Nahed Taher · Bandar Hajjar

Energy and Environment in Saudi Arabia: Concerns and Opportunities

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Introduction

The global dilemma of environmental issues in the past three decades has resulted in awakening of the whole world. These issues, which are largely associated with humankind's insatiable quest for natural resources in the industrialization process, have raised global concerns for a considerable period of time, such that during the past few decades a number of high powered reports have highlighted and proffered a wide range of solutions to such challenges both at national and international levels. At the international level, tackling environmental problems, such as global warming, depletion of the ozone layer, contamination of coastal and marine resources, and diminution of tropical forests, requires concerted efforts of all countries, as well as cross-border cooperation and agreements. At the national level, however, the nature and extent of the challenges exhibit considerable variation across countries, and some countries especially in the developed world and in key emerging economies have turned these environmental challenges into profitable business opportunities that have attracted significant volumes of private investments.

Meanwhile, the Kingdom of Saudi Arabia as the world's largest producer of oil and an oil revenue-dependent economy has taken these issues lightly, although it had long been participating in international environmental events, particularly those associated with ecological problems arising from fossil fuel. Lately, however, Saudi Arabia looked very differently at these environmental challenges as uniquely associated with paradigm shifts in the nature and composition of its oil wealth with serious implications for future government revenues, foreign exchange earnings, and sustainable economic growth and development. With over 260 billion barrels of proven oil reserves, the Kingdom is home to the world's largest oil reserves, accounting for 25 % of the known global oil reserves. Oil accounts for around 90 % of the Kingdom's total export earnings and a significant proportion of government revenues, which support the execution of developmental programs across all sectors of the economy. But the vast endowment of oil resources has for decades encouraged a generous system of oil subsidies, making Saudi Arabia one of the leading countries in the world with the cheapest domestic price of oil. Unfortunately, however, such subsidies have encouraged inefficient utilization of oil which is largely consumed in the power, water, and transportation sectors. These problems are exacerbated by the rapidly growing population, urbanization, changes in income and consumption patterns, as well as industrialization. If current domestic consumption pattern persists, Saudi Arabia will consume the whole of the oil it produces by 2030, which will reflect negatively on the financial capacity of the government to execute its development plans.

Thus, the concerns for Saudi Arabia are largely viewed from resource constraint perspective rather than from challenges caused by CO_2 emissions alone, as such environmental challenges in the kingdom could be a blessing in disguise, which could form the basis of profitable investment opportunities. Nonetheless, the growing demand on water for residential, industrial and irrigation purposes has led to the expansion of desalination capacity and power generation stations which rely heavily on burning fossil fuel, which can be harmful to the environment. Urbanization has advanced quite rapidly in Saudi Arabia, and has added a new dimension to the environmental challenges. Moreover, building more entertainment, commercial, and residential projects on the beaches has caused irreversible harm to the coral reefs. It is clearly apparent that the pace of the challenges is increasing despite the continuous efforts to reduce the impact of such challenges. It is rather disappointing that in the Kingdom as much as in the rest of the world, the population is continuing to inhale polluted air from industrial chimneys and car exhausts, eat general foods that are full of chemicals, and sea foods that are fed by wastes thrown into the sea from residential and industrial networks. In essence, available statistics suggest that more than 30% of the world's population still cannot find clean drinking water and around 50% live in areas that lack sewage facilities. The blatant pollution of air, water, and land is the main cause of various deadly diseases, such as cancer, kidney failure, fibrosis symptoms, and other chronic diseases. Unless the root causes of these environmental challenges are addressed properly, the Kingdom's economic well-being will be grossly undermined and its industrialization aspirations will remain unfulfilled.

This book gives a different perspective on these challenges by looking at them as investment opportunities, not financial constraints on the government budget, as lessons of experience from many economies around the world demonstrate. The main objectives of the book are to examine the nature and extent of the environmental challenges facing Saudi Arabia, and to explore various options for turning these challenges into profitable investment opportunities that could create jobs, boost income, develop capability in clean energy technology, and promote environmental sustainability. As a major producer of oil, Saudi Arabia will surely continue to harness this valuable natural resource, but it is important that the Kingdom takes major strides to embrace, develop, and deploy clean energies, including energy efficient technologies. Attracting large-scale private sector investments into nonconventional energy sources in the Kingdom will, however, require a combination of financial and regulatory incentives as lessons from many developed and emerging economies would suggest. After all, Saudi Arabia has all the ingredients for development of renewable energy, such as solar, due to the abundance of sun rays that are key raw materials in the production of solar energy. By reforming the existing subsidy regimes and redirecting some of the fossil fuel subsidies to renewable energy and energy efficiency activities, the Kingdom could easily become a clean energy powerhouse that could enable it to establish a strong physical presence in the international export market for renewable energy. All these issues are covered in this book.

Chapter 1 of the book discusses the various environmental challenges in Saudi Arabia, and assesses the nature and extent of the existing national institutions, policies, and regulatory framework for environmental protection in the Kingdom. In order to attract significant private sector participation in clean technology investments that would help to tackle environmental concerns in the Kingdom, there is a need to restructure and strengthen institutions, as well as to review and revamp the General Environmental Law and the bylaws to accommodate ongoing developments and to foster collaborations between research institutions.

The link between environmental challenges and sustainable economic growth is explored in Chap. 2. In particular, the chapter estimates the opportunity costs of domestic oil usage in the power, water, and transportation sectors, suggesting that total revenue losses from increased domestic oil consumption in these three sectors during the next three decades could be colossal.

Chapter 3 discusses the challenges of mobilizing global capital into clean energy technology and other related industries with a view to providing important lessons for Saudi Arabia where environmental investments are currently negligible. If the Kingdom is to achieve sustainable growth and development, which in itself is a bankable concept, concerted efforts must be made to promote and attract substantial volumes of environmental investments.

Chapter 4 of the book discusses the various incentive structures that the government of Saudi Arabia could bring to bear on clean energy technologies in the Kingdom. It highlights the benefits of environmental investments, particularly in achieving both commercial and social objectives by generating high rates of return for investors and promoting environmental sustainability, economic prosperity, and social well-being. In addition, in many developing countries, investments in green projects such as renewable energy face significant barriers including highly subsidized prices of conventional energy products and a lack of comprehensive policy agenda and political commitment. These and other related factors serve to discourage private sector involvement in environmental investments in many emerging and developing countries. Overcoming these constraints would require substantial government intervention through a wide range of incentives on environmental investments, as discussed in the chapter.

Chapter 5 discusses the relative merits and demerits of a wide range of environmental business channels based on projected future trends and global opportunities. The chapter not only examines the nature and extent of the global clean energy business, but also it estimates the elasticities of environmental business with respect to policy incentives. The aim is to determine the impact of incentives on environmental business in order to unearth the relative importance of these business clusters and their potential for profitable entrepreneurial opportunities in Saudi Arabia.

Chapter 6 provides a roadmap on clean technology investments in Saudi Arabia in light of the outlook for global economic growth, demand for conventional oil, developments in renewable energy sources, and demographic dynamics. The aim is to produce a sustainable energy blueprint that explicitly identifies a pathway for Saudi Arabia to achieve its full potential for optimal energy mix. It should be noted that clean energy involves a wide range of different industries and subsectors; each of these requires to be tackled independently. The Kingdom, therefore, has to focus on the most relevant sectors and subsectors in its strategic plan toward achieving a green economy.

Preface

The idea of writing a book on energy and the environment in Saudi Arabia has emerged from a series of debates and discussions by the authors on the environmental challenges facing the world in general, and Saudi Arabia in particular. The book focuses on these challenges from a different perspective by looking at them as investment opportunities rather than additional financial constraints on fiscal space. This innovative perspective was sparked by debates provoked by the strategic move by the Custodian of the Two Holy Mosques, King Abdullah Bin Abdulaziz Al-Saud, towards diversification of the Kingdom's sources and usage of energy rather than dependence on "OIL" as the single source of energy. As a first step towards actualizing the strategic vision on energy and economic diversification, the King Abdullah City for Atomic and Renewable Energy (KACARE) was established. The authors have been major participants in conferences and seminars in different energy and environmental issues, locally and internationally. And one of the authors participated in advising and executing some energy and PPP projects in the Kingdom, and sits on the Advisory Board of King Abdullah Petroleum Studies and Research Center (KAPSARC). The other author, by being a member of the economic and energy committee in the Saudi Shoura Council for various years, has participated in setting and reviewing laws and bi-laws of related issues. These have enabled the authors to gain massive insights into the energy and environmental challenges and business opportunities in the Kingdom. Although the debate on this topic is ongoing, there is consensus on the need to crystallize the innovative ideas into a book for the benefit of all stakeholders, especially policy makers and the business community, based on a succinct review of best international practices and custom-tailoring them to fit the special peculiarity of the Kingdom. Thus, the main objectives of the book are to examine the nature and extent of the energy and environmental concerns facing the Kingdom of Saudi Arabia, and to explore various options for turning these challenges into profitable investment opportunities that could create jobs, boost income, develop capability in clean energy technology, and promote environmental sustainability.

The bulk of the book was written more than one-and-a-half years ago, but it is only now that it is being released for publication. With God's blessing, we hope that through this book we have managed to convey the Kingdom's efforts, locally and internationally, in diversifying energy resources and usages. It is hoped that by pursuing a mixture of conventional and renewable energy as its long term policy and strategic goal, Saudi Arabia could retain its position as the leading economy in the international energy market in many decades to come.

Contents

Acronyms

ADICE	Australian Dynamic Integrated Model of Climate and the Economy
ADWEA	Abu Dhabi Water and Electricity Authority
BOT	Build Operate Transfer
BRICS	Brazil, Russia, India, China, and South Africa
CAGR	Compound Annual Growth Rate
Capex	Capital Expenditure
CDM	Clean Development Mechanism
CER	Certified Emissions Reductions
CFIs	Commercial Financial Institutions
CHP	Combined Heat and Power
CIWM	Chartered Institute of Waste Management
CLC 1969	Civil Liability for Oil Pollution Damage of 1969
CO_2	Carbon Dioxide
CORFO	Corporación de Fomento de la Producción de Chile
CSP	Concentrating Solar Power
CUSUM	Cumulative Sum of Regression Residuals
CUSUM-SQD	Cumulative Sum of Regression Residuals Squared
DEWA	Dubai Electricity and Water Authority
DFIs	Development financial institutions
DNA	Designated National Authorities
EBRD	European Bank for Reconstruction and Development
ECRA	Electricity Cogeneration and Regulatory Authority
EE	Energy Efficiency
EFs	Environmental Funds
EGS	Environmental Goods and Services
EIA	Energy Information Administration
EKC	Environmental Kuznets Curve
EPA	Environmental Protection Agency
EPC	Engineering, Procurement and Construction
EPI	Environmental Pollution Index
ERPA	Emissions Reductions Purchase Agreements

ESCO	Energy Service Company
ESCWA	United Nations Economic and Social Commission in Western Asia
ESG	Environmental, Social and Corporate Governance
ETS	Emissions Trading Schemes
EU	European Union
FIT	Feed-in Tariffs
GCC	Gulf Cooperation Council
GDP	Gross Domestic Product
GEL	General Environment Law
GHG	Green House Gas
GW	Giga Watts
IEA	International Energy Agency
IEEJ	The Institute of Electrical Engineers of Japan
IESE	Instituto de Estudios Superiores de la Empresa Business school
IFC	International Finance Corporation
IMF	International Monetary Fund
IPO	Initial Public Offering
IREDA	India Renewable Energy Development Agency
IRENA	International Renewable Energy Association
IRR	Internal Rate of Return
ITC	Investment Tax Credits
IWPP	Independent Water and Power Project
KACARE	King Abdullah City for Atomic and Renewable Energy
KACST	King Abdulaziz City for Science and Technology
KAPSARC	King Abdullah Petroleum Studies and Research Centre
KAUST	King Abdullah University of Science and Technology
Kg	Kilogram
KSA	Kingdom of Saudi Arabia
kWh	Kilo Watt Hour
kWp	Kilowatt-Peak
LCOE	Levelized Cost of Electricity
LED	Light Emitting Diode
LEED	Leadership in Energy and Environmental Design
M^3/D	Cubic Meter Day
mbd	Million Barrel Day
mboe	Million Barrels of Oil Equivalent
MBR	Membrane Bio Reactor
MENA	Middle East and North Africa
MEPA	Meteorology and Environmental Protection Administration
MEPS	Minimum Energy Performance Standards
MNRE	Ministry of New and Renewable Energy
MW	Mega Watts
NA	Not Available

O&M	Operations and Maintenance
OECD	Organization for Economic Co-operation and Development
Oilpol 1954	International Convention for the Prevention of Pollution of the Sea by Oil of 1954
PFI	Private Finance Initiative
PFMs	Public Finance Mechanisms
PME	Presidency of Meteorology and Environment
POTWs	Publicly Owned Treatment Works
PPP	Purchasing Power Parity
PPPCU	Public Private Partnership Central Unit
PPPs	Public Private Partnerships
PTC	Production Tax Credits
PV	Photovoltaic
R&D	Research and Development
ROE	Return on Equity
RES	Renewable Energy Sources
RFI	Radio Frequency Interference
RO	Reverse Osmosis
RPS	Renewable Portfolio Standard
SAPTCO	Saudi Public Transport Company
SAR	Saudi Riyals
SEC	Saudi Electricity Company
SEPA	State Environmental Protection Administration
SIC	Standard Industry Classification
SMEs	Small and Medium Enterprises
SO_2	Sulphur Dioxide
SOPs	Standard Operating Procedures
SPV	Special Purpose Vehicle
SSL	Solid State Lighting
STEG	Société Tunisienne de l’Electricité et de Gaz
SWCC	Saline Water Conversion Company
SWFs	Sovereign Wealth Funds
SWH	Solar Water Heating
SWRO	Sea Water Reverse Osmosis
UAE	United Arab Emirates
UK	United Kingdom
UN	United Nations
UNEP	United Nations Environment Programme
UNFCC	United Nations Framework Convention on Climate Change
US	United States of America
US$	American Dollar
UV	Ultra-Violet
VAT	Value Added Tax
VC	Venture Capital

VCPE	Venture Capital – Private Equity
VCs	Venture Capitalists
VSPP	Very Small Power Producer
WAMITAB	Waste Management Industry Training and Advisory Board
WEC	Water and Electricity Company

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About the Authors

Dr. Bandar Hajjar obtained his Master's degree in Economics from Indiana University in the United States and a PhD in Economics from Loughborough University in the UK. The title of his PhD thesis is "Financing Small Businesses in Saudi Arabia. After completing his doctoral studies, Dr. Hajjar returned to Saudi Arabia to teach in King Abdulaziz University in Jeddah, where he became the Vice Dean of the Faculty of Administration and Economics. Then he became a member of the Shoura Council and later became its Vice President. Dr. Hajjar has served as a member of the Council's committee on economics and energy as well as that of Foreign Affairs. Dr. Hajjar founded and headed the Human Rights Commission in Saudi Arabia. He also served as Chief Editor of Money and Markets magazine, a specialized economic magazine in Saudi Arabia, for over a decade. He also headed the investment committee of King Abdulaziz "Al-Aziziah" Water Endowment in Jeddah for various years. Dr. Hajjar also participated in several energy and environment conferences globally.

Dr. Nahed Taher is the Founder and Chief Executive Officer (CEO) of *Gulf One Investment Bank* in Bahrain and Chairman of *Gulf One Capital* in Saudi Arabia. Dr. Taher got her MSc in International Economics from King Abdul-Aziz University Jeddah as well as a Master's degree and PhD in Economics from the University of Lancaster in the UK, before returning to King Abdul-Aziz University where she had been teaching since 1990. She also worked with Saudi Arabia's National Commercial Bank (NCB) as Senior Strategy Economist and Chairman of the Portfolio Management Committee. In 2005, Dr. Taher became the CEO of *Gulf One Investment Bank*, becoming the first woman to lead a bank in the Gulf Cooperation Council region. Dr. Taher sits on boards and committees of a number of national and international institutions and organizations, including King Abdullah Petroleum Studies and Research Centre; International Institute for Management Development (IMD) in Switzerland; Saudi-German Business Group; Moya Water Company; and the Presidency for Meteorology and Environment, Saudi Arabia's Supreme body on the Environment. Dr. Taher has also been ranked by *Forbes Magazine* and the UK *Financial Times* among the top business women in the world for various years.

Chapter 1
Environmental Challenges, Regulations and Institutions in Saudi Arabia

1.1 Overview

It is widely recognized that the current global environmental problems largely stem from man's unreasonable exploration and exploitation of natural resources for economic development purposes. Like many other developing countries, the Kingdom of Saudi Arabia faces various environmental challenges. These challenges escalate as a result of rising population growth, urbanization, industrialization and expansion of transportation.

More importantly, from the unique position of Saudi Arabia in the international energy market, the Kingdom has its specific ecological concerns, as accelerating demand for power, water and transportation (highly dependent on burning oil or natural gas) in the Kingdom has created various challenges to the environment. Noteworthy are non-targeted subsidies (i.e. subsidies being provided to all people regardless of their income level and status), which had contributed substantially to encouraging the current high domestic consumption of oil in transportation, utilities and other sectors of the local economy.

Meanwhile, the high local consumption of oil, triggered by the above-mentioned factors, has become a major source of concern to the Kingdom which has recently nudged policymakers into making new moves in new directions in the energy sector, focusing on renewable and clean energy development. The new approaches are aimed to serve dual objectives of reducing oil consumption, and hence free more oil for exports in the global market, and have a much cleaner environment in tandem. We believe Saudi Arabia should not take offensive decisions to protect the world oil market in this age of worries on energy security. The Kingdom should rather accept responsibility for the increasing demand for energy. As a leader in the world energy market, the Kingdom should lead in taking proactive actions in the renewable energy and environmental business to respond positively to current trends and exploit new market opportunities based on its competitive edge.

Beyond the energy sector, the Kingdom is well known for the accumulation and build-up of waste including residential, commercial, medical and industrial wastes. Sewage waste, which increases the level of air and marine pollution, has increased massively in the Kingdom. In addition, the growing demand of water for residential,

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industrial and irrigation purposes has led to the expansion of desalination capacity and power generation stations which rely heavily on burning fossil fuel. This has harmed the environment enormously in different ways. Urbanization, which has advanced quite rapidly in Saudi Arabia, has also added a new dimension to the environmental challenges. Although the Kingdom is a desert by nature, industrial and residential urbanization had impacted adversely on its agriculture sector in various regions of the Kingdom, such as Madinah, Abha and Al-Ahsaa.

Moreover, building more residential, commercial and entertainment projects on the Kingdom's coastlines has caused irreversible harm to the coral reefs. Environmental deterioration of Saudi shores and marine pollution in the Red Sea and the Gulf, disposal of home and hotel wastes into the sea, sewage waste and water desalination salt and waste that is either thrown in the sea or injected deeply in the ground could all harm the environment massively. These kinds of challenges have been turned into environmental business opportunities in other countries of the world, and so Saudi Arabia should borrow a leaf from these countries to turn its wastes into profitable business opportunities, including recycling of these wastes (medical, industrial and electronic wastes) as a recent study by the Presidency of Meteorology and Environment (PME) has illustrated.

The key question is why did other countries manage to succeed in turning these challenges into investment opportunities while others did not. The answer lies in the presence of appropriate laws and regulations and the enforcement of the laws in addition to effective coordination and collaborations between related institutions in executing or implementing these regulations in a very professional and organized manner. This chapter sheds light on these issues, as it aims to undertake a condensed assessment of the nature and extent of the current national institutions, policies and regulatory framework for environmental protection in Saudi Arabia. Section 1 of this chapter discusses the various environmental challenges. Sections 2 and 3 examine the environmental regulations and institutions, respectively. Section 4 looks at lessons on environmental laws from around the world, while Section 5 provides a comparative assessment of Saudi Arabia's environmental laws on waste control and management vis-à-vis similar laws in other countries. Section 6 highlights lessons on energy efficiency and Section 7 pulls together the main conclusions of the chapter.

1.1.1 Key Environmental Challenges

As stated earlier, the key environmental challenges facing the Kingdom of Saudi Arabia are varied but a great part of them is directly linked to inefficiencies associated with the regimes of subsidies which encourage increased domestic consumption of oil in different manners. Others, in turn, generate increased environmental effluents (pollution, waste, CO_2 emissions and environmental degradation) that not only affect the health and well-being of the people but also undermine the sustainability of economic growth and prosperity of the Kingdom.

Table 1.1 Energy subsidies in selected Arab oil-producing countries, 2010. (Source: International Energy Agency (2010), *World Energy Outlook 2010*, Paris: IEA Press)

	Average rate of subsidization (%)	Subsidy (US$/person)	Total subsidy (% of GDP)	Subsidy by fuel			Total subsidy (US$ bn)
				Oil	Gas	Electricity	
Algeria	59.8	298.4	6.6	8.46	0	2.13	10.59
Libya	71	665	5.7	3.17	0.26	0.78	4.21
Egypt	55.6	250.1	9.3	14.07	2.4	3.81	20.28
Saudi Arabia	75.8	1,586.60	9.8	30.57	0	12.95	43.52
Iraq	56.7	357.3	13.8	8.87	0.28	2.16	11.31
Kuwait	85.5	2,798.60	5.8	2.81	0.9	3.91	7.62
Qatar	75.3	2,446.00	3.2	1.15	1.41	1.59	4.15
UAE	67.8	2,489.60	6.0	2.65	9.99	5.51	18.15

GDP gross domestic product.

Table 1.2 Estimates of government subsidies in Saudi Arabia, 2011–2020. (Source: Ibrahim Al-Omar, *Al Watan Newspaper*, 17 October 2012)

Year	SAR billion
2011	254.87
2012	270.63
2013	287.37
2014	305.14
2015	324.01
2016	344.05
2017	365.32
2018	387.92
2019	411.90
2020	437.36
Total	3,388.59

Saudi Arabia and other Gulf Cooperation Council (GCC) countries tend to have the highest rates of energy subsidies per capita in the Middle East and North Africa (MENA) region, ranging from US$ 1,587 per person in Saudi Arabia to US$ 2,798 per person in Kuwait. In terms of absolute value of subsidies, Saudi Arabia has the largest subsidy regime worth US$ 43 billion in 2010 (Table 1.1).

In essence, the size of the government subsidy on energy consumption in Saudi Arabia has increased substantially during the past decades growing at an annual average rate of 25 % and, on current trends, the subsidy will amount to a whooping Saudi riyals (SAR) 3.39 trillion (US$ 904 billion) by the year 2020, from SAR 270 billion or US$ 72 billion in 2012 (Table 1.2). Such a subsidy regime keeps prices low, encourages increased consumption and discourages energy efficiency as well as research and development in clean energy, which includes both renewable energy and energy efficiency. It also increases government expenditures and exacerbates income inequality between the different classes of the society as the money used to subsidize oil for all could be more efficiently used directly to help promote economic diversification and development.

It is estimated that of the SAR 1.3 trillion total fuel subsidy granted during the last decade, around 10 % of it, equivalent to about SAR 150 billion, was on account of smuggling and illegal exports. The extent of subsidy in the Kingdom reflects the large difference between domestic and international prices. For example, according to Al Omar (2012), crude oil is sold locally for one fifth (20 %) its international price, while gasoline is sold locally at 10 % its price in Europe and one seventh of its price in the USA. Subsidies on the production of electricity and desalinated water are also similar to those granted for crude oil. This large difference between global and domestic energy prices is on account of indirect support provided by the government to abuse energy sources, and, at the same time, it represents a distortion of the market mechanism that would otherwise lead to an automatic balance between energy supply and present and future needs/demand for energy.

Opinion is, however, divided on the desirability or appropriateness of these subsidies. On the one hand, critics have argued that the subsidies per se are not the main problem but the non-discriminatory nature of the subsidies makes it highly inefficient, unfair and inequitable and undermines social justice and sustainable economic growth by encouraging conspicuous activities (consumption and production) that are harmful to the economy. Thus, opponents of the current subsidy regimes have argued that subsidies should be targeted and means tested so that they should only be provided to individuals and organizations that deserve it instead of giving it to each and every one.

On the other hand, however, proponents of the current subsidy regime in the Kingdom argue that subsidies constitute an effective method of redistributing the Kingdom's oil wealth to the population at large. Strictly speaking, they argue that the energy subsidy, reflected in the low cost of fuel and public utilities in Saudi Arabia, cannot be regarded as subsidies per se as they do not entail explicit government transfer to individuals. Rather, the low energy prices reflect the comparative advantage the Kingdom has in natural resource endowment, as although the domestic energy prices are lower than the international energy prices, they are well above the costs of production. This implies that the lower domestic oil prices do not, in themselves, wreck financial havoc to national oil dealers, and, hence, the government does not need to make an explicit transfer to compensate the national oil companies' financial losses.

Even so, critics have pointed out that the relatively low energy pricing structure involves an implicit subsidy or an implicit government transfer. It is implicit subsidy because the economic rent or revenue is wasted by failing to sell oil at the higher international market prices. It also involves a transfer from the government to the final consumers without such a transfer appearing explicitly on state oil companies' records or in the government budget. If this foregone revenue had been collected, it could have been used by the government in a variety of ways, including, for instance, to increase spending in more productive areas such as infrastructure, education and health; and to provide incentives on investments in environmental protection activities. Furthermore, because losses in foregone revenues on government records are implicit, it is difficult for governments to convey these to the public as real losses or costs. Also, the lack of transparency about the size of the implicit transfers, their direct and indirect costs and the identities of the main beneficiaries makes it difficult for governments to initiate energy pricing reform.

Nonetheless, the subsidy regimes in Saudi Arabia play a key role in promoting high and inefficient consumption of domestic oil, especially in the power, water and transportation sectors. It is, therefore, not surprising that these three sectors account for not only the lion's share of domestic consumption of oil, but also the bulk of environmental damage in Saudi Arabia.

The transport sector, in particular, will continue to pose serious challenges for environmental protection efforts in Saudi Arabia, as the very limited means of public transportation system for citizens implies that the Kingdom has one of the highest numbers of cars per population. Greater reliance on private transport and increased size and number of cars lead to congestion in huge streets and roads. The significantly high ratios of private car ownership, including by youth and low-wage labour, create nuisance and misuse of vehicles inside and outside the cities.

Recent available data show that there were around 336 vehicles per 1,000 Saudis in 2008,[1] and this figure must be much higher now than it was 5 years ago due to growth in population and changes in disposable income and lifestyle. The transport sector will undoubtedly continue to rely on fossil fuel energy regardless of the situation since renewable energy developments are likely to be more amenable to the power sector than the transport sector in the medium term due to the complex nature of energy substitutability in the transport sector. Of course, Saudi Arabia has a public transportation system operated by the Saudi Public Transport Company (SAPTCO), which, in turn, operates a fleet of around 3,000 buses of various capacities and sizes carrying out nearly 580 scheduled trips across 600 cities, towns and villages in the Kingdom.[2] However, this transportation service is largely patronized by low-income, unskilled expatriate workers, and the system heavily relies on highly subsidized fossil fuel. Furthermore, the mechanical conditions of some of the buses used by SAPTCO do not meet strict environmental standards.

Water desalination activities pose yet another serious environmental challenge in Saudi Arabia. The Kingdom has a number of desalination and power stations (Table 1.3). In addition to Saline Water Conversion Company (SWCC), Water and Electricity Company (WEC) and Marafiq plants, there are a number of private sector water providers with significant facilities which have not been included in the table due to data unavailability. Saudi Arabia produces 24 million m^3 of water per day from desalination technology, accounting for half the world's total desalination output. The water desalination activities in the Kingdom use a tremendous amount of energy, equivalent to around 1.5 mmboe per day, to provide power to the Kingdom's 30 government-operated water desalination plants. Undoubtedly, these activities pose serious environmental challenges unless sustained efforts are

[1] CIA World Factbook, https://www.cia.gov/library/publications/the-world-factbook/.

[2] These statistics are obtained from SAPTCO website: http://www.saptco.com.sa/en/company_profile.htm.

Table 1.3 Water desalination and power plants in Saudi Arabia. (Source: Saline Water Conversion Corporation Website at: http://www.swcc.gov.sa)

Location	Process type	Water capacity (M^3/D)	Power generation (MW)	Year of operation
SWCC-West Coast				
Shoaiba Phase 2	MSF	390,909	340.0	2002
Shoaiba Phase 1	MSF	191,780	157.0	1989
Jeddah Phase 4	MSF	190,555	500.0	1981
Yanbu Phase 2	MSF	120,096	35.0	1999
Yanbu RO	RO	106,904	NA	1999
Yanbu Phase 1	MSF	94,625	250.0	1981
Shuqaiq Phase 1	MSF	83,432	62.0	1989
Jeddah Phase 3	MSF	75,987	200.0	1979
Jeddah RO Phase 1	RO	48,848	NA	1989
Jeddah RO Phase 2	RO	48,848	NA	1994
Jeddah Phase 2	MSF	37,916	71.0	1978
Rabigh Transferred Phase 2	MED	18,000	NA	2009
Al Wajh Phase 3	MED	9,000	NA	2009
Al-Qunfidah Phase 1	MED	9,000	NA	2009
Ummlujj Phase 3	MED	9,000	NA	2009
Al Azizia Phase 1	MED	3,870	NA	1987
Dubai Phase 3	RO	3,784	NA	1989
Haqi Phase 2	RO	3,784	NA	1990
Ummlujj Phase 2	RO	3,784	NA	1986
Al Birk Phase 1	RO	1,952	NA	1983
Rabigh Phase 1	MSF	1,204	NA	1982
Farasan Transferred Phase 1	MSF	1,075	NA	1978
Al Wajh Transferred Phase 2	MED	1,032	NA	1983
Al Wajh Transferred Phase 1	MED	825	NA	1981
Rabigh Transferred Phase 1	MSF	774	NA	1979
Al Wajh Phase 2	MSF	473	NA	1979
Al Wajh Transferred Phase 3	MSF	473	NA	1979
Farasan Phase 1	MSF	430	NA	1979
Total		1,458,360	1,615.0	
SWCC-East Coast				
Jubail Phase 2	MSF	815,185	762	1983
Al Khobar Phase 3	MSF	240,800	311	2002
Al Khobar Phase 2	MSF	191,780	500	1982
Jubail Phase 1	MSF	118,447	238	1982
Jubail RO	RO	78,182	NA	2002
Khafji Phase 2	MSF	19,682	NA	1986
Total		1,464,076	1,811	
SWCC Grand Total		2,922,436	3,426.0	
Water production facilities				
Jubail WPP	MED	800,000	2,500.0	In Construction
Yanbu MSF 2	MSF	54,510	NA	1986
Yanbu RO	SWRO	50,400	NA	2007
Jubail 2	MSF	32,000	NA	1996
Yanbu MSF 3	MSF	27,400	NA	1996
Yanbu MSF 1	MSF	27,300	NA	1982

Table 1.3 (continued)

Location	Process type	Water capacity (M^3/D)	Power generation (MW)	Year of operation
Jubail 1	MSF	16,000	NA	1984
Total		1,007,610	2,500.0	
Additional plants				
Shuaiba III	NA	880,000	NA	2007
Ras Al-Zour	NA	800,000	NA	2007
Al Jubail II Ext	NA	730,000	NA	2007
Fujairah	RO	455,000	NA	NA
Al Jubail	NA	408,600	NA	2007
Al Jubail I Ext	NA	272,000	NA	2007
Al Jubail III	NA	272,000	NA	2006
Al Khobar IV	NA	272,000	NA	2006
Shuaiba IV	NA	272,000	NA	2007
Ras Az Zawr	NA	227,000	NA	2006
Al Bahah	NA	182,000	NA	2006
Al Wasia	NA	153,000	NA	2004
Tabul I	NA	113,636	NA	2007
Shuqaiq II	NA	109,000	NA	2006
Kindasa Water Services 2	NA	25,500	NA	NA
Kindasa Water Services 1	NA	14,000	NA	NA
Sawaco North Obhor	SWRO	13,350	NA	2006
Sawaco	NA	12,000	NA	NA
Jebel Ali Station	MSF	636	NA	2004
Total		5,211,722		

SWCC, Saline Water Conversion Corporation; MSF, multi-stage flash distillation; RO, reverse osmosis; MED, multi-effect distillation; SWRO, seawater reverse osmosis.

made towards clean energy technologies for desalination and power generation. It is reported that Saudi Arabia is currently building the largest solar-powered water desalination plant in the world in the city of Al-Khafji on the shores of the Persian Gulf (Saudi Gazette, 12 February 2012). This will go a long way in addressing some of the environmental challenges, but more of such initiatives need to be executed not only in the water desalination sector but also in the power and transportation industries.

Another environmental challenge facing Saudi Arabia relates to wastes of all kinds—residential, industrial, medical and electronic wastes—and lack of appropriate waste disposal systems. For instance, around 50,000 cubic metres of waste from Al Misk Lake in Jeddah are thrown into the Red Sea daily,[3] with serious implications for marine environment. The marine pollution not only has a negative impact on sea creatures but also poisons fish stock which, in turn, passes to human beings, thereby causing food-poisoning problems. These unnecessary health hazards could easily be avoided by treating the sewage wastes and reusing it in irrigation, industry and several services. This will provide substantial business opportunities in waste

[3] Saudi Gazette, 28 November 2009.

treatment and environmental protection that will have a huge positive financial and environmental impact on the Saudi economy.

There is also the issue of filling up of coastal areas with sand which affects environmental sustainability and leads to global warming. Similarly, building on and closing rain flood areas also creates environmental problems such as the 2009 Jeddah flood catastrophe which cost an estimated SAR 6 billion of damage.[4] Gas leakages also pose serious threats to the environment. For example, in Dammam there was a gas leakage from the Industrial City No. 1 which caused substantial air pollution. Such pollution is very dangerous as it causes severe irritation of the human respiratory system. Addressing these and related environmental issues could also provide green business opportunities.

What is worrying is that the rapidly changing demographic dynamics, changes in lifestyle and the rapidly expanding energy-intensive industries in the Kingdom will lead to an astronomical increase in the demand for power, water desalination and transportation in the next two decades. Thus, the opportunity cost of the domestic oil consumption in these three sectors alone will be colossal, estimated at around 35 % of government revenue by the year 2030, up from just 16.3 % of government in 2010. Moreover, in the absence of any credible energy efficiency and resource conservation policies, oil reserves would be decreasing rapidly with increasing costs of extraction so much so that the Kingdom could become a net importer of oil instead of its present status as the world's leading oil-exporting country if no action is taken. In addition, as fossil fuel (including oil) is not environmentally friendly, the increased domestic consumption of oil in the Kingdom could further exacerbate environmental degradation, thereby heightening the widespread concerns that, left unchecked, increased environmental pollution could retard economic growth and prosperity. Clearly, these potential challenges call for major policy actions in several fronts including promotion of energy efficiency and harnessing renewable energy technology, through a combination of incentives such as feed-in-tariffs, capital subsidies, investment credits, public investment, loans or financings as practised in many countries around the world.

1.2 Environmental Regulations

To address the myriad of environmental challenges, the Government of Saudi Arabia has over the past decades attempted to formulate a national environmental policy through a number of publications, including national development plans, periodic environmental reports, policy proposal reports and proceedings of conferences. Indeed, Saudi Arabia's attempts at crafting basic laws for the protection of the environment in the Kingdom dates back to the early 1970s when the government unveiled its first national development plan covering the period 1970–1975. A con-

[4] The National, 03 April 2011, cited on http://www.thenational.ae/business/industry-insights/economics/jeddah-floods-a-real-drain-on-its-economy.

siderable space in the plan was devoted to the link between economic development and environmental protection, with key environmental issues and policy direction for environmental protection highlighted. Successive development plans have also stressed the importance of environmental protection, with the current plan (Ninth Development Plan) emphasizing the strategic role of environmental management by ‘encouraging various developmental sectors to participate effectively in environmental activities, and developing the institutional and technical capacities of the parties concerned’ (Ninth Development Plan, 2010–2014, p. 235). In essence, the Ninth Development Plan adopted many policies and programmes for the protection and proper management of the environment as well as conservation and development of natural resources, including the following:

- ‘Improving environmental performance indicators of the sectors responsible for protection of the environment by enhancing the preventive mechanisms adopted for protection of the environment, conservation of natural resources and maintenance of public health.
- Preparing specialists in the field of environmental protection through appropriate education and training programs inside the Kingdom and abroad.
- Enhancing environmental management in the Kingdom by supporting mechanisms and channels of coordination and cooperation between the General Presidency for Meteorology and Environmental Protection and all other relevant agencies.
- Withstanding the pressures of increased urbanization and development in all sectors within the efforts of maintaining sustainable development.
- Seeking accuracy of monitoring and forecasts, and contributing to minimization of the impacts of natural disasters’.

