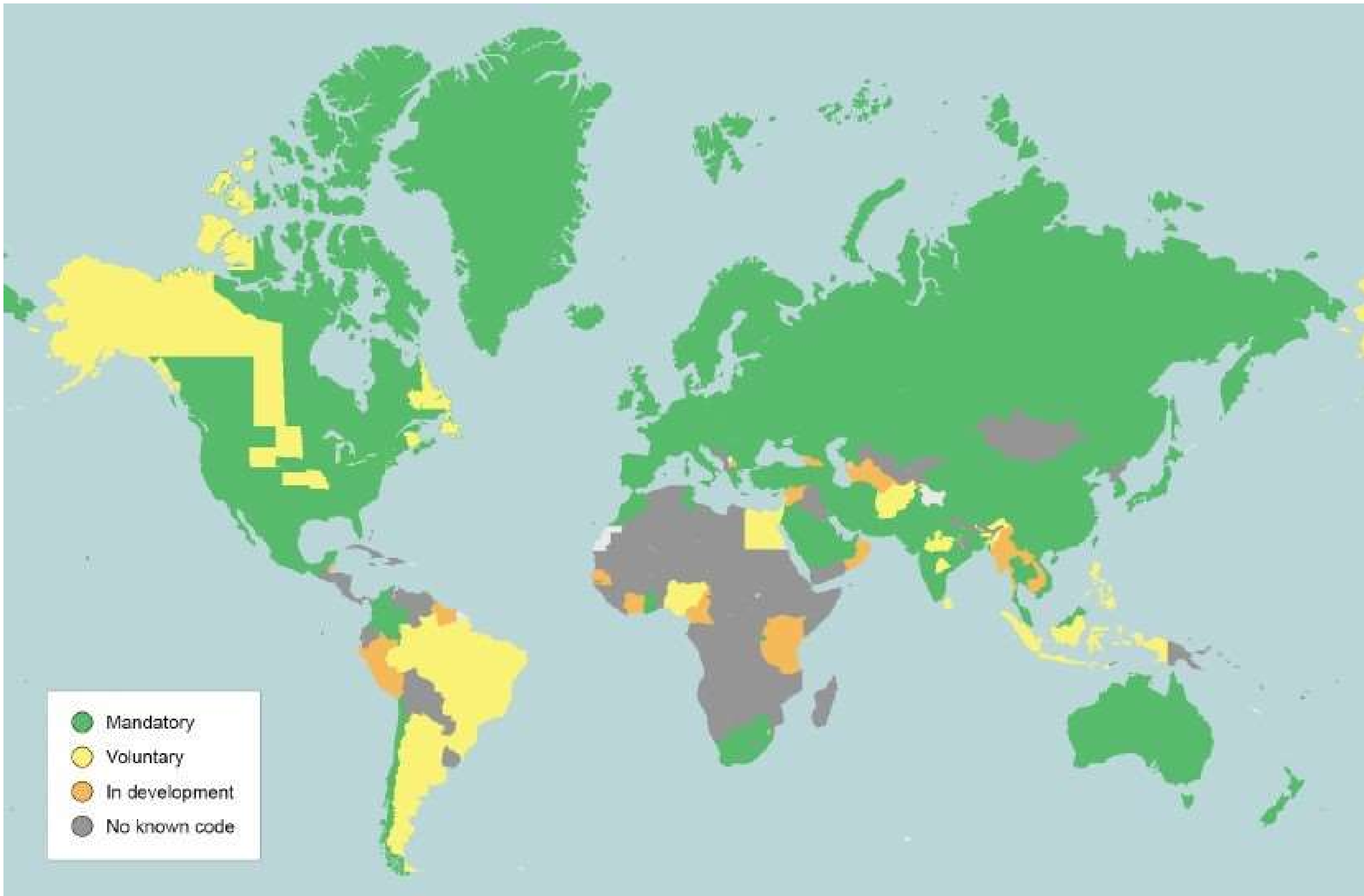


Note: MEPS = minimum energy performance standards; MV&E = monitoring, verification and enforcement.

Regulations, information and incentives to improve energy efficiency need to be signalled in advance and underpinned by robust institutional capacity.

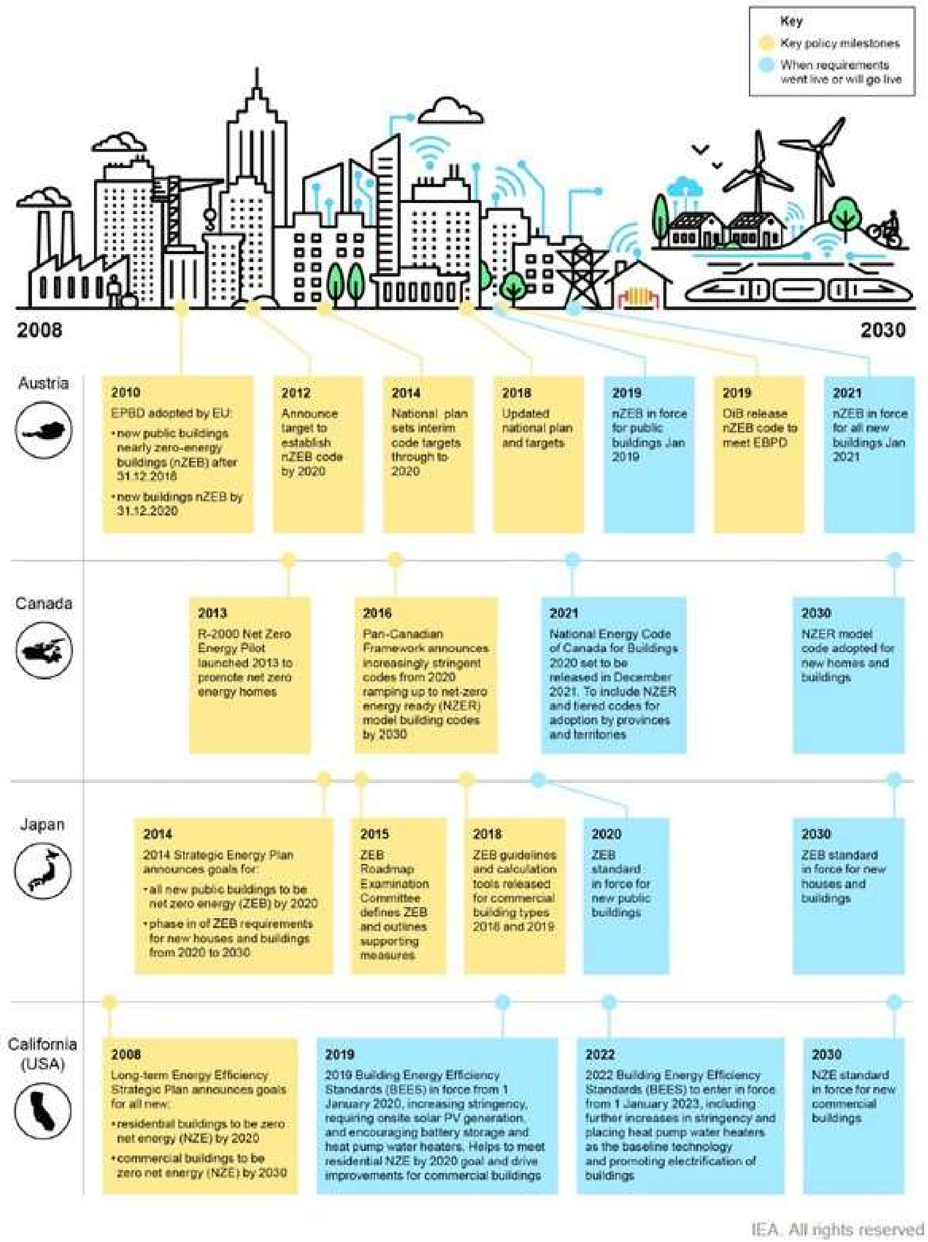
Source: IEA, 2018

Coverage of energy codes for new buildings, 2021



Source: IEA, 2021

Selected timelines for zero carbon ready building codes



Source: IEA, 2021

EE policy area

Cross-sectoral

1. Energy efficiency data collection and indicators
2. Strategies and action plans;
3. Competitive energy markets with appropriate regulation;
4. Private investment in energy efficiency
5. Monitoring, enforcement and evaluation of policies and measures.

Buildings

6. Mandatory building energy codes and minimum energy performance requirements;
7. Aiming for net zero energy consumption in buildings;
8. Improving the energy efficiency of existing buildings;
9. Building energy labels or certificates;
10. Improved energy performance of building components and systems.

Appliances and Equipment

11. Mandatory MEPS and labels for appliances and equipment;
12. Test standards and measurement protocols for appliances and equipment
13. Market transformation policies for appliances and equipment

Lighting

14. Phase-out of inefficient lighting products and systems;
15. Energy efficient lighting systems

Transport

16. Mandatory vehicle fuel efficiency standards;
17. Measure to improve vehicle fuel efficiency;
18. Fuel-efficient non-engine components
19. Improved vehicle operational efficiency through Eco-driving and other measures .
20. Transport system efficiency

Industry

21. Energy Management in industry;
22. High efficiency industrial equipment and systems;
23. Energy efficiency services for small and medium enterprises;
24. Complementary policies to support industrial energy efficiency

Energy utilities

25. Energy Utilities and end-use energy efficiency.

#EnergyEfficientWorld

Policy targets

- **Building:** existing buildings; new buildings; energy class; building code type; building types
- **Appliances:** residential; commercial; lighting
- **Transport:** scope; vehicle type; fuel type; non-engine components; vehicle operation; transport systems
- **Industry:** energy management; processes; equipment; products; sectors
- **Energy Utilities:** Combined heating & power (CHP); electricity; demand-side management; fossil-fuel production; heating

Policy Types

- **Information and education:** Advice/aid in implementation; labelling; professional training and qualification
- **Economic instruments:** fiscal incentives; market-based instruments; direct investment
- **Regulatory instruments:** codes & standards; auditing; monitoring; obligations schemes
- **Research, Development &Deployment (RD&D)**
- **Voluntary approaches:** public/private sector agreements; public voluntary schemes
- **Policy support measures:** strategic planning

Examples of proven measures in demand/Suply-side sectors include

Supply side segment	Examples of energy efficiency measures
Domestic and commercial buildings	• For heating and cooling services—use of efficient equipment, adjustments in use patterns (behavioural changes, temperature modifications, etc.) and good maintenance. • Lighting—using efficient light-bulbs, changing types of light sources, maximum use of natural lighting, behavioural changes (e.g. switching off when not needed, manually or automatically). • Office equipment and domestic appliances—installing energy efficient items, switching off when not used (e.g. reducing waste when on standby), and adopting good operating practices (e.g. running appliances only when full). • Construction materials—ensuring that appropriate materials and controls are utilized in new and retrofitted buildings (e.g. insulation, building orientation, double glazed windows).
Industry	• Operations in general—routine data collection and regular analysis of energy performance, improved maintenance, good energy management using skilled and experienced staff. • Boilers and furnaces—proper combustion control with appropriate instrumentation, insulation and refractory brought up to good modern standards, burners well maintained.