Meanwhile, on the energy ecological side, the same development plan contains the following objectives:

- Maintaining petroleum resources and rationalisation in its consumption
- Maximization of both social and economic returns of energy resources
- Increasing energy efficiency and enhancing its utilization in the domestic market
- Developing complementary energy resources for oil and gas
- Developing solar and wind energy resources in electricity production
- Developing renewable energy resources and energy efficiency programmes

A number of policies were specified to achieve the aforementioned objectives, including the following:

- Providing financial, organizational and legal requirements to enable the usage of solar and nuclear energy in producing electricity and water desalination
- Subduing all oil and gas industry to environmental regulations and bylaws
- Employing best technical, economic and environmental practices in oil production

However, most of the environmental policies highlighted in the various development plans suffer from implementation problems despite recent attempts to have a more synthesized regulatory framework for addressing the environmental challenges facing the Kingdom under the auspices of the PME. Apparently, lots of gaps exist in the current national environmental regulatory framework and the activities of the various institutions involved with environmental policies are highly fragmented and lack proper coordination.

In spite of all this, however, the incorporation of environmental protection into the Kingdom's Basic Law of Governance was a relatively recent phenomenon, following the Royal Decree No. A/91 on 1/3/1992. Article 32 of the Basic Law states that: 'The State shall endeavour to preserve, protect and improve the environment and prevent its pollution'. Even so, it took nearly a decade before a national regulatory framework for environmental law, dubbed the General Environment Law (GEL), was enacted by the Royal Decree M/34 of 15 October 2001 following a Council of Ministers' Resolution No. 193 (KPMG, Al Fozan and Al Sadhan 2010). In the same year, the erstwhile Meteorology and Environmental Protection Administration (MEPA) was also renamed as the PME. Indeed, the GEL replaced the many decrees and regulations which preceded it and constituted a single national reference of environmental law in the Kingdom. The GEL also assigned to the PME the responsibility for crafting environmental regulations and standards and their enforcement. The Law entered into force on 31 October 2002, but its Implementing Rules were published on 30 September 2003.

The GEL contains a general obligation on all persons engaged in production, servicing or other activities to take the 'necessary precautions' to:

- Prevent contamination of surface, ground and coastal waters
- Preserve the soil and land and minimize deterioration or contamination
- Limit noise pollution, particularly when operating machinery

As an additional control, project finance loans from lending agencies must include, as a condition precedent, an obligation on the borrower to commit to the environmental protection regulations and standards. Broadly speaking, project developers must abide by the following procedures (KPMG, Al Fozan and Al Sadhan 2010):

- Use the best possible technologies to protect the local environment.
- Use materials which cause the lowest possible level of pollution.
- Prepare emergency plans to prevent or alleviate adverse environmental impact.
- Ensure that the design and operation of a project complies with all applicable regulations and standards.
- Take appropriate action to minimize the probability of occurrence, or limit the impact, or activities involving potential adverse environmental impacts.
- Take necessary precautions for the safe storage and transportation of waste and the avoidance of leaks or emissions of air pollutants beyond allowable limits.

What are the key provisions of the GEL and what are their implementation mechanisms? The GEL consists of 24 Articles (Appendix 1.1). Article 2 of the Law specifically stipulates the main objectives to be achieved by the Implementation Rules, which include, inter alia: preserving, protecting and developing the environment and safeguarding it from pollution; protecting public health from activities and acts that harm the environment; conserving and developing natural resources and rationalising their use; using environmental planning as an integral part of overall development planning in all industrial, agricultural, architectural and other areas; and raising awareness of environmental issues and strengthening individual and collective feelings of the sole and collective responsibility for preserving and improving the environment and encouraging national voluntary efforts in this area.

The legislation also sets out wide-ranging prohibitions of pollution and contamination of air, land and water, with particular reference to all parties involved in services, industry or other economic activities. The law also requires owners of projects, especially utilities and facilities which may have an effect on the environment, to comply with existing and future environmental specifications, standards, measurements and guidelines as promulgated by the PME and set out in the appendices of the Implementation Rules. Article 5 of the Law requires that, prior to project take-off, an environmental evaluation study must be completed and approved by the PME.

Apart from the above-mentioned national environmental legislation, a number of other specific environmental regulations are also available in the Kingdom. One such regulation is the Royal Commission for the Industrial Cities of Jubail and Yanbu, which has issued detailed local environmental regulations relating to the industrial activities of entities located within the Royal Commission areas. In fact, the Jubail Industrial City Royal Commission Environmental Regulations of September 1999 came into force even before the enactment of the national GEL.

Another environmental regulatory framework deals specifically with pollution and contamination incidents within ports under the administration of the Saudi Arabian Seaports Authority. These environmental pollutants are governed by the Rules and Regulations for Seaports of the Co-operation Council for the Arab States of the Gulf of 1985, as revised in 2006.

Similarly, Saudi Aramco, which administers the oil-loading terminals at Ras Tanura, Ju'aymah and several smaller terminals independently of the Seaports Authority, has its own set of rules entitled 'Saudi Aramco Oil Ports & Terminals Rules, Regulations and General Information'.

Saudi Arabia has also ratified the International Convention for the Prevention of Pollution of the Sea by Oil of 1954 and its Amendments of 1962, 1969 and 1971, and the International Convention on Civil Liability for Oil Pollution Damage of 1969 and its Protocols of 1976 and 1992.[5]

1.3 Institutions Responsible for Environmental Policies in Saudi Arabia

The GEL empowers the PME with the responsibility for enforcing and implementing the provisions of the Law, in coordination with the relevant agencies or institutions. There are around 16 government institutions responsible for environmental issues

[5] .http://www.saudilegal.com/saudilaw/18_law.html.

in Saudi Arabia. These institutions, which constitute the Environmental Council, headed by the PME, are as follows:

1. Ministry of Municipality
2. Ministry of Interior
3. Ministry of Foreign Affairs
4. Ministry of Petroleum
5. Ministry of Health
6. Ministry of Commerce & Industry
7. Ministry of Water & Electricity
8. Ministry of Agriculture
9. Ministry of Transportation
10. Ministry of Finance
11. Ministry of Economy
12. Ministry of Information
13. King Abdulaziz Centre for Science & Technology
14. Saudi Wildlife Authority
15. Saudi Commission of Tourism & Antiquities
16. Presidency of Meteorology & Environment (PME)

Each of these institutions has its own plans and programmes to protect the environment in its area of work. The PME coordinates with each institution in accordance with the bylaw of the Environmental Council. For example, Article 3 of the GEL entrusts the PME with the following duties and responsibilities (see Appendix A): reviewing and evaluating the condition of the environment and developing observational means and tools for the collection of information and conducting environmental studies; documenting and publishing the environmental information; preparing, reviewing, developing, interpreting and issuing environmental protection standards; preparing environmental regulations relevant to its areas of responsibility; ensuring that public agencies and individuals abide by the environmental regulations, standards and criteria, as well as adopting necessary procedures thereof in coordination and cooperation with the concerned and licensing agencies; reviewing the latest developments in the field of the environment and its management at the regional and international levels; and promoting environmental awareness at all levels. Thus, the PME not only has the full legal powers of coordination and cooperation with relevant institutions but also has the mandate to monitor and implement the environmental rules and standards.

Other institutions that have responsibilities for environmental protection are also required by the law to take appropriate actions to ensure that the rules set forth in the GEL are applied on their projects or projects under their supervision or those licensed by the PME. They are also required to demonstrate commitment to the environmental regulations, criteria and standards stated in the GEL and its Implementation Rules, as Article 4 of the environmental legislation stipulates (Appendix A). In addition, all public institutions responsible for the issuance of standards and specifications or rules relating to the practical implementation of activities that may impact the environment must liaise with the PME prior to issuance.

In spite of all this, however, there is utter lack of effective coordination and cooperation between the public institutions responsible for dealing with environmental protection issues, as the word ‘coordination’ is so elastic that it makes the enforcement of law and execution of performance indicators so weak. It also undermines the ability of the PME to execute or cajole these institutions to impose the standards and metrics of environment protection or to make them protect the environment and wildlife or even to adequately tackle natural disasters. Therefore, the General Environmental Council has become unable to arrest ecological degradation problems or to effectively promote environmental awareness. Thus, the PME needs to have the appropriate tools and techniques for effective coordination with other government institutions to ensure effective implementation of the environmental regulations.

1.3.1 Services Provided by PME

The services that are expected to be provided by the PME can be classified into two broad categories: environmental protection services and sustainable development services.

Environmental protection services: These include the following:

1. Reviewing and evaluating the condition of the environment
2. Preparing environmental protection laws, standards and regulations
3. Performing environmental supervision and monitoring
4. Dealing with environmental disasters
5. Controlling chemical and hazardous waste
6. Qualifying the private sector to enter into environmental projects and services
7. Evaluating and approving environmental projects
8. Conducting periodic environmental studies
9. Pursuing environmental violations and determining penalties
10. Adopting necessary procedures to coordinate and cooperate with relevant agencies or institutions that approve projects which may negatively impact the environment

Sustainable development services: These include the following services:

1. Promoting environmental awareness
2. Creating and executing natural resources protection policies
3. Undertaking environmental planning
4. Conducting research and preparing regional and international cooperation programmes

1.3.2 Achievements of the PME

The PME and its predecessor (MEPA) have been credited with some achievements, although critics have argued that such achievements have fallen short of expectations. Some of the visible achievements of the PME include the following:

- Prepared a plan for the management of coastal areas in the Kingdom with the aim of conservation of the marine environment and natural habitats
- Conducted a field study of toxic chemicals and hazardous waste in the Kingdom to draw up policies and future executive plans including criteria and standards for storage, transportation and treatment as well as final disposal of hazardous toxic materials
- Made a list of pollution control equipment, in collaboration with other agencies, in order to strengthen the national plan for control of oil pollution and other harmful materials
- Prepared guidelines for the Kingdom's pollution and control operations in collaboration with the Ministry of Petroleum and Mineral Resources

In spite of these achievements, a lot needs to be done by the PME in the area of environmental policy coordination and cooperation between the various institutions involved with environmental policy formulation and implementation. There is also a need for a more robust and proactive involvement of the PME with regard to monitoring and enforcement of environmental regulations in the Kingdom, as regulations are often violated with impunity with little or no sanctions and penalties being meted out.

1.3.3 Institutions Responsible for Renewable Energy

Creating a viable and attractive investment climate for developing renewable energy requires a thorough review of laws, regulations and procedures in that regard. It also requires the offering of subsidies and incentives to producers and consumers, and to motivate researchers and research institutions. This involves restructuring current institutions or establishing new ones that should be entrusted with these tasks. In this regard, the Electricity Cogeneration and Regulatory Authority (ECRA) in Saudi Arabia had prepared a plan in 2010 to develop renewable energy resources for utilization in electricity production and water desalination. The plan included determination of execution bodies that would be responsible for plan implementation with regard to two main programmes.

The first programme relates to generation mechanism which requires the private sector to build power generation stations from renewable energy resources, while the government commits to buying the electricity for 8 years from 2013 to 2020. The purchasing budget ranges from 3 to 15 billion riyals annually and could rise with an increase in generation capacity and number of stations.

The second programme deals with consumer preparation to use renewable energy products. It deals with providing subsidies to the service providers to enable them to buy, fix and maintain equipment used in producing energy from renewable sources and replacing equipment for consumers.

The plan tasks the following bodies with the responsibility for executing such programmes:

1. Renewable Energy Purchasing Management: a new department to be established within the Saudi Electricity Company (SEC) to conduct all energy procurement procedures.
2. The Saudi Office for Renewable Energy: a body that determines the targeted percentage of renewable energy utilization in total power generation.
3. The Academic Council of Renewable Energy: to handle the research activities and prepare conferences and workshops. This is currently taken care of by King Abdulaziz City for Science and Technology (KACST), so there is no need to establish a new institution to perform this function.
4. ECRA issues all licences for renewable energy projects, supervises purchasing processes and protects consumers and producers' rights.
5. Technical and Vocational Training Cooperation: prepares training programmes in the field of energy utilization efficiency.

The current ongoing institutions for renewable energy are:

1. King Abdullah Petroleum Studies and Research Centre (KAPSARC)
2. King Abdullah University of Science and Technology (KAUST)
3. King Abdullah City for Atomic and Renewable Energy (KACARE)
4. King Abdulaziz City for Science and Technology (KACST)

The first three institutions are actively engaged in academic research on renewable energy while KACST and Saudi Aramco are conducting pilot projects on the practical implementation of renewable energy strategies but these projects are not performed under a national strategy.

The KAPSARC was established in Riyadh in July 2007 by King Abdullah to conduct collaborative research on critical energy challenges facing both the Kingdom of Saudi Arabia and the world. KAPSARC is an independent non-profit institution that focuses on research in energy economics, policy, technology and the environment. Its mission, as published on its website,[6] is 'To push forward the insight and understanding of energy challenges and opportunities, both domestically and globally, through high caliber research in energy economics, policy, technology, and the environment, and to advance the knowledge of efficient and sustainable energy production and consumption to create future value and prosperity for humanity'. Because of the global outreach of its research activities, the Center considers itself as an international outfit that happens to be in Saudi Arabia rather than a Saudi centre that talks to the world. Hence, it strives to produce viable, responsible energy thinking and strategies throughout the globe.

The KAUST, located in Thuwal, north of the commercial city of Jeddah, was established in 2008 with the aim of advancing science and technology through collaborative research with a view to facilitating industrial development and diversification of the Saudi economy. KAUST has a three-part mission[7]:

[6] http://www.kapsarc.org.

[7] http://www.kaust.edu.sa.

- Research at KAUST—both basic and goal oriented—is dedicated to advancing science and technology of regional and global impact. Research excellence inspires teaching and the training of future leaders in science and technology.
- Research and education at KAUST energize innovation and enterprise to support knowledge-based economic diversification.
- Through the synergy of science and technology, and innovation and enterprise, KAUST is a catalyst for transforming people's lives.

K.A.CARE, located in Riyadh, was created by a Royal Decree on 17 April 2010 with a mandate to contribute to Saudi Arabia's sustainable development by meeting the Kingdom's future electricity demand. With renewable energy at its core, K.A.CARE is taking advantage of the Kingdom's abundant natural resources, such as high solar intensity and promising wind and geothermal resources, coupled with atomic energy, to help transition the Kingdom to a balanced energy mix, thereby strengthening Saudi Arabia's ability to meet future international demand for energy.[8] Shaped by science and research and brought to life through technology development and industry partnerships, the Kingdom is building a new generation of sustainable power production capabilities that harness renewable and atomic energy to create a reliable, long-term supply of electricity. The acquisition of technology to build an important new economic sector focused on renewable energy will create new business and job opportunities for Saudi citizens, and thereby help to diversify the economy, improve quality of life and make Saudi Arabia a world leader in renewable energy.

KACST is an independent scientific organization administratively reporting to King Abdullah, who is also the prime minister of Saudi Arabia. KACST serves as both a Saudi-Arabian national science agency and Saudi Arabia's national laboratories. The science agency function involves science and technology policymaking, data collection and funding of external research and services such as the patent office.

The main responsibilities of KACST include the following[9]:

- Proposing a national policy for the development of science and technology and developing strategies and plans for implementing the strategies
- Coordinating with government agencies, scientific institutions and research centres in the Kingdom to enhance research and exchange information and expertise
- Conducting applied research and providing advice to the government on science and technology matters
- Supporting scientific research and technology development
- Fostering national innovation and technology transfer between research institutes and the industry
- Fostering international cooperation in science and technology

[8] http://www.energy.gov.sa/default.htm.

[9] http://www.kacst.edu.sa.

The institutions listed earlier perform important research and analytical work but they lack clear national strategy of collaboration among themselves and between them and the private sector to commercialize their products or utilize their research in developing the private sector products and directions in the ecological and energy segments. Thus, in order to have a vital role to attract the private sector to take an active role in clean technology investments that would address the plethora of environmental challenges in the Kingdom, there is a need to restructure and strengthen these institutions, link them to execution entities and provide them with access to financing. There is also the need to review and revamp the General Law of the Environment and the bylaws to accommodate new updates and ongoing developments and to foster collaborations between research institutions, including universities, KACST and KAUST.

1.3.4 Strengthening Regulations and Institutions

A critical look at the various environmental laws and regulations over the past decades suggests that, on paper, these regulations are as good as can be found anywhere in the world, but what is lacking is effective enforcement of the rules. This lack of implementation of the rules stems from lack of political will as much as weak institutional framework, inadequate coordination of the activities of agencies responsible for environmental policies and inadequate monitoring and oversight functions. Ironically, these problems have been highlighted in Saudi Arabia's Fifth Development Plan (1990–1995) and they are equally valid today since no concrete actions have been taken to address them. Thus, there is an urgent need not only to address these regulatory and institutional weaknesses but also to reform the regulatory framework and restructure the institutional arrangements.

Strategies for strengthening the institutions and rules for implementation framework for environmental protection in Saudi Arabia should revolve around the following options:

- Enforcement of environmental regulations
- Establishing clear and transparent environmental standards
- Effective environmental monitoring
- Improving environmental awareness
- Mandatory environmental impact assessment studies
- Enhanced coordination of environmental activities
- Introducing a wide range of incentives to encourage environmentally friendly production and consumption

Needless to say, applying the existing environmental regulations is inadequate as there are no clearly defined mandates, responsibilities and authorities to impose these regulations. This is more serious in the absence of a sense of awareness and voluntary cooperation on the part of the public. Violators of environmental regulations should be made aware of the penalties for violation and must be made to pay such penalties if they violated the laws.

There is also the need for a clear set of environmental standards, specifications, targets and guidelines that must be observed in all activities on the environment. This calls for a comprehensive review and amendment of the existing rules and regulations to incorporate clearly defined standards and guidelines to allow for effective monitoring, licensing, implementation and enforcement of environmental regulations in the Kingdom. Furthermore, there is an urgent need to develop and implement a set of monitoring parameters on environmental degradation and violation.

Efforts must be made to sensitise the members of the public on environmental challenges and their implications for individuals and the economy. Such a public awareness campaign calls for close cooperation among all the relevant public institutions and agencies through education and widespread dissemination of information about the effects of public behaviour on the environment. It is highly unlikely that efforts at environmental protection will be successful without the citizens' understanding and cooperation on environmental conservation and preservation.

Furthermore, the government should make environmental impact assessment an integral part of feasibility studies for new projects or programmes. Although such a requirement is adumbrated in the GEL of the Kingdom, it has not been effectively implemented, and project developers have violated it with impunity without any consequences. The enforcement of environmental impact assessment and environmental cost–benefit analysis in project execution will be a potent tool for environmental protection as it will serve to curtail the growth of environmentally harmful projects.

In the absence of strong, transparent and credible institutions, environmental regulations in themselves will not address environmental challenges. One of the criticisms levelled against the institutions responsible for environmental policies in Saudi Arabia is that they are fragmented and they lack proper coordination and the required expertise to perform their duties and responsibilities effectively and efficiently. In other words, there is lack of coordination between the PME and the other agencies or institutions responsible for dealing with environmental issues and policies in the Kingdom. Efforts must be made to strengthen the oversight and coordinating functions of the PME to enhance cooperation among the relevant institutions to promote effective implementation and enforcement of the environmental regulations.

Finally, the government should provide a wide range of incentives to encourage the private sector to engage in activities (production and consumption) that will protect the environment. For instance, financial and regulatory incentives should be provided to individuals and firms that are willing to invest in low-carbon or clean energy businesses. These incentives, including tax rebates/breaks, loan guarantees and feed-in-tariffs, will be discussed in greater depth in Chap. 5 of this book. In the case of non-discriminatory subsidies that are provided to every citizen, there is a need to reform the system to make it means tested so that only those who are in dire need of the subsidy benefit from it. The savings from such a scheme could be used to promote low-carbon business activity in the Kingdom which can create jobs, boost income and promote sustainable growth and development.

1.4 Lessons from Around the World

Environmental concerns have prompted many countries across the world to put in place appropriate regulatory and institutional framework and enforcement mechanisms. The advanced countries, in particular, are well known not only for the robustness of their environmental management and protection policies but also for the effectiveness of environmental enforcement process. For the members of the European Union (EU), environmental laws are shaped by national and international considerations, particularly the European Community law. EU environmental regulations are directly applicable to and binding on the member states and, therefore, do not need to be transformed into national law. The EU also issues periodic directives, used as a kind of EU legislation, which are binding in regard to the desired results but leave the choice of method of implementation to the member states. However, the European Court of Justice states that if a member state delays the transformation of an EU directive into national law, then the country is not supposed to apply national law at variance with the directive. It is this compatibility between national law and EU law that strengthens the environmental regulatory, institutional and enforcement mechanisms of European countries.

In the case of emerging countries, however, the regulatory environment is relatively weak, but recent experiences from some emerging market countries, such as China, provide food for thought for developing countries. For example, having identified inadequate enforcement as one of the key factors in China's deteriorating environmental situation, the Chinese Government introduced environmental plans, alongside its national development plans, to strengthen environmental enforcement and compliance assurance. In other words, the Chinese Government has mainstreamed environmental agenda into its national development plans with a clear implementation framework.

China's recent five-year environmental plans are broken down into sectoral five-year plans, in areas such as water management in key rivers and lakes; air pollution reduction in specially designated regions ('acid rain control zones' and 'sulphur dioxide control zones'); hazardous waste management; and nature conservation. The five-year environmental plan envisaged a number of institutional and regulatory measures such as integrating environmental considerations into development decision-making; strengthening capacity of environmental management institutions; promoting the use of incentive mechanisms; and tightening up enforcement towards non-compliant enterprises responsible for severe pollution that damages public health. The programme also called for enhancing research and development efforts for environmental protection and promoting public participation in environmental policies. As a result, a more robust enforcement regime was created, leading to effective monitoring and supervision of environmental activities. The general public has also been gradually involved in non-compliance detection and compliance promotion.

China has also recently introduced 'green gross domestic product (GDP)' in order to measure environmental losses from economic development and to evaluate the performance of local government officials not only by economic indicators but also by environmental indicators. Similarly, various enterprise appraisal systems have been developed at the national and sub-national levels and, in specific sectors, to help promote compliant industries. Even so, there is a need to make environmental laws and regulations more consistent, transparent and non-discriminatory. There is also the need to further strengthen capacities of environmental administrations, and enforcement strategies should ensure that discretion of enforcement personnel is limited while promoting compliance through raising awareness, capacity building, public pressure and incentives for better environmental behaviour. For instance, according to OECD (2006), a significant proportion of small and medium enterprises (SMEs), including those in rural areas and in the service sector in urban areas, are not inspected due to the lack of capacity or constraints stemming from pragmatic enforcement or conflicts of interest between economic and environmental parts of the administration. There are also cases where some enterprises in China are able to escape the supervision process by asking local officials to sign permit documents without approval of environmental authorities while some local governments set up 'umbrella' schemes to prohibit the environmental authorities from inspecting and imposing fees and fines on firms which are significant polluters but are considered important to the local economy in terms of providing tax revenue or employment (OECD 2006).

1.5 Comparing Saudi and Other Countries' Laws on Waste Control and Management

As stated earlier, Saudi Arabia's General Environmental Regulation and Rules for Implementation cover a wide range of areas of environmental protection including environmental standards relating to planning for projects, air and noise pollution and waste. For example, Article 14 of the Saudi Rules for Implementation, which relates to hazardous waste, states that: 'no person or agency is allowed to dispose of hazardous waste without licence from the PME in accordance with procedures set out in Appendix 4, Hazardous Waste Control Rules and Procedures'. In essence, producers of hazardous wastes in the Kingdom are by law required to confirm with the PME whether or not they generate hazardous wastes as they will be 'held responsible for the identification of the types of waste and hazardous waste they generate, as well as for ensuring that such wastes are stored, treated and disposed of in an environmentally sound manner that does not cause its dispersal and also does not cause any detrimental effect on man's health, safety and welfare or the environment and the natural resources (Appendix 4, Article V of Saudi Arabia's General Environmental Regulation and Rules for Implementation).

Indeed, Appendix 4 of the RFI (Rules For Implemenation) sets out detailed requirements and procedures for hazardous waste management facilities and transporters of hazardous waste, and violation of these rules would result in fines. Article 18.2 of the RFI states that any violation of any of the Articles contained in the RFI will result in a fine; a comprehensive list is spelt out in the following clauses of Appendix 6 of the RFI:

- Appendix 6.7 No. 2: Dealing with hazardous wastes without being licensed by the competent agency—SAR 3,000–5,000.
- Appendix 6.7. No. 24: Transport of hazardous wastes to an agency or facility not authorized by the licensing agency—SAR 2,000–10,000.
- Appendix 6.7 No. 33: Failure to fully treat and dispose of hazardous waste in an appropriate manner—SAR 2,000–10,000 and enforcement of facility to dispose of waste in an appropriate manner specified by the licensing agency.

Despite a strong statutory framework to control hazardous wastes in Saudi Arabia, enforcement challenges appear to be a main source of concern. The effectiveness of any law depends on enforcement mechanisms, and this requires that compliance with the laws is strictly monitored by appropriately resourced agencies with trained personnel. In the absence of appropriate enforcement strategies, it will be difficult to ensure that all of identified wastes will be taken to a treatment facility. This contrasts sharply with the situations elsewhere around the globe. Most of the advanced countries have robust environmental laws and strict enforcement mechanisms. For example, the German Waste Water Changes Act (AbwAG) of 1976, updated in 1990, '…enables the Lander (regions) to impose fees on the discharge of waste and to calculate those fees in respect to the harmfulness of the discharged waste water. The revenues from those fees have to be spent for measures designed to maintain or improve water quality'. (Neumann 1996).

Similarly, the Swedish Law on Municipal Waste Pollution and Disposal Obligation (Section 8) states that:

> Unless other provision is made, municipalities shall ensure that: 1. Household waste generated in the municipality is transported to a waste treatment plant where necessary in order to protect human health and the environment and safeguard private interests; 2. Household waste generated in municipality is recycled or removed. When planning and deciding how to discharge this obligation, the municipality shall take into account the extent to which owners and tenants can dispose of household waste themselves in a manner that is acceptable in terms of protection of human health and the environment. In its planning and decisions, the municipality shall also ensure that the removal of waste is appropriate to the needs of various built environment, such plans and decisions should define the conditions in which owners and tenants of properties may themselves dispose of household waste and, where rules issued pursuant to section 10 are applicable, any other waste generated on their premises. (Swedish Ministry of the Environment 2000)

These laws will undoubtedly provide ample business opportunities in the field of wastewater management and recycling.

In the emerging economies, China again provides a classic example of a country that made tremendous progress in implementing appropriate laws on hazardous waste management dubbed the *Law of Prevention and Control of Solid Waste Pollution to the Environment* (Shouren 1999). A number of government agencies were established with specific responsibilities to implement the rules and regulations on hazardous waste. These include the State Environmental Protection Administration (SEPA); State Economic Management Departments; and Local Environmental Protection Bureaus. For instance, the SEPA is responsible for the following tasks (Shouren 1999):

- Implementing unanimous monitoring and management on hazardous waste pollution prevention and treatment nationwide
- Establishing national catalogue of hazardous waste together with related governmental departments
- Promulgating uniform standards and methods of hazardous waste identification and symbols of recognition
- Establishing, together with state economic management department and other related departments, the technical policy on hazardous waste pollution prevention
- Organizing and popularizing progressive techniques and production processes and equipment for hazardous waste pollution prevention and treatment

In the case of the *State Economic Management Departments,* they develop and promote, together with other related state departments, advanced production processes and equipment that produce less amounts of solid waste (cleaner production). In addition, they issue the list of outdated techniques and equipment causing serious pollution that should be banned. On the other hand, the *Local Environmental Protection Bureaus* supervise and monitor hazardous waste pollution protection; and issue punishment to those that produce but do not treat/dispose of hazardous waste. Similarly those that have not treated or disposed of hazardous waste or have not met the national demands after treatment/disposal, the wastes will be treated by an assigned agency but the waste generators will be forced to pay for it.

China also has favourable policies on hazardous waste utilization. For instance, the national government publishes a comprehensive list of companies that recycle hazardous wastes and offers them favourable tax incentives. Similarly, enterprises that utilize their own hazardous waste generated as main raw materials for production get income tax exemption for 5 years. In addition, enterprises that utilize hazardous waste generated from other enterprises get income tax reduction or exemption for 1 year (Shouren 1999).

These are noteworthy lessons that Saudi Arabia should seek to adopt and implement. The Kingdom is currently implementing a programme to improve the capacity for enforcement of its environmental regulations but incorporation of best practices from around the world would enhance the enforcement process quite considerably. Also, there should be an urgent need for extensive public education and cultural change programmes to help improve compliance with environmental regulations in the Kingdom. Thus, in order to enhance the level of enforcement, a number of strategies should be implemented by the government and its environmental agency, the PME. However, some of these responsibilities could be outsourced to the private sector provided that the activities of the private companies are appropriately authorized in law. Changes to an enforcement regime, however, will require a gradual and progressive approach over a period of time, say 2–5 years, to provide both the waste producers and the waste management industry sufficient time to adapt to the new framework, as there is often a need for major expenditures of capital to provide the necessary treatment/disposal infrastructure either at the point of waste production or in off-site facilities.

1.6 Lessons on Energy Efficiency

Improving the efficiency of energy use is an innovative approach that could achieve better energy security, improve industry competitiveness and reduce the overall energy sector impacts on the environment. For instance, the International Energy Agency (IEA) states that 'increased adoption of energy efficiency measures account for a full two-thirds of the calculated reduction in global energy-related greenhouse gas emissions of 6.3 billion tons of carbon dioxide emissions when compared with the Reference Scenario'. (Taylor et al. 2008). Thus, energy efficiency programmes are increasingly becoming an integral part of national efforts across the globe to improve the security of future energy supply, and it is one of the favoured strategies for environmental improvement because it reduces the need for energy development, transportation and distribution, on-site use and all the associated environmental impacts (ibid). In addition, energy efficiency measures are relatively cheap and cost effective as they are only a fraction of the costs of acquiring additional energy supply. Potential cost-effective energy savings from energy efficiency can be found in industrial energy use, residential and commercial building energy use and energy use in the transport sector.

A recent World Bank study on energy efficiency projects in Brazil, India and China has emphasized the importance of strategic government support to promote new energy efficiency financing mechanisms more aggressively in each of these three countries. It also emphasizes the importance of establishing and maintaining practical, operationally focused dialogue between the financial sector community and the energy efficiency practitioner community. In essence, such a dialogue has helped to generate new energy efficiency lending programmes in several Indian banks, laid a platform for the development of a new energy efficiency-financing initiative with major Chinese banks with World Bank support; and fostered the development of a new energy efficiency company (ESCO) loan guarantee programme in Brazil (Taylor et al. 2008).

The Chinese Government has even gone further to set an ambitious target to reduce energy use per unit of GDP by 20 % between 2006 and 2010 and, as a result, the government adopted aggressive energy efficiency measures to achieve that target. In Brazil and India, however, the World Bank study has recommended the introduction of medium- and long-term strategic priorities to improve energy efficiency, including innovative financing mechanisms and sustained institutional development support, to enable the new strategies to gain stronger operational footholds and to scale up initial experiences. After all, the three biggest causes of operational failures in energy efficiency financing projects are the following:

- 'Mismatches between the attempted solutions and local institutional environments;
- Lack of proper balance between development of financial intermediation functions and project development functions; and
- Lack of sustained effort and follow through, especially for adjusting institutional mechanisms and approaches during implementation in response to market changes or arising operational inefficiencies'. (Taylor et al. 2008, p. 19).

To avoid these mistakes and to achieve best results possible in the future, the World Bank study recommended the following broad solutions:

- 'Careful diagnostic work on existing in-country conditions should form the basis for project design and interventions that fit within local institutional contexts;
- For projects involving financial intermediation, parallel attention is strongly recommended to (i) the details of developing capacities and mechanisms for financial intermediation; and (ii) project pipeline development and technical appraisal;
- It is important to incorporate period review and flexibility within the project design, so that programs can be adjusted during implementation; and
- All of the above result in exceptionally high labor intensity for program management, operation, and technical support, not only during preparation but also during program implementation. High-quality and concentrated attention from program management and expert personnel is essential for new institutional mechanisms to be nurtured to success'. (Taylor et al. 2008, p. 19).

In spite of all this, however, it is noteworthy that energy efficiency operations are time consuming and sometimes costly to undertake and implement. But, once done, these programmes can generate huge financial returns to enterprises and energy consumers, and with very high potential returns per unit of public investment in environmental and energy security benefits to countries. In other words, energy efficiency projects are 'win–win' projects because they are financially beneficial to the concerned enterprises and also beneficial to society's environmental interests. All this suggests that development of financing delivery mechanisms for sustainable energy efficiency can play a major role in mitigating future energy and environmental challenges in Saudi Arabia where demographic dynamics and changes in lifestyles are increasingly putting pressure on current energy supply sources and energy use.

1.7 Opportunities for the Private Sector

The key lesson to draw from the foregoing analysis is not only that strengthening the environmental regulatory and institutional framework will lead to compliance with environmental standards and practices but also that transparent enforcement of the rules and regulations will create conducive climate for increased participation of the private sector in environmental businesses. One stark difference between the environmental concern in Saudi Arabia and other countries such as China is that in the latter situation the main environmental challenge is posed by acid rain and sulphur dioxide (SO_2) while in Saudi Arabia the focus is on tackling the menace of carbon dioxide (CO_2). While reduction of SO_2 can incur significant costs to society, the presence of CO_2 can present profitable business opportunities for the private sector, as CO_2 can be injected into the ground to enhance the efficiency of oil exploration. It can also provide significant bankable investment opportunities in the area of carbon capture and storage. Thus, strengthening the environmental regulatory and institutional framework as well as providing appropriate incentives will attract substantial private sector activities in environmental activities, thereby achieving both commercial and social objectives for Saudi Arabia.

In addition, there are many other channels through which private sector can participate in environmental protection and pollution control activities, including investments in environmentally oriented activities and businesses such as environmental resources (e.g. clean energy investments including energy efficiency); environmental equipment (e.g. clean technology equipment); and environmental services (e.g. waste treatment, recycling and analytical and consultancy services). For example, enforcing the regulation on environmental impact assessment for new projects will boost the market for consultancy and advisory services on environmental issues and projects. The private sector could also play a key role in providing environmental awareness and other related services.

According to the International Renewable Energy Association (IRENA), around US$ 109 billion are required as potential investments of renewable energy in Saudi Arabia to meet one third of its electricity requirements by 2030.[10] This will provide considerable profitable investment opportunities for the private sector over the coming decades.

Furthermore, ample business opportunities for the private sector exist in the area of hazardous waste management in the Kingdom where around 1.2 million tonnes of such waste were produced in 2009, and these were forecast to increase to nearly 2.0 million tonnes by 2020. These estimates of hazardous waste are based on the Kingdom's population growth rate as well as the projected growth rates of the various sectors that largely generate such wastes, including petrochemical waste, medical waste, general manufacturing and commercial waste and wastewater treatment sludge. According to Saudi Arabia's Eighth Development Plan 2005–2009 document, oil-refining sector is projected to grow by 4.3 % annually over the period 2004–2024, while manufacturing, healthcare and wastewater are forecast to grow by 6.7 %, 7.0 % and 2.5 % during the same period.[11] These along with a population growth rate of around 0.87 % would combine to produce nearly 2.0 million tonnes of hazardous waste in less than a decade, providing profitable investment opportunities for the private sector in the waste treatment business sector. In essence, the

[10] Alsharq Alawsat newspaper, 23 December 2012 Issue No. 12444.

[11] The Development Plan document was prepared by the Saudi Arabia Ministry of Economy and Planning.

opportunities lie largely in the development of economically feasible waste management facilities as the Kingdom still has inadequate or undeveloped facilities to effectively manage hazardous wastes.

In the petrochemical industry, there are significant investment opportunities in the treatment of the following types of waste: wastewater treatment sludge and incinerable as well as non-incinerable (spent catalyst) petrochemicals. The opportunities are even more in the general manufacturing sector, which consists of the following types of waste: spent solvents; acid, alkaline or saline wastes; used oils; spent chemical catalysts; industrial effluent sludges; metallic wastes and glass wastes; mineral wastes; combustion wastes; discarded vehicles, batteries and accumulators wastes; e-wastes; contaminated soils and polluted dredging spoils; and solidified, stabilized or vitrified wastes. The healthcare sector too provides huge investment opportunities in the disposal of medical wastes. Each of these wastes presents opportunities in the business of waste management, which would require different treatment methods and facilities. Although the waste treatment methods may vary across the different types of waste, the most common approaches would revolve around landfill disposal, solidification prior to landfill disposal, physical chemical treatment and incineration techniques.

Hazardous waste exists everywhere in the Kingdom, but the bulk of it is generated in most major cities, especially in Riyadh, Jeddah, Makkah, Madinah and the Eastern Province. It is reckoned that most of the potential waste treatment facilities would, however, be based in the Makkah and Riyadh Provinces due to the cosmopolitan nature of these areas.

The success of the waste treatment business will, however, depend largely on the effectiveness of the regulatory environment as well as enforcement and compliance mechanisms for waste management requirements. But the Government of Saudi Arabia is now more than ever before keen on strengthening the regulatory framework which would consequently spur increased activities in waste management services, such as recovery and recycling. For example, the Kingdom's General Environmental Regulations and Rules for Implementation discussed earlier contains the basic ingredients for an effective management of hazardous wastes but the regulatory system, including the relevant agencies, would need to be strengthened to meet the administrative challenges of dealing with a rapidly growing demand for a hazardous waste management system.