Source: UNIDO

Industry	industrial processes—operated in accordance with design standards, heat losses minimized by good insulation, waste heat recovered for use elsewhere in the plant. • Industrial buildings—similar to the buildings sector, including attention to heating, cooling, lighting, etc. • Equipment—utilizing existing equipment well (e.g. electric motor speed and load controls) and replacing obsolete items with new higher efficiency equipment (motors, fans, boilers, pumps, etc.)
Transport	• Modal shifting—ensure freight and passenger transport is carried out in the most energy efficient mode (e.g. consider switching from road to rail, encouraging public transport over individual vehicles, etc., whenever possible). • Vehicles—encourage fleet replacement to modern higher efficiency equipment, improve maintenance, driver education. • Improved road maintenance.
Resources and resources preparation	• Clean coal technologies—they allow improving the efficiency of the extraction, preparation and use of coal. They offer various solutions for coal cleaning as well as reducing noxious emissions and improve the efficiency of power generation. • Fuel substitutions—also referred to as fuel switching, is simply the process of substituting one fuel for another. This could be either a fossil fuel that allows for using more efficient conversion technologies (i.e. natural gas) or renewables (i.e. wind. solar, biomass, hydro, etc.).
Power generation and energy conversion	• Plant operations in general—these include routine data collection and regular analysis of energy performance, improved maintenance, improved logistics, good energy management using skilled and experienced staff. • Improved boilers and furnaces control—proper combustion control with appropriate instrumentation, insulation and refractory brought up to good modern standards, burners well maintained. • Upgrading generating units—it includes installation of new and improved burners, extra flue gas heat recovery, additional heat recovery from hot blow-down water as well as modernization of instrumentation and combustion control systems. • Cogeneration—the combined production of electricity and heat can bring about major efficiency gains wherever a demand for heat exists next to a power plant (process heat for industrial factories, district heating, etc.).[1]
Transmission and distribution	• Transmission and distribution line upgrading—this includes replacement/upgrade of equipment (transformers, switchgear, insulators, system control and data acquisition systems, etc.) as well as substations. • Improved control and operations—this includes data and system monitoring, power factor improvement, voltage regulation, phase balancing, preventive maintenance and other measures to reduce technical losses while increasing reliability.

[1]It has to be noted there are also cogeneration systems, usually part of big industrial factories, for

Source: UNIDO

Energy efficiency labels

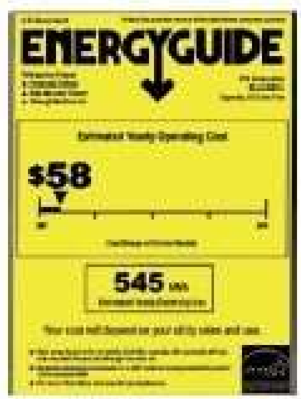
Standards & labelling (S&L) programmes

In this publication, S&L programmes refer to market interventions that aim to ensure that services and products (in this case, electrical equipment) use less energy than the market would have otherwise delivered.

Standards generally take one of two forms: either as minimum energy performance standards (MEPS) applying to every individual product, or as an average efficiency requirement spread across the range of products sold by a particular supplier.

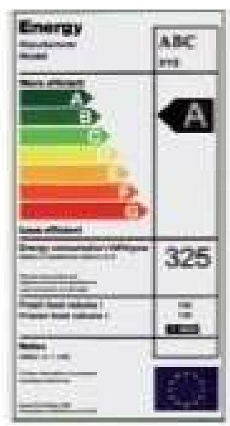
Minimum energy performance standards	*Minimum efficiency levels (or maximum energy consumption levels) require that manufacturers ensure that every product attains the stipulated level. This is the approach in most countries.*
Class average standards	*The average efficiency of all products made by that manufacturer is specified, which permits less efficient models to be sold as long as the overall mix of total sales achieves the efficiency goal. This approach is used in parts of Asia.*

Source: www.clasponline.org modified by the IEA.



United States

Source: US Federal Trade Commission 16CFR305

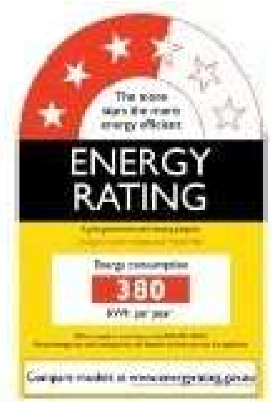


Europe

Source: European Commission Directives 2003/66/EC and 94/2/EC

Korea

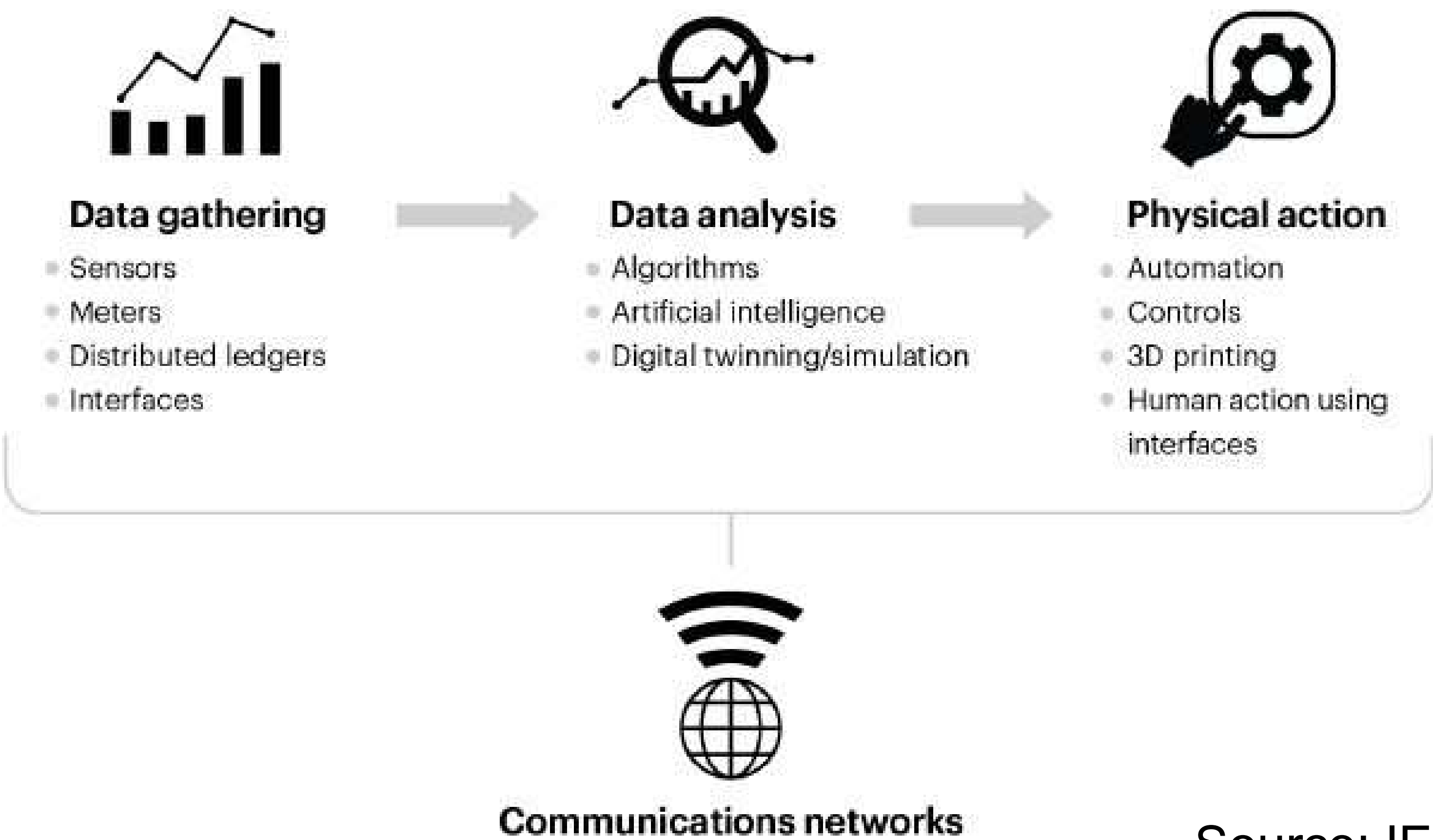
Source: Korean Energy Management Corporation