Chapter 2
Environmental Concerns and Policies in Saudi Arabia

2.1 Overview

Environmental concerns have recently taken centre stage in policy discussions around the globe due to the frequently observed impact of environmental degradation on socio-economic phenomena. Moreover, and to a large extent, many developed economies have managed to turn environmental challenges into profitable businesses rather than fee-based generation problems that constitute a burden and high cost for the economy. Through collaborations between public and private sectors, companies in those economies have been able to make environmental issues a core part of their business strategy.

The prevailing economic development patterns, which have been persistent for a long time in many emerging and developing countries, including Saudi Arabia, are based on conspicuous consumption. These patterns are designed to drive the society towards excessive increase in production and consumption of goods and services and are draining our natural resources. Such over-consumption is perpetrated without due regard to human rights or clean environment. As a result, economies have grown to look after increasing population and economic growth at the cost of environmental protection and the rights of future generations to natural resources. According to several international reports, 25 % of the world population consumes 75 % of the world's natural resources.

Mounting economic, social and environmental transformations necessitate most countries to have a paradigm shift in reviewing their current economic development models, and to create new mechanisms that strike a balance between preserving our limited natural resources and enhancing economic growth. In other words, the recent traction for a sustainable green economic concept that places value on material wealth in Saudi Arabia should not be delivered at the expense of growing environmental risks, ecological scarcities and social disparities, but should develop appropriate incentives into the mainstream of policy discourse. Undoubtedly, this phenomenon has also resulted from a sense of fatigue emanating from the concurrent market failures and the 2008 financial crises.

This chapter offers an economic development model that illustrates the current relationship between economic and environmental issues in Saudi Arabia framed

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by its own economic structures. The Kingdom depends heavily on oil revenues for government budget; it is the largest exporter of oil, as it owns 25 % of the world's oil reserves, and has an approach of balancing between production and consumption of resources in addition to looking to balance economic growth and environmental challenges. These factors play a key role in shaping Saudi Arabia's policies towards protecting its oil wealth, increasing its energy consumption efficiency and developing sustainable energy resources through an appropriate energy mix. Meanwhile, the Kingdom should focus on all energy ecological matters to protect its environment and to move towards the new world energy paradigm. Based on this notion, and using an econometric model, an inverted-U relationship between environmental degradation and economic growth, popularly known as the 'Environmental Kuznets Curve' (EKC) analogous to the income inequality relationship postulated by Simon Kuznets, is envisaged for Saudi Arabia.

Understanding the nature of the relationship between economic growth and environment would help strategists, planners and policymakers to undertake the appropriate policies that achieve sustainable green economic development. It will also answer various questions, including principally the following: What is the relationship between environmental degradation and economic growth in the Kingdom of Saudi Arabia? What policy measures are currently being implemented to improve environmental quality in the Kingdom? Are these environmental measures sufficient enough to warrant economic growth sustainability? What form of environmental policies should the government adopt to incentivize 'green' production and consumption? What are the opportunity costs of domestic energy usage in both industrial and household consumptions? What is the link between domestic energy production and consumption and environmental damage? What are the costs and benefits of environmental protection to promote sustainable economic growth in the Kingdom? These and other related questions are investigated in this chapter through a variety of methods, including econometric modelling and forecasting of Saudi Arabia's gross domestic product (GDP) that explicitly takes into account environmental factors.

2.2 Stylised Facts

Saudi Arabia is the largest country in the *Gulf Cooperation Council* (GCC) region in terms of the size of the economy and demography, with a GDP of SAR 2,163 billion (US$ 577.6 billion) and total population of 28 million people in 2011. Relative to the countries in the GCC region, Saudi Arabia accounts for 42 % and 65 % of regional GDP and population, respectively. As a result, Saudi Arabia also faces serious environmental issues in the region. This is to be expected because empirical evidence from elsewhere around the world suggests that, up to a point, environmental pollution is positively correlated with the level of economic activity or industrial development (Fig. 2.1).

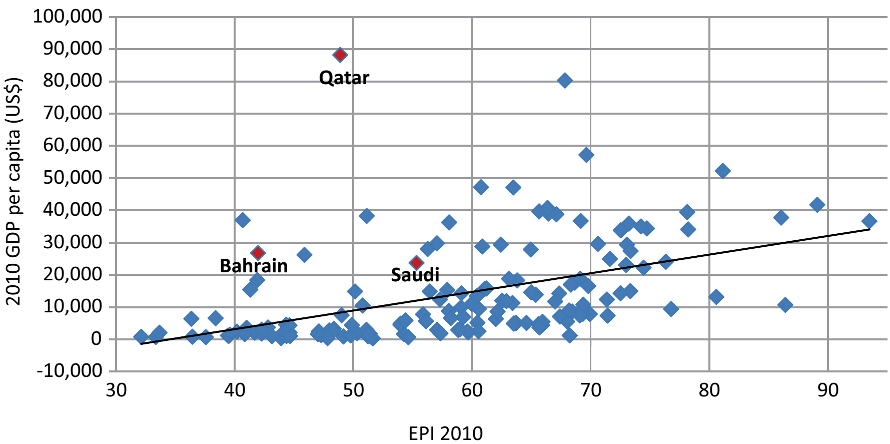


Fig. 2.1 Correlation between per capita gross domestic product (GDP) and Environment Pollution Index (EPI). (Source: World Bank (2012))

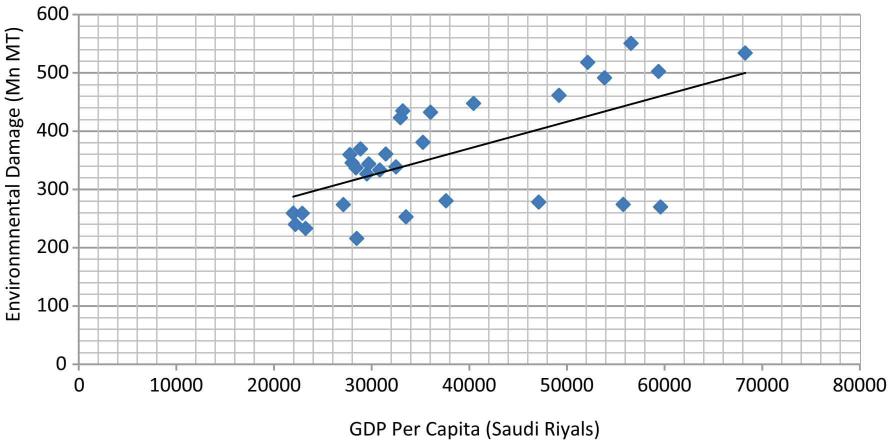


Fig. 2.2 Saudi Arabia: Relationship between per capita gross domestic product (GDP) and pollution (1980–2010). (Source: World Resources Institute (2011); IMF (2012))

The historical time series data for Saudi Arabia also tend to support the generally observed relationship between environmental pollution and per capita income. For example, during the period 1980–2010, both environmental pollution and per capita GDP in Saudi Arabia increased in tandem (Fig. 2.2).

Saudi Arabia, with the highest concentration of industrial activities in the GCC region, and consequently the highest level of CO_2 emission from industrial processes, is likely to witness increased environmental pollution as the Kingdom continues to emerge from a developing to a developed country status. In other words, the quest

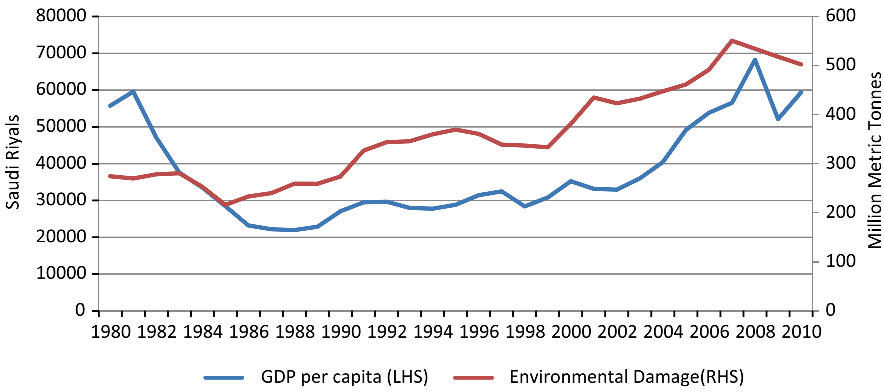


Fig. 2.3 Per capita income and environmental pollution in Saudi Arabia. GDP, gross domestic product. (Source: World Resources Institute (2011))

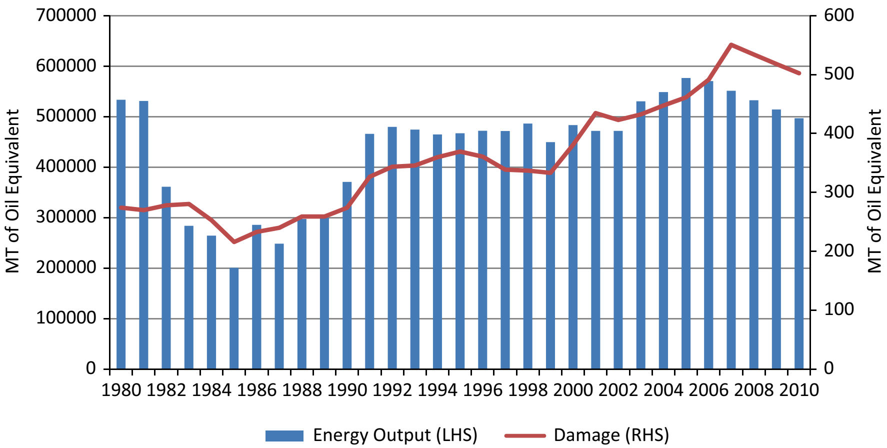


Fig. 2.4 Energy production and environmental pollution in Saudi Arabia. (Source: World Resources Institute (2011))

for industrialization and rapid economic growth would lead to increased use and extraction of natural resources and the pollution that is associated with such activities. For example, environmental pollution from greenhouse gas (GHG) emissions and waste by-products in the Kingdom has increased *pari pasu* with per capita income, energy production and energy consumption (Figs. 2.3–2.5). This means that, unless appropriate measures are put in place to tackle environmental degradation associated with production and consumption patterns, Saudi Arabia will face bigger environmental challenges in the future with grave implications for the welfare of future generations.

Decomposition of the total environmental damage suggests that the bulk of Saudi Arabia's environmental pollution is on account of CO_2 emission, which

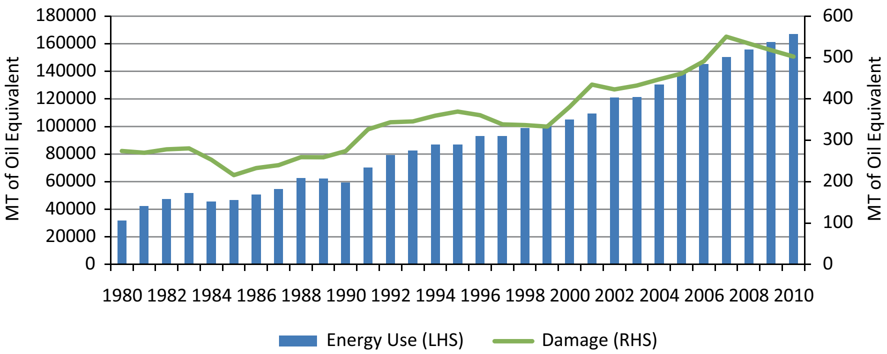


Fig. 2.5 Saudi Arabia: Energy use and environmental pollution. (Source: World Resources Institute (2011))

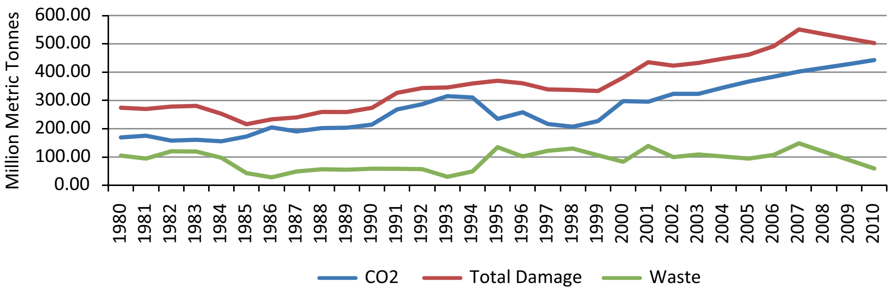


Fig. 2.6 Composition of environmental damage in Saudi Arabia. (Source: World Resources Institute (2011))

has increased more rapidly over the past years than waste by-products (Fig. 2.6). Unfortunately, disaggregated data on waste emissions (municipal or household, industrial and medical wastes) for Saudi Arabia are not available but we were able to estimate it from the global and regional statistics on waste using the relative size of Kingdom's GDP in the 'rest of the world' (Africa, Middle East and Latin America) as a scaling factor. The data on global waste by regions were obtained from a report published by Quantum Economics Partnership (2010) and from the Eurostat Database.

In the case of CO_2 emissions, the data are available by sectors, which suggest that around 50% of the CO_2emissions in Saudi Arabia are accounted for by the power and electricity sector, followed by the transport sector and the industrial/construction sector (Fig. 2.7).

How big is the monetary cost of these CO_2 emissions in the Kingdom? Unfortunately, data on the precise price of CO_2 emissions are not available although carbon trading prices in European countries exist, but the World Bank provides data on the

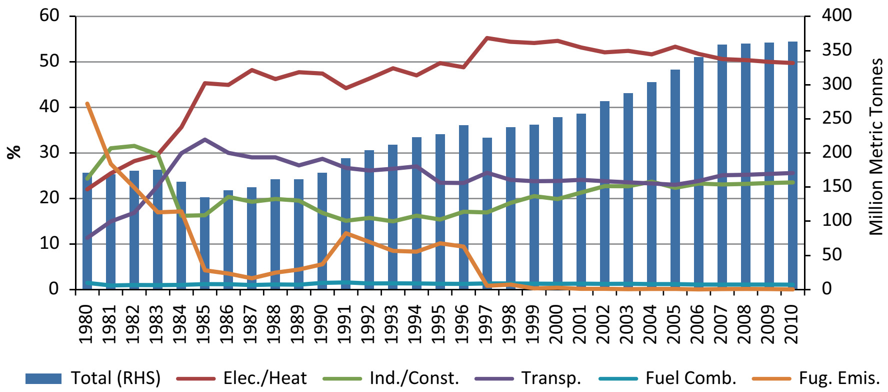


Fig. 2.7 CO_2 emissions in Saudi Arabia by sectors. (Source: World Resources Institute (2011))

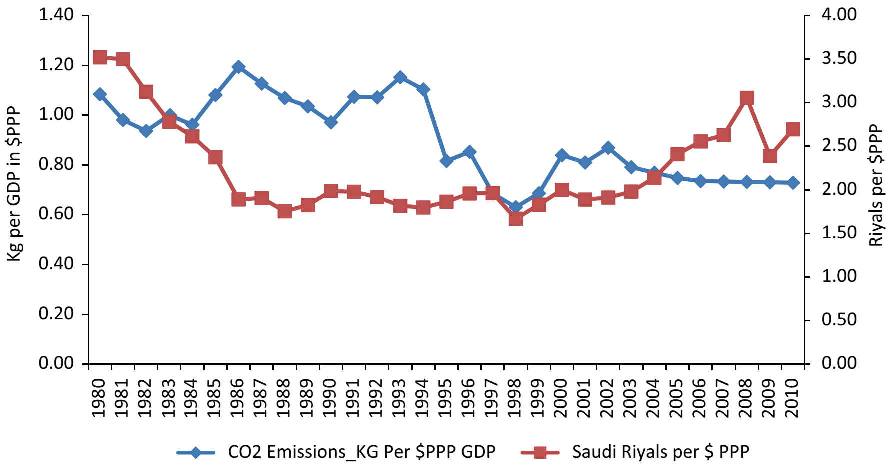


Fig. 2.8 CO_2 emissions (kg per GDP PPP) and SAR/$ purchasing power parity (PPP) conversion rate. (Source: World Bank (2011))

cost of CO_2 emissions per GDP evaluated at international dollar (purchasing power parity, (PPP)). Figure 2.8 shows the aggregate valuation of CO_2 emissions in Saudi Arabia in terms of kilograms per international dollar of GDP and the conversion factor between Saudi riyals and the international dollar. Costs of CO_2 emissions range from 1.08 kg per PPP dollar in 1980 to around 0.70 kg per PPP dollar by 2005, which, on average, translate to around 1 kg of CO_2 emissions per international dollar.

We used the information in Fig. 2.8 (the link between CO_2 emissions and GDP as well as the conversion factor between the PPP dollar and Saudi riyals) to estimate the costs of CO_2 emissions in the three biggest emitting sectors in Saudi Arabia: power, water and transport. Tables 2.1 and 2.2 show the estimated costs of CO_2 emissions in the three sectors for the period 1980–2010 and forecast values for

Table 2.1 Costs of CO_2 emissions in the power, water and transport sectors in Saudi Arabia (% of government revenues). (Source: IMF (2011); World Bank (2011); World Resources Institute (2011))

	SAR million			% of government revenues		
	Power and water	Transport	Total	Power and water	Transport	Total
1980	122,429	63,000	185,429	35.17	18.10	53.27
1985	134,122	97,463	231,585	100.42	72.97	173.39
1990	165,942	100,465	266,407	87.11	52.74	139.85
1995	258,467	121,927	380,394	176.43	83.23	259.65
2000	328,182	143,237	471,419	127.17	55.50	182.67
2005	553,900	239,089	792,989	98.15	42.37	140.52
2010	784,496	342,802	1,127,298	95.50	41.73	137.24
2015	1,119,888	416,106	1,535,994	105.06	39.04	144.10
2020	1,632,209	530,368	2,162,577	104.28	33.88	138.16
2025	2,394,927	687,963	3,082,890	101.54	29.17	130.70
2030	3,521,692	898,020	4,419,712	98.55	25.13	123.68

Table 2.2 Costs of CO_2 emissions in the power, water and transport sectors in Saudi Arabia (% of GDP)

	SAR million			% of GDP		
	Power and water	Transport	Total	Power and water	Transport	Total
1980	122,429	63,000	185,429	22.40	11.53	33.92
1985	134,122	97,463	231,585	35.64	25.90	61.54
1990	165,942	100,465	266,407	37.94	22.97	60.92
1995	258,467	121,927	380,394	48.45	22.85	71.30
2000	328,182	143,237	471,419	46.44	20.27	66.71
2005	553,900	239,089	792,989	46.84	20.22	67.06
2010	784,496	342,802	1,127,298	48.13	21.03	69.16
2015	1,119,888	416,106	1,535,994	46.96	17.45	64.41
2020	1,632,209	530,368	2,162,577	46.36	15.06	61.42
2025	2,394,927	687,963	3,082,890	45.89	13.18	59.07
2030	3,521,692	898,020	4,419,712	45.44	11.59	57.03

GDP, gross domestic product.

the year 2011–2030 using historical trends and autoregressive relationships. These estimates suggest that the total cost of CO_2 emissions in the power, water and transport sectors can be colossal as it outstrips fiscal revenues by a considerable margin (Table 2.1). It also accounts for a big chunk of the GDP ranging from one third to two thirds of the Kingdom's national income (Table 2.2).

CO_2 emissions in the power, water and transport sectors are set to increase quite considerably in the future, in relative terms (as a percentage of both government revenues and GDP). The Tables 2.1 and 2.2 demonstrate that in 2010, the total CO_2 emissions cost the Kingdom more than 137 % of its government revenues and

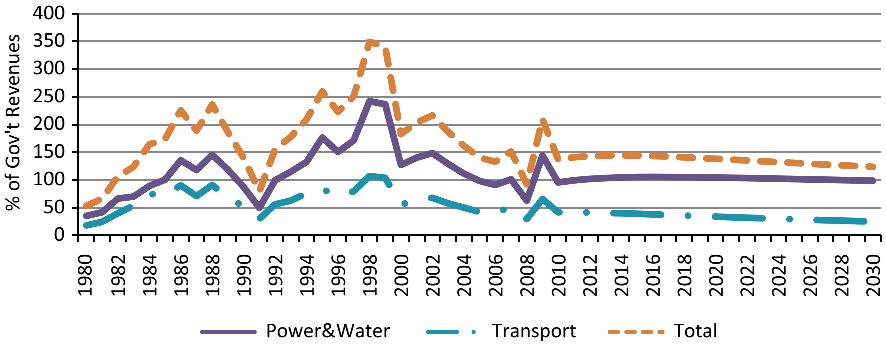


Fig. 2.9 CO_2 emissions in the power and water and transport sectors in Saudi Arabia (% of government revenues). (Source: World Bank (2011))

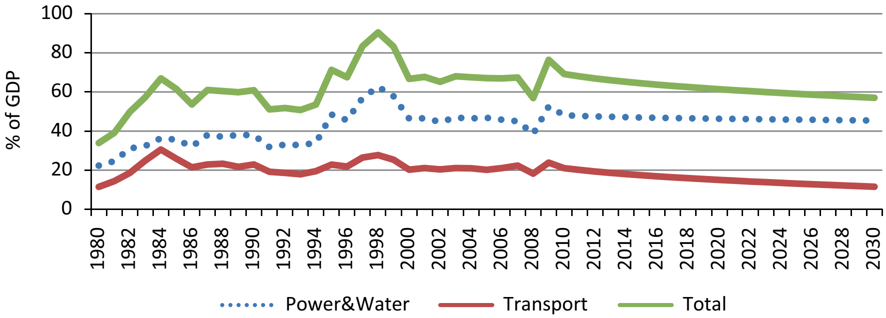


Fig. 2.10 CO_2 emissions in the power and water and transport sectors in Saudi Arabia (% of GDP). (Source: World Bank (2011))

around 69 % of its GDP. This implies that carbon emissions from burning fuel, mainly in generating power and water supplies, negatively affect the economy in such a way that requires more than the government's revenue or 69 % of the Kingdom's GDP to clean up or reverse the impact.

The emissions are likely to moderate due to a number of reasons, including abatement measures that are likely to reduce pollution and increase sustainability of absolute GDP and economic growth. As Fig. 2.8 suggests, the CO_2 emissions per international dollar have decreased substantially, and the current unit costs are much lower than the peak levels recorded in mid-1980s. This suggests that, on current trends, the CO_2 emissions per PPP of GDP are likely to be lower in the future than in the past, thereby further reducing the share of CO_2 emissions costs in GDP (Figs. 2.9 and 2.10).

In addition to the costs of CO_2 emissions, the three sectors (power, water and transport) account for a considerable share of domestic consumption of oil (non-renewable energy) in Saudi Arabia. Due to fast-changing demographic dynamics in the Kingdom and the rapidly expanding energy-intensive industries, the demand for power, water and transport has grown exponentially over the years and it is forecast to accelerate further in the future. As Table 2.3 and Fig. 2.11 show, the transport

Table 2.3 Oil consumption in the power, water and transport sectors in Saudi Arabia (Million barrels of oil equivalent). (Source: IMF (2011); World Bank (2011))

Year	Power	Growth %	Water	Growth %	Transport	Growth %
1980	20.72	–	19.5	–	40.7	–
1985	36.52	15.3	26.7	7.3	95.2	26.8
1990	63.42	14.7	36.3	7.3	130.0	7.3
1995	95.36	10.1	49.6	7.3	151.2	3.3
2000	143.39	10.1	67.6	7.3	165.2	1.9
2001	155.57	8.5	71.9	6.4	169.9	2.8
2002	168.8	8.5	76.5	6.4	175.1	3.0
2003	183.15	8.5	81.4	6.4	180.8	3.3
2004	198.71	8.5	86.6	6.4	187.3	3.6
2005	215.6	8.5	92.2	6.4	194.5	3.9
2006	233.93	8.5	98.1	6.4	202.6	4.1
2007	253.82	8.5	104.3	6.4	211.6	4.5
2008	274.84	8.3	111.0	6.4	222.1	5.0
2009	298.2	8.5	118.1	6.4	232.8	4.8
2010	323.54	8.5	125.8	6.4	245.2	5.3

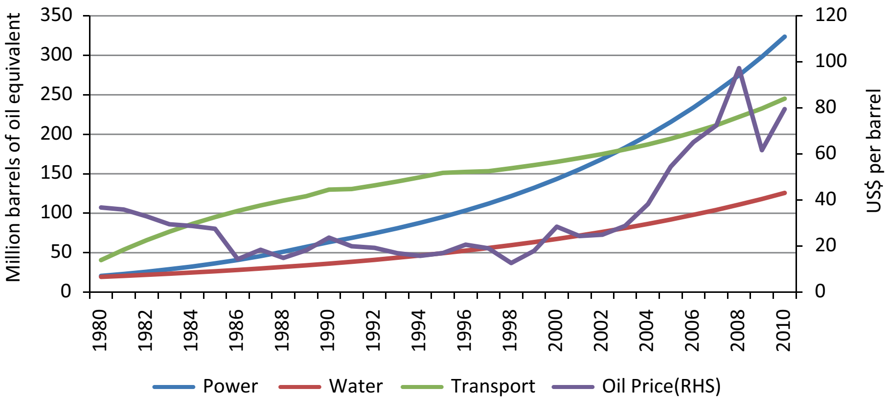


Fig. 2.11 Oil consumption in the power, water and transport sectors in Saudi Arabia. (Source: IEEJ (2011))

sector was the largest consumer of oil in the Kingdom for a long period of time until it was overtaken by the power sector in the recent years. It rose from around 41 million barrels of oil equivalent (mboe) in 1980 to over 245 mboe in 2010. In contrast, consumption of oil in the power sector in the Kingdom was estimated to have increased astronomically to over 323 mboe in 2010, from just around 21 mboe in 1980, while that for the water sector, mostly linked to desalination activities, rose from 20 mboe to 126 mboe during the same period.

From another dimension, oil consumption in the power sector has grown massively by having the highest average growth rate of 8.5 % annually in the period 1980–2010, while water and transport sectors have a lesser growth rate of 6.4 % and 5.3 %, consecutively through the same period. In the medium to long run, this is putting high pressure on oil resources in the Saudi economy. Therefore, policymakers

Table 2.4 Actual and forecast GDP, government revenue and oil consumption in the power, water and transport sectors in Saudi Arabia, 1980–2030 (million Saudi riyals). (Source: IMF (2011); World Bank (2011))

	GDP	Government revenue	Value of domestic oil consumption			
			Power	Water	Power and water	Transport
1980	546,604	348,100	2,861.69	2,698.98	5,560.67	5,621.18
1985	376,318	133,565	3,773.90	2,754.14	6,528.04	9,836.73
1990	437,334	190,491	5,643.41	3,233.79	8,877.20	11,566.19
1995	533,504	146,500	6,086.28	3,162.88	9,249.16	9,651.75
2000	706,657	258,065	15,324.49	7,222.30	22,546.79	17,657.87
2005	1,182,510	564,335	44,080.42	18,840.60	62,921.02	39,762.83
2010	1,629,998	821,420	96,456.50	37,504.13	133,960.62	73,104.36
2015	2,384,620	1,065,935	157,158.83	56,852.39	214,011.23	106,315.18
2020	3,520,801	1,565,262	266,920.41	90,319.42	357,239.83	1,675,11.73
2025	5,219,045	2,358,702	433,773.04	137,679.98	571,453.02	255,433.18
2030	7,749,755	3,573,614	676,733.23	201,840.81	878,574.04	371,687.36

GDP, gross domestic product.

in Saudi Arabia are realizing challenges occurring from this high consumption of oil to meet demand for utilities and transportation. If this rising oil consumption trend continues, then it will have a serious consequence for government revenue and GDP in the coming years, thereby posing a serious challenge in financing development. At the same time, the levelized cost of electricity (LCOE) is declining for renewable energy due to rapid deployment of these resources, working in combination with the high learning curves for some technologies. This would create a massive opportunity for the Kingdom to shift away from producing electricity by burning oil towards renewable energy revolution, which would reduce local oil consumption quite considerably.

Evaluated at the international oil price, the opportunity cost of the domestic oil consumption in the power and water sectors in Saudi Arabia is colossal. Indeed, the monetary value of oil consumed by the power and water sectors stood at about SAR 134 billion in 2010 equivalent to 8.2 % of GDP and 16.3 % of government revenues as opposed to a mere SAR 6.5 billion in the mid-1980s, representing just 1.7 % of GDP and 4.9 % of government revenues (Tables 2.4 and 2.5). In the case of the transport sector, however, its consumption of oil rose from SAR 10 billion in the mid-1980s (i.e. 2.6 % of GDP and 7.4 % of government revenues) to SAR 73 billion in 2010, equivalent to 4.5 % of GDP and 8.9 % government revenues (Tables 2.4 and 2.5).

On current trends, and according to forecasts by energy analysts, domestic oil consumption in Saudi Arabia could reach 8.5 mbd (3,102.5 million barrels per annum) by the year 2030, thereby drastically reducing oil exports/revenues. As a result, the value of oil usage in the combined power and water sectors in Saudi Arabia is likely to reach SAR 878.6 billion by 2030, accounting for over 24 % of government revenues and 11.3 % of GDP. In the case of the transport sector, oil

Table 2.5 Oil consumption in power, water and transport sectors in Saudi Arabia as percentage of GDP and government revenues, 1980–2030 (Source: IMF (2011); World Bank (2011))

	% Share in gross domestic product (GDP)				% Share in government revenue			
	Power	Water	Power and water	Transport	Power	Water	Power and water	Transport
1980	0.52	0.49	1.02	1.03	0.82	0.78	1.60	1.61
1985	1.00	0.73	1.73	2.61	2.83	2.06	4.89	7.36
1990	1.29	0.74	2.03	2.64	2.96	1.70	4.66	6.07
1995	1.14	0.59	1.73	1.81	4.15	2.16	6.31	6.59
2000	2.17	1.02	3.19	2.50	5.94	2.80	8.74	6.84
2005	3.73	1.59	5.32	3.36	7.81	3.34	11.15	7.05
2010	5.92	2.30	8.22	4.48	11.74	4.57	16.31	8.90
2015	6.59	2.38	8.97	4.46	14.74	5.33	20.08	9.97
2020	7.58	2.57	10.15	4.76	17.05	5.77	22.82	10.70
2025	8.31	2.64	10.95	4.89	18.39	5.84	24.23	10.83
2030	8.73	2.60	11.34	4.80	18.94	5.65	24.59	10.40

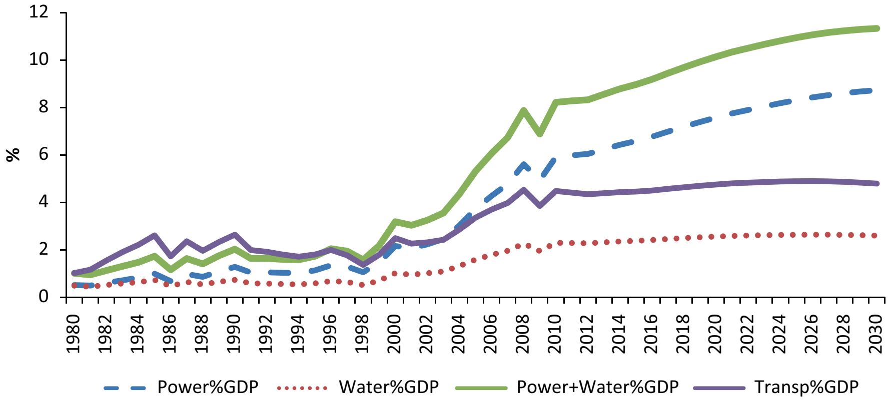


Fig. 2.12 Oil consumption in power, water and transport sectors in Saudi Arabia (% of gross domestic product (GDP)). (Source: IEEJ (2011))

consumption by the year 2030 is forecast to reach SAR 371.8 billion, equivalent to 10.4 % of government revenues and 4.8 % of GDP (Tables 2.4 and 2.5).[1] The actual and predicted trends in the share of oil consumption in the three sectors in GDP and government revenues are shown, respectively, in Figs. 2.12 and 2.13.

Thus, when these domestic oil consumption costs are added to the CO_2 emission costs, they account for even bigger shares of budgetary revenues and GDP. As Table 2.6 and Figs. 2.14 and 2.15 illustrate, the combined costs of domestic oil usage in the power, water and transport sectors in Saudi Arabia are estimated to have risen from over SAR 196 billion in 1980 to about SAR 1.3 trillion by 2010. On this

[1] See Figs. A.4 and A.5 for the complete yearly data set.

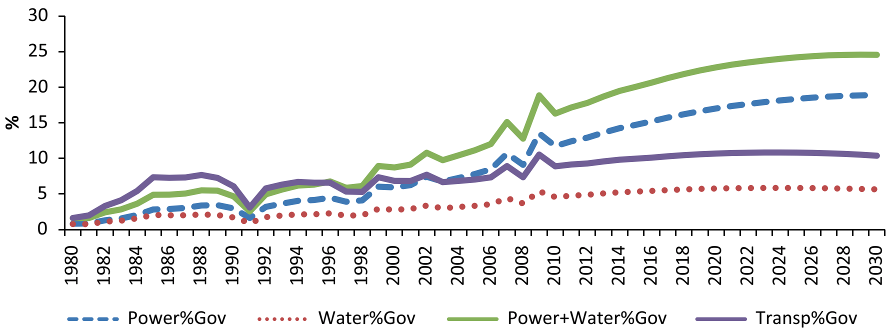


Fig. 2.13 Oil consumption in power, water and transport Sectors in Saudi Arabia (% of Government Revenues). (Source: IEEJ (2011))

Table 2.6 Costs of CO_2 emissions and domestic oil usage in the power, water and transport sectors in Saudi Arabia. (Source: IMF (2011); World Bank (2011); World Resources Institute (2011))

	CO_2 emission costs			Cost of oil usage			Total costs of CO_2 emissions and oil usage		
	SAR Mn	% Rev	% GDP	SAR Mn	% Rev	%GDP	SAR Mn	% Rev	% GDP
1980	185,429	53.27	33.92	11,182	3.21	2.05	196,611	56.48	35.97
1985	231,585	173.39	61.54	16,365	12.25	4.35	247,950	185.64	65.89
1990	266,407	139.85	60.92	20,443	10.73	4.67	286,850	150.58	65.59
1995	380,394	259.65	71.30	18,901	12.90	3.54	399,295	272.56	74.84
2000	471,419	182.67	66.71	40,205	15.58	5.69	511,624	198.25	72.40
2005	792,989	140.52	67.06	102,684	18.20	8.68	895,673	158.71	75.74
2010	1,127,298	137.24	69.16	207,065	25.21	12.70	1,334,363	162.45	81.86
2015	1,535,994	144.10	64.41	320,326	30.05	13.43	1,856,320	174.15	77.85
2020	2,162,577	138.16	61.42	524,752	33.52	14.90	2,687,329	171.69	76.33
2025	3,082,890	130.70	59.07	826,886	35.06	15.84	3,909,776	165.76	74.91
2030	4,419,712	123.68	57.03	1,250,261	34.99	16.13	5,669,973	158.66	73.16

GDP, gross domestic product.

trend, these combined costs are forecast to reach around SAR 5.6 trillion by 2030, accounting for over 158 % of government revenue or 74 % of GDP. This illustrates that not only would the costs of pollution and domestic oil consumption have a significant negative impact on the Saudi economy, but they would also drastically reduce exports and government revenues due to increased usage of oil to produce power and water. This scenario is explained by the opportunity cost of exporting oil at international prices (over US$ 100 per barrel) instead of providing it to be burnt in generating utilities at a very cheap subsidized price (US$ 4 per barrel). Even public utility companies record the highly subsidized price on their books only, but they do not actually pay it to Aramco, the Kingdom's national oil company.

On another front, this policy undermines the relative competitiveness of renewable energy in the Kingdom due to the extremely high subsidies granted to oil-based utilities, especially if the consumer purchasing prices of such utilities are taken into account. Therefore, apart from the environmental perspective, a comparison of the

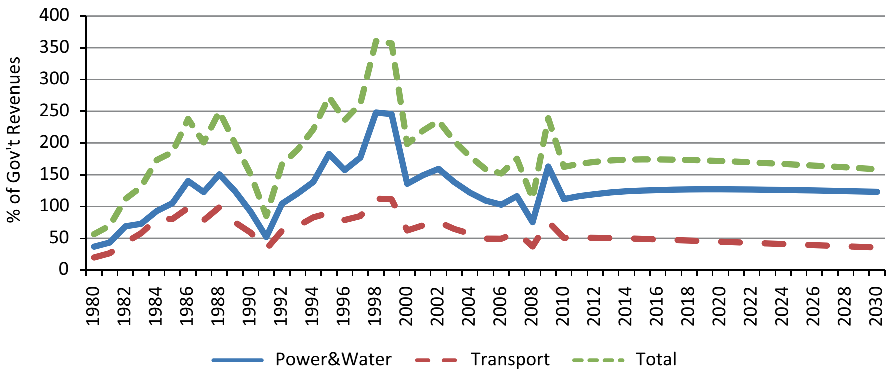


Fig. 2.14 Combined CO_2 emissions and oil usage costs in the power, water and transport sectors in Saudi Arabia (% of Government Revenues). (Source: World Bank (2011); IEEJ (2011))

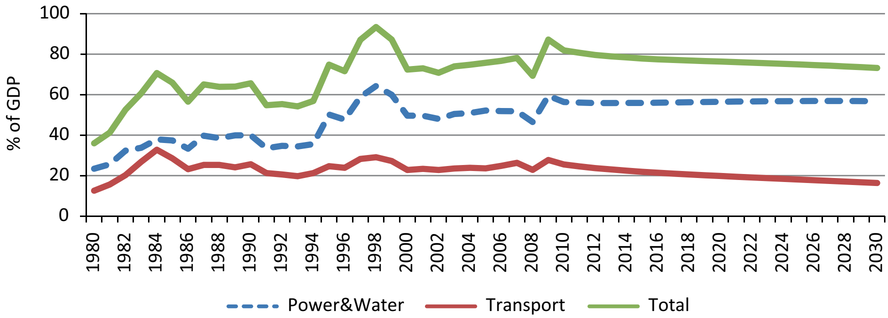


Fig. 2.15 Combined CO_2 emissions and oil usage costs in the power, water and transport sectors in Saudi Arabia (% of gross domestic product (GDP)). (Source: World Bank (2011); IEEJ (2011))

cost of renewable energy relative to fossil fuel-based projects in utilities in the Kingdom should be undertaken based on international prices, not locally subsidized oil prices. This, in turn, discourages utility companies and businesses from making any efforts or taking any constructive decisions towards promoting a greener economy.

There are two apparent implications of these growth trajectories on the costs of CO_2 emissions and domestic oil demand in the power, water and transport sectors. The first one is that oil is a non-renewable resource and in the absence of credible energy efficiency and resource conservation policies, oil reserves would be grossly depleted so much so that the Kingdom could become a net importer of oil instead of its present status as the world's leading oil exporting country. Secondly, as fossil fuel (including oil) is not environmentally friendly, the increased domestic consumption of oil in the Kingdom could further exacerbate environmental degradation, thereby heightening the widespread concerns that, left unchecked, increased environmental pollution could retard economic growth and prosperity. Clearly, these potential challenges call for urgent policy actions in several fronts including promotion of fossil energy efficiency and harnessing renewable energy technology, through a combination of incentives, such as feed-in-tariffs, capital subsidies, investment credits and public investment, loans or financings as practised around the world.

In sum, the stylised facts discussed here suggest that environmental pollution in Saudi Arabia is intertwined with economic activity. This means that measures aimed at boosting economic growth and prosperity must be complemented with measures for enhancing environmental quality. In other words, concrete pollution abatement measures and 'green' investment strategies must be pursued alongside efforts aimed at increasing production and consumption. A holistic approach at addressing environmental degradation must be the overarching principle, including environment monitoring and pollution control policies, waste treatment and management mechanisms, environment data collection and statistical analysis for effective modelling, planning, management and assessment of environmental quality. In the next section, we discuss the theoretical underpinnings and methodological approaches for modelling the relationship between economic activity and environmental pollution in general with a view to adopting it to Saudi Arabia.

2.3 Literature Review of the Economic Growth–Environment Nexus

At the heart of environmental economics is the debate about how economic activity and policy affect the environment in which the economic activity itself takes place. In general, such a debate in the empirical literature has centred on the following questions, succinctly summarized by Panayotou (2003):

- 'Does an inverted U-shaped relationship between income and environmental degradation, known as the environmental Kuznets curve (EKC), exist? If so, how robust and widespread is such a relationship?
- What is the role of other factors, such as population growth, income distribution, international trade and time-and-space-dependent (rather than income-dependent) variables?
- How relevant is a statistical relationship estimated from cross-country or panel data to an individual country's environmental trajectory and to the likely path of today's developing countries and transition economies.
- What are the implications of ecological thresholds and irreversible damages for the inverted-U-shaped relationship between environmental degradation and economic growth? Can a static statistical relationship be interpreted in terms of carrying capacity, ecosystem resilience and sustainability?
- What is the role of environmental policy both in explaining the shape of the income–environment relationship, and in lowering the environmental price of economic growth and ensuring more sustainable outcomes?'

There have been several attempts in recent years to investigate the theoretical underpinnings of the so-called EKC (environment–income relationship). Two such attempts are provided by Grossman and Kreuger (1993) and Selden and Song (1994), both of which found empirical evidence to suggest that an inverted U-relationship exists between the emissions of certain types of environmental pollutants and per capita GDP. This means that emissions and economic growth are positively related up to a certain level of income per capita, but after that level or turning point, emissions tend to decline despite rising per capita income levels. Similarly, findings from de Bruyn et al. (1998) tend to indicate some kind of decoupling or de-linking between environmental pressure and growth in some specific cases of emissions of air pollutants and countries. However, earlier results by Xepapadeas (1997) appear to show the existence of a negative relationship between the probability of a country having unacceptable environmental quality, measured in terms of concentrations of certain pollutants in air and water, and the stage of the country's economic development. This is not surprising because the link between economic growth and pollution can be broken by emission preventative measures or mechanisms including 'changing the structure of production and moving away from high-toxic intensive heavy industry to low-toxic intensive high-technology industry and/or introducing clean technologies (e.g. best-practice technologies) that would allow output growth without excess emissions' (Xepapadeas 1997).

Indeed, the importance of other factors of production, especially technological change or technological progress, on pollution can also have a significant effect in altering the link between economic growth and environmental emissions. For example, as Islam (2001) has pointed out, 'technologies developed and designed to combat global warming can reduce greenhouse gas (GHG) emissions, reduce the adverse effects of GHG and global warming, and help adapt to the circumstances caused by global warming'. This suggests that the characteristics of production and abatement technology and their evolution with income growth underlie the shape of the income environment relationship albeit not everyone agrees on the exact transmission mechanism. Whilst some authors tend to argue that shifts in production technology are brought about by the structural changes accompanying economic growth, others have emphasized the characteristics of abatement technology, and yet others have focused on the properties of preferences and especially the income elasticity for environmental quality (Panayotou 2003).

2.4 Modelling the Economic Growth–Environment Link for Saudi Arabia

All empirical studies that have attempted to investigate the relationship between economic growth and the environment naturally combined elements of an economic model with those of an ecosystem model. Such models generally involve the maximisation of a social welfare function subject to economic and ecosystem (e.g. climate change) constraints. The differences that exist among various studies, however, relate to the type of model estimation techniques employed (e.g. single equation versus computable general equilibrium), measures of ecosystem indicators used in the model and nature/scope of the study. Most of the environment–growth models often tend to use reduced-form single equation specifications linking an environmental variable (such as CO_2, SO_2 and composite indexes of environmental degradation) to per capita income. However, as Panayotou (2003) has argued, 'the ad hoc specifications and reduced form of these models turn them into a 'black box' that shrouds the underlying determinants of environmental quality and circumscribes their usefulness in policy formulation'.

In view of this apparent criticism of the reduced-form single equation methodology, we shall adopt a systems-wide approach to estimate the linkages between economic growth and the environment for Saudi Arabia. The motivation for this approach is credited to Islam's (2001) estimation of the Australian Dynamic Integrated Model of Climate and the Economy (ADICE), which itself has its roots in Gottinger (1991). The model emphasises the role of technical progress and net emissions reduction in the economic growth process in addition to the standard factors of production, such as capital and labour. Detailed discussions of the critical evaluation of the dynamic integrated model of climate–economic growth and further developments in this field can be found in Azar (1995) and Nordhaus and Boyer (2000). A comparative analyses of the structures of other optimisation models of the environment and economic growth are discussed in Khanna (1998).

The stylised form of the model that we intend to use in this chapter is as follows:

$$Y(t) = \Omega(t)A(t)K(t)^{\gamma} L(t)^{1-\gamma} \left(\text{Production function}\right) \tag{2.1}$$

$$\Omega(t) = [1 - TC(t) / Y(t)] / [1 + DM(t) / Y(t)]\left(\text{Net environmental pollution}\right) \tag{2.2}$$

$$TC(t) / Y(t) = b_1 \mu(t)^{b_2} \text{ (Emissions-reduction cost function)} \tag{2.3}$$

$$D(t) / Y(t) = \theta_1 T(t) \theta_2 \left(\text{Environmental damage function}\right) \tag{2.4}$$

$$E(t) = [1 - \mu(t)]\sigma(t)Y(t)\,\text{(Emissions-Economic output function)} \tag{2.5}$$

$$C(t) = \alpha_0 [Y(t)]^{\alpha 1} \left(\text{Consumption function}\right) \tag{2.6}$$

$$K(t) = (1 - \delta_k)K(t-1) + l(t)\left(\text{Capital accumulation function}\right) \tag{2.7}$$

$$R(t) =_{\gamma} Y(t) / K(t)(1 - \delta_k)\,\text{(Discount rate)} \tag{2.8}$$

$$Y(t) = C(t) + l(t) + NX(t)\text{(National Income Identity)} \tag{2.9}$$

Where:

Y(t)	Gross domestic product
$\Omega(t)$	Output scaling factor due to emissions controls and environmental damage

$A(t)$	Growth of technological progress
$K(t)$	Stock of capital
$L(t)$	Labour force
$TC(t)$	Total cost of reducing environmental emissions
$D(t)$	Damage from environmental emissions (GHG and waste)
$E(t)$	Environmental emissions
$T(t)$	Atmospheric temperature relative to base period
$C(t)$	Total aggregate consumption
$I(t)$	Gross fixed capital formation (investment)
$NX(t)$	Net exports (exports minus imports)

Parameters:

γ	elasticity of output with respect to capital
$(1-\gamma)$	elasticity of output with respect to labour, assuming a constant return to scale Cobb–Douglas-type production function.
b_1, b_2	parameters of emissions-reduction costs function
θ_1, θ_2	parameters of damage function
$\mu(t)$	rate of emissions reduction (the emissions control rate)
$\sigma(t)$	ratio of the uncontrolled emissions to output
δ_k	rate of capital depreciation
α_0 and α_1	autonomous consumption and marginal propensity to consume, respectively.

Equation (2.1) describes the production function of the overall economy where real GDP depends not only on the usual factor inputs of capital, $K(t)$ and labour, $L(t)$, but also on the technological progress, $A(t)$, and on an environmental scaling factor, $\Omega(t)$, which captures the net environmental pollution.

Equation (2.2) shows that the net environmental pollution [environmental output scaling factor, $\Omega(t)$] itself is jointly determined by costs of emissions abatement and environmental damage. The environmental damage function, in turn, is defined by non-linear scaling parameters (θ_1 and θ_2). To reduce the output loss due to environmental damage, policymakers will have to formulate a number of environmental protection measures that will reduce emissions and the total cost of such measures. Equation (2.3) suggests that the total cost of environmental policy is determined by the emissions-reduction ratio (μ), while Eq. (2.4) provides the link between environmental damage and the earth's atmospheric temperature.

Equation (2.5) shows the relationship between environmental emissions and real GDP where such a relationship is also influenced by key parameters: the rate of emissions reduction (μ), which is a policy variable under the control of the policymakers, and the uncontrollable emissions (σ) that are directly related to economic activity but outside the control of policymakers. For instance, in the ADICE model only CO_2 and chlorofluorocarbon gases are assumed to be under the policy control and the rest of the GHGs are exogenous to the model.

Equation (2.6) is a standard consumption function, where aggregate consumption in the economy depends on GDP. Equation (2.7) defines the economy's capital accumulation process where current stock of capital depends on the previous stock and current investment (i.e. gross fixed capital formation). Equation (2.8) defines discount rate as output–capital ratio with allowances for capital depreciation, while Eq. (2.9) is the national income identity, which consists of aggregate consumption (private and public), investment (private and public) and net exports (i.e. exports minus imports).

The model depends on key assumptions. On the economic side of the model, investment, labour force, technological progress and net exports are assumed to be exogenous, although future growth of labour force is inextricably linked to the growth rate of population just as technical progress is heavily influenced by the growth rate of technology. For simplicity of exposition, investment is assumed to be an important economic policy instrument in the same manner as the emissions reduction variable is used in the ecosystem model.

2.4.1 Analysis of the Results

We estimated the above-mentioned environmental–economic model for Saudi Arabia for the period 1980–2010 and used the estimated parameters to perform out-of-sample forecasts of income and environment variables for the years 2011–2030 based on three scenarios of pollution abatement policies. The simulated GDP and its growth rates can be considered to be optimal and sustainable over the long horizon since net costs of environmental degradation, via the emissions reduction policies, have been factored into their estimation. The model is also used to test the existence (or lack of it) of the EKC (the inverted-U relationship between pollution and economic growth or development). Here, we used the cumulative sum of regression residuals (CUSUM) and CUSUM-squared techniques to detect for any structural breaks in the environment–growth relationship over time.

The model was estimated using the E-Views statistical software. Table 2.7 summarizes the results of the production function, using three different pollution reduction policy scenarios. Equation 1 of Table 2.7 corresponds to our baseline scenario which assumes that policymakers in Saudi Arabia introduce a 1 % cut in emissions in the Kingdom for the foreseeable future. This pollution abatement policy assumption is reflected in the environmental damage variable OMEGA1. Equation 2 of Table 2.7 corresponds to a pessimistic scenario of a lower pollution abatement rate of only 0.65 % than the one for the baseline scenario. This pollution reduction policy scenario is reflected in the environmental damage variable OMEGA2 in the production function. Finally, in the case of the optimistic scenario (Equation 3 of Table 2.7), we assumed that Saudi Arabian policymakers introduce a more ambitious cut in emissions of around 5 %. This is picked up by the net environmental damage variable OMEGA3.

Table 2.7 Estimated production function for Saudi Arabia (Dependent variable: Log of real GDP, 1980–2010)

Independent variable	Baseline scenario (Equation 1)	Pessimistic scenario (Equation 2)	Optimistic scenario (Equation 3)
C	−34.878***	−50.620***	−5.811
	(−3.443)	(−2.837)	(−0.470)
Omega 1	−10.214***		
	(−7.066)		
Omega 2		−28.443**	
		(−2.068)	
Omega 3			−0.075*
			(−1.521)
INV	0.105	0.293**	0.176**
	(1.381)	(2.377)	(2.333)
LF	0.367***	0.022	0.595***
	(3.999)	(0.183)	(6.629)
TFP	13.209***	18.190***	3.591
	(3.917)	(3.059)	(0.872)
Adjusted R-squared	0.961	0.903	0.978
F-statistic	188.691	71.337	297.487
Akaike info criterion	−3.24	−2.321	−3.755
Schwarz criterion	−3.009	−2.089	−3.515
Hannan–Quinn criterion	−3.165	−2.245	−3.684
Durbin–Watson statistic	0.958	1.055	1.272
No. of observations	31	31	27

GDP gross domestic product
All independent variables are in natural logarithms; *, ** and*** represent 10%, 5% and 1% significance levels, respectively; figures in parentheses are absolute values of *t* statistics

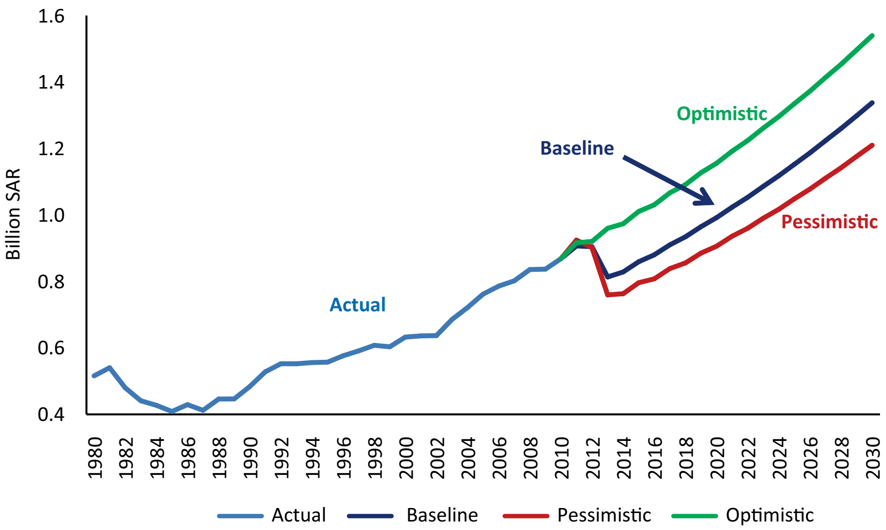
As anticipated, the estimated coefficient of the environment degradation variable is negative and statistically significant at various levels, suggesting that pollution reduces economic growth in Saudi Arabia. But the harmful effect of pollution on growth tends to ease as one moves away from a less ambitious pollution-reduction policy to a more ambitious one. For example, in the baseline scenario (Equation 1 of Table 2.7), the coefficient of the environmental variable, OMEGA1, is −10.214. This means that, maintaining 1% cut in environmental pollution, *ceteris paribus* will reduce Saudi Arabia's GDP by around 10%. In contrast, in the absence of such a policy, an increase in environmental pollution will reduce GDP by 28% (pessimistic scenario of Equation 3 Table 2.7). However, in the presence of a more robust emissions cut equivalent to 5%, environmental pollution will reduce GDP by a negligible amount (i.e. 0.075%, as the optimistic scenario of Equation 3 of Table 2.7 shows). This is because of the high level of environmental pollution that currently exists in the Kingdom coupled with the rapid growth in the expected rate of pollution over the coming decades.

However, the above-mentioned model insinuates a gradual decrease in pollution through ecological regulations and investments in the Kingdom. But it should also be pointed out that a sudden paradigm shift in reducing emissions and introducing stricter environmental regulations might have a huge cost on the economy. Therefore, medium- to long-term investments with a well custom-tailored regulatory framework for environmental policies will absolutely have a positive impact on economic growth in Saudi Arabia. However, prioritizing government and private sector investments should be done through spending in areas that generate returns and stimulate the greening of economic sectors.

Derived from the above results, the government should avoid locking in unsustainable assets and systems or of losing valuable natural capital that people depend on for their livelihoods. This is to ensure the realization of green infrastructure and technologies, especially those with substantial non-financial benefits or financial benefits that are difficult for private actors to capture. It should also foster green infant industries, as part of a strategy to build comparative advantage and drive long-term employment and growth. On the other hand, the private sector has to engage immensely in such an economic transformation. The international community, as a whole, can also play a critical role in providing technical and financial investments to unleash environmental business opportunities in the Kingdom.

2.4.2 Economic Growth Forecasts Based on the Three Emissions Reduction Scenarios

We used the estimated production equations to produce forecasts of real GDP in Saudi Arabia over the period 2011–2030 based on the three emissions reduction scenarios. The baseline scenario is based on the assumption that the government introduces a 1 % cut in CO_2 emissions. With such a policy scenario, the Kingdom's real GDP is forecast to increase from around SAR 904 billion in 2011 to SAR 1.34 trillion by 2030. However, with more ambitious cuts in environmental pollution, the Kingdom could see a sustainable increase in GDP, which could reach around SAR 1.54 trillion in the next two decades corresponding to a 5 % cut in environmental pollution (Fig. 2.16). In contrast, under a limited or less ambitious emissions reduction plan, the build-up of environmental pollution would slow down the growth rate of GDP. For instance, under the pessimistic scenario, which corresponds to limited emissions reduction policy of half a percentage point, real GDP will expand only sluggishly to reach SAR 1.2 trillion by 2030. Thus, the deeper the cut in emissions, the larger the GDP and vice versa (Fig. 2.16 and Table 2.8). It, therefore, pays for the government of Saudi Arabia to redouble efforts towards a more ambitious and sustainable environmental pollution abatement policy to promote a greener economy that will preserve the environment for future generations as well as create jobs and promote sustainable economic growth and prosperity of the Kingdom.



Note: Based on estimated regresssion equations in Table 2.7 above

Fig. 2.16 Real gross domestic product (GDP) forecasts under the three scenarios

Table 2.8 Key economic and environment indicators under the three scenarios

Indicator	Model	Period 2011	2020	2030
Output (Billion SAR)	Pessimistic	904.00	906.66	1,210.64
	Baseline	904.00	992.35	1,338.36
	Optimistic	904.00	1,156.16	1,540.21
Emission abatement rate (%)	Pessimistic	0.65000	0.65000	0.65000
	Baseline	0.98000	0.9800	0.9800
	Optimistic	5.00000	5.00000	5.00000
Total cost to GDP ratio (%)	Pessimistic	0.015839	0.015475	0.014837
	Baseline	0.024557	0.019558	0.016367
	Optimistic	0.13386	0.048369	0.023927
Total damage to GDP ratio (Metric Tonnes/SAR)	Pessimistic	0.0014966	0.00149	0.00148
	Baseline	0.00154	0.00153	0.00152
	Optimistic	0.00120	0.00120	0.00120

GDP gross domestic product

2.4.3 Testing for Structural Breaks in the Environment–Growth Relationship

To test for structural breaks in the relationship between pollution and economic development, we used the CUSUM (or CUSUM-squared) technique to (a) an equation linking CO_2 emissions to per capita GDP and its squares; (b) an equation linking 'waste by-products' to per capita GDP and its squares; and (c) the production function. In each case, the analysis was applied to the estimated GDP calibrated from the three emission reduction scenarios.

In the case of the link between CO_2 emissions to real per capita GDP (and its squares), there appear to be multiple structural breaks under the three scenarios. Both the baseline and the pessimistic scenarios have detected dual structural breaks (1991 and 2025 for the baseline scenario, and 1991 and 2026 for the pessimistic scenario), as illustrated by Appendix Figs. C.1 and C.2, respectively. Under the optimistic scenario, however, four structural breaks in the relationship between CO_2 emissions and real per capita GDP were detected (1997, 1998, 2010 and 2019) as shown in Appendix Fig. C.3.

With regard to the regression of 'waste by-product' on real per capita GDP (and its squares), evidence of dual structural breaks was also observed in all three scenarios. In the case of the baseline scenario, breaks occurred in 1996 and 2023 (Appendix Fig. C.4), while such breaks correspond to 2011 and 2024 under the pessimistic scenario (Appendix Fig. C.5) and to 2007 and 2019 under the optimistic case (Appendix Fig. C.6).

Finally, structural breaks were also detected in the estimated production function in two of the three scenarios. In the baseline scenario, breaks were noticeable in 1994 and 2023 (Appendix Fig. C.7), and in 1994 and 2011 in the case of the pessimistic scenario (Appendix Fig. C.8). The optimistic scenario, however, does not provide any evidence of structural break throughout the entire period (Appendix Fig. C.9). This goes to suggest that the relationship between economic growth and the environment will remain stable when credible efforts to tackle environmental pollution are put in place.

2.5 Policy Implications

This chapter has examined the relationship between economic growth and the environment in the Kingdom of Saudi Arabia. Based on a review of the copious literature and methodological approaches on this subject, an appropriate econometric model that captures the inter-linkages or interdependencies between the economic sector and the ecosystem was specified, estimated, analysed and used to forecast real GDP for the period 2011–2030 under three different pollution abatement scenarios. The key findings of the results suggest that sustainability of economic growth in Saudi Arabia critically depends on aggressive emissions reduction policies since policy simulations corresponding to higher pollution cuts yielded higher long-term GDP. In contrast, the 'do nothing' or less ambitious emissions reduction policies are associated with low economic growth. We also attempted to test for the presence of the EKC, which hypothesizes an inverted-U relationship between economic growth and the environment using standard econometric tests for structural breaks.

The absence of structural breaks would underline the stability of the link between environmental emissions and economic development at all income levels. The presence of a structural break, however, suggests that there is a turning point in the relationship between economic growth and the environment. Results from the cumulative sum of squares of residuals (CUSUM-squared) yielded multiple breaks in the relationship between per capita income and pollution (for both CO_2 emissions and waste equations) under all three pollution abatement scenarios, thereby providing no clear-cut evidence to support the EKC hypothesis in Saudi Arabia. In fact, the application of the CUSUM-squared test to the production function, which includes an environmental variable, found no evidence of a structural break under the so-called optimistic scenario which reflects the most ambitious pollution abatement assumption. This result suggests either that there is no evidence of the EKC hypothesis or that the evidence of EKC hypothesis in the Kingdom is, at best, weak.

What are the policy implications of the findings? A number of policy implications could be highlighted here. For one, it is heartening that there is little or no evidence of the EKC hypothesis for Saudi Arabia, otherwise it will send a wrong signal to policymakers that a 'turning point' has been reached in the income and environmental pollution or degradation relationship. This finding tends to corroborate results found elsewhere in other developing countries and also in line with theoretical proposition that developing countries in general are to the left of the turning point of the EKC while developed countries tend to be to the right of the turning point of the inverted-U curve. For example, a recent study on Kenya found no evidence for the Kuznets inverted-U relationship (Kamande, 2010), while another study Olusegun (2009), which investigated the relationship between economic growth and carbon dioxide emissions in Nigeria, also arrived at a similar conclusion. This suggests that a vigorous green or clean environmental policy alongside economic development policy in both Kenya and Nigeria, as much as in Saudi Arabia, must be pursued simultaneously. For more mature industrialized, service-oriented economies, however, the relationship between emissions and per capita income may not be inconclusive, thus suggesting that too rigorous pursuit of environmental protection policies might be harmful to economic growth, since these countries are already employing clean technology anyway. A key lesson from these empirical studies is that it is possible for developing countries to improve their environmental quality if they can manage to succeed in decoupling environmental pollution and resource use from economic growth. This can be achieved through a variety of options including structural change, technological change or policy change or a combination of all three.

Another important implication of the findings is that the results unambiguously suggest that environment degradation is harmful to economic growth in Saudi Arabia; hence, appropriate measures must be put in place to tackle environmental pollution in the Kingdom. Given that Saudi Arabia is one of the largest polluters in the Gulf region, apparently due to both the sheer size of its economy and its increased reliance on fossil fuel energy that is generally regarded as environmentally unfriendly, the Kingdom's ability to sustain long-term economic growth and prosperity would crucially depend on its willingness to formulate and implement aggressive environmental protection policies. Such policies are costly but achieving optimal pollution level does not necessarily mean reducing pollution to zero, but bringing down pollution levels until the marginal abatement cost equals the marginal environmental damage. This is the point where the level of pollution abatement maximizes the net benefit to society and guarantees economic growth sustainability that will be beneficial to the present as well as future generations.

Thus, government policies to tackle pollution and other environmental degradation in the Kingdom would involve a wide range of measures based on experiences from comparator countries. For instance, Panayotou (2003) has suggested that the decoupling of growth and environment in developing countries, and thus progress towards sustainable development, calls for action on many fronts, including the following:

- Adoption of an effective mix of economic instruments, such as taxes, charges and tradeable permits, to correct market and policy failures, internalize environmental and social costs and induce changes in the composition of consumption and production;
- Improvements in the efficiency of resource use and the 'dematerialization' of the economy;
- Introduction of specific policies to preserve the living standards of those directly affected by the required adjustment and to avoid unemployment and social disruption; issues of inequality and social exclusion must be addressed;
- Education to encourage industrial and collective responsibility and thereby induce behavioural changes that will support sustainable development.

The Kingdom's vision should be to utilize the most appropriate measures to turn major negative environmental challenges into sustainable green businesses. Saudi Arabia shares many common features of the above measures too. For example, setting realistic and achievable pollution reduction targets and choosing the appropriate instruments for achieving those targets (e.g. pollution taxes or emissions trading to incentivize 'green' production and consumption) will be a desirable policy option. In addition, there is the need to establish and strengthen legal and regulatory institutions for environmental protection purposes, as the introduction of environmental regulation will slow the rate of pollution. Also, constant monitoring, assessment and effective management of environmental pollution should be the cornerstone of environmental policy in the Kingdom. Yet another policy option for addressing the pollution challenges revolves around increased deployment of pollution abatement technologies and also increased R&D activities on 'green' technologies should be encouraged.

Thus, one of the main findings of the model indicates that the Kingdom should pursue energy efficiency policies in parallel with renewable energy policies in the short to medium term. Such efforts will not only improve environmental quality but also generate substantial revenue and conserve conventional energy for future generations. This is relevant given that domestic consumption of energy (oil) in Saudi Arabia, especially in power and water sectors, is rising rapidly due to rapidly expanding energy-intensive industries and demographic dynamics. In essence, on current trends, domestic oil consumption by 2030 (estimated at 8.5 mbd) could exhaust domestic oil supply, thereby drastically reducing oil exports/revenues. Government should devise a number of incentive mechanisms to harness and nurture renewable energy through methods such as price subsidies (feed-in-tariffs), capital subsidies, investment credits and public investment, loans or financings as practised around the world. Efforts should also be made to encourage private sector participation in green/ethical investment.

A number of private sector participants around the world, including private equity, hedge funds and investment banks, have already started to establish special environment funds (or ethical investment funds) to invest in 'green' products. Such schemes should be encouraged and popularized in the Kingdom and elsewhere in the GCC countries. These issues will be discussed and analysed in the rest of this book, with the next chapter focusing exclusively on innovative financing mechanisms for environmental environments.

Chapter 3
Environmental Investments

3.1 Overview

Investments in environmental business can play a key role in promoting sustainable development, which in itself is a bankable concept since such investments could generate returns with a substantial net present value. Environmental investments could, therefore, serve as a catalyst or multiplier to wealth creation and can also induce policy changes that could create jobs, boost national income and promote sustainable economic growth and prosperity. Thus, environmental investments allow for the simultaneous attainment of business and social objectives through financing of environmentally friendly activities. It is reckoned that, under the current practice of business as usual, the world is spending billions of US dollars annually in direct and indirect subsidies to key sectors such as water, energy, agrochemicals, deforestation and heavily polluting industries that degrade the environment. As a result, investment in clean energy and other environmental goods and services would go a long way in addressing environmental degradation and generating substantial returns to private investors.

However, a major challenge to environmental business is inadequate funding from both public and private sources. A number of financing mechanisms are currently being explored by many countries around the globe, but the magnitude of such challenges requires new thinking and new ideas on innovative mechanisms that could result in increased financial resources for environmental investments. Some of the new alternative mechanisms that are bandied around include 'green bonds', 'green sukuk', venture capital, environmental funds (EFs; including private equity funds) and innovative sustainable infrastructure financing through public–private partnership (PPP) schemes. These additional initiatives are propagated due to operational difficulties associated with the erstwhile mechanisms such as the Clean Development Mechanism (CDM), Global Environmental Facility and environmental finance centres that were considered to be innovative a decade or so ago.

This chapter discusses the various innovative mechanisms for financing environmental technology business. Section 3.2 focuses on 'green' bonds and 'green' *sukuk*. Sections 3.3 and 3.4 discuss the roles of venture capital and EFs, respectively,

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while Sect. 3.5 examines the CDM of the Kyoto framework. PPPs are discussed in Sect. 3.6, and Sect. 3.7 pulls together the main conclusions of the chapter.

3.2 Green Bonds and Green Sukuk

Green bonds and their Islamic counterparts, Green *Sukuk*, are debt instruments issued to raise capital to finance specific environmental projects. These instruments have recently been increasing in popularity as one of the most innovative financing mechanisms for environmental investments in many countries around the world. Examples of green bonds include green gilts; green investment bank bonds; green corporate bonds; green infrastructure bonds; index-linked carbon bonds; and water bonds. Globally, the total issuance of green bonds stood at around US$ 3.5 billion in 2010 (World Bank 2011), largely issued by international financial institutions, led by the World Bank, with investors ranging from institutional investors to socially responsible investment (SRI)-focused retail investors.

Capital raised through these green debt instruments is invested responsibly in green products or in solutions that will help restore the health of the planet for the benefit of future generations. Of course, investments in environmental business may be a big task especially in tough economic times, but can eventually be rewarding, as Raymond Thomas Rybak, the Mayor of Minneapolis in the USA, said: 'If people can put up money now to support this (green investment) in the short term, they might realize a benefit down the road and help the environment at the same time'.[1]

3.2.1 Why Green Bonds?

The recent global financial crisis has introduced tremendous uncertainty and market volatility which affected funding for conventional business activities let alone environmental investments. Under such circumstances, green bonds can be seen not only as an innovative mechanism for financing environmental goods and services but also as a safer and more secure option for investors. With green bonds, 'as long as the projects are technologically sound and commercially viable, you've got a relatively well-established cash stream and return… that's the basis of reasonable investment product' (Heinztman 2009).

Green bonds are largely driven by investor demand for high returns in the high-growth clean energy and environmental business sector as opposed to highly volatile equities. They are also driven by demand for low-risk products from bond issuers, as investors are unlikely to invest capital directly into individual projects given that such direct investments can often increase exposure to regulatory uncertainty and technology risk. Such a fixed-income investment structure

[1] See Bielenberg (2011).

Table 3.1 Top issuers of green bonds, 2011. (Source: Bloomberg (2012))

	US$ million
1. World Bank Group	3,300.00
2. European Investment Bank	1,849.80
3. Asian Development Bank	897.20
4. African Development Bank	426.30
5. Kommunalbanken AS	400.30
6. Nordic Investment Bank	208.70
7. European Bank for Reconstruction and Development	63.40

provides a relatively easy mechanism to integrate environmental investment policies into a portfolio strategy and to signal strong commitment to stakeholders and policymakers.

It is widely recognised that green bonds in the USA tend to be attractive to investors because they command the same top-notch credit rating as the US Treasury notes but their yields are roughly twice as the rate on the US Treasury notes. According to California State Treasurer, Bill Lockyer, green bond is 'very safe, it accelerates the conversion to a non-carbon economy and it makes money' (Bielenberg 2011).

Besides the green government bonds, some companies have started issuing green corporate bonds, some of which yield higher returns than green government bonds. For example, in October 2010, Ecotricity (a green electricity company in the UK), launched a corporate bond dubbed 'Ecobond 1' to raise money for developing wind-farm capacity paying a 6 % annual return, rising to 6.5 % for Ecotricity customers (Brignall 2011). A year later, the same company launched 'Ecobond 2' with the aim of raising additional capital to provide green energy solution to households without the need to stick any equipment on their roof. Due to its attractiveness, the bond with an initial 4-year term was oversubscribed by 50 % (Brignall 2011).

Needless to say, the demand for green bonds is likely to rise in the coming years when ground rules for defining the 'green theme' for investors are established.

3.2.2 Leading Issuers of Green Bonds

So far, the principal multilateral development banks, such as the World Bank, European Investment Bank, the African Development Bank and the Asian Development Bank are the leading issuers of green bonds, used largely to fund clean air, energy and water projects. For instance, the World Bank has issued US$ 3.3 billion of the green bonds, followed by US$ 1.8 billion from the European Investment Bank and US$ 897 million from the Asian Development Bank (Table 3.1).

The leading role of the World Bank is not surprising as it pioneered the concept in 2008 as part of its 'Strategic Framework for Development and Climate Change'. The key aim was to tap into a large global pool of assets allocated to fixed-income investment held by pension funds and sovereign wealth funds (SWFs). The first green bond issued by the World Bank was for 2.325 billion Swedish kroner (US$ 350 million), with 6-year maturity and 3.5 % interest (World Bank 2011). It is widely acknowledged that the World Bank green bonds have consistently outperformed conventional bonds on the secondary market as investors continued to look for differentiation. Since 2008, the World Bank has issued green bonds in 16 various currencies, and other agencies, including government agencies, have also issued green bonds across a wide range of jurisdictions.

Following the 2008 global financial crisis, the US Government introduced green bond as a mechanism for financing the development of clean technologies in order to create jobs and promote sustainable economic growth and development. Box 3.1 describes the US green bond framework.

Box 3.1: The US Green Bond Model

Setup (Phase I)

The US Federal Government acts as an incubator for the first 5 years of the programme, and then the programme migrates to and is sustained within the private and non-profit sectors. The US Department of the Treasury will be responsible for supervising the sale of bonds and will redeem investors' securities when the bonds mature.

Distribution of Revenues

Green Bond investment revenues will be distributed *locally* and *regionally* in the form of grants, loans, incentives, cooperative agreements and awards for individuals and green enterprises in all three sectors of the US economy: private, non-profit and public.

- *Who will be eligible for funding?* Individuals (e.g. social entrepreneurs, inventors and innovators), small businesses, non-profits, manufacturers, waste and recycling companies, etc.
- *What sort of activities will be funded?* Small- and large-scale research and development, green cottage industries, recycling/re-use centres, community clean-up initiatives, environmental education, new product development using reclaimed materials, reclamation systems, reconstitution and refabrication of existing products and materials, product lines that use existing materials for new purposes, etc.

Revenue Return Loop (Phase II)

The *Green Bond* programme will pay out both principal and dividends earned when bonds mature in 10 years and will also have the capacity to sustain a high level of investment in green ventures after the bond aspect of the programme concludes, i.e. it must create and inject revenue from a new source back into the programme coffers after investor securities are redeemed. Revenue to sustain and grow the programme over time will be generated from the following four sources:

1. Loan repayments
2. Return on shares of profit realized from products/processes developed with grant support
3. Surcharge on locally produced products/packaging that use only first generation materials
4. Tariff on products produced outside the USA that use only first-generation materials

The utilization of low-profit limited liability corporations (L3Cs) may provide another viable avenue for growing and sustaining phase II of the programme.