Australia

Source: Australian Department of Energy Efficiency and Climate change

How digital technologies, when combined, could boost energy efficiency

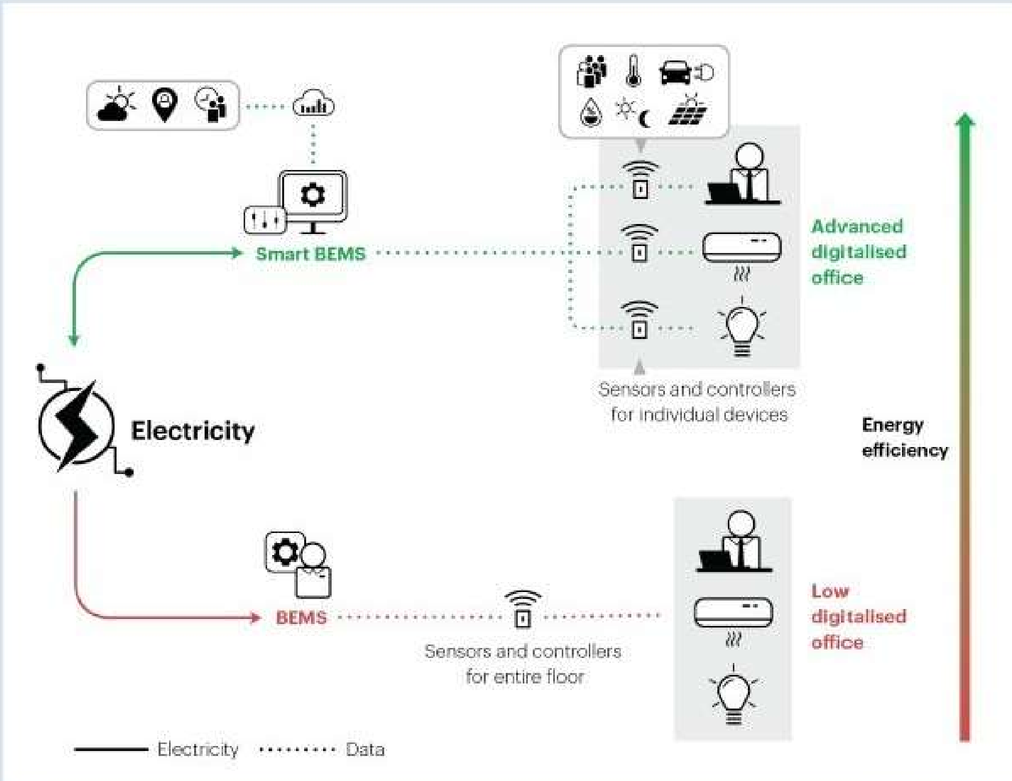


Source: IEA, 2019

collect data from heating, ventilation and air-conditioning (HVAC), from thermostats, networked lighting systems, room occupancy sensors, and/or other building technologies. These data are then displayed on a standard dashboard for a building energy manager or facility manager, for example, who is able to make decisions that improve the energy or operational efficiency of the facility.

A smart BEMS combines data from a traditional BEMS with other data sources (for example weather conditions, planned staffing levels or traffic patterns affecting staff arrival times, patient operation scheduling, lecture hall times, etc.) These data are then analysed using advanced software, incorporating AI algorithms.

The role of a smart BEMS in an efficient, highly-digitalised office building

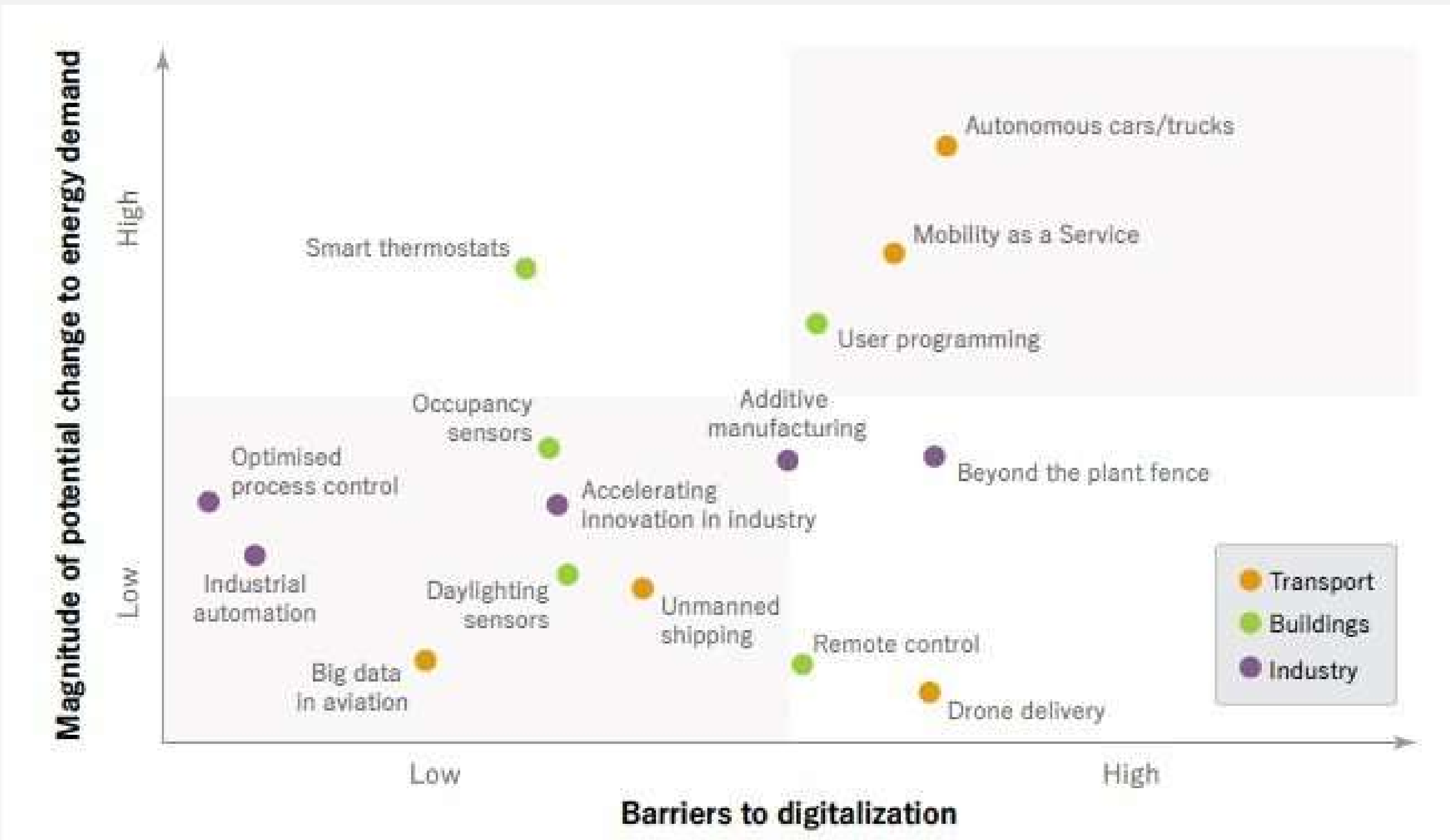


The AI in these systems generates much larger quantities and ranges of real-time, actionable insights than traditional BEMS can. For example, a smart BEMS can provide intelligence on when a building should operate certain systems to maximise the consumption of renewable energy, while also balancing building occupants' comfort requirements.

An AI-enabled smart BEMS can also forecast how a facility is likely to "behave", based on patterns identified in historical data such as weather, occupancy rates and energy prices. These predictive capabilities open up the possibility of buildings providing their flexible load to the grid, a process

Source: IEA, 2019

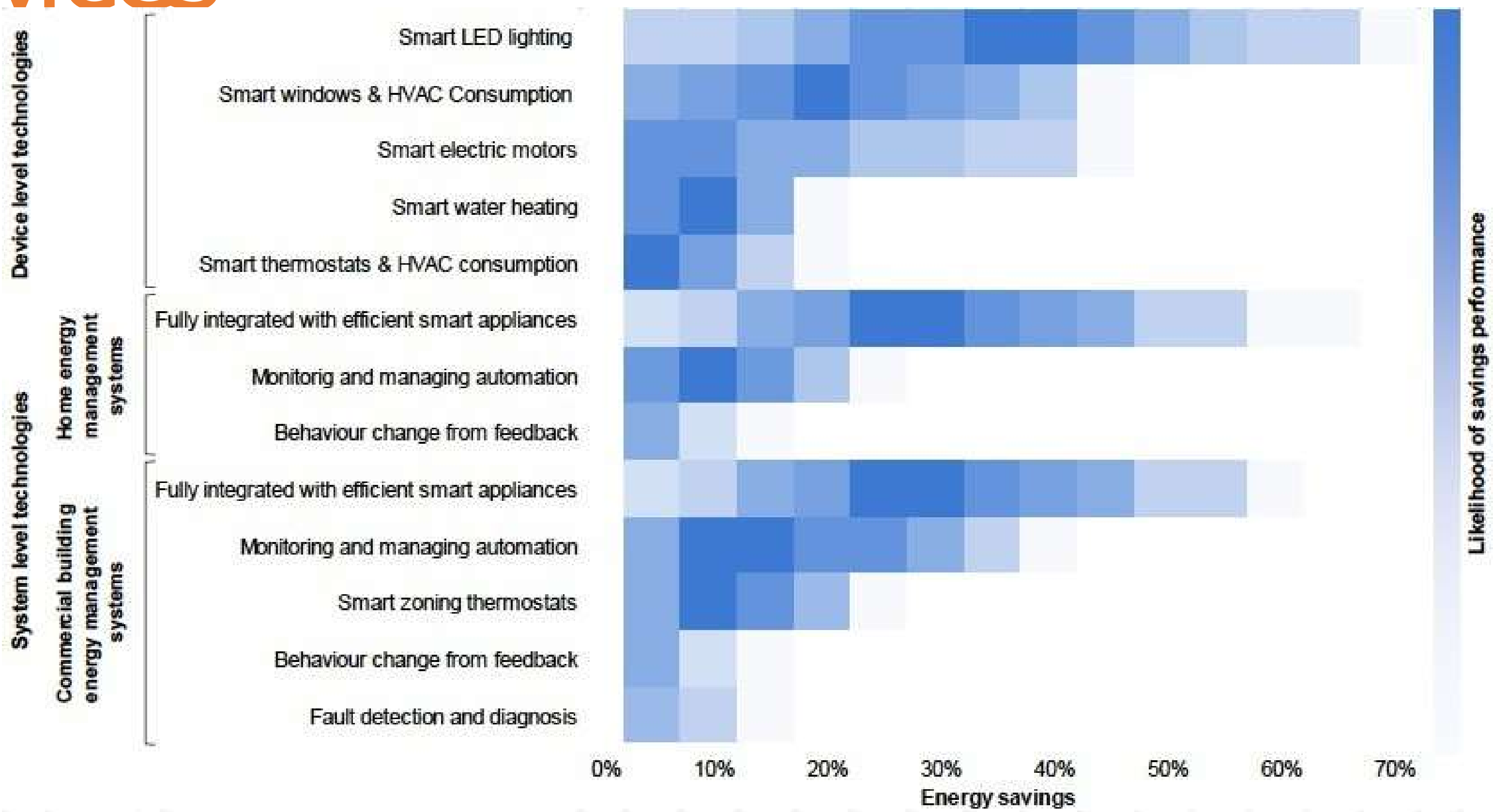
Digitalization's potential impact on transport, buildings, and industry



Key message: Digital technologies and applications face a variety of barriers to adoption and use, and their impacts on energy use differ across demand sectors.

Source: IEA, 2017

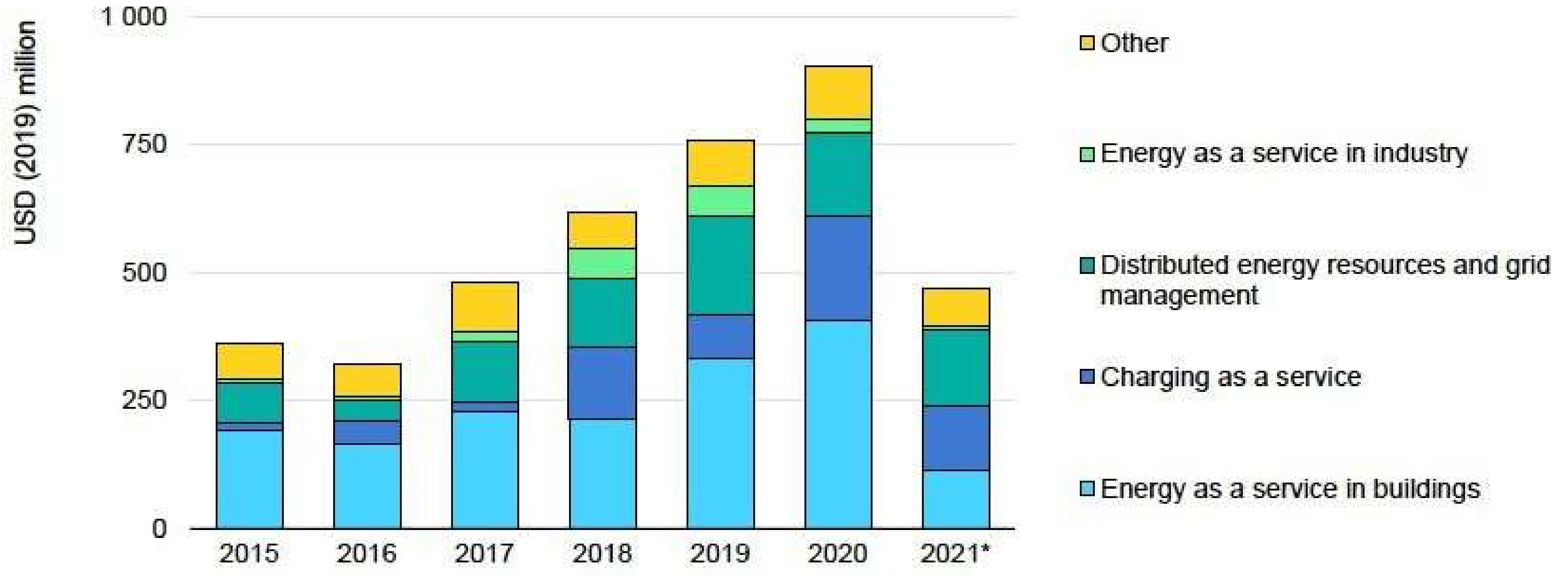
Expanding the scale of energy efficiency with digital devices



Note: HVAC = heating, ventilation and air conditioning.
Source: IEA analysis based on case studies.

Source: IEA, 2021

Global early-stage venture capital investments in energy efficiency start-ups

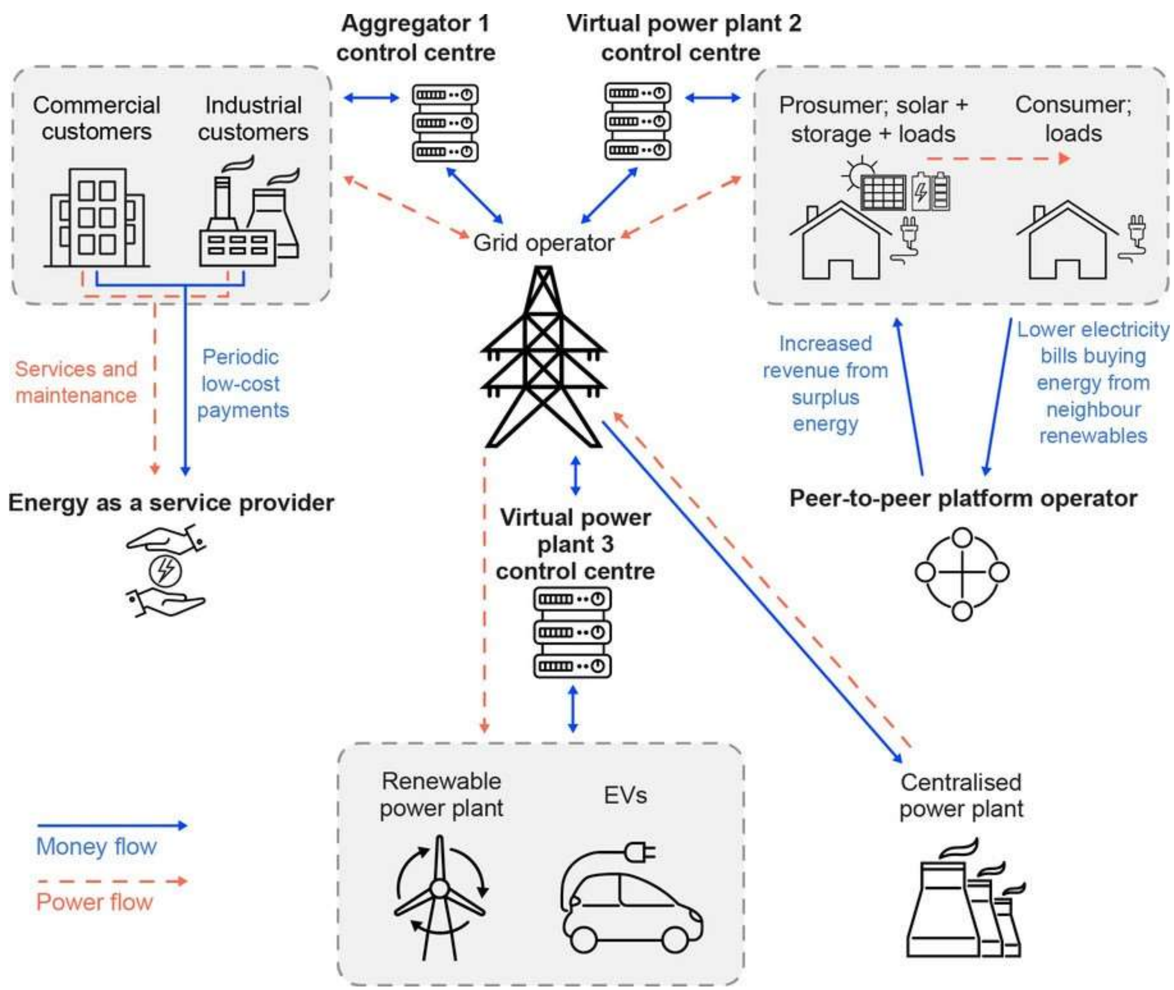


Notes: This classification considers start-ups developing energy technologies, services and solutions including both hardware and software and that are engaging with end users directly. Start-ups that focus on manufacturing or distributing hardware only are excluded. Energy as a service in buildings includes smart heating and cooling, energy management systems, lighting and smart devices for residential and commercial buildings, as well as "pay as you go" business models. Distributed energy resources and grid management includes virtual power plants, energy trading schemes including peer to peer, energy as a service for power grids, and off-grid access solutions. Early-stage investments include seed, series A and B financing rounds. The figure excludes outlier investments of above USD 150 million in a single deal that distort annual trends. These aggregated to about USD 350 million in 2020. *Preliminary data up to mid-July 2021 are included.

Source: IEA analysis based on Cleantech Group, i3 database.