Source: US Department of Treasury (2009).

Similarly, the Canadian Government has recently issued green bonds worth Can$ 41 billion to fund its ‘Green Stimulus Package’, while the UK Government’s ‘Green Investment Bank’ issued green bonds to attract private sector investment in green technologies. These countries were also joined by the Republic of Ireland which used green bonds, carbon tax and the auctioning of carbon permits to fund its ‘Green New Deal’ programmes. The United Nations Framework Convention on Climate Change (UNFCC) too has been administering green bonds issued on behalf of developing countries to investors from developed countries.

Proceeds from green bonds can be used to finance a wide range of green projects. In the case of the World Bank, the beneficiary projects must meet specific criteria for low-carbon development, including promoting the transition to low-carbon and climate-resilient growth in the recipient country as well as projects that target mitigation of climate change adaptation to climate change. According to the World Bank (2011), some of the beneficiary projects from the World Bank’s green bond scheme include: Rural Renewable Energy in Mexico, worth US$ 15 million; Eco-farming in China, at US$ 120 million; Energy Infrastructure in India (US$ 600 million); and Disaster Risk Management in the Dominican Republic (US$ 80 million).

To date, climate-themed issuance stands at US$ 16 billion, led largely by the World Bank and the European Investment Bank. This still pales into insignificance when compared with clean energy corporate, currently totalling around US$ 30 billion (Table 3.2 and Fig. 3.1).

3.2.3 Leading Underwriters of Green Bonds

Swedish and Japanese banks are the most active underwriters of green bonds, led by Skandinaviska Enskilda Banken AB of Sweden with green bonds worth nearly US$ 2.0 billion in 2011, followed by Daiwa Securities Group Inc of Japan with US$ 1.18 billion (Table 3.3). Together, the Swedish and Japanese banks accounted for almost twice the US$ 2.6 billion underwritten by the British, American and Canadian banks.

Table 3.2 Precedence bond issuances. (Source: World Bank 2011)

Issuer	Year	Type	Value (US$)
European Bank for Reconstruction and Development (EBRD)	2011	Environmental Sustainability Bond	23,000,000
International Finance Corporation (IFC)	2011	Green Bond	135,000,000
Sunpower/Andromeda Finance	2010	Solar Project Bond	260,000,000
Asian Development Bank	2010	Water Bond	640,000,000
Novachem	2010	EE Corporate Bond	1,540,000
Nordic Investment Bank	2010	Environmental Support Bond	200,000,000
African Development Bank	2010	Clean Energy Bond	220,000,000
US municipal governments	2009–2010	Property Assessed Clean Energy Bonds	9,690,000
US Government agencies and utilities	2009–2010	Clean Renewable Energy Bond Programme	2,200,000,000
World Bank	2008–2010	Green Bonds	1,896,700,000
World Bank	2008	CER-Linked Uridashi Bond	31,500,000
European Investment Bank	2007–2010	Climate Awareness Bonds	1,630,000,000
World Bank	2007–2008	Eco 3+Notes	360,000,000

CER, Certified Emission Reduction.

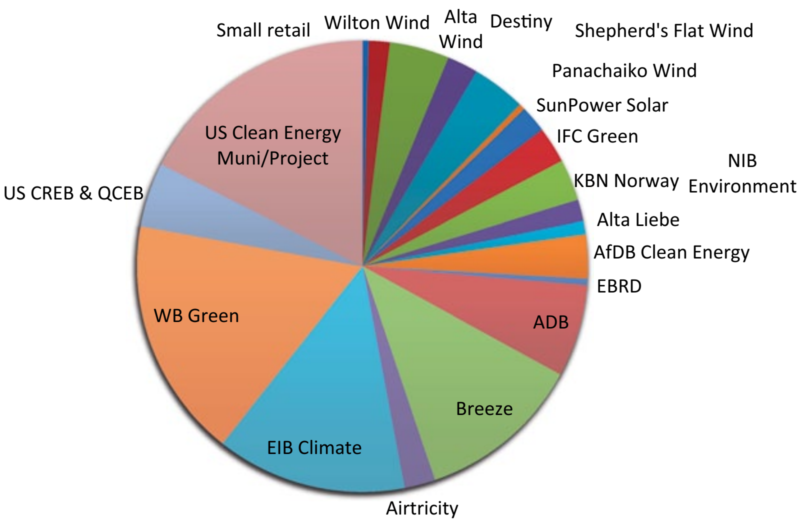


Fig. 3.1 Type of bond issuance. (Source: World Bank 2011)

3.2.4 Prospects of Green Bonds

The outlook for green bonds appears to be encouraging as its growing importance is prompting the Climate Bonds Initiative (CBI) to launch a first set of international standards on green bonds. The supposedly brighter prospects for green bonds ema-

Table 3.3 Top underwriters of green bonds, 2011. (Source: Bloomberg (2012))

	US$ million
1. Skandinaviska Enskilda Banken AB	1,909.00
2. Daiwa Securities Group Inc.	1,183.50
3. HSBC Bank Plc	966.50
4. JPMorgan Chase & Co.	549.30
5. TD Securities, Inc.	543.40
6. Swedbank AB	327.50
7. Mizuho International Plc	309.20
8. Nomura International Plc	301.00
9. Bank of America Merrill Lynch	271.10
10. Dresdner Kleinwort Ltd.	269.00

nate from a number of factors, including the rapidly increasing number and scale of clean energy projects such as solar and wind power. This is aided by the proven technologies for clean energy which have helped to reduce the risk profile of the sector. Other factors include: proliferation of green bond issuers; introduction of green indices; increased complexity of products that appeal to investors with different risk appetites (e.g. high-yield green bonds); market reform of the energy sector; saturation of conventional sources of financing; and competitive pricing structures (Bielenberg 2011).

3.2.5 Key Issues and Challenges

Despite their attractiveness, green bonds face a number of challenges that would have to be sorted to achieve its full potential. Some of the key challenges are as follows (Bielenberg 2011):

- 'Liquidity—currently a small number of investors holding green bonds; pension funds and other institutional investors traditionally require a robust secondary market;
- Standards—need for standards and verification systems for measuring performance of green bonds and acceptable use of proceeds. Also need to establish standard terms and conditions;
- Policies and Government Support—green infrastructure is dependent on policy instruments lacking a long term track record and government funding, with associated political risks which are frequently complex and volatile;
- Transactional Risk—greater technological risks associated with constructing and operating green technologies;
- Risk and reward—higher yields required to offset the illiquidity of the green bond market and any preconceptions of higher political or technical risk;
- Government backstop—issue as to whether green bonds will require a government guarantee'.

3.2.6 Islamic Bonds (Sukuks)

Sukuks are essentially assets-backed instruments representing a beneficial ownership interest in the underlying assets. They are an Islamic equivalent of a bond that complies with Shari'ah law and its investment principles, which prohibit the charging or paying of interest. Sukuks may be issued on existing as well as specific assets that may become available at a future date. The essential characteristics of sukuks are: 'transparency and clarity of rights and obligations; income from securities must be related to the purpose for which the funding is used; and securities should be backed by real underlying assets and not simply paper derivatives' (Sole 2007).

From a sustainability perspective, sukuks would be the most ideal financial solution for debt raising to ecological and energy projects. Islamic financing products are most attractive to project finance sponsors in large capital projects when they can deliver additional capital participation.

3.2.6.1 Green Sukuks

Green sukuks (Islamic green bonds) can be a powerful financing mechanism for environmental projects by connecting environmentally focused conventional investors to *Shari'ah*-compliant investors. The advantage of using green sukuks is that it can open up projects to both Islamic and conventional investors, offering the required liquidity for the project. By performing such a role, green sukuks can lead the way in achieving both environmental standards and Shari'ah compliance. Thus, the green sukuk market can be well suited for channelling the growing global pool of *Shari'ah*-compliant capital to fund clean energy and environmental investment projects. Since clean technology projects frequently require large capital outlays with a relatively predictable long stream of income, green sukuks could provide a way to raise money for such projects.

Despite its great potential, however, green sukuks are yet to be issued anywhere in the world. Since 2011, efforts were being made to launch the Middle East green sukuks consultative process that can develop standards, recommendations and best practices to facilitate the issuance of the first green sukuks in the region. Such a consultative process is jointly led by the CBI, the Clean Energy Business Council and the Gulf Bond and Sukuk Association. Already, increasing calls are being made for green debt instruments to help raise the money needed to combat climate change—more than US$ 10 trillion over the next two decades (International Energy Agency (IEA) 2011). The completion of the draft guidelines will undoubtedly open the doors for green sukuks issuance not only in the Middle East but also around other regions of the world.

The World Bank is currently exploring potential in a number of developing countries to issue its first ever green sukuks to fund low-carbon development or environmental projects. In the Gulf Cooperation Council (GCC) region, Dubai plans to issue green sukuks to finance solar parks, biogas plants and energy efficiency

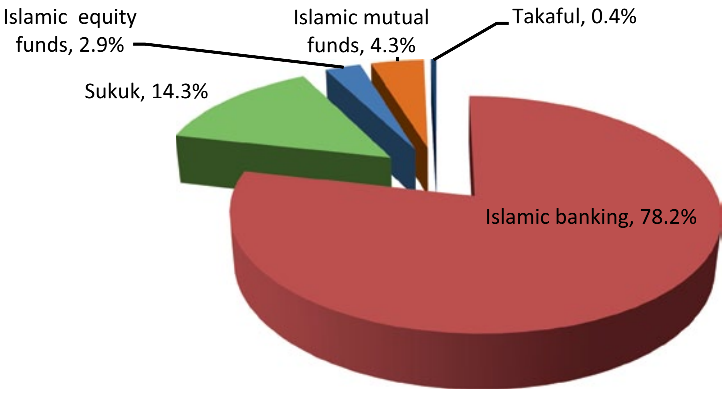


Fig. 3.2 Islamic finance assets worldwide, 2011. (Source: Kuwait Finance House (2012))

devices for homes.[2] The potential issuers in the Middle East include sovereign entities, government agencies such as utility providers, the World Bank, International Monetary Fund, International Finance Corporation, Arab Monetary Fund, Islamic Development Bank, Arab Bank for Economic Development in Africa and the Arab Fund for Economic and Social Development.

It is widely recognised that through green sukuks Islamic finance could provide a unique and culturally sensitive approach to sustainable economic development and payments for ecosystem services. While Islamic finance assets currently account for a small proportion of global finance, they have experienced an enviable growth of 15–20 % per annum over the past decade, reaching US$ 1.3 trillion in 2011, according to a recent report by the Kuwait Finance House,[3] with the GCC countries being responsible for much of the increase. The spectacular growth in Islamic finance could be attributed to several factors, including flight from the highly leveraged conventional financial assets and the rise in per capita income of the Gulf and Asian Islamic nations. These and other factors have contributed to the rapid growth in the Islamic finance industry, especially sukuks which are the fastest growing segment of the Islamic finance market. Between 2001 and 2010, the primary sukuk market grew at a compound annual growth rate (CAGR) of 57 % to reach US$ 177 billion by the end of November 2011 and was estimated to reach US$ 200 billion in 2012, accounting for around 14.3 % of the global Islamic finance assets (Fig. 3.2). In 2011 alone, sukuk issuances stood at US$ 84.4 billion, soaring by 62.3 %, up from US$ 52 billion in 2010 (Fig. 3.3). With such an unprecedented growth, the sukuk industry has emerged as one of the main components of the Islamic financial system.

The highly coveted sukuk market is dominated by regional investors from the Gulf states and Malaysia, but other non-Muslim countries, such as Japan, Russia,

[2] http://www.zawya.com.

[3] http://www.kfh.com/en.

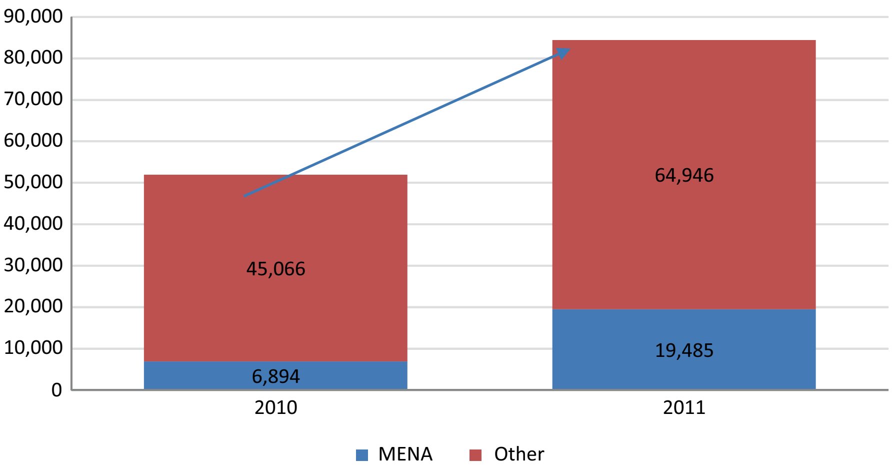


Fig. 3.3 Sukuk issuance 2011 vs. 2010 (US$ million). (Source: Zawya Sukuk Monitor, www.zawya.com)

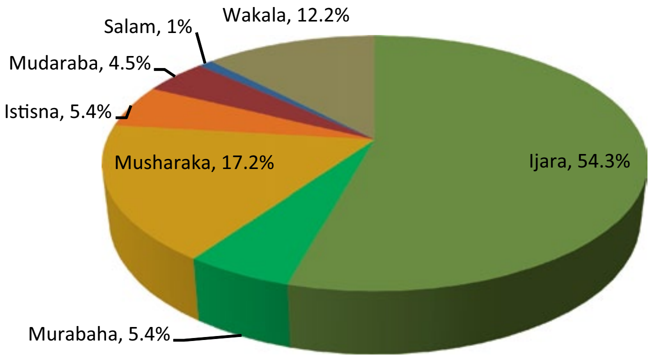


Fig. 3.4 Composition of global sukuk in 2010. (Source: Standard & Poor's (2011))

South Africa and South Korea, have expressed profound interests to tap the Islamic investors' liquidity by issuing sukuks.

Since Islamic finance involves assets-backed financing, sukuks are not generally issued on the capital market but through a special purpose vehicle (SPV) in which the owners of the sukuks are shareholders in the SPV, owning the rights of the tangible assets for a determined period of time. Such a financing mechanism has now become an important instrument for fundraising and investment activities around the globe. They are structured on the various Islamic financing modes such as *musharaka, murabaha, ijara* and *istisna*, but at least 51 % of the underpinning assets must be leased-back real assets, not debt instruments. Over half of the global sukuk transactions in 2010 were based on the *ijara* mode of financing, followed by *musharaka* with 17.2 % (Fig. 3.4).

An example of a typical sukuk *ijara* is as follows: An SPV issuing sukuks purchases buildings, gives cash to the land and then puts these buildings on *ijara* (leasing). The land, therefore, pays rents to the SPV, which in return pays a variable income to the investors, i.e. owners of the *sukuks*. In some cases, the income can be indexed to key economic indicators such as inflation and financial sector performance measures.

Islamic finance has started to shift away from its consumer-oriented and commodity-oriented market niches to ecological projects such as renewable energy, energy efficiency and low-carbon manufacturing activities. In essence, some Western energy firms have also started to incorporate Shari'ah-based financial instruments. For example, the Texas-based oil group, East Cameron Partners, sold a US$ 166 million sukuks in July 2006, which is actually the first Islamic securitisation in the USA. This financing agreement demonstrates a clear trend in which Western companies utilize Islamic debt to gain access to vast GCC oil wealth, and GCC Arab firms are turning to Islamic financing to speed up European energy acquisitions.

Moreover, sukuks, as a debt instrument, would provide an excellent foundation for asset-based sustainable growth in addition to being a socially responsible Shari'ah-compliant financial tool. It will also attract international intelligent liquidity especially in the currently turbulent global market. The recent global financial crisis, triggered by speculative derivative trading and securitisation of risky mortgages and debts, presents unique opportunities for nurturing and strengthening Islamic finance instruments such as green sukuks.

The establishment, in February 2011, of the Standard & Poor's/Hawkamah Pan Arab environmental, social and corporate governance (ESG) index will undoubtedly encourage environmental investments in the region. The ESG index ranks and tracks performance, transparency and disclosure of companies on ESG performance in Middle East and North Africa (MENA) equity markets. This will provide an incentive to MENA companies to pursue sustainable ESG business practices, and it will also give a big boost to green sukuks in the region.

3.3 Venture Capital

Venture capital has increasingly been playing a key role in providing equity finance to companies that are generally small and young, particularly innovative start-up firms with perceived long-term growth potential. This type of investment entails high risks since returns to the venture capitalists are linked to the success of beneficiary companies, many of which do not see light at the end of the tunnel. Venture capitalists often tend to minimize such risks by providing important non-financial support to these companies, including consultancy services, financial advice, marketing strategy, training, etc. Venture capital funds generally target new technology and new markets and have investment horizon of around 4–7 years. Return require-

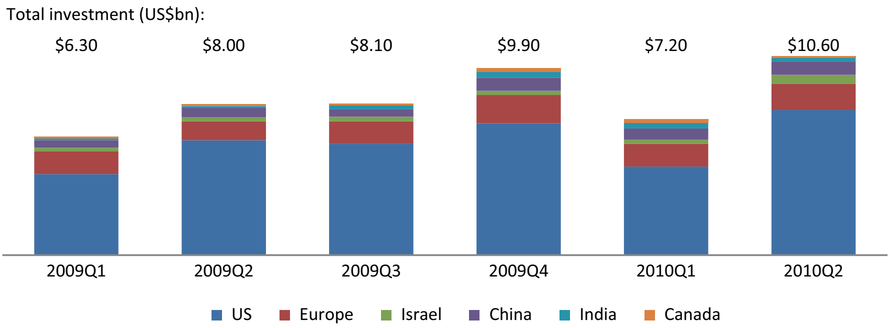


Fig. 3.5 Global quarterly venture capital investment by country. (Source: Ernst and Young (2011))

ments are often several multiples of the original investments, with internal rate of return (IRR) ranging from 50 to 500 % (Bloomberg 2011).

3.3.1 *Why Venture Capital?*

Venture capital is particularly important because it provides easy access to promising but untested business entities that often face serious challenges of finding access to traditional sources of funding due to the perceived high levels of uncertainty regarding their future prospects. Anecdotal evidence suggests that companies backed by venture capital tend to create high-quality jobs since such a financing mechanism principally supports the creation of the most successful and innovative businesses. Thus, venture capital helps to drive innovation, sustainable economic growth and job creation through mobilization of stable investment. Recent empirical research findings have found conclusive evidence that shows a positive correlation between venture capital investments and economic growth. It is also acknowledged that an increase in venture capital investments is generally associated with an increase in real gross domestic product (GDP) growth but that early-stage investments in small and medium-sized enterprises (SMEs) in particular have a more pronounced impact on real economic growth.

3.3.2 *Global Landscape of Venture Capital*

Globally, investment by venture capitalists has increased considerably since the 2008 US-inspired financial crisis. Quarterly investments rose from over US$ 6 billion in Q1 of 2009 to US$ 10.6 billion in Q2 of 2010 (Fig. 3.5), an improvement of nearly 33 % compared with Q2 of 2009. It is estimated that global investment could reach around US$ 40 billion by the end of 2011.

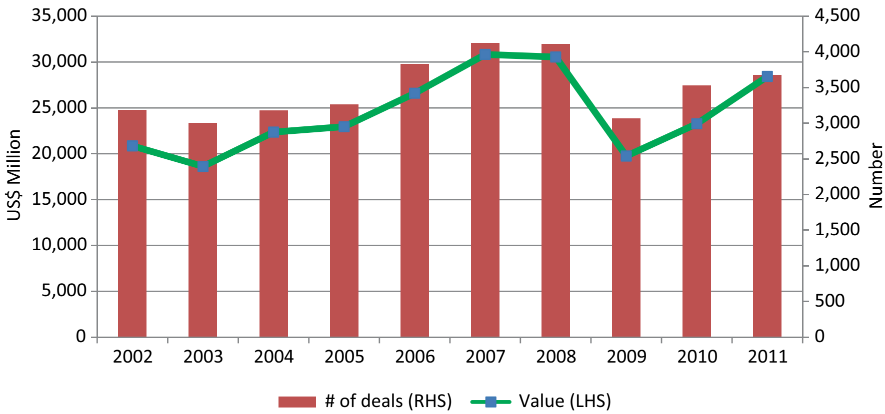


Fig. 3.6 Total venture capital investments in the USA. (Source: PwC/National Venture Capital Association; Thomson Reuters)

The venture capital industry is spreading in line with the globalisation of the world economy, as a recent survey suggests that VCs in every region of the world plan to significantly increase their cross-border investments over the next 5 years. As companies and markets become increasingly globalised, the investment opportunities for VC firms also become highly globalised. For example, of the 222 US venture capitalists surveyed, 20 % of them plan to increase their investments in China over the next 5 years, while 18 % plan to do so in India.

In spite of their global outreach, the USA is the leading country in the world in terms of venture capital investments. Since the beginning of the twenty-first century, total venture capital investments in the USA reached a peak of over US$ 30 billion in 2007 before the 2008 global financial crisis put a dent on their activities. Since 2010, however, venture capital investments started to pick up, reaching US$ 28.4 billion in 2011 (Fig. 3.6).

In line with the observed empiricism in emerging and developing countries, venture capital investment in the USA is also largely concentrated in firms that are in their early stages of development. Even so, there appears to be a substantial physical presence of venture capitalists in companies that are in the expansion and later development stages as well (Fig. 3.7). Evidence from the USA also shows that venture capitalists provide sizeable seed funding to a wide range of entities.

Other regions with smaller markets than that of the USA also experienced faster recovery during 1st half of year 2010 (Jan.–June)—notably, India, which saw venture capital investment grow by 146 % from the same period in the preceding year. China experienced growth in venture capital investments of about 51 % to US$ 1.3 billion in the first half of 2010, while Canada's US$ 313.5 million investment during the same period represented a 49 % growth. In contrast, European venture capital investment in the first half of 2010 grew at a slower pace of 17 % than that in the USA, reaching a total investment outlay of US$ 2.6 billion.

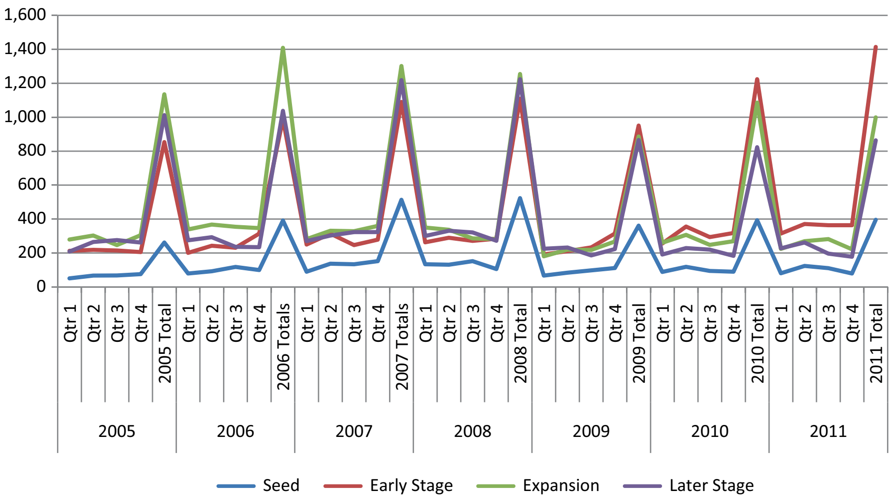


Fig. 3.7 Venture capital investments by stages of development in the USA (number of deals). (Source: PwC/VCNA, Thomson Reuters)

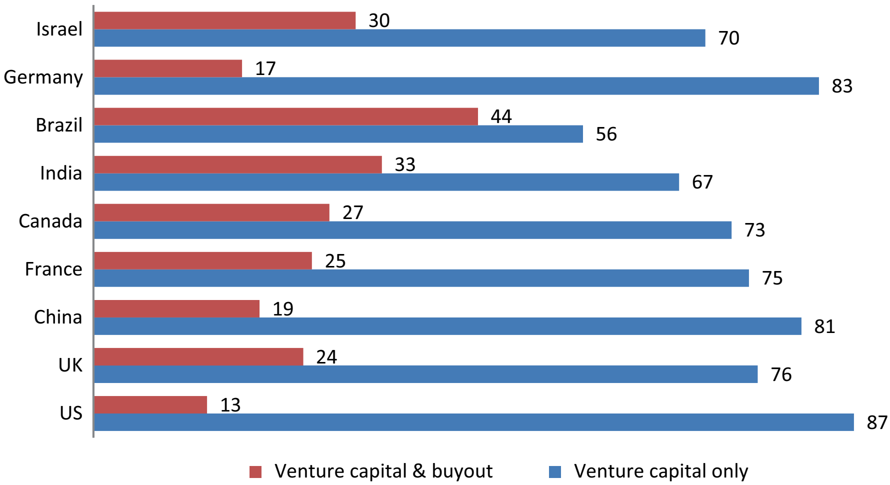


Fig. 3.8 Percentage of primary investment focus by country. (Source: Deloitte Development LLC)

The primary investment focus of venture capitalists in most countries in the world is largely on company growth, although some of them seek to engage in buy-out operations. For instance, in the USA, around 87 % of investments are primarily aimed at venture capital only (the highest in the world), followed by Germany and China (Fig. 3.8).

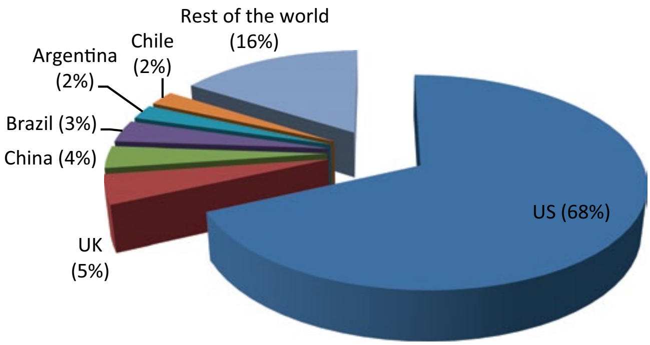


Fig. 3.9 Venture capital and private equity financing in clean energy 2010. (Source: World Economic Forum (2011))

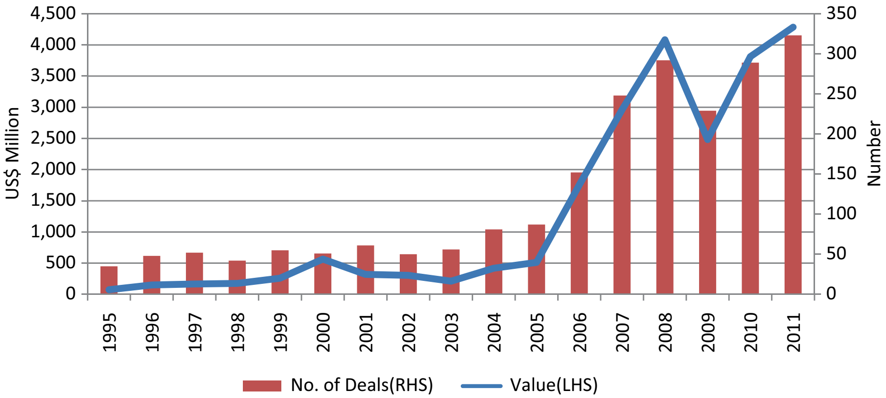


Fig. 3.10 Venture capital investments in clean technology in the USA. (Source: PwC/National Venture Capital Association; Thomson Reuters)

3.3.3 Venture Capital Investment in Environmental or 'Green' Products

Investment in clean technologies has become one of the major drivers of overall venture capital investment. Clean technology's share of global venture capital investment rose from 2 % in 2003 to 15 % in 2010. The USA accounts for 68 % of the nearly US$ 10 billion global venture capital and private equity investments in clean technology companies globally (Fig. 3.9).

Needless to say, the global trend in venture capital investment in environmental or 'green' products buck the US trend. For instance, venture capital investment in the clean technology sector in the USA rose from a mere US$ 73 million in 1995 to nearly US$ 4.3 billion in 2011. Similarly, the number of deals associated with these investments also rose from 35 to 323 during the same period (Fig. 3.10). As a result,

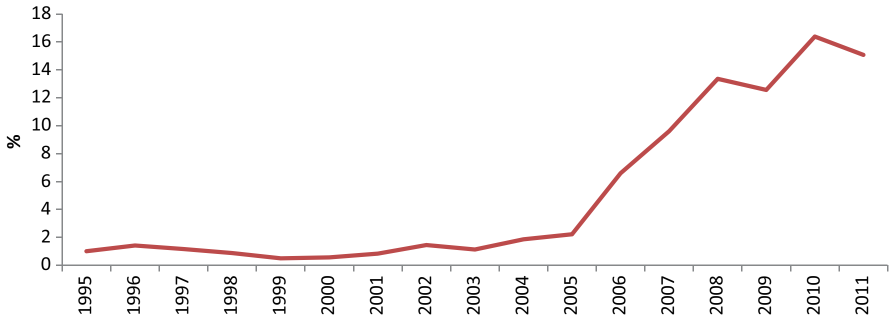


Fig. 3.11 CleanTech share in total venture capital investments in the USA. (Source: PwC/National Venture Capital Association; Thomson Reuters)

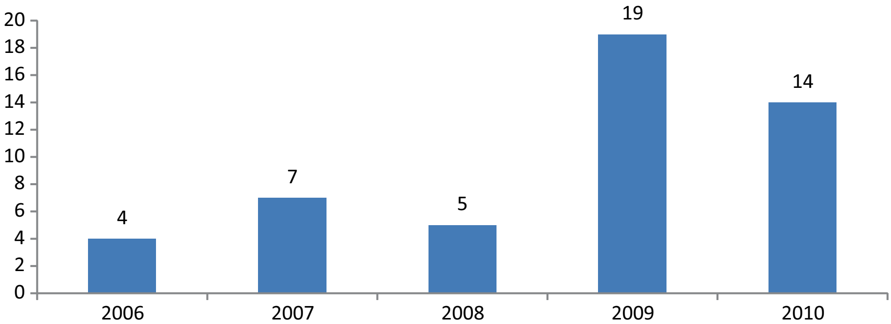


Fig. 3.12 Number of venture capital transactions. (Source: Zawya Online Database)

the share of the clean technology sector in total venture capital investments in the US surged from just 1 % in 1995 to over 16 % in 2010 before declining marginally to 15 % in 2011 (Fig. 3.11).

3.3.4 Venture Capital in the GCC Region

The venture capital industry is just beginning to take off in the GCC region, but since the 2008 global financial crisis the region has seen a significant increase in VC-related transactions with 33 transactions in 2009–2010 compared with just 16 in the preceding 2 years (Fig. 3.12). This contrasts sharply with the private equity industry, which experienced a decline in deal volumes. Venture capital professionals in the region are expecting the VC transactions in the region to rise even further over the coming years, as given the nature and size of VC investments, significant portions are not publically announced or, if they are announced, the value of the investment is not.

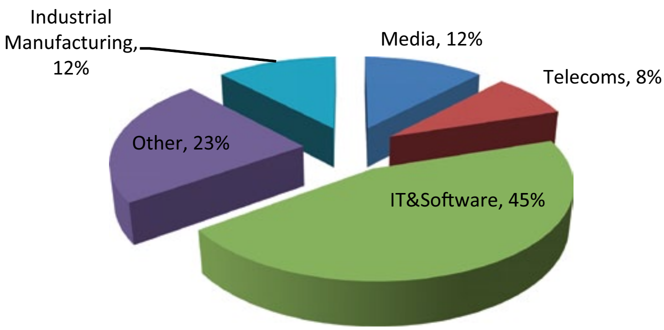
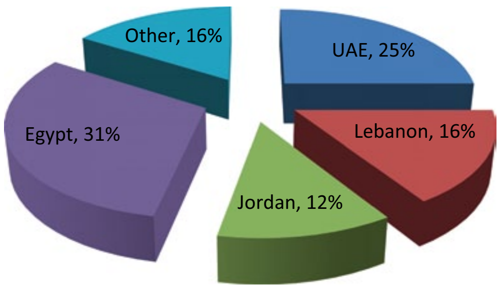


Fig. 3.13 Sector concentration of venture capital since 2006. (Source: Zawya)

Fig. 3.14 Venture capital investment by country since 2006. (Source: Zawya)



Venture capital and entrepreneurship activity in the GCC is dominated by two countries: Saudi Arabia, the largest economy in the region, and the UAE, the most dynamic economy in the region. However, the overall level of entrepreneurship activity in the region remains below par when compared to similarly sized regions in emerging markets.

In terms of sectoral composition, the GCC region has witnessed substantial venture capital investment interest in the information technology (IT) and software industry with 45 % of the total transactions since 2006 (representing 22 completed transactions), followed by industrial manufacturing and media sector with 12 % of the total transaction (Fig. 3.13).

Within the wider MENA region, Egypt and the UAE accounted for more than half of the region's total transactions since 2006 (56 %) as Fig. 3.14 illustrates. In fact, Egypt's large and fast-growing population and the UAE's growing propensity to invest make them popular destinations for fund managers, including venture capitalists.

The venture capital–private equity (VCPE) attractiveness index published by Spain's *Instituto de Estudios Superiores de la Empresa* (IESE) Business School measures the degree of attractiveness for investment in VCPE assets in the region or country with respect to six key drivers: economic activity, depth of the capital market, taxation, investor protection and corporate governance, human and social environment and entrepreneurial culture and deal opportunities. Index value equal to

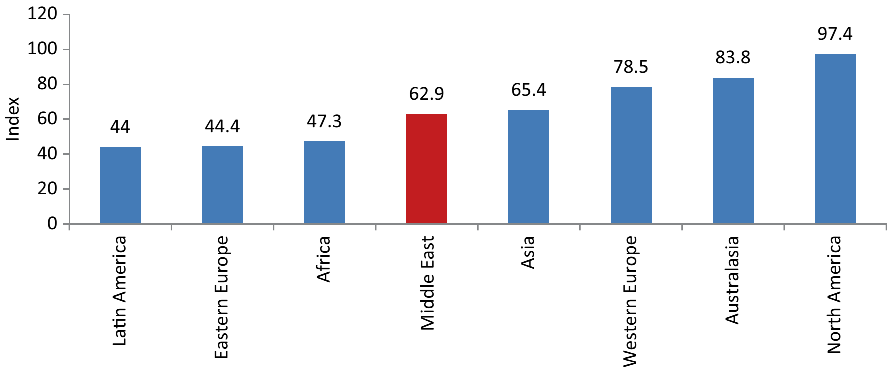


Fig. 3.15 Venture capital–private equity index, 2011. (Source: IESE Business School)

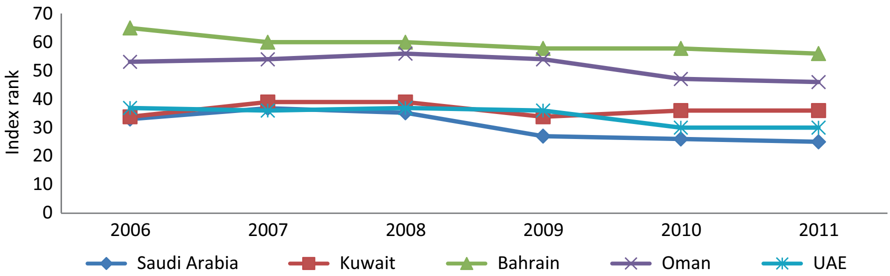


Fig. 3.16 Venture capital and private equity index rank in the Gulf Cooperation Council (GCC) countries. (Source: IESE Business School)

100 represents the best score (or best rank), while 1 is the worst. Figure 3.15 shows that the Middle East is ranked highly, as fifth most attractive region for VCPE investment, well above Latin America, Africa and Eastern Europe.

Saudi Arabia and the UAE have witnessed improvements in their VCPE rankings in recent years. While Saudi Arabia's ranking in the VCPE index improved from the 33rd global position in 2006 to the 25th position in 2011, that of the UAE improved from 37th to 30th positions during the same period (Fig. 3.16). Here again, despite such improvements, the overall level of entrepreneurship activity in the GCC still remains below what is obtained in comparator countries.

3.3.5 Investment Strategies of Venture Capital Funds

In helping to manage and grow a company, venture capital firms have different strategies with some being more hands on and active than others. Regardless of their strategies, however, all VC firms aim to add strategic value to their portfolios. VC firms make money by selling their equity stake in private (non-listed) companies at a higher price than the entry price. The majority of that profit is channelled back to the investors (limited partners) in the fund while the fund managers (general partners) retain part of that profit as ‘performance fees’ (usually 20 % of the profits). Generally speaking, investments are held for a period of 3–8 years (depending on the fund strategy and the stage of maturity of the investment), after which VC firms realize an exit through a trade sale, a management buy-back or an initial public offering (IPO).

In general, VC firms focus on investments in industries and companies with the following characteristics: high growth, efficient scale operations, high profit margins and capabilities to easily displace incumbent competitors. In more mature markets, venture capital firms have typically focused on technology-driven companies. In the MENA region, however, venture capital firms invest not only in technology-driven companies but also in other high-growth sectors.

3.4 Private Equity and EFs

Over the past decades, there have been substantial concerns about environmental protection in different parts of the world, which led to growing interests culminating in the establishment of a number of EFs. In fact, in historical perspective, the environmental concerns date back to the industrial revolution in Europe when the emergence of heavy industrial factories and the consumption of immense quantities of natural resources such as coal and fuel polluted the environment. Similarly, the significant rise of the nuclear industry in many countries gave rise to additional concerns about environmental damage. However, it was not until the late 1990s that the United Nations (UN) adopted a formal framework in the form of the Kyoto Protocol to fight global warming in all its ramifications.

Since then, significant developments have occurred in the environmental business area, which have raised the potential of investment in the clean technology sector. For example, investment in clean energy is projected to increase by 17 % between 2006 and 2015 from nearly US$ 40 billion to over US$ 167 billion. There are also additional commitments on the part of individual countries to upgrade the utilization of renewable energy as an alternative to electricity consumption derived from fuel. For example, China and the European Union (EU) have set specific targets of 15 and 20 %, respectively, to have their total electricity consumption coming from renewable energy by 2020. Also, waste management strategy like recycling industry is growing in importance. For example, the UK has set a target to increase recycling of household wastes to 45 % by 2015 and then to 50 % by 2020. Reducing the CO_2 emission is also one of the main items in the wildlife conservation agenda. The European Commission proposed to cut the CO_2 emissions produced by new cars by 25 % to 120 grams per kilometre by 2012. Also, in London, the introduction of congestion charges is reported to have reduced the number of vehicles on the road by 20 %, thereby reducing CO_2 emissions (Asplund 2008).

Environmental protection awareness globally has led to the emergence of a large number of programmes, including establishment of EFs. For example, the USA

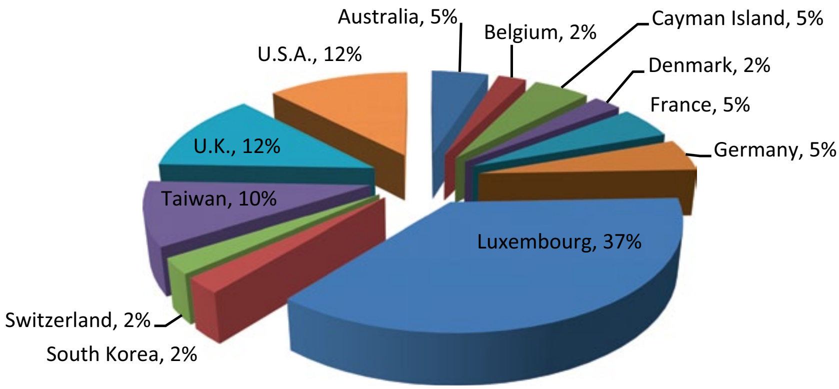


Fig. 3.17 Environmental funds in the world (%). (Source: Tresvista (2011))

has set up a Federal Superfund Program to clean up hazardous waste; China has a 5-year plan on sustainable development; and many European countries have increased their budgetary allocations on environmental services. In the private sector, many institutions have established EFs to invest in environmental goods and services.

The following section briefly sheds light on EFs worldwide, in terms of the key players, their strategies, geographical and sectoral allocations and performances.

3.4.1 Environmental Funds

EFs are introduced in many countries to guarantee concrete long-term financial resources for investment in environmental protection field. They are mainly created and managed by private institutions and supported by governmental organizations and other donor agencies.[4] The available information[5] on these EFs shows that many of them are basically launched in developed countries, such as Luxembourg, the USA, the UK, Germany, France and Denmark, but there has been growing interests in recent years in some developing countries like Taiwan and South Korea (Fig. 3.17).

Most of these EFs are mainly investing in the USA, followed by Germany, Japan and the UK. A total of 23 out of 41 environment funds invest in the USA, 20 invest in Germany and 14 each are actively engaged in Japan and the UK (Fig. 3.18). The lowest number is registered in India and Sweden, each with only one environmental fund. A list of all 41 EFs along with their location, size of assets, inception date and sector, is presented in Appendix Table B.1.

[4] http://shores-system.mysite.com/ef/ef_handbook.html.

[5] The percentage shown is out of 41 EFs around the world.

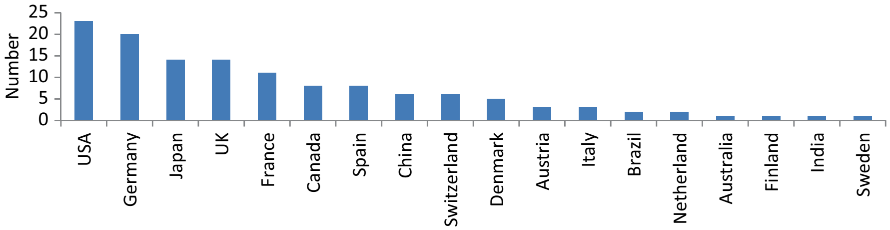


Fig. 3.18 Global geographical allocation of environmental funds. (Source: Tresvista (2011))

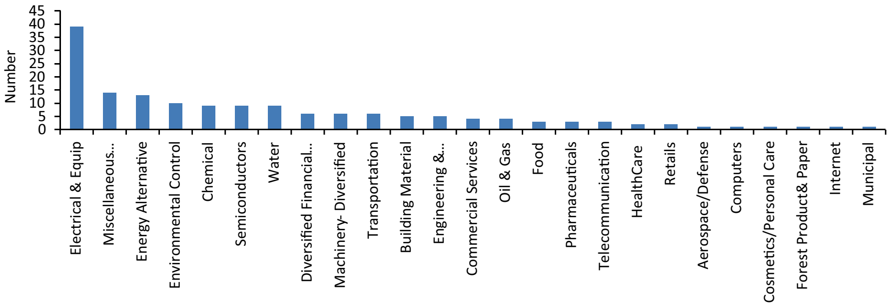


Fig. 3.19 Sectoral allocation of environmental funds in the world. (Source: Tresvista (2011))

It is noteworthy that EFs are important because they guarantee a 'dependable source' of finance for environmental investment over a long period of time. In fact, sectors of interest are mainly clean energy, waste management, green transport, sustainable living, environmental services, water management, alternative energy sources, forest products and paper, enabling energy technologies which include emissions trading (Fig. 3.19).

3.4.2 *Investment Strategy of EFs*

The investment strategy of EFs can be structured in different ways. Some invest considerable amounts of assets in equity securities of domestic environmental companies. These companies are selected based on their performance and their experience to deal with the issue of environmental protection. Companies targeted may be small-size enterprises with market capitalization below US$ 2 billion, and also medium-sized enterprises with market capitalization between US$ 2 billion and US$ 10 billion. EFs may invest in various types of derivatives, contracts whose value is based on, for example, indexes, currencies or securities, particularly futures (Fig. 3.20). A summary of the risk–return profile of the 41 EFs are presented in Appendix Table B.2.

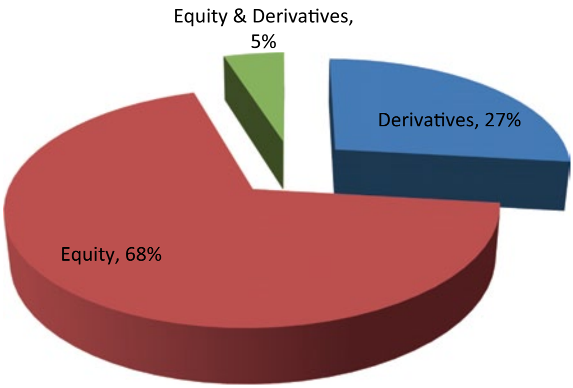


Fig. 3.20 Percentage of investment strategy of environmental funds. (Source: Tresvista (2011))

3.4.2.1 Risks Facing EFs

EFs have many advantages in carrying out environmental projects, but they also encounter many risks. We can group them into three: market risk, macroeconomic risk and institutional risks.

3.4.2.2 Market Risks

Market risk groups market price fluctuation and interest rate risks. In fact, certain valuation methodologies such as ‘fair value pricing’ used in the investment of the EFs may be very sensitive to any market fluctuations and can affect the value upon sale of the investment. Derivative risks are another issue related to market risks. It represents the risk of mismatch between the derivative and the security, index or currency to which it relates. Given this situation, the fund may face difficulties in selling the derivatives and may be exposed to the leverage effect that may magnify the fund’s exposure to market fluctuation and amplify the loss. In the short term, the price of securities may be exposed to interest rate risks. In fact, any rise in the interest rate may be reflected by a decrease of the price of securities and increase of the costs associated with any leverage used by the company.

3.4.2.3 Macroeconomic Risks

Macroeconomic risks group inflation risks, oil price fluctuation and currency risks. In fact, any increase in the inflation rate may result in loss of the value of the investment in real terms. Also, oil price fluctuation is another issue. As cited earlier, EFs invest mainly in oil field to protect the environment and companies involved in alternative energy to fuels. Given this subjective nature of investment, any oil price volatility may affect directly or indirectly the demand for renewable energy and impact negatively the profitability of these companies. The third type of macroeconomic risks encountered by the environmental fund is the currency risk. In fact, fund investment in securities denominated in foreign currencies may be affected by the exchange rate fluctuation and encounter significant losses of the value.

3.4.2.4 Institutional Risks

Institutional risks involve political risks, informational risks and regulation risks. In essence, EFs may encounter the problem of the outflow of profits to investors abroad because some governments imposed strict restrictions on the exchange or foreign currency.

Another institutional risk is related to informational transparency. Some companies based in foreign markets are usually not subject to accounting, auditing and financial reporting standards and practices as stringent as those in the USA. Therefore, their financial reports may present an incomplete, untimely or misleading picture of a foreign company, as compared to the financial reports of US companies. Brokerage commissions and other fees are generally higher for foreign investments. The procedures and rules governing foreign transactions and custody may also involve delays in payment, delivery or recovery of money or investments.

3.4.3 Performance of EFs

Environmental investments are increasingly becoming popular not only due to the growing attention environmental issues are receiving locally, nationally, regionally and globally but also because of the regulatory changes and policy incentives being offered to green activities aimed at mitigation and/or adaptation of environmental problems. Above all, environmental investments make business sense by generating high returns for stakeholders, and investments in green technology, in particular, could lead to a significant increase in future scientific innovation and investments. For instance, Deutsche Asset Management (2007) put the potential size of the global green investment market at around US$ 500 billion by 2050.

In terms of financial performance, environmental or SRI funds have performed better than their traditional counterparts over short-term and medium-term periods (Berton 2000). Thus, SRI funds could in fact combine environmental, societal and ethical concerns with profit maximisation.

Using a sample of over 300 ‘green’ companies from a wide range of sectors, Boulatoff and Boyer (2009) found that many of these sectors, including solar, water, biofuels, efficiency and geothermal, have consistently exhibited high positive returns. For example, in terms of the annualized 5-year return of each of these sectors, regardless of their country of origin, solar appears to be the most profitable project with a 20.1% return, followed by water (18.16%) and wind (13.9%), as shown in Table 3.4.

Table 3.4 Stock performance of environmental investments by sector. (Source: Boulatoff and Boyer (2009))

	5-year return	EPS 2007		Price to earnings
Solar	20.10	34.33	Renewable energy project	1,650.71
Water	18.16	8.09	Energy storage	52.32
Wind	13.90	0.66	Wind	49.00
Geothermal	8.38	0.1	Geothermal	27.35
Energy storage	6.05	−0.41	Efficiency	27.13
Renewable energy project	4.30	0.89	Solar	25.72
Biofuels	2.06	−0.17	Water	22.45
Efficiency	1.45	0.1	Transportation	16.03
Recycling/Green chemicals	−5.60	0.57	Fuel cells	15.00
Transportation	−23.38	−0.34	Biofuels	12.78
Fuel cells	−24.16	−0.39	Recycling/Green chemicals	10.55

EPS, earnings per share.

Table 3.5 Ratio of capital expenditures to assets by sector and country (%). (Source: Boulatoff and Boyer (2009))

Sector	Country	No. of firms	Capex to assets	Sector	Country	No. of firms	Capex to assets
Biofuels	Canada	2	38.13	Renewable energy projects	Denmark	1	42.13
	Britain	3	33.73		USA	7	30.06
	Switzerl.	1	30.94		Canada	4	8.64
Efficiency	Taiwan	1	8.57	Solar	India	1	25.66
	USA	21	5.08		Canada	6	20.76
	Britain	3	3.07		China	9	20.38
Energy storage	USA	17	8.04	Transportation	Germany	1	8.99
	Canada	2	3.95		USA	9	4.73
	Britain	2	3.76		Canada	7	2.61
Fuel cells	USA	11	12.86	Water	Canada	4	40.29
	Britain	2	5.3		Japan	1	11.19
	Germany	2	4.29		Britain	1	8.17
Geothermal	Canada	4	21.88		Singapore	1	6.04
	Germany	1	17.3		France	2	5.83
	USA	2	14.9		Canada	2	17.2
Recycling and green chemicals	Britain	1	11.82	Wind	China	2	11.09
	Spain	1	10.24		India	1	10.88
	USA	12	8.15		USA	6	10.11

The amount of capital expenditure is a major distinguishing feature of firms across countries. For instance, renewable energy in Denmark has the highest ratio of capital expenditures to assets (42 %), followed by water in Canada (40.29 %) and biofuels with 38.13 % and 33.73 % in Canada and the UK, respectively. In the USA, the renewable energy projects have the greatest capital expenditures to assets ratio (30.06 %), as shown in Table 3.5.

Table 3.6 Risk indicators of environmental firms by sector. (Source: Boulatoff and Boyer (2009))

	Altman's measure			
Sector	Bankruptcy Z score	Current ratio	Sector	Debt–equity ratio
Solar	32.48	6.47	Recycle/Green chemicals	156.54
Renewable energy	20.14	3.04	Renewable energy	98.72
Efficiency	10.30	5.51	Fuel cells	69.03
Fuel cells	9.73	5.83	Biofuels	62.41
Wind	9.20	5.85	Water	36.62
Water	8.86	4.21	Energy storage	30.65
Geothermal	8.50	4.83	Solar	29.45
Energy storage	4.88	6.42	Efficiency	21.59
Biofuels	4.03	4.28	Transportation	18.43
Recycle/Green chemicals	3.33	1.92	Wind	17.70
Transportation	−6.69	4.21	Geothermal	11.84

The Altman's Z score, the current ratio, and the debt-to-equity ratio are often used to gauge the green investment risks associated with each sector. Altman's Z score is a measure of the likelihood that a firm will go bankrupt, especially when the score is less than 3. All industries, with the exception of transportation, have Altman's Z score above 3, led by solar, renewable energy projects, efficiency, fuel cells, wind, water and geothermal (Table 3.6). This suggests that the environmental firms are less likely to falter. This is not surprising since these sectors were also found to exhibit the highest returns.

The ability of firms to meet their short-term debt obligations is often measured by the current ratio; firms having a current ratio of at least 2 are adjudged to be highly liquid. On this measure, all the environmental firms under study have current ratios larger than 2 with the exception of chemical recycling, which has a current ratio of 1.92, which is still relatively liquid (Table 3.6). This is not surprising because the recycling industry is also the most leveraged sector, partly due to its relatively large capital requirements.

Even though the firms included in the above-mentioned analysis were mainly drawn from the USA, Canada and Europe, the findings may be applicable to firms in emerging and developing countries as well, suggesting that investing in green industries in these countries can be profitable and can also promote sustainable development.

In spite of the relative positive performances of green firms, the analysis of comparable performance of these companies with their 'traditional' counterparts at the NASDAQ stock exchange shows that, on average, the performance of the green firms in the sample lagged behind that of those in NASDAQ, although some green firms in the solar, wind and water sectors outperformed the NASDAQ firms. This finding is broadly in line with what other studies at the portfolio level have hinted for SRI investment funds (see Renneboog et al. 2008). This is likely due to the capital-intensive nature of investment of environmental companies, which in the short run may weigh on their performance but in the longer run environmental firms are more likely to outperform their traditional counterparts.

Environmental firms have been found to imbibe better corporate governance than NASDAQ-based firms, a feature that will be pleasing for shareholders and other stakeholders in EFs. Green investments can also provide investors the opportunities to realize substantial benefits from diversification of investment portfolios.

3.5 Clean Development Mechanism

The CDM, introduced within the UN's Kyoto Protocol, is one of the early financing mechanisms. Basically, the CDM allows industrialised countries to generate emission credits through investment in emission reduction projects in developing countries. Essentially, the CDM has two main goals: to help developing countries achieve sustainable development and to assist developed countries achieve compliance by allowing them to purchase offsets created by CDM projects. In other words, the CDM allows developed countries to invest in low-cost abatement opportunities in developing countries and receive credit for the resulting emissions reductions (Certified Emission Reduction (CER)). Developed countries can then apply this credit against their 2008–2012 targets, reducing the cutbacks that would have to be made within their borders. By selling their emission reduction on the market, developing countries get a new source of financing projects for sustainable development through the introduction of clean and renewable technologies (World Bank 2005).

Thus, carbon finance like CDM potentially could provide bankable, hard-currency revenue streams for clean technology projects. These revenue streams can increase IRRs of projects quite considerably depending on the technology and the 'carbon intensity' of the fuels displaced.

3.5.1 CDM Project Eligibility and Trends

With the exceptions of nuclear power and deforestation projects, a broad range of projects are eligible for CDM accreditation, including hydropower, wind energy, fuel-switching and energy efficiency projects. To qualify for accreditation the project developers must prove 'additionality', defined as emission reductions that are additional to what would have otherwise occurred. This is calculated by using an approved methodology to subtract the estimated emissions of a given project from a hypothetical 'business-as-usual' emissions baseline.

The projects must qualify through a rigorous and public registration and issuance process, with approval given by the Designated National Authorities (DNA). The mechanism is overseen by the CDM Executive Board, answerable ultimately to the countries that have ratified the Kyoto Protocol. Once registered, projects are then issued CERs, an internationally recognised currency for trading emission cuts, with each CER unit equal to a reduction of one ton of carbon dioxide equivalent. These

CERs, or offsets, can be bought and used by developed countries to meet their Kyoto commitments. Companies can also purchase CERs to contribute towards their own emission reduction targets under mandatory emissions trading schemes (such as the EU Emissions Trading Scheme (ETS)) or voluntary schemes. The CDM is seen by many as a trailblazer as it is the first global environmental investment and credit scheme of its kind, providing a standardized instrument (CERs) for offsetting emissions.

There are currently over 3,000 registered projects delivering an average of 500 million CERs per year (UK Guardian 26 July 2011). The overwhelming demand for CERs comes from the ETS, the world's largest functioning compliance carbon market. Between 2008 and 2010, European companies were reported to have used 277 million CERs to meet their emissions reductions targets.

The mechanism is anticipated to produce CERs amounting to more than 2.9 billion tons of CO_2 equivalent in the first commitment period of the Kyoto Protocol, 2008–2012, with projects in 81 countries driving investment in a market worth US$ 19.8 billion in 2010. The CDM has created a system where emission reduction opportunities are actively sought out, and an institutional framework that stimulates secure and focused global investment in sustainable development projects.

In addition, the UN estimates that around 44 % of all projects currently in the pipeline involve some form of technology transfer, with a significant proportion of this occurring in biomass energy and wind projects, methane avoidance projects, energy efficiency projects and landfill gas projects. The CDM can, therefore, be said to have made a considerable contribution to the development and transfer of knowledge and technology in developing countries and positively influenced local communities through the creation of jobs and infrastructure. The first phase of the Kyoto agreement is expected to come to an end in 2012, by which time it is expected to have generated around 2 billion CERs.

The CDM has already achieved significant emission reductions, but it has the potential to do much more when applied not only to individual projects but also to groups of projects, programmes and possibly even to entire sectors of the economy. Negotiators are clearly indicating that they want to see more of the CDM, not less. Parties to the Kyoto Protocol have recently extended it to cover the period 2013–2020, which will also be CDM's second commitment period. The challenge is now to design a deal that will deliver the type of emission reductions that are urgently needed.

3.5.2 Limitations of CDM

Despite their relative attractiveness, CDM projects are not without controversies. The effectiveness of the CDM for facilitating investments, especially in renewable energy, is limited for two reasons. The CDM approval process imposes high costs of transaction, and it is estimated that, with the CER price of around US$ 4 per ton, the net present value of future CER-revenue streams is less than 2 % of the initial cost of investment in wind farms or small hydropower. This explains why project developers are experiencing a financing gap because they are unable to monetize their emissions reductions purchase agreements (ERPAs). Monetization allows clean energy project developers to bring additional capital, and, thereby, help to close the financing gap.

The geographical distribution of CDM projects has also come under attack, as over 80 % of these projects are concentrated in China and India. This geographical imbalance calls into question the ability of the CDM to drive sustainable development across other developing countries. Yet another drawback of the CDM stems from its 'additionality' element which makes it extremely difficult for many developing countries to prove the 'additionality' of a project in comparison to a hypothetical baseline. There is also the problem that the CDM over-relies on incentive of carbon credits, without which the 'additionality' element of the scheme may not be realized.

These concerns are real and the challenge is how to find better ways of overcoming them with a view to improving the CDM, not only with regard to its rules and regulations but also with respect to the nature and types of projects that can and should be brought within the scope of the CDM. Efforts are currently made to scrutinize the scale, scope, effectiveness, efficiency and accessibility of the CDM in order to enhance its overall performance.

3.6 Public Private Partnerships

Globally, PPPs have now become a standard mechanism for financing projects, especially large-scale infrastructure projects. Such an innovative financing mechanism basically recognises the relative importance of both public and private sectors in performing specific tasks and it allocates responsibilities on the basis of each partner's comparative advantages.

The motivations and rationales for undertaking a joint venture between the public and private entities are as follows:

- PPPs can free up government resources, thereby creating fiscal space that will enable policymakers to meet other competing ends. Governments around the world are facing ever-increasing financial constraints to develop and maintain infrastructure facilities and services due to a wide range of factors including increasing demands associated with demographic dynamics. These factors will continue to put tremendous pressures on infrastructure services, which will, in turn, put additional pressures on government finances. For example, the global infrastructure financing gap is estimated at around US$ 40 trillion over the next decade. In the GCC countries alone, the infrastructure financing gap is estimated at US$ 1.5 trillion over the next 5 years, suggesting that even in this wealthy region, resources may be limited to address all the infrastructure challenges. A properly structured PPP could, therefore, help to mobilize previously untapped resources from the private sector, thereby creating a fiscal space for the public

Table 3.7 Cost and time comparisons of public–private partnership (PPP) and non-PPP procurements in the UK and Australia. (Source: Ernst and Young (2011))

Improved project delivery	Study	Non-PPP procurement	PPP procurement
Cost overrun	UK	73%	22%
	Australia	35.3%	22%
Time overrun	UK	70%	24%
	Australia	25.6%	13.2%

PPP, public–private partnership.

sector, allowing the government to keep spending on other areas. The private sector will also benefit from the project through fees for services rendered and/or appropriate return on capital invested.

- PPPs can improve the efficiency and quality of public services through the private sector's capacity and experience in managing businesses efficiently. If the PPP is structured to allow the private sector operator to pursue its profit maximisation goal, the efficiency of infrastructure services will be enhanced considerably. Improving the efficiency of services and operations also increases the chances that those services are economically sustainable and provided at affordable rates—even after satisfying the profit requirements of the private operators. Thus, PPPs allow governments to pass operational roles to efficient private sector operators while retaining and improving focus on core public sector responsibilities, such as regulation and supervision, resulting in better and cheaper services to the consumers (Asian Development Bank 2011).
- PPPs can also lead to timely completion of projects. Empirical evidence from the UK and Australia clearly shows that cost and time overruns for PPP procurement are substantially lower than those for non-PPP procurement (Table 3.7). The transparent bidding process of PPPs can also result in efficiency gains since it helps to keep costs under control.
- PPPs can mitigate project risk through a risk sharing arrangement between the public sector and the private sector. Normally, the private sector is called upon to handle operational, financial, market and completion risks. Its expertise and technical know-how can also help to reduce risk of mistakes in planning, building and operating the projects. On the other hand, the public sector is better placed to deal with political, contractual, macroeconomic and legal risks. Risk sharing also ensures that both parties remain committed to the project on a long-term basis.

3.6.1 Global PPP Landscape

The PPP concept is a relatively recent phenomenon, dating back to the mid-1980s. Since then, however, more than 50 countries have experimented with different modes of PPPs. The UK is, however, widely acknowledged to be the country that

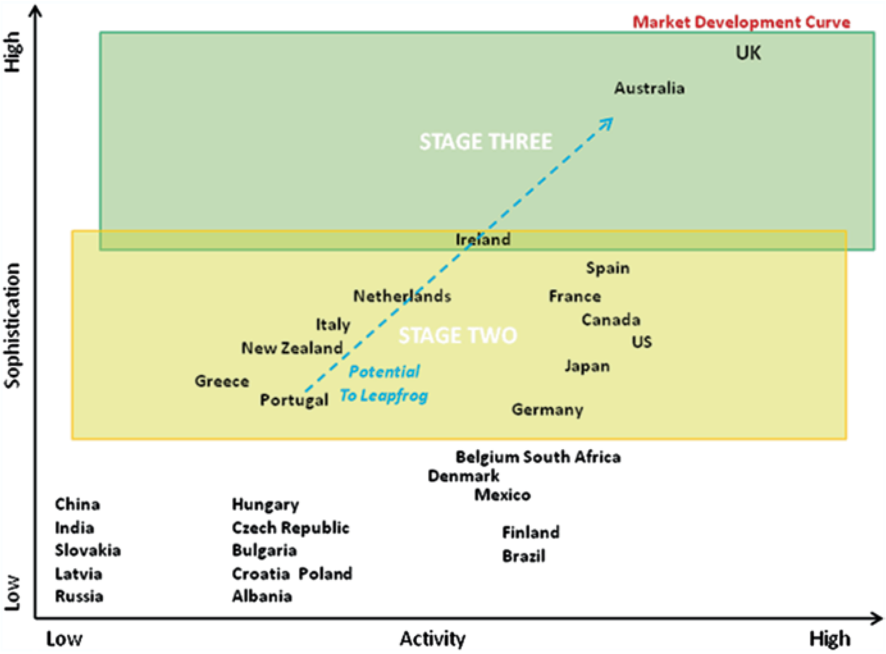


Fig. 3.21 Public–private partnership (PPP) market maturity curve. (Source: Going global: the world of public private partnerships, CBI 2007)

pioneered the PPP framework through its private finance initiative (PFI). Under such an initiative, the private sector designs, builds and maintains infrastructure and other capital assets and then operates those assets to sell services to the public sector. The PFI gives the private operator strong incentives to deliver the project on cost and on time, while it enables the government to spread the cost of investment over a long period of time, say 25–30 years (Confederation of British Industries, 2007).

Thus, the UK, along with Australia, is considered to be at the top of PPP maturity curve, for a number of reasons including: well-defined PPP policies; well-functioning PPP units with clearly defined tasks and authorities; a well-established successful track record of projects across various sectors; and a clear and ongoing access to commercial debt/project finance on attractive terms (Qatar Financial Center Authority, 2012). Other developed nations such as the USA, France, Germany, New Zealand and Canada are in the middle phase of the PPP maturity curve (Fig. 3.21). These countries do have a successful track record of PPP projects in various sectors but their PPP policy framework is still nascent or evolving and the capacity or authority of their PPP units may need to be deepened or strengthened.

At the lower end of the PPP maturity curve are emerging economies. These countries are still lagging behind their industrialised counterparts but many of them are fast embracing the PPP concept as a standard mechanism for delivering large-scale

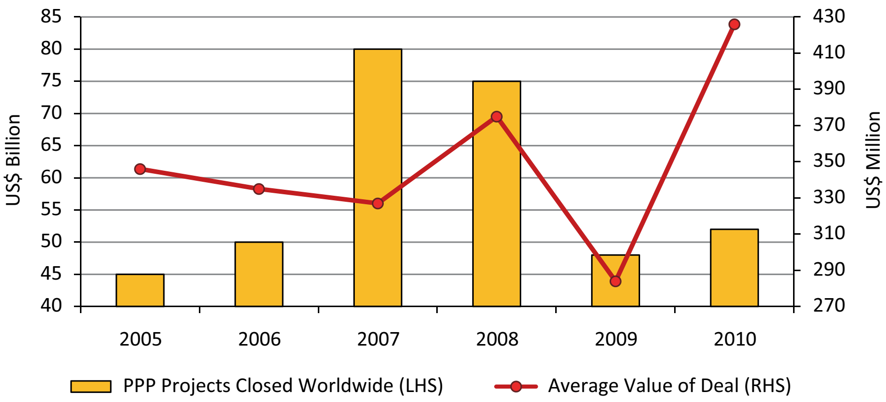


Fig. 3.22 Value of public private partnerships (PPP) projects closed worldwide (2005–2010). (Source: Infrastructure Journal Website; Dealogic Database)

infrastructure services. Some of these countries, such as China and the GCC countries, have delivered excellent stand-alone PPP projects or have exhibited strong success in one or two key sectors but have legal, regulatory and other policy issues to contend with.

The growing international deployment of the PPP model clearly demonstrates its attractiveness and applicability as an innovative framework for financing mega-infrastructure projects. For example, over US$ 1.5 trillion was spent in PPP projects around the world over the past two and a half decades. And, more recently, around US$ 350 billion worth of PPP projects achieved financial close with an average value of deals of around US$ 448 million over the period 2005–2010 (Fig. 3.22).

The plethora of PPP deals cut across a wide range of sectors; many physical and social infrastructure projects in the field of transport (roads, railways, airports and sea ports), utilities (water and power), schools and hospitals have been executed through the PPP mechanism. Even so, the infrastructure financing gap in these sectors is still huge with the water sector alone accounting for 43 % of the projected US$ 40 trillion of the global infrastructure investment over the next 20 years.

3.6.2 PPPs in the GCC Region

The emergence of PPPs in the GCC region is a recent phenomenon dating back only to the beginning of this century.[6] The oft-cited justification for private sector involvement in infrastructure projects in the region revolves around the quest for efficiency gains in the delivery and management of such projects. This argument

[6] In fact, the first PPP model in the GCC region can be traced back to 1994 with the signing of the Al-Manah independent power project in Oman and the subsequent signing of a project in Abu Dhabi in 1998, but the rapid adoption of the PPP framework picked up only less than a decade ago.

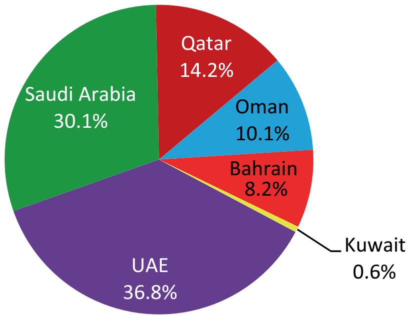


Fig. 3.23 Share of Gulf Cooperation Council (GCC) countries in regional public–private partnership (PPP) deals (Total value of GCC PPP deals as at September 2010: US$ 54.4 billion). (Source: MEED, 'Private partnerships win acceptance in the Middle East', February 2011)

may, however, be overstated because despite the hydrocarbon wealth and the ongoing as well as planned mega-infrastructure projects, the GCC region has a huge infrastructure financing gap of at least US$ 1.5 trillion over the next 5 years which could not be wholly filled by the public sector. So, in addition to efficiency gains, countries in the GCC region could benefit from additional fiscal space through private sector funding.

Since 2007, there has been almost US$ 90 billion of private project financing in the MENA countries, with the GCC region accounting for over 80 % of the value of projects, according to the Middle East Economic Digest (MEED). In fact, in September 2010 alone, the value of PPP deals in the GCC region stood at US$ 54.4 billion. The UAE and Saudi Arabia are the leading GCC countries in the region, accounting for 36 % and 30 %, respectively, of total PPP deals (Fig. 3.23).

Kuwait is the country in the region with the least visible presence in the PPP market but many projects have now been announced and programmed for the coming years.

Nearly 90 % of the PPP projects in the GCC region in 2010 were in the power and water sectors executed through the independent water and power project (IWPP) initiatives. Of the remaining 10 %, the wastewater and education sectors accounted for 4.3 and 3.6 %, respectively, while transport (1.7 %) and health (1.1 %) were yet to attract significant deals (Fig. 3.24). Both sectors are, however, expected to witness a rapid increase in PPP activities in the coming years as airports and health facilities are being improved and expanded across the region.

The dominance of the power and water sectors in PPP deals in the GCC region is not surprising as the first wave of PPPs which began in Oman and Abu Dhabi in the late 1990s were applied to these sectors. The successful application of the PPP principle to the IWPPs in both countries led to its widespread introduction in other GCC countries.

Besides the IWPPs, success stories of PPPs in the GCC region can also be found in the education and the transport sectors. For example, around 176 schools in the cities of Abu Dhabi, Al-Ain and Al-Gharbia in the UAE are currently run by PPP operators (MEED 2011). In the transport sector, however, the Hajj Terminal at King

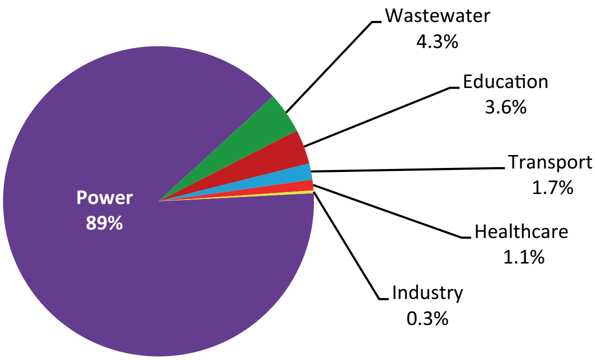


Fig. 3.24 Sectoral composition of public private partnership (PPP) deals in the Gulf Cooperation Council (GCC) region, Sept. 2010. (Source: MEED (2011))

Abdul Aziz Airport in Jeddah, Saudi Arabia, provides a classic example of a successful PPP deal, based on a 20-year build–operate–transfer (BOT) arrangement.[7] Outside the GCC region, Queen Alia International Airport in Jordan provides another example of a major successful PPP project in the region based on a 25-year concession agreement.

3.6.3 Challenges Facing PPPs in the GCC Region

Despite a huge fanfare that greeted the introduction of PPPs in the GCC region and the success stories of the IWPP initiatives, the future of PPPs in the region still hangs in the balance due to a number of challenges. The problems were also confounded by the shelving of some of the high-profile or flagship PPP projects such as the US$ 6 billion Landbridge rail project in Saudi Arabia and the US$ 3 billion Mafraq-Ghweifat road project in Abu Dhabi. Many other PPP deals were also either cancelled or delayed. For instance, the Tawam Hospital in Abu Dhabi, originally expected to be financed through a PPP scheme, has been cancelled.

Similarly, plans to develop car parks in Abu Dhabi through the private sector have also been shelved, just as the wastewater treatment plant at Tubli was reviewed and relaunched as an engineering, procurement and construction (EPC) project. These projects were initially perceived as a springboard for catapulting PPPs to new heights in the region, and so their cancellation and subsequent reversion back to government financing has added policy uncertainty that has consequently eroded private sector confidence.

The scepticism of the private sector is not surprising since a cancellation of PPP deals can lead to substantial losses to investors not only in terms of financial resources and time wasted in preparing and competing for bids but also in terms of the colossal opportunity costs of these resources. According to a popular adage, 'once

[7] The Hajj Terminal BOT is the first ever PPP deal that was structured based entirely on Islamic principles. Advisory services for the deal were provided by Gulf One Investment Bank.

beaten twice shy', so the recent abandonment of PPP deals in the region has sent a bad signal to investors who are unwilling to get their hands burnt again in competing for projects that might never happen.

So, what are the principal reasons for the change of heart by governments in the GCC region with regard to PPPs? There are a number of explanations but the oft-cited reason is the credit crunch that was triggered by the recent global financial crisis. The crisis severely constrained lending to the private sector, and governments around the world were compelled to fill in the void through a wide range of fiscal stimuli to sustain economic activities. Governments in the GCC region spent substantial amounts of money in extra spending in the form of fiscal stimulus, and this explains why many of the 'too big to fail' PPP projects such as the Saudi Landbridge and Abu Dhabi's Mafraq-Ghweifat projects were cancelled and are now being implemented through EPC instead of PPP.

The global financial crisis also triggered substantial capital flight out of the GCC region as foreign investors pulled their investments (both direct investment and portfolio investment) out of the region to quench the burning fires in the home countries, especially in the USA and Europe. The foreign capital outflow in the UAE has been most pronounced in the region because of the significant exposure of its banks to foreign liabilities. Dubai, with a disproportionately high level of foreign investment, was subsequently hit badly by the crisis which forced the government to default on its debt repayment obligations.