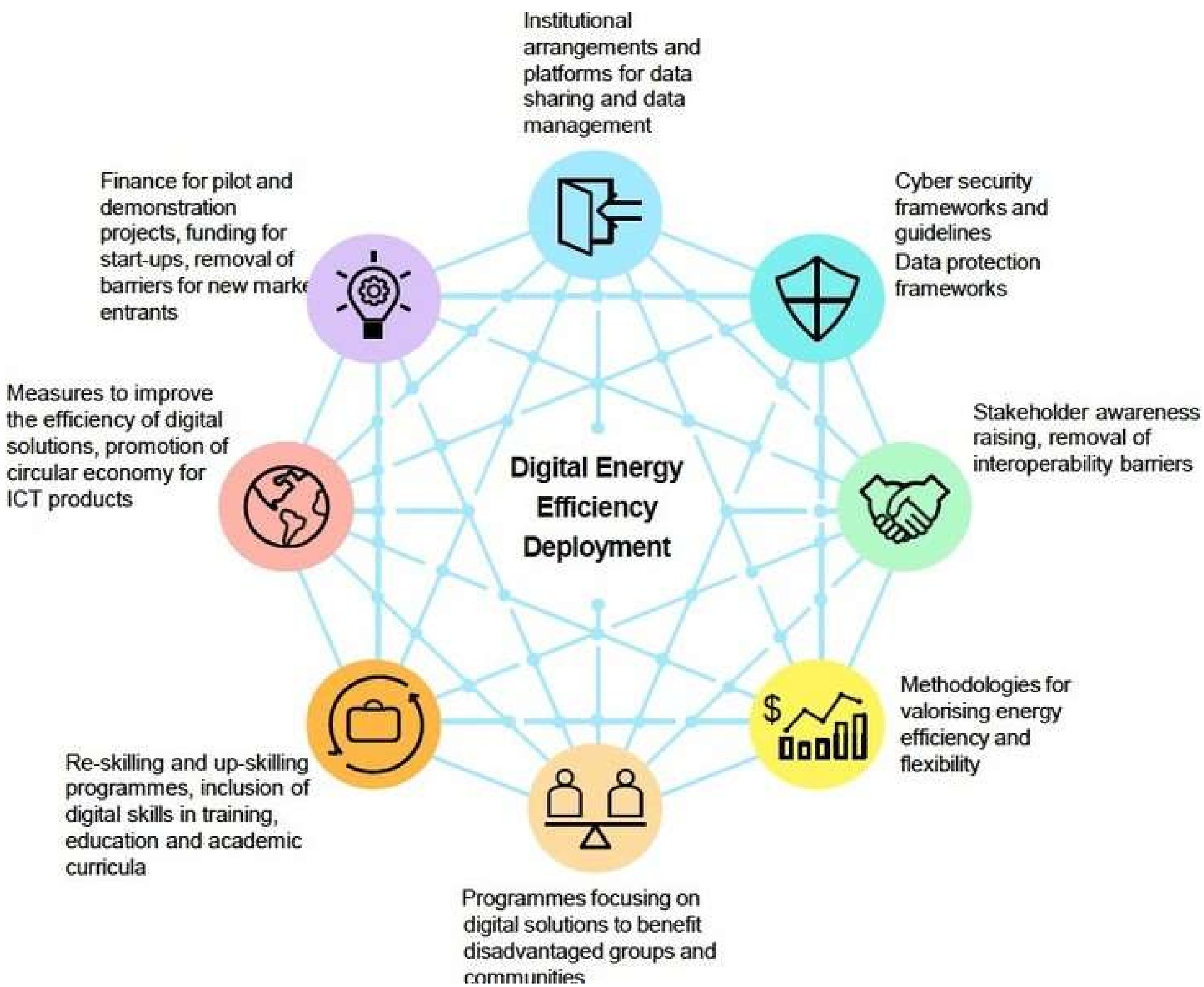
Source: IEA, 2021

Innovative digitally-enabled business models in decentralised energy systems



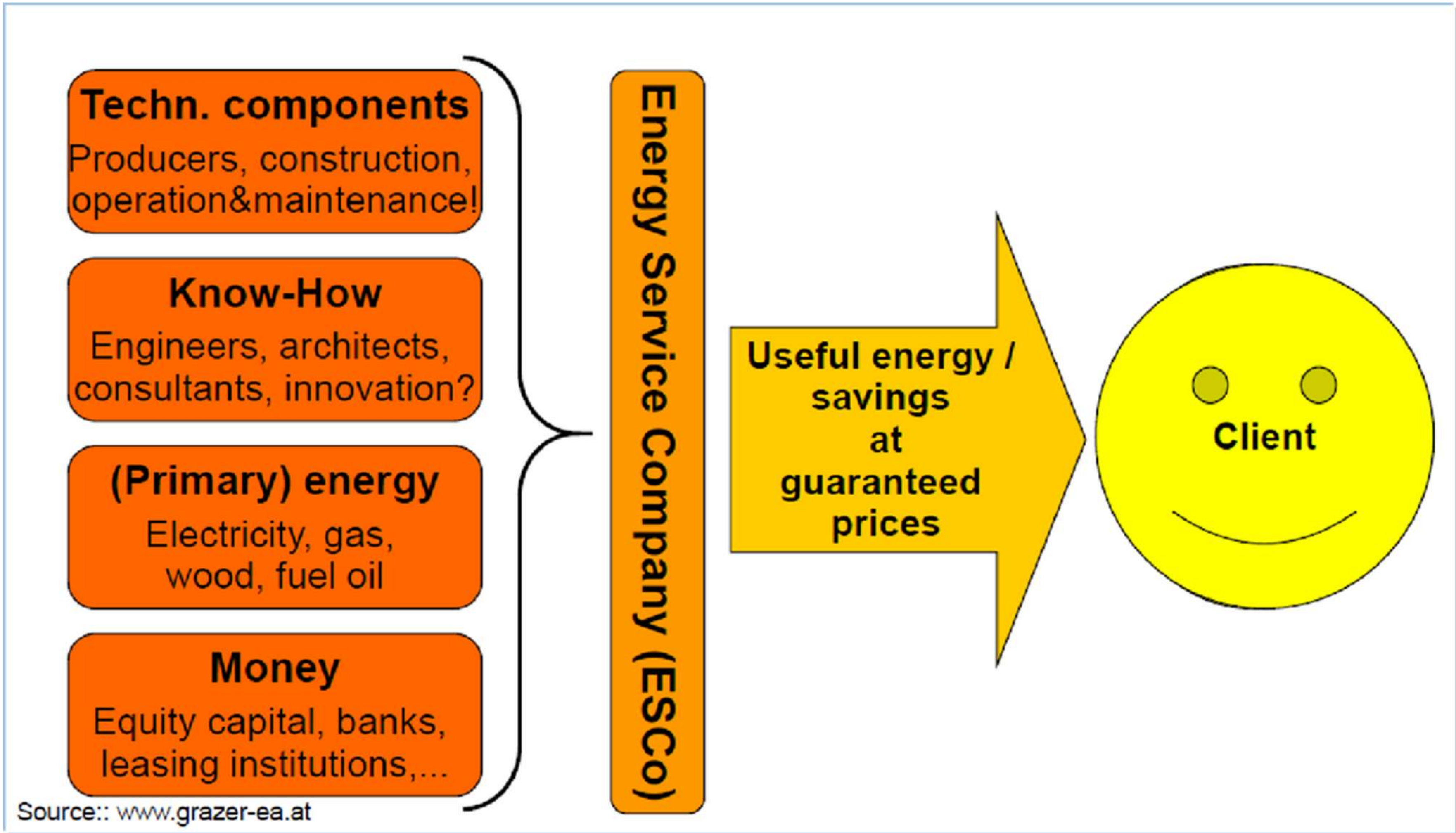
Source: IEA, 2021

Strategies for digital energy efficiency deployment



Source: IEA, 2021

Energy Service Company (ESCO)



Energy service model

Decision criteria:	In house	Energy Service
Investment costs	100 %	0 – 100 %
Economic and technical risks	Owner	Contractor
Optimal maintenance of facility	only with a high owner commitment	Contractor's own interest
Performance warranties (e.g. maximum consumption, efficiency)	No	Yes
Functional guarantees	only warranty period	over total contract period
Cost limits (eg investment, prices)	No	Yes
Long-term contractual obligation	No	Yes
Project co-ordination / know-how	building owner + engineer	Consultant + ESCO
Service package / outsourcing	No	Yes
Size of the building / facility	any	Floorspace > 2,000 m² Energy costs > 20,000 € /a
Life cycle costs	usually higher	usually lower

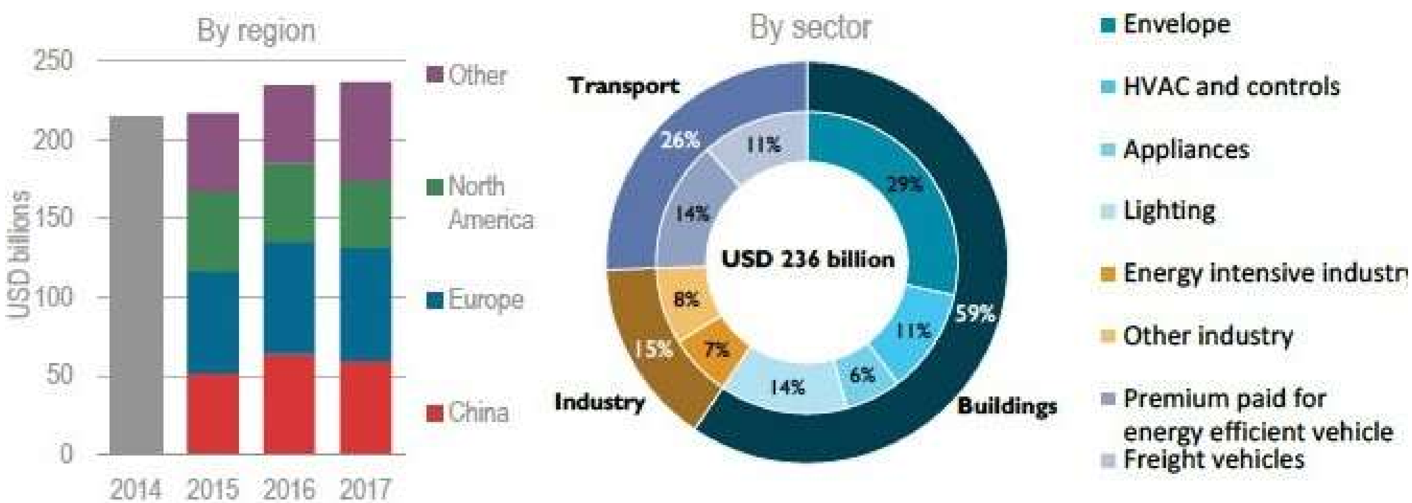
Source:: www.grazer-ea.at

Highlights

- Digitalization is having a major impact on transport, buildings and industry. How significant this will turn out to be in the future will differ for each sector and particular application.
- **Transport** is becoming smarter and more connected, improving safety and efficiency. In road transport, connectivity is enabling new mobility sharing services. Combined with advances in vehicle automation and electrification, digitalization could result in substantial but uncertain energy and emissions impacts. Over the longer term, road transport energy use could either drop by about half or more than double, depending on the interplay between technology, policy and behaviour.
- Digitalization could cut total energy use in residential and commercial **buildings** by around 10% to 2040. These efficiency gains are largest in heating and cooling, particularly through the use of smart thermostats and sensors. Smart lighting allows for potentially substantial cuts in lighting electricity demand. However, new services and comforts brought about by digitalization – as well as greater use of standby power by idle devices and appliances – could offset potential savings.
- **Industry** has been using digital technologies for a long time to improve safety and productivity. Digitalization could lead to further significant energy savings with short payback periods through improved process controls within industrial plants and beyond the plant fence. Three-dimensional (3D) printing, machine learning and enhanced connectivity could have an even bigger impact.
- Sector-specific and cross-sectoral policies are needed to maximise benefits made possible by digital technologies and to address challenges, including cybersecurity, data privacy and job losses.

Source: IEA, 2017

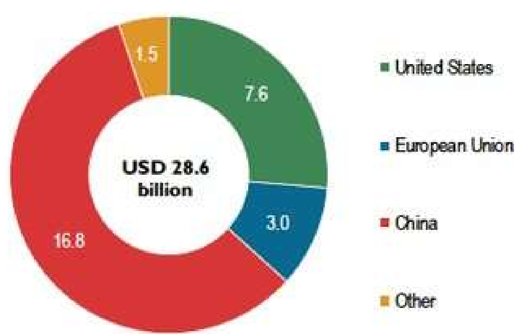
Energy efficiency investment by sector and region



Note: HVAC = heating, ventilation and air conditioning.

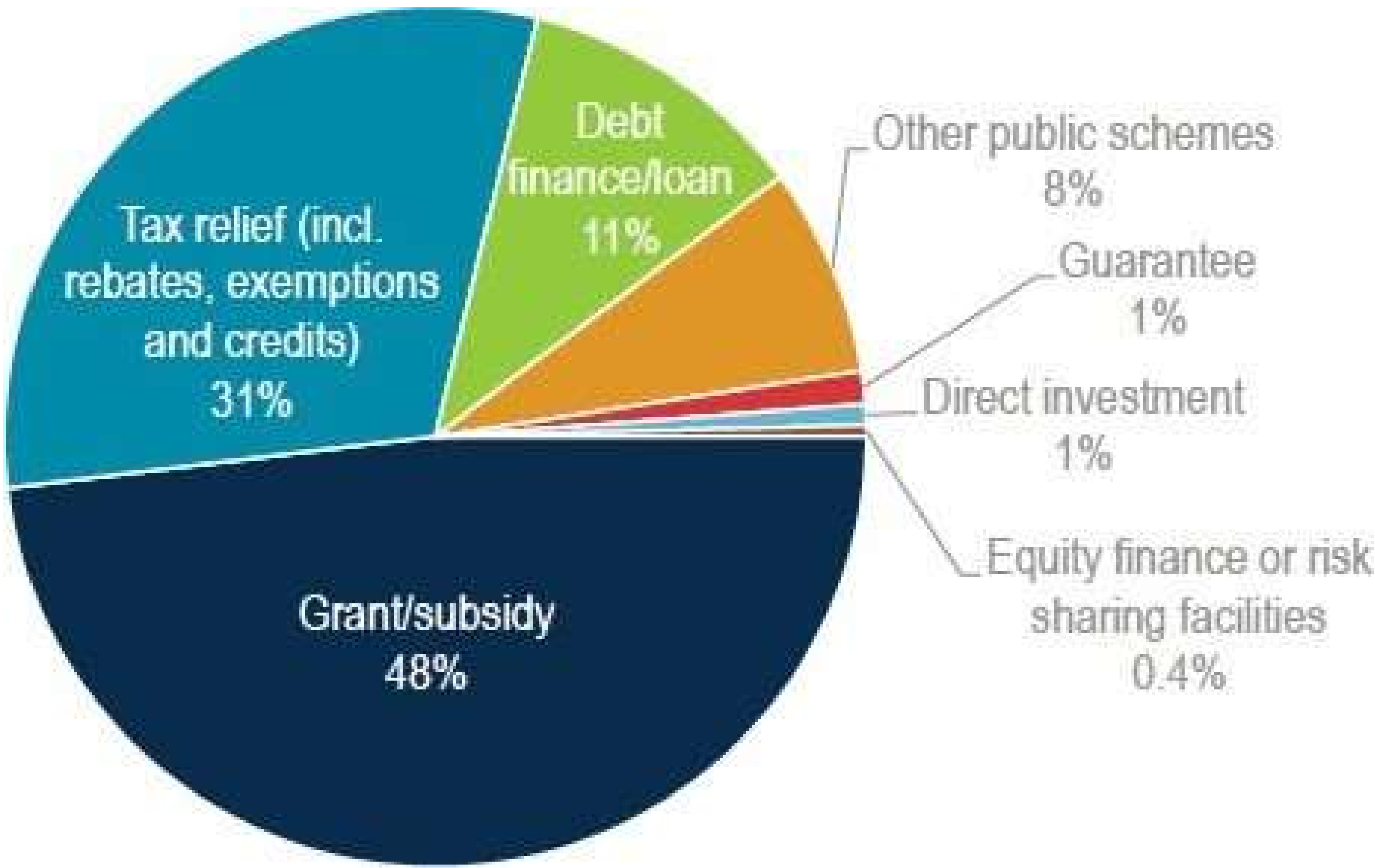
Sources: Includes inputs from Navigant Research (2016); IHS Markit (2018).

Figure 5.4 ESCO revenue by region, 2017



Source: IEA, 2019

Government expenditure on incentives for energy efficiency by type of incentive



Source: IEA, 2018

An ambitious energy efficiency initiative

Ahead of COP26, SEAD is focusing on **four products that account for over 40% of global electricity consumption**

1) Industrial motor systems
2) Air conditioners
3) Refrigerators
4) Lighting

Doubling the energy efficiency of new products of these types sold across all SEAD member countries could

- Reduce electricity consumption by over **4,600 TWh per year by 2030** (equivalent to the generation of more than 2,100 coal-fired power plants)
- Avoid **1.9 Gt of CO_2** emissions per year by 2030
- Result in additional benefits for **air quality, jobs and health**

Source: SEAD & IEA

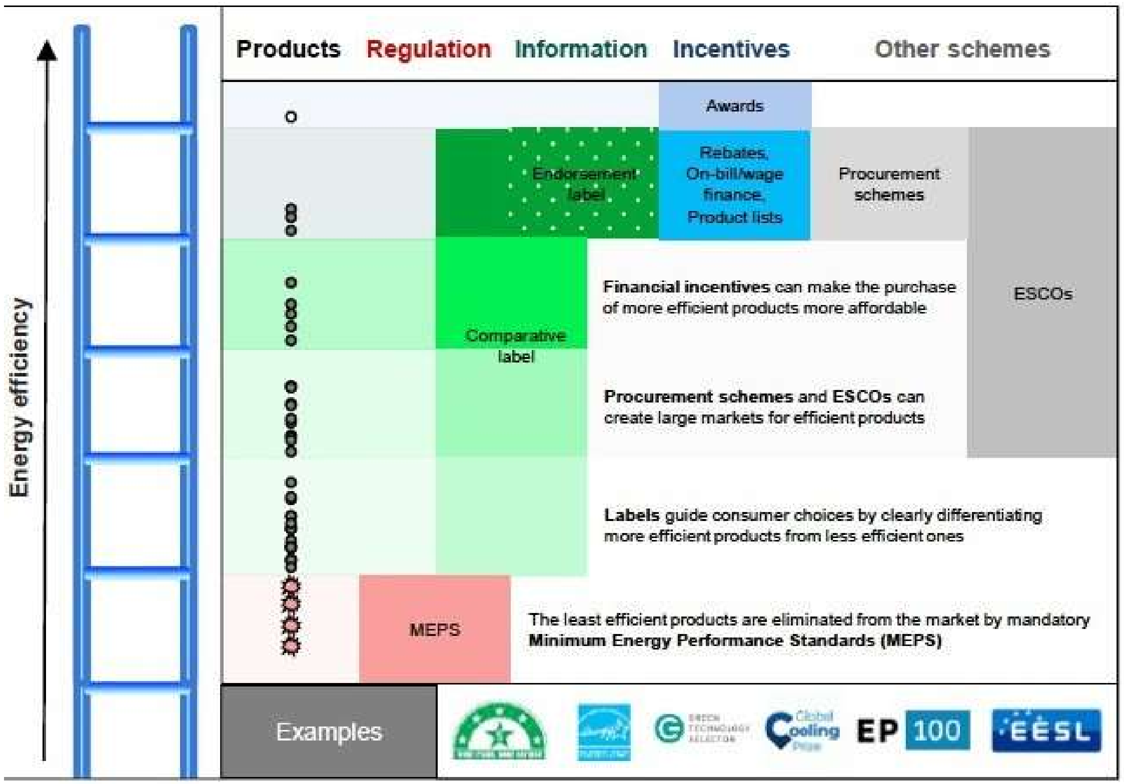
ıll to Action — Objectives

s COP26 President, the UK wants to drive international action on product energy efficiency policy. head of COP26, the UK and IEA have launched a **call to action** to strengthen the **Super-efficient quipment and Appliance Deployment (SEAD) Initiative** to support countries in achieving raised ambi **ıore quickly, easily and at a lower cost**. The objectives of the call to action are to:

- **Set countries on a trajectory to double the efficiency of key products sold globally by 2030** – industrial motor systems; residential lighting, ACs and refrigerators
- Support the delivery of crucial **national climate change targets**
- Provide consumers and businesses with more efficient products that are **affordable and cost-effective** to own and operate
- Stimulate **innovation** and provide businesses with **increased market and export opportunities**
- Promote a dual course of action, making products both **energy efficient and climate friendly** by reducing the use of refrigerants in cooling appliances

\ single framework for a range of policies

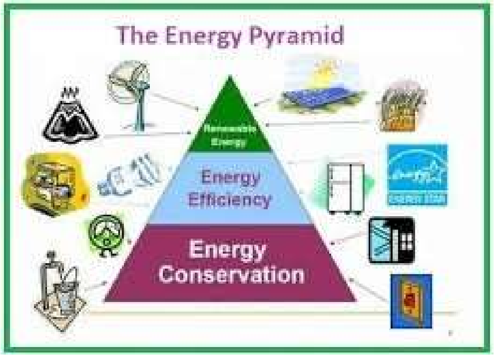
\ range of policies can improve the efficiency of electrical appliances, lighting and motors sold in a market.