The Arab uprising, which started in 2010 in Tunisia, has also put a brake on some PPP projects especially in non-GCC MENA countries. Within the GCC region, however, Bahrain is the only GCC country that experienced strong and long-lasting social unrest that nearly crippled economic activities. Oman was also affected by widespread protestations albeit for a limited period. Both Bahrain and Oman received substantial financial support from other GCC countries to enable them to cope with the aftermath of the social unrest. Although other GCC countries did not experience the same level of revolt, they implemented various welfare-enhancing programmes costing around US$ 150 billion, equivalent to 12.7 % of the combined GDP of GCC countries, to assuage the concerns of their citizens. Thus, in the context of the GCC countries, the Arab uprising played little or no role in the cancellation of PPP projects but it had triggered reforms.

Clearly, the global credit crunch crisis and its aftermath provided a force majeure for the abandonment of some of the signature PPP deals, but the reality is that even prior to the 2008 financial crisis PPPs were facing serious challenges in the GCC region. One such challenge is lack of political will. This problem arises from the fact that hydrocarbon resources generate substantial revenues to the GCC governments, thereby making them complacent and less receptive to collaborative engagement with the private sector. But PPP is most effective when the government is totally committed to PPP ethos and designates a focal point or unit, usually within the finance ministry, to closely coordinate project implementation. In other words, PPPs are more effective if their execution is closely coordinated with the Ministry of Finance, as it facilitates synchronization with other ministries, and, thereby, helps to overcome bureaucratic obstacles. Being involved in the PPP will undoubtedly give the finance ministry a strong incentive to work towards the success of the project.

Experiences from around the world, especially from the Organisation for Economic Co-operation and Development (OECD) countries, suggest that fiscal integration is a key success factor for PPPs, but a champion within the government is always needed to make PPPs work because without a high-level government support for the PPP programmes, a PPP unit is most likely to be a toothless bull dog. Therefore, the success of a PPP unit crucially depends on government effectiveness, political support granted to the PPP unit and its status within governmental structures, as lessons from a wide range of countries illustrate (Box 3.1).

Box 3.2: Designing a PPP Unit: Lessons from Around the World

A set of recent case studies conducted by Sanghi et al. (2011) on Bangladesh, Jamaica, the Philippines, Portugal, South Africa, UK, Korea, Australia, France, Brazil, Italy, the Netherlands, Poland and Czech Republic provides the following lessons on the design of PPP units and the correlation between successful PPP programmes and the use of PPP units:

- 'Less effective governments tend to have less effective PPP units. Lack of political commitment to advancing a PPP program, or lack of transparency and coordination within government agencies, will reduce the chances of success for a PPP unit. Even with a good design, a PPP unit is unlikely to be effective in such an environment. The least effective PPP units are in countries whose governments as a whole are relatively less effective.
- Without high-level political support for the PPP program, a PPP unit will most likely fail.
- Relatively successful PPP units directly target specific government failures. A clear focus on responding to particular government failures is essential in ensuring the success of the institutional solution selected.
- The authority of a PPP unit must match what it is expected to achieve. If a PPP unit is expected to provide quality control or assurance, it needs the authority to stop or alter a PPP that it perceives to be poorly designed. But this executive power must be coupled with a mandate to promote good PPPs—or the unit may simply wield a veto without adding value.
- A PPP unit's location in the government is among the most important design features, because of the importance of interagency coordination and political support for a PPP unit's objectives. In a parliamentary system of government a PPP unit is most likely to be effective if located in a strong ministry of finance or treasury. In no parliamentary systems, such as the presidential system of the Philippines and many Latin American countries, the best location for a PPP unit is less clear. In a country with a strong planning or policy coordination agency, that agency might make a natural home for a PPP unit'.

Source: Sanghi et al. (2011).

Thus, in setting up PPP units, policymakers in the GCC region should consider these fundamental points before turning to its other ingredients, such as its structure or staffing. In addition, policymakers should first think about what kinds of government failures to address and they should provide the PPP units with sufficient powers and authority to address those failures.

Within the broader MENA region, Egypt has led the way on PPP units with its May 2010 landmark PPP law. The country has established a PPP Central Unit (PPP-CU), situated within the Ministry of Finance, which is responsible for the development of PPP programmes that are based on Egypt's public sector needs and interests of the Egyptian people. The PPPCU works closely with Line Ministries and their agencies and departments to develop and implement individual PPP projects within their portfolios. The key features of Egypt's PPPCU are summarized in Box 3.2. GCC countries should, therefore, take a cue from the Egyptian blueprint and set up the necessary structures for effective implementation of PPP projects.

Box 3.3: Egypt's PPPCU

Mission Statement

The principal aims and objectives of the PPPCU are to:

- 'Promote the national PPP initiative to key stakeholders (within Government, to private sectors, to public consumers, etc.);
- Identify and facilitate solutions to formal legal and institutional obstacles to the overall PPP project cycle;
- Develop PPP best practices, models, and standards for Egypt;
- Validate and develop PPP project proposals;
- Shepherd pilot procurements of PPPs;
- Build capacity in the public sector to identify, analyse, prepare, tender, contract, and monitor successful PPP transactions;
- Alert and stimulate private contractors and lenders to enter the new PPP market;
- Assist public infrastructure authorities in the selection of experienced and quality PPP transaction advisors;
- Work together with the public infrastructure authorities and the advisors to ensure quality and consistency in procedures;
- Ensure that set PPP principles, rules, and Standard Operating Procedures (SOPs) are followed;
- Assist awarding authorities in the transparent and competitive selection of private sector partners; and
- Report to the Ministerial PPP Committee on the progress of the PPP Project'.

Primary Functions

The main functions of Egypt's PPPCU are to:

- 'Serve as the public face of PPP initiative in Egypt;

- Establish a national PPP policy framework for implementation;
- Set PPP guidelines and methodologies appropriate to Egypt;
- Assist line ministries to identify potential PPP projects as part of line ministries' five-year strategic plans;
- Draft and issue standard project documents, contracts and PPP laws;
- Provide technical and advisory support to line ministries on project development and transaction implementation;
- Monitor project implementation post contract closure;
- Coordinate PPP Programme activities among line ministries, private sector partners and service providers, and the capital funding market;
- Identify and resolve issues that may impede successful development of Egypt's PPP programmes;
- Act as the centre of PPP expertise, support and intelligence gatherer and disseminator; and
- Serve as a Capacity Building Centre for PPP knowledge and expertise throughout Egypt'.

Source: Egypt PPPCU (2009).

Besides an apparent lack of PPP units and political support, the GCC region suffers from lack of adequate or sound regulatory environments for PPPs. Simplification of legal procedures as well as strengthening the institutional and administrative capacity to enforce laws, regulations and contracts will provide great incentives for PPPs in the region. It is proven that the success of PPP depends on clear and straightforward laws and regulations associated with PPP contracts and the general legal environment including procurement laws (Bohmer 2011).

Indeed, lack of transparent rules and regulations tends to add indirect costs to the private sector seeking to forge partnership with the public sector. For example, many private sector investors tend to cite high transaction costs as one of the major challenges facing PPP deals in the region. Large tendering and contracting costs represent a real obstacle for the private sector participation as total tendering costs for some projects can reach around 3 % of total project costs compared with just 1 % for their conventional counterparts (Ernst and Young 2011). In addition, high legal fees in contract negotiations represent material indirect costs for private investors.

Yet another challenge facing the GCC countries revolves around their inability to adapt or modify imported models of PPP. Of course, countries in the region should borrow a leaf from PPP experiences around the world, but they should also strive to modify such models to reflect their own national peculiarities, local circumstances and needs. Today, countries with proven track records of PPPs have relied on PPP models which 'not only take into account the government's needs but also the social, political and demographic environments, as well as their long-term direction' (Qatar Financial Center Authority 2012). For instance, the models used by the three most successful PPP countries (UK, Australia and Canada) all differ from each other in several respects. As Box 3.3 illustrates, the UK has largely relied on the PFI model; Canada has introduced creativity to its PPP financing architecture; and Australia used two different types of PPP models to finance a number of infrastructure facilities. The GCC countries must develop institutional capability and build human capital endowments for effective adaptation and application of PPP models and approaches, as home-grown PPPs often tend to be successful.

Box 3.4: Selected PPP Models and Experiences

The UK PFI:

The UK's model of PPP is grounded in the concept of PFI, established in the 1990s. The success story of such an innovative financing framework is reflected in the large number of projects executed across a wide range of sectors over a relatively short period of time. Some of the noteworthy features of the UK PFI are as follows, according to a recent report by the Qatar Financial Center Authority:

- During the past decade or so, around 10–15 % of all infrastructure projects in the UK have been financed through the PFI mechanism.
- The value of PPP projects undertaken in the UK between 2002 and 2006 ranged from US$ 6 billion to US$ 12 billion per annum, before plummeting substantially in the aftermath of the 2008 financial global crisis.
- Since then, however, the UK government has established an infrastructure finance unit to provide greater financial support, which has spurred several PPP/PFI projects across a wide range of sectors, including health care, education, transport and defence. In essence, the UK social infrastructure sector (health care and education) has been the most vibrant in terms of PPP/PFI activity, with an aggregate value of projects exceeding US$ 22 billion in the 4 years prior to the 2008 global financial crisis.
- The key drivers behind the success story of PPP in the UK revolve around: a well-defined PPP agenda; clarity about the nature of the partnership, bidding process and contractual obligations; and predictability about the entire PPP process.

Australia's PPP Models:

Australia uses two types of PPP models simultaneously: 'core services PPP model' and 'economic privately funded project model' or 'economic model'. In the case of the core services model, mainly applied to the social sector, the government takes on the key revenue and demand risks while the private sector is responsible for ancillary services. In the case of the 'economic model', applied widely to utilities and toll roads, the private sector explicitly deals with both demand and revenue risks. Both models have been very successful in attracting long-term debt financing from banks and capital markets, with project finance consistently exceeding 80 % of the project value. For example, the US$ 3-billion Victoria Desalination project closed in September 2009 with an 83 % debt component. The Australian Government has played an active role in addressing funding gaps, including accepting partially underwritten bids and providing co-lending support on a subordinated basis. All this contributes significantly to the successful implementation of Australia's PPP projects.

Canada's Funding Model:

Canada differs from the UK and Australia in its approach to PPP in the sense that its PPP programme is structured on a bottom up framework, with the provinces being the main drivers of PPP activities in the country. Four of the 13 provinces in Canada (British Columbia, Ontario, Quebec and Alberta) have been at the forefront of promoting PPP programmes. It was only in 2008 that Canada created the first federal level outfit, known as 'PPP Canada', to facilitate the development of PPP projects throughout the country. A year later, PPP Canada set up a CUS$ 1.2 billion 'PPP Canada Fund', aimed at leveraging up to CUS$ 5 billion towards PPP projects. PPP Canada used the following criteria to assess project proposals: '(i) eligibility; (ii) public benefit; (iii) market readiness; (iv) market development; (v) PPP value for money; (vi) procurement strategy and processes; (vii) scope of private sector involvement; and (viii) revenue potential'.[8] Canada's PPP programme is well known for efficient procurement and timely completion of projects. For example, the construction of Terminal 3 at the Toronto Pearson Airport, based on a PPP arrangement, was completed ahead of schedule by 18 months.

Source: Qatar Financial Center Authority (2012).

3.6.4 Policy Options for Successful Implementation of PPPs in the GCC Region

In spite of the recent setback on PPPs, the huge infrastructure financing gap in the GCC region has not yet vanished. As stated earlier, the region has lined up a wide range of infrastructure development programmes over the coming decades, and many of these planned projects will require massive involvement of the private sector. However, to be able to attract significant interests from the private sector, governments in the region will have to review, reassess and address the key challenges that are militating against the successful implementation of PPPs in the region.

The first step is for countries in the region to have a high-level government commitment to PPPs, preferably at Presidential (Premiership) or Vice Presidential (Deputy Premiership) level who could act as a strong champion for PPPs within the government to push forward the implementation of PPP programmes.

Second, concrete action should be taken towards strengthening legal, regulatory and institutional framework on PPPs in the region. Some countries have started to

[8] Qatar Financial Center Authority (2012).

address this issue, but much progress is still needed to allay the concerns of private sector operators. Thus, a clear, transparent and well-articulated policy framework on PPPs should be crafted and mainstreamed in national development strategies to demonstrate strong commitment to PPP implementation. A PPP-friendly environment must exist to attract investors, encourage public support and ensure long-term project success. Addressing red tape and bureaucratic tendencies should also be given top priority as much as upgrading the region's human capital to strengthen administrative capacity.

Third, the boundary between PPPs and privatization is often blurred and not properly clarified, sending mixed signals to stakeholders, especially among those who abhor privatization of public infrastructure. An effective communication strategy for PPPs should be put in place to distinguish it clearly from privatization issues. A handbook on PPP should be drafted to spell out the processes, procedures, as well as the business planning, procurement and PPP implementation issues.

Fourth, governments in the region should use SWFs as vanguards for PPPs. SWFs should be used to facilitate the PPP process and help manage risks by providing guarantees that the private sector may request. With existing and planned public expenditures on infrastructure lagging behind 'required' infrastructure financing, increased private and public investments in infrastructure are not only desirable but also profitable considering the potentially high expected return on unlisted infrastructure asset class. Rather than stashing away funds in the West, SWFs should look inwards by investing a considerable proportion of their wealth in the region, particularly on infrastructure projects. Governments in the region should 'reprioritise investments to focus on creation of competitive advantage platforms, realign SWF investment objectives to support local economies, and proactively drive the creation of regional champions and global challengers'.[9] Thus, the region's SWFs should take a proactive role in leading such an 'inward' investment strategy by acting as catalysts for PPPs to finance regional infrastructure projects.

3.7 Conclusion

This chapter has examined a wide range of options for environmental investments. These include 'green' bonds ('green' sukuks), venture capital, EFs, clean development mechanism and PPPs. These innovative mechanisms are well suited for financing investments in environmental technologies due to their long-term characteristics. Even so, many of the environmental technology businesses, such as clean energy projects, may be unappealing without significant government incentives, including financial, legal, regulatory and political considerations. Saudi Arabia and other GCC countries must, therefore, be prepared to undertake the necessary reforms of the business environment and provide appropriate policy and financial incentives to attract the right kinds of private sector financing that could rapidly

[9] Business News 24/7, 04 February 2009.

promote investments in environmental technologies in the region. The next chapter is devoted to assessing the nature and variety of incentives that are currently provided by governments around the world and the impact of such incentives on environmental business channels. The experiences from around the world will provide important lessons for policymakers in Saudi Arabia.

Chapter 4
Incentive Structures

4.1 Overview

Environmental ('green' or 'clean') investments can achieve both commercial and social objectives by generating high rates of return for investors and promoting environmental sustainability, economic prosperity, and social well-being. However, investments in clean products or technologies are generally characterised by relatively high sunk costs albeit with low operational and maintenance costs. These characteristics make green investments attractive in the long run but less so in the short run where the premium is on immediate cost minimisation. In addition, in many developing countries, investments in green projects such as renewable energy (RE), as opposed to conventional energy, face significant barriers in the form of highly subsidized prices of conventional energy products; limited awareness of the consequences of environmental degradation and the benefits of mitigation and adaptation policies and programmes; lack of financial and non-monetary incentives; absence of or weak legal and regulatory statutes on environmental protection; inadequate institutional capacity; trader barriers hampering deployment of green technologies; market failure; and lack of a comprehensive policy agenda and political commitment. These and other related factors serve to discourage private sector involvement in environmental investments in many emerging and developing countries.

Recent developments at global and national levels, however, have nudged governments in both developed and developing countries towards taking proactive policies to promote environmental investments. First, energy security issues triggered by ever-rising prices of conventional energy have spurred the quest for green investment. Thus, the concerns about energy security will not go away since supply-side constraints and geopolitics are likely to continue to push the prices of conventional energy to levels that will trigger investments in clean energy in the developed countries and oil-importing developing countries. Second, demographic dynamics in the emerging markets and in oil-producing countries, coupled with exhaustibility issues about conventional energy, are forcing policymakers to increasingly focus attention on energy efficiency and RE. Third, the Kyoto Protocol initiative, aimed at

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climate change mitigation and environmental protection, has brought green investment to the forefront of international economic and social agenda.

To achieve the green agenda objectives, governments around the world have been providing a wide range of ‘carrots and sticks’ to promote investment in clean technologies. The ‘carrots’ take the form of incentives, some of which are direct support instruments, such as fiscal incentives and public finance mechanisms (PFMs); some revolve around market instruments; and the rest deal with legal, regulatory, and institutional capacity-building issues. The ‘sticks’ are disincentives or penalties imposed by policymakers to discourage investments in non-green or environmentally harmful products. Such disincentives or penalties also take the form of pecuniary and non-pecuniary measures. Thus, any government policy which directly or indirectly encourages (or discourages) growth in market demand for clean energy, for example, will also encourage (or discourage) capital investment in clean energy generation.

The rest of the chapter is structured as follows: The next section discusses the various incentive schemes that are currently practised around the world to encourage environmental investments. Eclectic success stories on each of the incentive measures will be highlighted in boxes. The chapter concludes by pulling together the salient points and proposing a number of policy options for Saudi Arabia and other Gulf Cooperation Council (GCC) countries towards the promotion of green investments and green economies in the Gulf region.

4.2 Incentives Schemes for Green Investments

Lessons of experience abound on the array of incentives that governments around the world have been offering to whet the appetite for environmental investments, which can help to create more jobs and promote sustainable economic growth. Such incentives will accelerate the achievement of clean energy targets which countries have set for themselves. The European Union (EU) countries are well ahead of other nations in terms of setting clean energy targets. For instance, the average RE target for RE used in final energy in the 27 EU countries by 2020 is around 20 %. This number, however, masks considerable variation across individual countries with many of the Nordic countries, such as Sweden and Finland, close to achieving their targets (Fig. 4.1). These countries are well known for environmental awareness and their increasing use of incentives to promote green investments.

Outside the EU, progress on targets has varied considerably from little or no targets in Africa and the Middle East to sizeable strides in China, Japan and some states in the USA (Table 4.1).

Incentives could, therefore, play a key role in scaling up environmental investments. There are a variety of incentives for environmental investments, which can be classified under the following broad headings: direct financial incentives and guarantee, and legal and regulatory incentives.

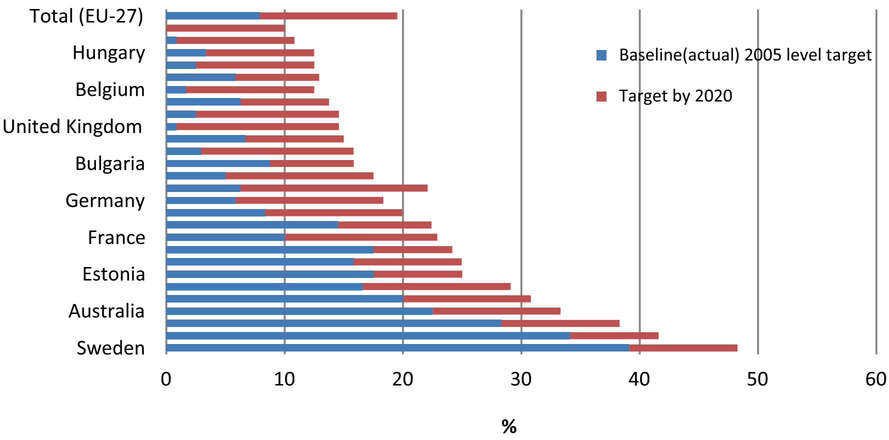

Fig. 4.1 European Union (EU) renewable energy targets: % of final energy by 2020. (Source: European Renewable Energy Council (2008))

Table 4.1 Non-EU countries with renewable energy targets. (Source: Renewable Energy Policy Network for the 21st Century, REN21 (2007), cited in Asplund (2008))

North America	
USA	5–30 % of electricity in 18 states (including DC)
Canada	3.5–15 % of electricity in four provinces; other types of targets in six provinces
Non-EU Europe	
Switzerland	3.5 terawatt-hours from electricity and heat by 2010
Norway	7 terawatt-hours from heat and wind by 2010
Asia and Pacific	
Japan	1.35 % of electricity by 2010, excluding geothermal and large hydro
China	10 % of electric power capacity by 2010 (expected 60 GW); 5 % of primary energy by 2010 and 10 % of primary energy by 2020
Korea	7 % of electricity by 2010, including large hydro, and 1.3 GW of grid-connected solar PV by 2011, including 100,000 homes (300 MW)
Malaysia	5 % of electricity by 2005
Philippines	4.7 GW total existing capacity by 2013
Thailand	8 % of total primary energy by 2011 (excluding traditional rural biomass)
Singapore	35 megawatt-thermal of solar thermal systems by 2012
India	10 % of added electricity power capacity during 2003–2012 (expected/planned)
Australia	9.5 terawatt-hours of electricity annually by 2012
New Zealand	30,000 terajoules of added capacity (including heat and transport fuels) by 2012
Middle East and Africa	
Israel	2 % of electricity by 2007; 5 % of electricity by 2016
Egypt	3 % of electricity by 2010
South Africa	10 terawatt-hours added final energy by 2013
South/Central America, Caribbean	
Brazil	3.3 GW added by 2006 from wind, biomass, small hydro
Dominican Republic	500 MW wind power capacity by 2015

4.3 Direct Financial Incentives

Direct financial incentives are a set of monetary instruments that aim to reduce costs and improve the relative competitiveness of green investments. They consist of a variety of fiscal support measures, such as tax concessions; direct subsidies; soft loans and grants; employment premiums for investments that create jobs; interest subsidies; and outright PFMs. These kinds of financial incentives are very common in the RE sector.

4.3.1 Tax Instruments

A wide range of tax incentives are often offered to businesses and consumers that invest in environmental projects (such as solar, wind, geothermal, hybrid vehicles, and biofuels). Incentives are also given to those investing in energy efficiency solutions. Generally, the principal aim of tax incentives is to either reduce the cost of the investment or increase the investors' net revenue from the sales of the output via tax breaks on returns from investments in environmentally sound initiatives (KfW Development Bank 2005).

Tax incentives can take several forms including: investment tax credits (ITC), production tax credits (PTC), sales tax rebates, excise tax exemptions, and value added tax (VAT) reductions. In the case of ITC or PTC, it provides the "investor or owner of qualifying property with an annual income tax credit based on the amount of money invested in that facility or the amount of electricity that it generates during the relevant year" (REN21 2011). This kind of tax concession allows investments in green projects to be fully or partially deducted from tax obligations or income, and, thereby, helps to lower the operational costs. Similarly, reductions in sales tax (VAT) and excise taxes on purchase (or production) of green technologies also help encourage green growth as they reduce capital costs as well as operations and maintenance costs.

Tax incentives offered to environment projects are prevalent in both developed as well as emerging and developing countries. For instance, in some European countries, such as the Netherlands, Germany, Belgium, and the Nordic bloc, tax rebates are offered with the sole objective of promoting investment in energy-efficient equipment and environmental protection. These include allowances for accelerated depreciation of capital investments in technologies that reduce environmental stress; allowances which target investment in energy-saving equipment; and those which promote capital investment in environmental protection (REN21 2011). Here again, the tax incentives are aimed at lowering the sunk costs of green investment. In Spain, wind power investors can deduct up to 15 % of their earnings from wind power before handing in their tax returns. In Denmark, a wind turbine owner does not have to pay taxes on the level of production, which equals their annual power consumption. Similar tax breaks also exist in the Netherlands (KfW Development Bank 2005).

Tax incentives can also be provided to investments in environmental protection activity, i.e. an activity that serves to prevent, fight, or remedy pollution, or treat, clean up, remove, or store waste. Such incentives are prevalent in Australia where the major tax provisions granted include deductibility on capital expenditures or revenue on environmental protection activities, environmental impact assessments, mining site rehabilitation, land care operations, and facilities for conserving or conveying water.

In the emerging and developing countries, India and China provide classic examples of applications of tax incentives for environmental investments. In China, for instance, the imports of RE technologies are exempt from payment of import duty, while in India this is the case only for RE technologies not produced in India. However, the VAT on RE equipment in India is much lower than the normal rate.

4.3.2 Subsidies, Direct Grants, and Soft Loans

In the case of capital subsidies, direct grants or soft loans, they are characterised by one-time payments by the government to cover a percentage of the sunk cost (initial capital cost) of investment activities. For instance, subsidies could be offered on research and development (R&D) activities on green technologies for promoting energy efficiency and the reduction of environmental stress or a green production payment can also be offered, which involves a direct payment of the government subsidies per unit of green output produced. In other words, subsidies could be applied to either the process (input) or output of a green investment activity.

Subsidies and direct grants to support environmental projects are used in both developed and developing countries, especially for purchases of equipment to jump-start demand for RE. For instance, in the Netherlands, until 1995, investors in wind farms were given a 30 % subsidy, in Denmark until the mid-1980s. In Spain, during the second half of the 1990s, investment subsidies of up to 40 % were given to investment in RE for wind farms not larger than 20 MW each; and the subsidy limit per project was US$ 2.8 million (KfW Development Bank Germany 2005). Some German 'Länder' offer a capital subsidy of up to 8 % to wind energy projects. Soft loans are another form of capital subsidies. Such loans are prevalent in, for example, Germany where investors in wind farms can get 10-year loans at a concessionary rate of interest.

Outside the EU, lessons can also be drawn from countries such as Canada, the USA, and Australia. In effect, Australia's experience in using direct grants as the main incentives for promoting solar energy development is well known. This often takes several forms, including grants channelled to its so-called Solar Cities Project and developments of low-emission technologies, RE technologies, and electricity storage technologies (Box 4.1).

Box 4.1: Success story of Australia's Direct Grants for Clean Technologies

The Solar Cities Project: The Australian government has committed substantial amounts of money to support the establishment of solar cities trials in Adelaide and in at least three other electricity grid-connected urban areas around Australia. The trials were aimed to demonstrate the merits of solar energy and involve the uptake by substantial numbers of domestic and business users of solar energy and energy-efficient technologies. The objectives of these solar energy trials are to:

- "demonstrate the economic and environmental impacts of integrating cost-reflective pricing with the concentrated uptake of solar, energy efficiency and smart metering technologies, and
- identify and implement options for addressing barriers to distributed solar generation, energy efficiency, and demand side management for grid connected urban areas."

Fund to Demonstrate Low-Emission Technologies: As part of its 'Securing Australia's Energy Future' Energy White Paper, the government has established a US$ 500 million fund to promote greater investment in demonstrating a range of low-emission technologies. While this is aimed at conventional fuel sources as well as at REs, one of those technologies specifically referred to as being potentially eligible is large solar-power concentrators.

Fund for Electricity Storage Technologies: One of the major obstacles to the widespread use of solar energy is that, like wind, it is intermittent. Clearly, solar energy can only be generated when there is sufficient sunlight. As such, it cannot always deliver electricity on demand. The government agreed to provide US$ 20 million to assist in the development of advanced technology storage technologies for RE, including batteries, electromechanical, and chemical storage.

Source: (KfW Development Bank 2005).

In developing countries, two types of subsidies are often granted: market jump-starting subsidies given to household photovoltaic (PV) systems and investment subsidies offered to grid-connected regenerators. Government loans or direct grants are also a common form of assistance in the developing world which, in the case of RE, can be used for the development of a wide range of RE technologies. The success story of public lending policies in India, highlighted in Box 4.2, provides a classic example of assistance in the developing countries.

Box 4.2: Success Story of Public Lending Policies in India

The India Renewable Energy Development Agency (IREDA) has funded projects valued at over USD 1 billion since its inception in 1987. As a government-owned corporation under the control of the Ministry of New and Renewable Energy (MNRE), IREDA provides funding options for RE infrastructure development projects ranging in size from USD 200,000 to USD 25 million. Through its lending policies, funds are available to cover up to 80 % of the total investment cost of these projects. IREDA has funded projects developing a multitude of RE technologies. By lending as well as encouraging investment and working with other partners in the international community, such as the World Bank, IREDA has contributed to the development of the renewables sector in India.

Source: IREDA; REN21 (2011)

4.4 Public Finance Mechanisms

PFMs are being widely used for climate mitigation purposes around the world with the principal objectives of directly mobilizing or leveraging commercial investment into low-carbon technology innovation and deployment, indirectly building commercially sustainable markets for these technologies and increasing capacity to deliver clean energy and other climate mitigation projects.

The idea behind the PFMs came from the United Nations (UN) Framework Convention on Climate Change, which estimated that US$ 210 billion in additional investment will be required annually by 2030 to meet global greenhouse gas emission reduction targets. The lion's share of this amount is expected to come from the private sector but that it will require substantial additional public funding to mobilize and leverage that private capital.

With respect to mobilization of commercial investment in green projects, PFMs can help to alleviate the initial financing constraints at a critical time when the private sector is not willing to provide capital on a purely commercial basis. Thus, public funding can act as a catalyst for leveraging private capital to a project. The public funding multiplier of private capital depends on the nature and type of the PFM schemes. For instance, with a multiplier of 4 or 5–1, a public funding of, say, US$ 1 billion could directly mobilize private capital of US$ 4–5 billion in environmental investment. In addition, many PFMs 'roll over' and support multiple generations of investments before they are fully expended, and so the long-term capital mobilization can be significantly larger (UNEP 2008).

In the case of scaling up of market sustainability, PFMs can help to build and improve the capacities of commercial financial institutions (CFIs) to deliver capital to climate mitigation markets. Such a programme support mechanism establishes relationships with first movers in industry, enabling them to gain experience with managing the risks and to learn where new profitable lines of business lie. As the CFI gains market experience, it rolls out new climate finance products across its branches and subsidiaries, and as this experience is made public, more CFIs may be encouraged to enter the market. Technical assistance and capacity building are critically important to achieve this objective of PFMs.

Typically, public monies are provided as grants from a funding body to the development financial institution (DFI), which provides the PFM to the CFI, which, in turn, provides structured financing to the projects. The sequence in the chain will vary for different mechanisms, applications, and circumstances. PFMs are largely being operated through DFIs as well as other relevant institutions such as national investment authorities, energy management agencies, and public–private investment companies. Cases from Chile and India illustrate the financing chain in the PFM scheme (Boxes 4.3 and 4.4).

Box 4.3: Combining Finance Supply and Demand Strategies: The CORFO Experience

Corporación de Fomento de la Producción de Chile (CORFO) has since 2005 been offering credit lines to commercial banks for on-lending to RE projects. These credit lines offer banks a 30-month grace period and repayment terms of up to 12 years, allowing them to on-lend up to USD 5 million (soon USD 13 million) to individual projects. To ensure the uptake of this bank financing, CORFO also offers project preparation matching funds for early stage project development activities such as resource assessment, feasibility and environmental studies, and Clean Development Mechanism (CDM) documentation. Advanced project development activities are eligible for cost sharing up to a maximum of 5% of the estimated investment. To date, over 100 project developments have been supported with 15 projects now in construction or already operational.

Source: UNEP (2008)

Box 4.4: India Renewable Energy Development Agency

IREDA is a government-owned company incorporated in 1987 that provides debt financing to RE and EE projects. IREDA has built up its own staff capability to originate clean energy project investments—projects as small as USD 200,000 and as large as USD 25 million. IREDA invests mainly as a senior lender, lending up to 80% of a project's investment cost on terms up to 10 years with up to 2-year grace periods. IREDA also makes technical assistance funding available to help prospective project sponsors and build up the pipeline of prospective investments. Funded projects total over USD 1 billion and have included wind, hydro, and biomass cogeneration, industrial waste heat recovery power plants, and industrial process efficiency. It has received international credit lines from the World Bank, the Asian Development Bank (ADB), and KfW, amongst others, as well as grant support from the Global Environment Facility (GEF). About one third of its capital is now raised domestically, through both bank borrowing and the issuance of tax-free bonds. In India, state governments are now authorised to establish energy conservation funds; IREDA, as a national entity, has potential to replicate its capability by supporting development of such state funds investments in their respective markets.

Source: UNEP (2008)

Climate mitigation-focused PFMs can take several forms, such as: c*redit lines* to local CFIs for providing both senior and mezzanine debts to projects; g*uarantees* to share with local CFIs the commercial credit risks of lending to projects and companies; c*arbon finance* facilities that monetise the advanced sale of emissions reductions to finance project investment costs; g*rants* to share project development costs; l*oan-softening programmes* to mobilize domestic sources of capital; i*nducement prizes* to stimulate R&D or technology development; and t*echnical assistance* to build the capacity of all actors along the financing chain (UNEP 2008). Key features of the PFMs are summarized in Table 4.2.

4.5 Legal and Regulatory Policies

Financial incentives and guarantees are key instruments to the growth of green investments, but these alone are not enough to enable environmental investments to flourish. They have to be complemented by sound and appropriate legal and regulatory policies. The laws and regulatory policies often used to prop up RE fall into two broad categories: pricing laws and quantitative (quota system) laws. The pricing policy aims to guarantee renewable producers with fixed, minimum prices and to obligate electric utilities to provide grid access to RE plants, while quota-related regulations allow governments to set specific targets and let the market determine prices (Sawin 2004). In the case of the RE industry, these legal and regulatory policies are often implemented through the following specific instruments (REN21 2011):

- Feed-in tariffs (FITs)
- Utility quota obligation (e.g. Renewable Portfolio Standards or other quota policies)
- Net metering
- Obligation and mandate

Here again, the EU countries are ahead of the rest of the world in terms of a wide range of incentives (financial and non-financial) they offer to promote green growth (Table 4.3).

Table 4.2 Overview of public finance mechanisms. (Source: UNEP (2008))

Mechanism		Description	Barriers	Financial Markets	Sectors
Debt	Credit line for senior debt	Credit line provided to CFIs for on-lending to projects or corporations in the form of senior debt	CFIs lack funds and have high interest rates	Underdeveloped financial markets where there is lack of liquidity, particularly for long-term lending, and borrowing costs are high	Large-scale RE and EE; wholesale loans for energy access markets
	Credit line for subordinated debt	Credit line to CFIs for on-lending to projects with subordinated repayment obligations	Debt–equity gap, whereby project sponsors lack sufficient equity to secure senior debt	Lack of liquidity in both equity and debt markets	Medium and small scale
	Guarantee	Shares project credit (i.e. loan) risks with CFIs	High credit risks, particularly perceived risks	Existence of guarantee institutions and experience with credit enhancements	Large-scale RE and EE and energy access markets
	Project loan facility	Debt provided by DFIs directly to projects	CFIs unable to address the sector	Strong political environment to enforce contracts and enabling laws for special purpose entity	Large- and medium-scale EE and RE
Equity	Private equity fund	Equity investments in companies or projects	Lack of risk capital; restrictive debt-to-equity ratio	Highly developed capital markets to allow equity investors to exit from the investee	Large-scale grid-connected RE; energy companies
	Venture capital fund	Equity investments in technology companies	Lack of risk capital for new technology development	Developed capital markets to allow eventual exits	Any new technology
Carbon	Carbon finance	Monetisation of future cash flows from the advanced sale of Carbon Credits to finance project investment costs	Lack of project development capital; lack of cash flow for additional security; uncertain delivery of carbon credits	Availability of underlying financing for projects. Adequate institutional capacity to host CDM/JI project and to enforce contracts	Large-scale RE and EE; programme of activities such as in energy access markets
	Carbon transaction in post 2012 credits	Contracting for the purchase of Carbon Credits to be delivered after 2012	Lack of regulatory framework and short-term compliance-driven buyers	Availability of underlying financing. Adequate institutional capacity to host CDM/JI project and to enforce contracts	Any GHG emissions reduction project

Table 4.2 (continued)

Mechanism		Description	Barriers	Financial Markets	Sectors
Innovative Grants	Project development grants	Grants 'loaned' without interest or repayment until projects are financially viable	Poorly capitalised developers; costly and time-consuming development process	Can be needed in any financial market context	Any sector
	Loan-softening programmes	Grants to help CFIs begin lending their own capital to end users initially on concessional terms	Lack of FI interest in lending to new sectors; limited knowledge of market demand	Competitive local lending markets	Medium- and small-scale EE and RE
	Inducement prizes	'Ex-ante prizes' to stimulate technology development. Unproven in climate sector	High and risky technology development costs and spill-over effects	Sufficient financing availability to deploy winning technologies	Any technology sector

CDM/JI Clean Development Mechanism/Joint Implementation, *CFI* commercial financial institution, *DFI* development financial institution, *EE* energy efficiency, *FI* financial institution, *GHG* greenhouse gas, *RE* renewable energy

Table 4.3 Renewable energy promotion policies. (Source: REN21 (2011))

Country	Feed-in tariff	Capital subsidies, grants, rebates	Investment or other tax credits	Sales tax, energy tax, excise tax, or VAT reduction	Tradable RE certificates	Public investment, loans, or financing
Denmark	×	×	×	×	×	×
France	×	×	×	×	×	×
Germany	×	×	×	×		×
Italy	×	×	×	×	×	×
Spain	×	×	×	×	×	×
UK	×	×		×	×	×
Japan	×	×	×		×	×
USA	(*)	×	×	(*)	(*)	(*)
Brazil			×			×
China	×	×	×	×		×
India	(*)	×	×	×	×	×
Morocco			×	×		×
Tunisia		×		×		×

RE renewable energy, *VAT* value added tax
*means that some states/provinces within these countries have state/province- level policies but there is no national-level policy

4.5.1 Feed-in Tariffs

An FIT is one of the most popular regulatory instruments that is used to support the development of new RE projects based on long-term purchase agreements for the sale of RE electricity (Menanteau et al. 2003; Lipp 2007; Rickerson et al. 2007; Fouquet and Johansson 2008; Mendonça 2007; IEA 2008). Basically, power suppliers are provided with a government-determined price at which they can sell their electricity to the grid, allowing them to benefit from a guaranteed return on the green investment. Thus, an FIT policy makes it easier for power developers to obtain capital financing for their projects.