Ladder 'steps' are defined as energy performance levels, and thresholds for differen types of policy can then be set at steps:

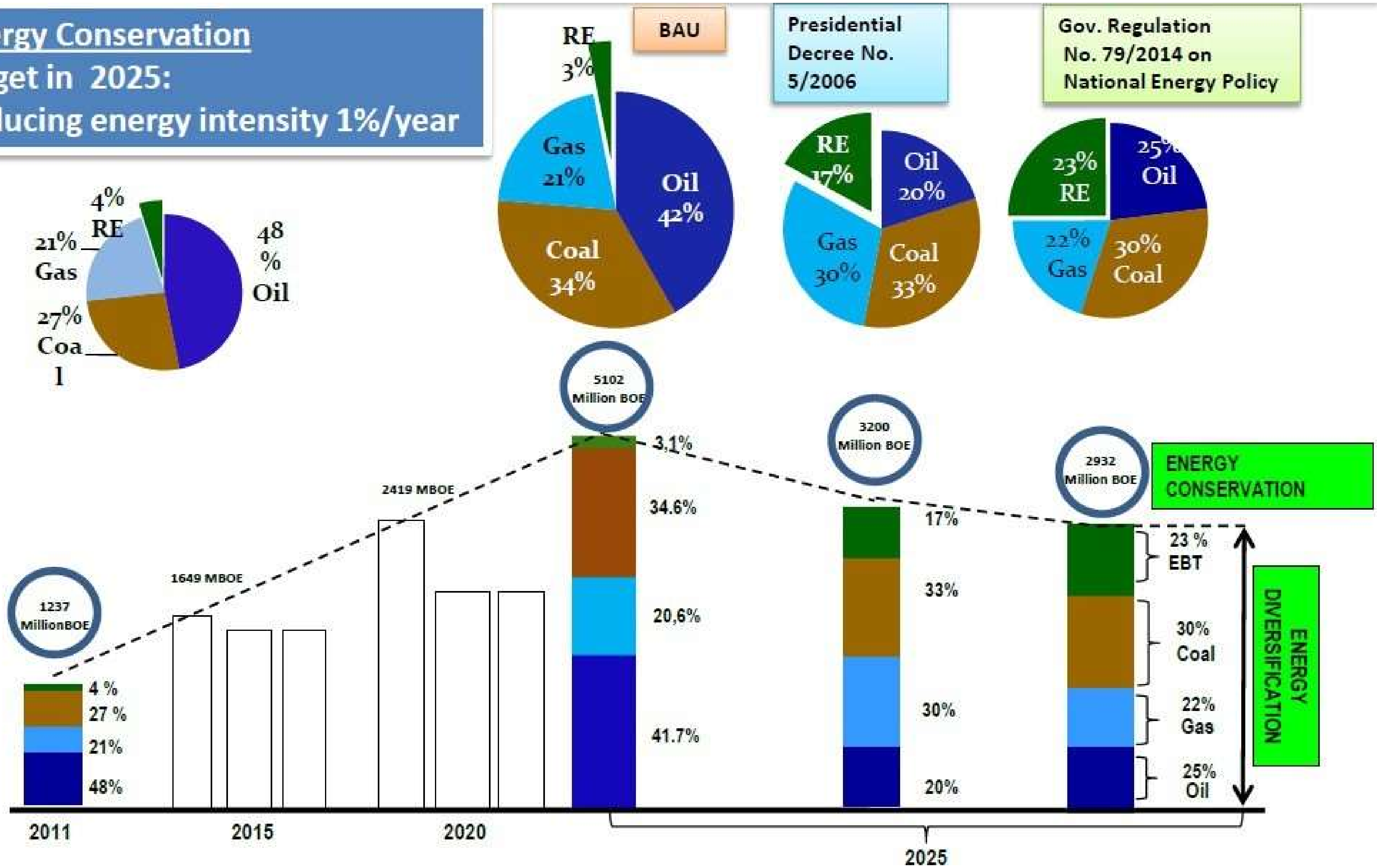
- **Regulation:** Mandatory **Minimum energy performance standards (MEPS)** eliminate the least efficient products from the market
- **Information: Energy performance labelling** allows consumers to make more informed purchasing decisions, given information about a product's energy use and operating costs
- **Incentives: High energy performance standards (HEPS)** promote the sale of the highest-performing products using financial incentives (such as obligation programmes and rebates) and technology product lists
- **R&D policy** can help drive innovation in the longer term

Indonesia's EE policy



Energy conservation direction

Energy Conservation
Target in 2025:
Reducing energy intensity 1%/year



Indonesia's Energy Saving Potential

INDUSTRY
Consumption 2016: 217 MBOE
Energy saving potential
10-30 %

Programs:
- Energy Audit / IGA / ESCO
- Energy Management / ISO 50001
- Online reporting system
- Energy manager & auditor certification
- Increase public awareness
- Pilot Project

COMMERCIAL
Consumption 2016: 40 MBOE
Energy saving Potential
10-30 %

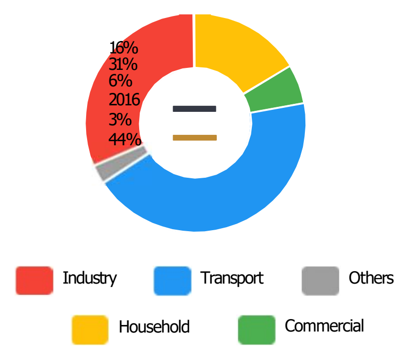
Programs:
- Energy Audit / IGA / ESCO
- Pilot Project
- Energy Efficiency Standard
- Online Reporting System for Government Building

TRANSPORT
Consumption 2016: 303 MBOE
Energy saving Potential
15-35 %

Programs:
- Mass transport (BRT/MRT/LRT)
- Fuel Switching (Fuel oil to Natural Gas & Biodiesel)
- Transport Management System

HOUSEHOLD
Consumption 2016: 115 MBOE
Energy saving Potential
15-30 %

Programs:
- EE Standard (Label/MEPS)
- Public awareness



Source: MEMR

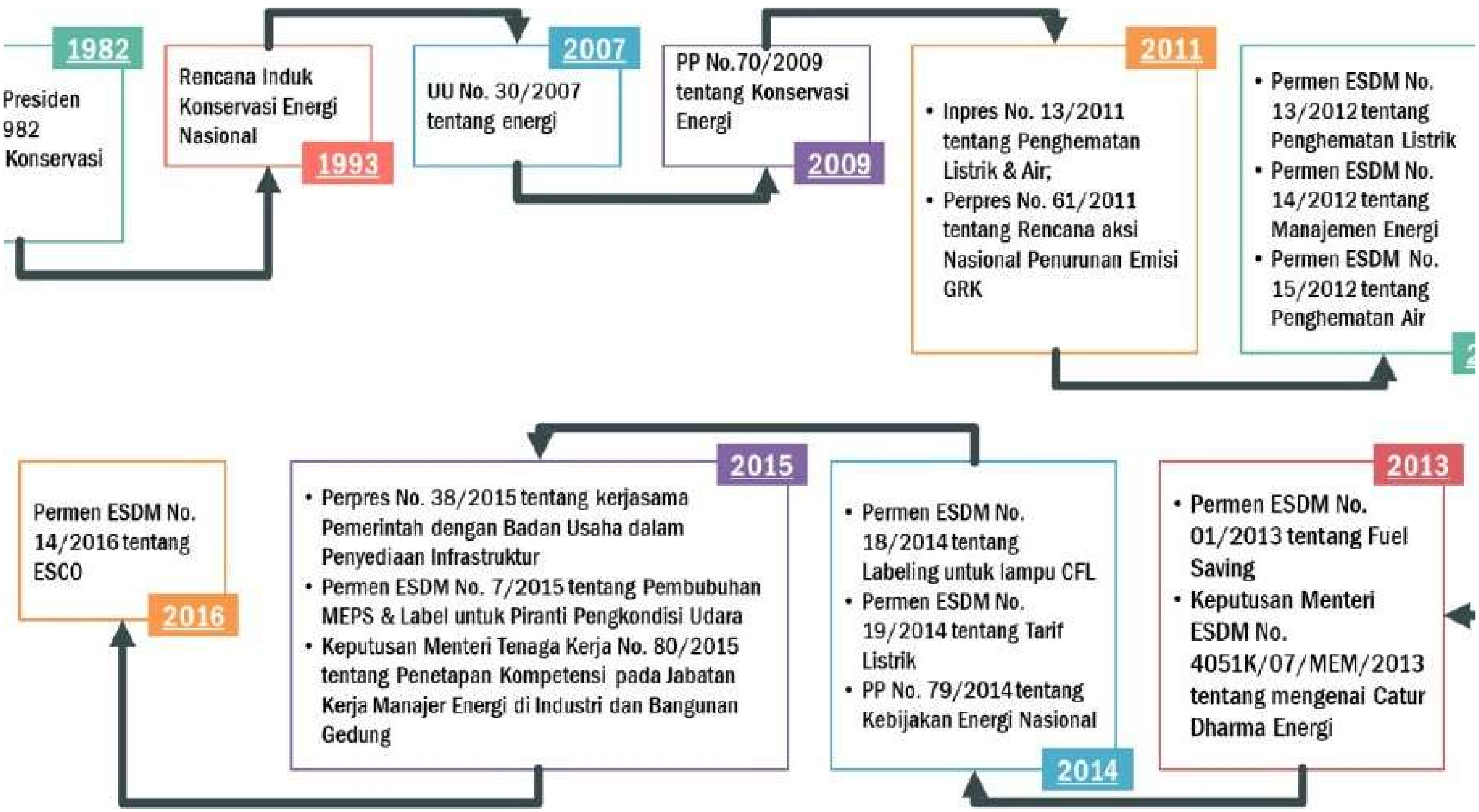
Energy Conservastion Roadmap

	UNIT	2010	2015	2020	2025	2030	2040	2050
FINAL ENERGY		**748**						
BAU SCENARIO	Million BOE		1.100	1.613	2.162	2.859	4.471	6.011
EFICIENT SCENARIO	Million BOE		1.026	1.393	1.796	2.272	3.518	4.691
SAVINGS	**Million BOE**		**73**	**220**	**367**	**586**	**953**	**1.319**
	%		**7%**	**14%**	**17%**	**21%**	**21%**	**22%**
ENERGY INTENSITY	BOE/BillionRp	344	325	296	258	229	181	134
ENERGY PERCAPITA	BOE/capita	3,15	4,10	5,35	6,60	8,14	11,80	15,25
CO2 REDUCTION POTENTIAL	**Million Ton**	**0**	**29.01**	**87.04**	**145.06**	**232.10**	**377.16**	**522.22**

1. Reducing energy intensity 1% per year and energy elasticity less than (1) in 2025
2. Final energy saving 17% in 2025

Source: EBTKE

EE Regulation



Energy conservation roadmap and targets

	UNIT	2010	2015	2020	2025	2030	2040	2050
FINAL ENERGY		748						
BAU SCENARIO	Million BOE		1.100	1.613	2.162	2.859	4.471	6.011
EFICIENT SCENARIO	Million BOE		1.026	1.393	1.796	2.272	3.518	4.691
SAVINGS	Million BOE		73	220	367	586	953	1.319
	%		7%	14%	17%	21%	21%	22%
ENERGY INTENSITY	BOE/BillionRp	344	325	296	258	229	181	134
ENERGY PERCAPITA	BOE/capita	3,15	4,10	5,35	6,60	8,14	11,80	15,25
CO2 REDUCTION POTENTIAL	Million Ton	0	29.01	87.04	145.06	232.10	377.16	522.22

1. Reducing energy intensity 1% per year and energy elasticity less than (1) in 2025
2. Final energy saving 17% in 2025

14

Source: EBTKE

Energy efficiency policies

Table 8 Summary of energy efficiency policies and programmes in the Asia-Pacific

	T&D Loss Reduction	Demand-Side Management	Efficient Lighting	Electric Appliance Standards/ Labels	Industrial/ Commercial Programmes/ Energy Audits	Building Codes	Combined Heat and Power	Energy Efficiency Funds
Bangladesh	✓	✓	✓	✓	✓		✓	
Bhutan				✓				
Cambodia			✓	✓				
Fiji					✓		✓	✓
India	✓	✓	✓	✓	✓	✓	✓	✓
Indonesia	✓	✓	✓	✓	✓	✓		
Lao PDR	✓	✓						
Malaysia				✓	✓	✓		
Mongolia	✓				✓	✓		
Nepal	✓							
Papua New Guinea						✓		
Philippines	✓	✓	✓	✓				
Samoa	✓		✓	✓	✓			
Solomon Islands	✓		✓	✓				
Sri Lanka				✓	✓	✓		✓
Thailand	✓				✓			✓
Vanuatu			✓	✓				
Viet Nam				✓	✓			

Source: Country Rapid Assessment and Gap Analyses, and Country Energy Reviews (2012).

Source: UNDP, 2013

MEPS

Table 1: Regulated Appliances and its Energy Performance Testing Standards

	Product	EPTS
1.	Ballast (magnetic)	SNI IEC 60929-2009
2.	Fluorescent lamps	SNI IEC 60901-2009
3.	Incandescent lamps	SNI IEC 60432-1-2009
4.	Room air conditioners - split type	ISO 5151
5.	Room air conditioners - window	ISO 5151
6.	Household refrigerators	SNI IEC 15502-2009
7.	Clothes washers	SNI IEC 60456-2009
8.	Electric irons	SNI IEC 60311-2009
9.	Vacuum cleaner	SNI IEC 60312-2009

Table 2: SNI for Buildings

1.	SNI 03-6389-2000	Energy conservation for building envelopes (*Konservasi energy selubung bangunan pada bangunan gedung*)
2.	SNI 03-6390-2000	Energy conservation for air-conditioning systems in buildings (*Konservasi energy system tata udara pada bangunan gedung*)
3.	SNI 03-6197-2000	Energy conservation for lighting systems in building structures (*Konservasi energy system pencahayaan pada bangunan sedung*)
4.	SNI 03-6196-2000	Energy auditing procedure for buildings (*Prosedur audit energy pada bangunan gedung*)

EE policy industrial sector in ASEAN

- Different in applied policy depending on industrial structure.

	Management	Standard / labeling	Financial support
Brunei	Voluntary	N/A	N/A
Cambodia	Regulatory	N/A (planning)	N/A
Indonesia	Regulatory	Standard + Labeling	Grant
Japan	Regulatory	Standard	Grant + Tax
Korea	Regulatory + Voluntary	Standard	Grant + Tax + Loan
Lao PDR	Voluntary	Standard (planned)	Tax
Malaysia	Voluntary	N/A	Grant + Tax + Loan
New Zealand	Voluntary	Standard	N/A
Singapore	Regulatory + Voluntary	Standard + Labeling	Grant + Tax
Viet Nam	Regulatory	Labeling	Tax

EE policy commercial and residential sector in ASEAN

- Standard and labeling system is commonly applied.

	Management	Standard / labeling	Financial support
Brunei	Regulatory + Voluntary	Standard	N/A
Cambodia	Regulatory	NGuideline	N/A
Indonesia	N/A	Standard + Labeling	N/A
Japan	Regulatory	Standard + Labeling	Grant + Tax
Korea	Regulatory + Voluntary	Standard + Labeling	Grant + Tax + Loan
Lao PDR	Regulatory + Voluntary	Labeling (planned)	Grant
Malaysia	Voluntary	Standard + Labeling	Grant
New Zealand	Voluntary	Standard + Labeling	N/A
Singapore	Regulatory + Voluntary	Standard + Labeling	Grant + Tax
Viet Nam	Regulatory + Voluntary	Labeling	Tax

Energy efficiency Indonesia by IEA

Highlights

- **Indonesia is the largest energy consumer in Southeast Asia, accounting for over 36% of the region's primary energy demand.** Between 2000 and 2015, Indonesia's gross domestic product (GDP) doubled and its demand for electricity increased 150%. Economic growth is set to drive up Indonesia's energy needs. It is projected that electricity generation capacity will need to increase by 4.1 gigawatts (GW) per year to 2030, with 50% coming from coal-fired power plants. Efficiency will be essential to avoid unnecessary energy use and expenditure and reduce emissions.

- **Effective implementation and enforcement of current energy efficiency policies are projected to deliver a 2% reduction in energy use by 2025.** Enhancements to existing policies, and planned policies that have not yet been implemented, could achieve a further 4.5% reduction against a scenario with no policy change. However, beyond this there remains scope for greater savings.

- **Significant electricity savings are possible from improvements in the energy efficiency of lighting.** Switching to compact fluorescent lamps (CFLs) over the last decade with the help of government programmes saved Indonesian consumers USD 3.3 billion on their electricity bills in 2016. Light-emitting diodes (LEDs), which are even more efficient, are now taking a growing market share, reaching 30% of all lightbulb sales in 2016. If the current rate of LED uptake continues, Indonesian consumers could save nearly USD 560 million per year by 2030.

- **The take-up of more efficient space cooling technologies could save Indonesian consumers nearly USD 690 million per year by 2030.** Demand for space cooling is growing quickly and is likely to double between 2016 and 2020. Minimum energy performance standards (MEPS) for air conditioners were put in place in 2016, but current levels are not having a substantial effect on the market. If Indonesia accelerated the implementation of regional targets for space cooling energy efficiency, it could avoid 32 PJ of electricity consumption by 2030.

- **There is considerable potential to save energy in Indonesia's transport sector through increased uptake of electric motorcycles.** Two-wheelers are the leading form of passenger transport in Indonesia, with 80 million in use. If the penetration of more efficient electric two-wheelers was boosted to match the current level in China, Indonesia's spending on oil imports would be cut by USD 800 million in 2030. Local air pollution would also be reduced.

- **The introduction of fuel efficiency standards for heavy-duty vehicles (HDVs) – medium and large freight trucks – will also produce significant savings.** HDVs currently account for 40% of the country's total road transport energy use and it is projected that HDV fuel demand will grow 70% between 2015 and 2030. If Indonesia introduced HDV fuel efficiency standards that improved efficiency at the same rate as in China, USD 630 million in oil imports could be avoided in 2030 alone. Together with the increased uptake of electric motorcycles, savings in 2030 of over 75 000 barrels of oil per day could be achieved, equivalent to 13% of Indonesia's current net oil imports.

Source: IEA, 2017

Box 3.2. China: The story of an evolving ESCO market

In 2018, revenue from Chinese ESCOs totalled CNY 117 billion (Chinese Yuan renminbi, USD 16.4 billion), up 3% from 2017. Compared with 2011-2015, when the average annual growth rate was over 25%, the market is expanding at a significantly slower pace, reflecting changes to the policy landscape and market dynamics.

Initially, government subsidies rewarded ESCOs for the energy savings they achieved, in order to spur the market. Since 2015, central government agencies have phased out five subsidies and financial incentive programmes, with the goal of directing the ESCO industry from a policy-driven to a market-driven environment (Ministry of Finance, China, 2015).

The withdrawal of national government subsidies does not appear to have halted the ESCO market growth trend, probably because the Chinese ESCO market is mature and provincial and municipal governments have continued some tax rebates and financial incentives. In some regions, however, companies that were overly reliant on favourable national policies are gradually exiting the market (EMCA, 2019).

Another dynamic demonstrating the maturity of the Chinese ESCO market is the diversification of business models and actors in the market. In the early stages of China's ESCO market, the only contractual models used were energy performance certificates under the shared savings model. By 2018, shared savings contracts had declined to 48% of market share, with other contract models, including guaranteed savings, outsourced energy services and financial leasing, taking up more than half (EMCA, 2019).

Over time, more diverse actors have joined the ESCO market, which had been dominated by "traditional" ESCOs focused on equipment replacement. More companies are gradually entering that have expertise in other sectors, including technology (hardware) providers, software developers and building service management companies. This shift reflects technology trends, as emerging digital technologies allow for additional energy saving opportunities and other value-add services to be captured. It also signals a potential shift in the demands of ESCO clients, which may be moving beyond a singular focus on energy savings.

Source: IEA, 2019

Thank You