Nowadays, FIT is used as an umbrella term for a number of connotations, such as ‘feed-in laws’, ‘fixed price policies’, ‘minimum price policies’, ‘standard offer contracts’, and ‘advanced renewable tariffs’. In the USA, an FIT is simply called ‘renewable energy payments’ (U.S. Congress 2008) or ‘renewable energy dividends’ (Powers 2009).

Typically, an FIT policy involves the following three key elements: guaranteed access to the grid; stable, long-term purchase agreements (usually 15–20 years); and payment levels based on the costs of RE generation. FIT is provided to anyone with the ability to invest, including private investors, homeowners, business owners, government agencies, utilities, and non-profit organisations (Lipp 2007; Mendonça et al. 2009b).

FIT policies are currently practised in 45 countries, including most EU member countries, Japan, South Korea, Thailand, South Africa, Uganda, and Kenya with varying degrees of success. Box 4.5 highlights the success story of the FIT policy in Kenya.

Box 4.5: Success story of FITs in Kenya

Kenya's FIT introduced in March 2008 and further revised in the beginning of 2010 is focused on stimulating electricity generated by traditional biomass, as this is the predominant energy source in the country along with imported petroleum. It is expected that the FIT policy in Kenya could stimulate about 1,300 MW of electricity generation capacity. Since the introduction of the FIT policy, some sugar companies have planned to upgrade their biomass-based cogeneration potential in order to benefit from the FIT policy. If the projected generation capacity is realized, there is the 'triple-win' of additional renewables-based generation capacity to the country; enhancing employment and poverty alleviation in the rural areas; and increasing income opportunities for business development.

Source: REN21 (2011)

4.5.1.1 Duration of the FIT

As stated earlier, the duration for FITs varies across countries, but such an incentive is often provided for a relatively long period of time (20 years in most countries) to guarantee sustainability and profitability of environmental business activity. For example, in Germany, FIT is provided for 20 years with built-in annual decrease of 5 % from 2005 onward (Apslund 2008). Similarly, in France, new FITs for new installations came into effect in 2006 to last for 20 years. In other EU countries, such as Greece and Italy, FIT is also guaranteed for 20 years, while in Spain it is guaranteed for 25 years. The Netherlands is one of the few EU countries with a lower FIT threshold (Table 4.4).

The situation in developing countries is also similar to that in the advanced economies. As stated earlier, Kenya provides a classic example of a developing country with a robust FIT policy aimed at providing investment security and market stability for investors in renewable energy sources (RES) electricity generation; reducing transaction and administrative costs through elimination of the conventional bidding processes; and encouraging private investors to operate the power plant prudently and efficiently so as to maximise its returns. Initially, FIT in Kenya was guaranteed for a minimum of 15 years for biomass, but in January 2010 it was revised and extended to 20 years to include three additional RE sources: geothermal, biogas, and solar energy (UNEP 2010).

4.5.1.2 Advantages and Disadvantages of FITs

As with any policy initiative, the FIT policy does have its advantages and disadvantages. The following can be cited as some of the benefits of FITs:

- Providing a secure and stable market for investors (Fouquet and Johansson 2008; IEA 2008; Lipp 2007; Lesser and Su 2008; Ragwitz et al. 2007)

Table 4.4 Structure of feed-in tariffs in selected European Union countries. (Source: Asplund (2008))

Country	Nature, extent, and duration of feed-in tariffs
France	New FIT since 26 July 2006 guaranteed for 20 years; valid only for new installations: 0.30 € per kWh There is a supplementary tariff of 0.25 € per kWh for building integrated PV installations 50 % of the investment costs are tax deductible. Lower value added tax (VAT) of 5.5 % on system costs (without labour) plus accelerated depreciation of PV systems for enterprises
Germany	FIT for 20 years with built-in annual decrease of 5 % from 2005 onward. For plants, neither on building nor sound barriers, the annual decrease is 6.5 % from 2006 onward Tariffs for new installations in 2006: free-standing systems: 0.406 € per kWh; systems on buildings and sound barriers: 0.518 € per kWh for systems less than 30 kWp, 0.493 € per kWh for greater than 30 kWp, and 0.487 € per kWh for systems greater than 100 kWp
Greece	New FIT since June 2006, guaranteed for 20 years. Tariff structure is as follows: 0.45 €/kWh for all systems Commercial installations are eligible to grants (30–55 % of total system costs) while small domestic systems are eligible for a 20 % tax deduction capped at 500 € per system
Italy	FIT guaranteed for 20 years. Tariff structure as follows: up to 20 kW (0.445 €/kWh plus metering, meaning that each kWh used at home is deducted from the electricity bill); between 20 kW and 50 kW (0.46 €/kWh); between 40 kW and 1 MW (0.49 €/kWh)
The Netherlands	FIT guaranteed for 10 years plus net metering for up to 3,000 kWh per annum for existing systems. Tariff structure: 0.097 €/kWh
Spain	FIT guaranteed for 25 years with a cap of 150 MW. Tariff structure: 0.44 €/kWh for systems with less than 100 kWp (575 % of average electricity price); after 25 years, 460 % of average electricity price at 0.23 €/kWh for systems with more than 100 kWp for 25 years (300 % of average electricity price)

FIT feed-in tariff, *PV* photovoltaic, *VAT* value added tax

- Stimulating material growth of local industry and job creation (Germany BMU 2008b, 2009; Mendonça et al. 2009b; Fell 2009; Lipp 2007; Diekmann 2008; Langniss et al. 2009)
- Offering lower transaction costs (Menanteau et al. 2003; Fell 2009), as FIT costs money only when projects actually operational
- Acting as a hedge against volatility since FIT provides fixed-price benefits of RE generation for the utility's customers (de Miera et al. 2008; Munksgaard and Morthorst 2008; Lesser and Su 2008)
- Settling uncertainties related to grid access and interconnection (Lauber 2009; Mendonça 2007)
- Enhancing market access for investors and participants (Grace et al. 2008)
- Conferring a measurable impact on RE generation and capacity (IEA 2008; Germany BMU 2009; REN21 2009)
- Encouraging technologies at different stages of maturity, including emerging technologies (Mendonça 2007; Klein 2008; Lipp 2007; Ragwitz et al. 2007)

- Demonstrating a flexible project-specific design that allows for adjustments to ensure high levels of cost efficiency and effectiveness (Ragwitz et al. 2007; IEA 2008)

In spite of these advantages, critics have advanced the following limitations of FIT policies:

- FITs require an upfront and continuous administrative commitment to set the payments accurately (Lesser and Su 2008). For example, if the FIT payments are set too high, they could result in a higher overall policy cost; and if set too low, it could result in little or no new RE generation (Menanteau et al. 2003).
- FITs do not directly address the high upfront costs of RE technologies as they are generally designed to offer stable revenue streams over a period of 15–25 years, which enables the high upfront costs to be amortized over time (Lantz and Doris 2009).
- By resulting in rapid growth in emerging RE technologies, FITs can lead to upward pressure on electricity prices in the short run (Mendonça 2007; Lipp 2007; Lesser and Su 2008; Couture and Cory 2009).
- FITs accompanied by guaranteed grid interconnection could lead to less-than-optimal project siting and could adversely affect grid reliability (Couture and Cory 2009).
- In the absence of a long-term policy commitment to RE development, the success of FITs may be limited.
- Reliance on FIT policies to promote growth and expansion of clean energy technologies could make the clean energy industries excessively dependent on the FIT policy.

In sum, while FITs have many advantages, they also face a number of challenges which need to be addressed if FIT policies are to achieve their objectives in a timely and cost-effective manner.

4.5.2 Utility Quota Obligation

Utility quota obligation is another regulatory instrument for promoting environmental investments. Basically, this mechanism specifies a minimum percentage of power generation that RE providers and obligated utilities are required to supply or installed. It is designed to encourage new RE development by establishing a target or quota on the proportion of electricity generation that must come from RE sources by a certain date (Rader and Norgaard 1996; Wiser et al. 2007; Hurlbut 2008). The utility quota obligation instrument is also referred to as Renewable Portfolio Standard (RPS), Renewable Obligations, and Quota Policies.

To date, there are only nine countries which have implemented a utility quota obligation policy on a national level, including Australia, Italy, Japan, Poland, Romania, Sweden, and UK (REN21 2011). Japan, in particular, provides a classic example of the success story of such a regulatory scheme (Box 4.6).

Box 4.6: Success Story of Utility Quota Obligation in Japan

Japan's Renewable Portfolio Standard Law was enacted in 2003 with the goal of raising the share of the nation's electricity supply generated by RE by placing regulations on energy supply corporations. These companies can reach their imposed quota in three different methods:

1. *By generating* their own RE-generated electricity
2. By purchasing RE-generated electricity from another party
3. By purchasing 'New Energy Certificates'

The goal of the programme is to achieve a target of 16.0 TWh/fiscal year of new energy generation by electric retailers by 2014, up from 7.32 TWh/fiscal year at the introduction of the programme in 2003. By mandating the purchase of renewables, Japan has been successful in increasing the share of RE in their total electricity supply. In 2006, 18 of the 39 electricity suppliers under the obligations of the law surpassed their legally mandated shares of renewables in electricity supplied.

Source: RPS Japan; Japan for Sustainability; REN21 (2011).

In the USA, the RPS is one of the most common state-level RE policies, where 29 states and the District of Columbia have enacted mandatory RPS policies (DSIRE 2010a). In addition, six other states do have voluntary targets (Sullivan et al. 2009), while a number of other states (and the federal government) are considering to implement the RPS policies (Couture et. al. 2010).

4.5.3 Net Metering

Yet another regulatory incentive is the so-called net metering, which requires "a utility to provide consumer electricity users with a credit for any excess electricity that the consumer generates with an on-site power generation system (e.g. solar equipment) and feeds into the grid" (Asplund 2008). In other words, such an arrangement permits users generating power to sell any electricity in excess of requirements back to the grid to offset consumption. This allows a two-way flow of electricity between the electricity distribution grid and customers with their own generation, but customers only pay for the net electricity used.

It is noteworthy that net metering can increase the economic value of small RE technologies for customers by allowing them to use the grid to bank their energy, producing electricity at one time and consuming it at another. This kind of energy exchange is especially useful for such RE technologies as wind turbines and photovoltaics, which transmit electricity to the grid intermittently (when the wind is blowing or the sun is shining) and, at other times, are consumers of electricity from the grid.[1]

[1] http://www.eia.gov/cneaf/electricity/chg_str_fuel/html/chapter5.html.

Net metering regulation is used in 13 countries, including Thailand which provides a good example of application of such a regulatory framework in the developing world (Box 4.7).

Box 4.7: Success Story of Net Metering in Thailand

Thailand initiated the first net metering policy in the developing world in 2002. The Very Small Power Producer (VSPP) regulations were aimed at encouraging the use of small-scale renewable generation (under 1 MW). In conjunction with the nation's power utility corporations, the Thai government mandates the purchase of any surplus electricity generated at rates which are adjusted every 3 months. The VSPP programme covers production from a variety of sources including solar PV and bioenergy. The initial legislation was extended in 2006 and now includes mandates on the purchase of electricity derived from production of up to 10 MW.

Source: UNDP (2008); REN21 (2011)

4.5.4 Obligations and Mandates

These are regulatory instruments that are used to provide obligatory and mandatory rules for fuel blenders and retailers as well as for building codes and permits. For instance, in the USA, the government has "set mandates that require transportation fuel blenders to use a certain percentage of biofuels in the fuel they provide to consumers," and it also introduces "building code regulations and building permits in order to require builders and building owners to implement building techniques that result in improved building energy efficiency" (Asplund 2008).

Needless to say, regulatory standards are also key instruments to incentivizing green investments, as they can prevent the emergence of inferior technologies and generate greater confidence in products, thereby reducing risks and attracting investors. For instance, in 1979, Denmark adopted wind turbine standards which played a major role in making it the world's leading turbine manufacturer. Similarly, turbine standards and certification requirements in Germany have prevented the quality control problems experienced in other parts of the world. Similarly, standards and planning requirements can reduce opposition to renewables if they address potential concerns such as noise and visual or environmental impacts. For instance, lack of such laws has been cited as one of the main reasons behind the UK's insufficient progress on wind energy despite having the best wind resources in Europe (Sawin 2004).

Regulatory policies on obligations and mandate for biofuels blending are operational in around 27 countries with Argentina, Brazil, China, Colombia, and Portugal demonstrating substantially high blending mandates. Paraguay, however, provides an illustrative case of the success story of obligation and mandate policies (Box 4.8).

Box 4.8: Success Story of Obligation and Mandate Regulation in Paraguay

Since the passage of the Biofuels Promotion Law, in which the production of biofuels was deemed to be of 'national interest', Paraguay has seen an ever-expanding domestic biofuels industry take shape. Paraguay first initiated a blending mandate in 1999 which was subsequently expanded in 2005 and was again modified in 2009. Since 2009, the ethanol blending mandate has grown from 7 % (E7) to as much as 24 % (E24) and is expected to be increased to 25 % (E25). Paraguay is expected to produce nearly 155 million litres of ethanol in 2011. Currently, all biofuel production in Paraguay is used for domestic consumption. The increase in biofuels production is being matched by a growing demand for flex fuel and E85 vehicles in Paraguay.

Source: USDA; REN21 (2011)

4.5.5 Challenges Posed by Weak Legal and Institutional Capacities

Formulating legal and regulatory policies is one thing, but implementation of such laws and policies is another. Developing countries often tend to produce excellent laws and statutes on paper, but weak institutional capacities hamper the implementation of such laws. Efforts must be made to strengthen the judicial system, build and enhance institutional capacities, and inculcate the principle of good governance at both national and corporate levels.

While regulatory and financial incentives to lure green investments have been successful in some developing and developed countries, they may not be enough to attract investments beyond the threshold levels if the legal system is riddled with loopholes, and judges and regulators are perceived as weak and wanting. In other words, without regulatory certainty, administrative simplicity, and transparent and accountable judicial processes, the perceived level of risks can undermine incentives for investing in green projects that have significant upfront costs, thereby rendering economically viable projects unviable financially. This calls for a credible long-term national policy framework that can significantly reduce the risks of investing, so that capital is increasingly available for environmental investment.

4.5.6 Miscellaneous Incentives

In addition to legal, regulatory, and financial incentives, governments around the world have offered a variety of complementary programmes to focus attention on environmental concerns and how to mitigate them. Two such programmes focus on education and information dissemination as well as engagement with stakeholders.

4.5.7 Education and Information Dissemination

Education and public enlightenment campaign is crucial to sensitizing the stakeholders on environmental concerns and solutions. This is necessary because even if governments offer generous incentives and low-cost capital, people may hesitate to invest in RE if they are uninformed or misinformed about resource availability, technology development, the potential of renewables, the fuel mix of the energy they use, and the incentives themselves. For instance, in the past, countries have offered substantial subsidies for wind energy, but these measures evoked little interest due to ignorance about wind resources. Germany provides a classic example of best practice in public awareness campaign about the benefits of clean technology, as despite being a largely cloudy country it has more solar water heaters than sunnier Spain and France (Sawin 2004).

In the absence of a good education and dissemination campaign on environmental investments, many people are left with the perception that renewables do not work, or are inadequate to meet their needs, are too expensive, or are too risky as investments. Thus, it is important that policymakers and political leaders together with the private sector work in concert to educate all stakeholders about the importance of green projects.

4.5.8 Stakeholder Involvement

Involving all stakeholders in policymaking, project development, and ownership is a potent way of increasing the odds of success of environmental investments. In Germany and Denmark, where individuals (singly or as members of cooperatives) still own many of the turbines installed, there is strong and broad public support for wind energy. As of 2002, about 85 % of the installed wind capacity in Denmark was owned by farmers or cooperatives, and at least 340,000 Germans had collectively invested nearly US$ 14 billion in RE projects (Sawin 2004).

Public participation gives a sense of importance to stakeholders because when new ideas or technologies are forced on people without proper consultation, people often either place little value on such technologies or feel they have no stake in them. But when the public are properly consulted in the decision-making and ownership process, they feel empowered and become interested in the success of the technologies. For instance, Sawin (2004) reported that local participation in and ownership of solar mini-grid projects in Nepal and the Indian islands of the Sundarbans have helped ensure the projects' success and have eliminated electricity theft.

4.6 Policy Options for Saudi Arabia

There is no doubt that incentives have played a key role in the rise and growth of environmental business, especially RE activity, around the world particularly in the developed countries. Lessons of experience from the developing countries such as Kenya and China have also much to offer in terms of incentives for mobilizing financing from private investors into environmental goods and services. These policy experiences from other countries could provide a launching pad for Saudi Arabia towards creating conducive incentives for attracting increased private sector participation in environmental business activities in the Kingdom. A number of policy options could be recommended for Saudi Arabia and other GCC countries.

First, an FIT policy should provide the core of government incentive in attracting investment in the RE sector. Such a policy instrument would make it mandatory for energy companies or 'utilities' responsible for operating the national grid to purchase electricity from RE sources at a predetermined price that is sufficiently attractive to stimulate new investment in the renewable sector. This, in turn, ensures that those who produce electricity from identified RE sources such as solar, wind, and other renewable sources have a guaranteed market and an attractive return on investment for the electricity they produce. Aspects of an FIT include access to the grid, long-term power purchase agreements, and a set price per kilowatt hour (kWh) and should be guaranteed for a minimum period of 20 years.

The FIT policies can yield significant RE deployment quickly and effectively for Saudi Arabia and can, therefore, be a useful instrument to meet any aggressive RE targets that the Kingdom would set for itself. The following key elements provide compelling reasons for an FIT policy around the world and could provide overall guidance for its adaptation in Saudi Arabia: long-term policy stability; payments based on the costs of RE generation; differentiating the tariff prices to account for different technologies, project sizes, locations, and resource intensities; guaranteed grid access; eligibility for all end users and RE project developers; and a reliable must-take provision for the electricity generated.

Another policy option that could be pursued alongside the FIT policy relates to provision of subsidies on green investment. At the moment, the government is spending billions of Saudi riyals on subsidizing power using conventional energy sources, which contribute to inefficient energy production and consumption that generates intolerable levels of pollution. Directing such subsidies to producers and consumers of clean energy will not only boost the productive capacity of the Kingdom in clean energy but also diversify exports, encourage energy efficiency, and conserve current oil and gas resources for future generations. After all, Saudi Arabia has all the ingredients (sunshine and financial resources) for clean energy production, but it lacks the technology for exploiting the potential of such energy sources. Subsidies could also be offered on R&D activities on green technologies to accelerate the achievement of the Kingdom's potential comparative advantage in clean energy production while at the same time promoting energy efficiency in the production and use of conventional energy. Thus, with appropriate policy incentives and political will, the Kingdom could easily become the world's largest producer and exporter of clean energy comparable to its status as the world's largest exporter of oil.

Private sector operators are always sceptical in undertaking new unconventional ventures in an environment full of uncertainty and limited government support. One way of allaying the fears of investors who are willing to invest in green products and services is to provide government guarantees. With this policy, the government does not directly provide financial resources to private investors but promises to bail out financiers who may be hesitant to provide funding to potential investors willing to actively engage in environmental business activity in the Kingdom.

Yet another way of shoring up investor confidence in clean energy business in Saudi Arabia is by developing and strengthening legal and regulatory mechanisms. The absence of appropriate policy guidelines on environmental investments as well as weak institutions and regulatory bodies for dealing with matters relating to environmental investors could deter private investors from taking up the gauntlet in the clean energy sector. Government should ensure that appropriate oversight bodies for environmental investments are put in place with robust and clear mandate to woo investors, facilitate legal and adjudication processes, and ensure strict compliance with environmental protection laws. Having appropriate laws and regulatory bodies is a necessary but not sufficient condition for environmental business activity to blossom. This has to be complemented with the right kinds of human skills and expertise to oversee the legal and regulatory processes and agencies. In the absence of skilled human resources, such institutions will be highly bureaucratic, inefficient, and will deter rather than attract private investors into the green investment sector.

Chapter 5
Environmental Business Channels

5.1 Overview

Government incentives are undoubtedly key drivers and catalysts behind the rapid take-off of the environmental technology industry around the world. The same sets of incentives (financial, legal, and regulatory) could also play a key role in attracting private investments in environmental technologies in the Kingdom of Saudi Arabia. Needless to say, however, the green technology sector consists of a wide range of business channels that transcend across three broad segments, namely environmental services, environmental equipment, and environmental resources. The key question is which of these business channels have the potential of offering the most profitable investment opportunities.

The environmental services business segment comprises the following investment channels: analytical services; wastewater treatment works; solid waste management; hazardous waste management; remediation and industrial services; and environmental consulting and engineering. Examples of environmental services business include testing of environmental samples; collection and treatment of wastewaters; collection, processing. and disposal of solid waste; managing hazardous waste streams, medical waste, and nuclear waste handling; physical clean-up of contaminated sites and buildings and environmental cleaning of operating facilities; and engineering, consulting, design, assessment, permitting, project management, Operations and Maintenance (O&M), and monitoring services.

In the case of environmental equipment business segment, it consists of the following channels: water/wastewater equipment and chemicals; instrumentation and information systems; air pollution control equipment; waste management equipment; and process and prevention technology equipment. Examples of environmental equipment business include: supplying and maintenance of water and wastewater treatment equipment; producing instrumentation for the analysis of environmental samples; producing equipment and technology to control air pollution; supplying equipment for handling, storing, or transporting solid, liquid, or hazardous waste; and selling equipment and technology for in-process pollution prevention and waste treatment and recovery.

N. Taher, B. Hajjar, *Energy and Environment in Saudi Arabia: Concerns and Opportunities,*
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Finally, the environmental resources segment revolves around the following business channels: clean energy systems and power, water utilities, and resource recovery. Examples of the environmental resources business include: supplying water to end users; selling materials recovered and converted from industrial by-products or post-consumer waste; and supplying power and systems in solar, wind, geothermal, small-scale hydro, and energy efficiency (EE).

The responsiveness of these environmental technology business channels to the wide array of policy incentives may differ markedly, resulting in different financial outcomes or returns on investment. So, which of these environmental technology business channels does one choose from? The choice of a particular business channel or a combination of channels depends upon their elasticities with respect to government incentives as well as other factors that affect the demand for the products and services of these business channels, including income and demographic dynamics.

The main objectives of this chapter are to examine the nature and extent of the global environmental technology business and to estimate the elasticities of environmental business channels with respect to policy incentives and other important determinants. The aim is to determine the impact of incentives on environmental technology business in order to unearth the relative importance of these business clusters and their potential for profitable entrepreneurial opportunities in Saudi Arabia. Such an exercise will provide guidance to ensure that the kinds of environmental technology business to invest in the Kingdom will achieve both private and social environmental objectives.

Section 5.2 of the chapter discusses the global and regional environmental technology markets. Section 5.3 reviews the various environmental technology business channels, while Sect. 5.4 discusses the key players in the global environmental technology market. The impact of government incentives on environmental technology business is analysed in Sect. 5.5, while potential investment opportunities in the three environmental technologies (resources, services, and equipment) are discussed in Sects. 5.6, 5.7, and 5.8, respectively. Section 5.9 pulls together the main conclusions of the chapter.

5.2 Global and Regional Environmental Markets

The size of the global market for environmental technology products and services has expanded markedly in recent years due to a number of factors, including the growing concerns about environmental pollution and energy insecurity caused by supply-side constraints associated with conventional energy and its escalating prices. The global market value for environmental technologies grew by over 54 % during the past two decades (4.9 % per annum) to reach US$ 830 billion in 2011 and is expected to increase further to around US$ 860 billion by 2012 (Fig. 5.1).

With the exception of the 2009 global economic recession, which reduced the global demand for all products/services including environmental businesses, the

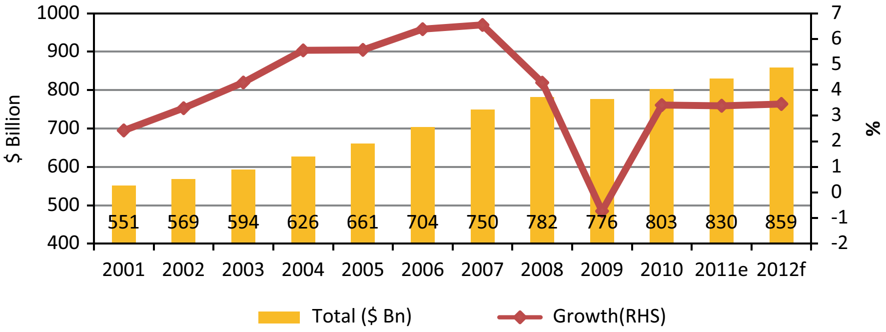


Fig. 5.1 Global market value of environmental technologies (2001–2012). (Source: Environmental Business International (EBI, 2011))

market for environmental technology business has been buoyant and would continue to blossom in the foreseeable future.

The global market for environmental technology business is largely dominated by the developed countries, especially the USA, Europe, and Japan, due to widespread awareness about environmental concerns and the availability of environmental technologies. In essence, the USA is the largest environmental market accounting for 37 % of the global environmental market, followed by western Europe with 27 % and Japan with 12 % (Table 5.1). Together, these three markets account for 76 % of the global environmental technologies, products, and services.

The dominance of the US environmental market is not surprising as it is the world's wealthiest economy, and it has a comprehensive and well-established system of environmental laws and regulations. The US environmental industry accounts for 2.5 % of its gross domestic product (GDP) and has been growing steadily at 5 % per annum during the past decade (EBI, 2011), but growth is likely to peter out as the economy stagnates and investor interests wane. That is why, following the painful economic lessons from the 2008 global financial crisis, US policymakers embarked on aggressive campaigns to attract substantial private sector investments in green technologies aimed at creating jobs and economic opportunities. One such environmental investment strategy revolves around the introduction of 'green bond' to act as a catalyst for private sector investments in environmental business, especially involving small- and medium-sized enterprises (SMEs). The government's active involvement in mobilizing funding for environmental investments will undoubtedly provide impetus to environmental activities in the USA for the foreseeable future.

However, in view of the ongoing shift in the balance of global economic power from the West to the East, more substantial environmental business opportunities are opening up in the emerging economies of Asia. For instance, since the beginning of this millennium, environmental business activity in Asia grew at 21.8 % per annum (Table 5.1), from US$ 24 billion in 2000 to US$ 82 billion in 2011.[1] Environ-

[1] Calculated from Table 1.

Table 5.1 Distribution of global market value of environmental technologies by country/region. (Source: EBI (2011))

	Global total	**Regional shares (%)**									
	(US$ Bn)	**USA**	**Europe**	**Japan**	**Asia**	**Canada**	**Australia–NZ**	**L/A**	**CEE**	**ME**	**Africa**
2000	537.8	38.2	29.3	17.4	4.5	2.8	1.6	2.6	1.7	1.3	0.6
2001	550.9	38.2	29.2	16.9	4.9	2.8	1.6	2.7	1.8	1.3	0.7
2002	569.0	37.8	29.3	16.3	5.4	2.8	1.6	2.8	1.9	1.3	0.7
2003	593.5	37.7	29.3	15.7	5.8	2.8	1.7	3.0	2.0	1.4	0.8
2004	626.5	37.2	29.1	15.1	6.4	2.7	1.7	3.1	2.1	1.6	0.9
2005	661.4	37.1	28.7	14.5	6.9	2.7	1.8	3.3	2.2	1.8	0.9
2006	703.6	36.6	29.4	14.0	7.2	2.7	1.7	3.3	2.2	2.0	1.0
2007	749.7	37.0	28.9	13.5	7.6	2.6	1.7	3.4	2.1	2.2	1.1
2008	781.9	37.6	28.5	12.9	8.0	2.6	1.6	3.4	2.0	2.3	1.2
2009	776.2	37.6	28.3	12.3	8.6	2.5	1.7	3.5	1.9	2.4	1.1
2010	802.7	37.2	27.8	12.2	9.3	2.5	1.7	3.6	1.9	2.6	1.2
2011	829.9	36.8	27.4	12.0	9.9	2.5	1.7	3.7	1.9	2.8	1.3
2012	858.6	36.5	27.0	11.8	10.5	2.6	1.7	3.8	1.9	2.9	1.4
Growth % p.a. (2000–2011)	4.9	4.4	4.0	0.6	21.8	3.7	6.0	11.9	6.7	21.9	19.8

CEE Central and Eastern Europe, *ME* Middle East, *NZ* New Zealand, *p.a.* per annum

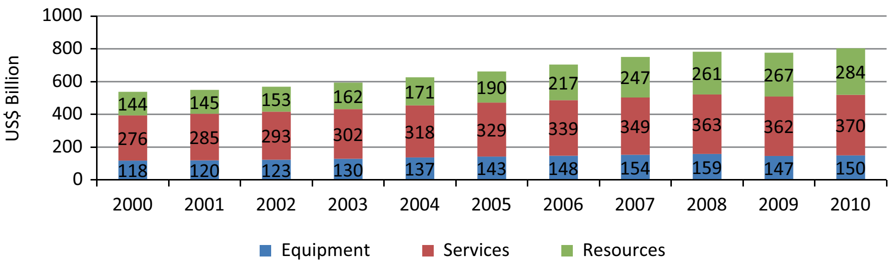


Fig. 5.2 Global market value of environmental technologies by business segments. (Source: EBI (2011))

mental business activity in the Middle East also grew by 21.9 %, albeit from a very low base, but the region still lags behind other regions of the world except Africa, accounting for only 2.8 % of the global market value for environmental business in 2011, up from 1.3 % in 2000. Even so, the major markets for environmental technology and services in the Middle East are concentrated in a handful of countries, principally Turkey, Egypt, and the UAE (EBI, 2011). Turkey, in particular, has made tremendous progress in overhauling its environmental laws, which have helped to build a sizeable environmental market with an estimated value of US$ 580 million in 2004, and Turkish firms are now taking corrective steps to improve their environmental management systems, in accordance with ISO 14001 standards.

5.3 Global Environmental Business Segments

As stated earlier, environment technology business can be classified into three broad segments: services, equipment, and resources. The services business is concerned with rendering services that generate revenues in the form of fees while the equipment business deals with supply or sales of specific hardware. On the other hand, the environmental resources business primarily revolves around clean energy and water utilities. Together, these three broad environmental technology categories have a total of 14 business investment opportunities, fashioned along the lines of the Standard Industry Classification (SIC) or harmonized code systems (EBI, 2011).

The global market of environmental technologies has, for long, been dominated by the services business, followed by resources. For example, in 2010, the global market value of environmental services stood at US$ 370 billion, while those for resources and equipment stood at US$ 284 billion and US$ 150 billion, respectively (Fig. 5.2). All three broad environmental business categories have experienced periods of strong growth during the past decade or so, with the resources business experiencing the fastest growth record. For example, during the decade 2000–2010, the global business in environmental resources grew by 98 % (8.9 % per annum), while services expanded by 40 % (3.7 % per annum) during the same period. En-

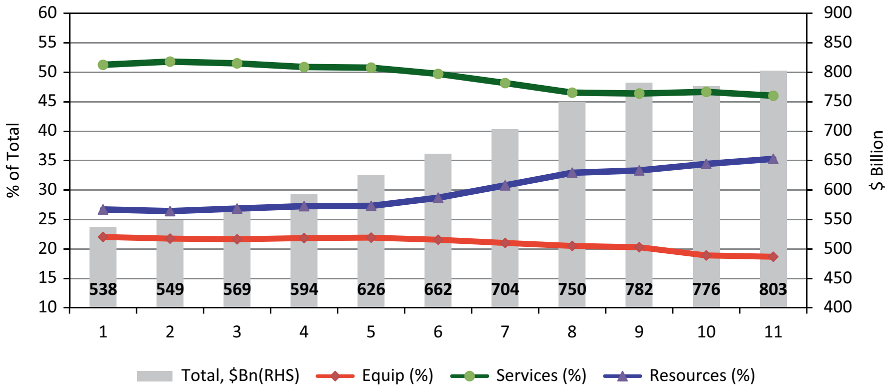


Fig. 5.3 Global market for environmental technologies. (Source: EBI (2011))

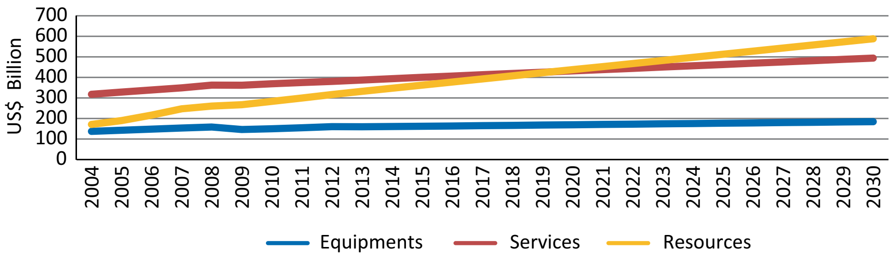


Fig. 5.4 Market size of global environmental technologies. (Actual and forecasted values)

vironmental technology equipment business, however, grew at the slowest pace of 28 % between 2000 and 2010 or 2.55 % per annum.

The increasing importance of environmental resources is reflected in its growing market share, from 27 % of the global market of environmental business in 2000 to 35 % in 2010. In contrast, business activities relating to environmental services experienced a slump in market share, from 51 % in 2000 to 47 % in 2010, while that for environmental equipment also fell by a smaller margin, from 22 % in 2000 to 19 % in 2010 (Fig. 5.3).

Based on current trends, the global business for environmental resources is likely to overtake that for environmental services by 2020 as the most dominant environmental technology market (Fig. 5.4). And, by the year 2030, the environmental resources market (clean energy, water utilities, and material recovery) will account for 46 % of the forecasted US$ 1.3 trillion global market value of environmental goods and services, while environmental services and equipment technologies will account for 39 % and 15 %, respectively.

There is paucity of data on the 14 environmental business segments by countries/regions, except the USA, which has an extensive set of historical data on these segments. Table 5.2 provides detailed information on the market value and growth rates of environmental technology business in the USA. All business segments across the three broad sectors (equipment, services, and resources) have exhibited tremendous growth over the past four decades, albeit with considerable variation across sectors.

During the decades of the 1970s and the 1980s, the fastest growing environmental technology businesses were in the services segment. These include remediation/industrial services, hazardous waste management, and consulting and engineering. Both remediation services and hazardous waste management services grew by a whopping 550 % each during the 1970s, but in the 1980s the market value of remediation services in the USA increased by 19-fold while that for hazardous waste management grew by ninefold.

Since the 1990s, however, the focus shifted dramatically to business activities in environmental resources technology, as the fastest growing businesses were found in that segment. Clean technology business, in particular, witnessed significant upsurge during this period. For example, the market value of the US environmental resources technology grew by a massive 733 % during the 1990s and by 155 % between 2000 and 2010 (Table 5.2). It is, therefore, not surprising that, up till now, the environmental resources segment continues to attract investors' attention due to America's frantic effort to wean itself from reliance on fossil fuel, imported largely from the Middle East.

Outside the USA, countries in the European Union (EU) are the most active participants in the global environmental technology market. However, disaggregated data on the 14 environmental market segments are not available for the 27 EU member countries despite the fact that they are well ahead of the USA in terms of the deployment of government incentives to clean technologies. Data limitations are also visible in the rest of the world although patchy and dated information on the environmental business channels can be found for China, Japan, Australia, Africa, and the Middle East (Table 5.3).

In the Asia and the Pacific region, China is the most dominant and vibrant market for environmental business. The biggest environmental market in China is that for water equipment and chemicals, followed by water utilities and solid waste management services (Table 5.3). This is not surprising given that China's daunting environmental challenges emanate from poor water quality and water supply constraints coupled with the choking air pollution in its major cities. It is reported that the Chinese government spends around US$ 2.3 billion (equivalent to 0.7 % of its GDP) annually on environmental protection. This may, however, be grossly inadequate to tackle environmental degradation in China, as the costs of pollution and ecosystem damage amount to about 9 % of GDP (EBI 2011).

Another major environmental technology market in Asia is Japan. Even though it lags behind China by a considerable margin, Japan's environmental technology business activity is largely concentrated in the services and resources segments, led by solid waste management, water utilities, and resource recovery. However, at the top of Japan's environmental needs is air pollution control arising from manufacturing facilities. In essence, 'air pollution control represents a significant component of

Table 5.2 Market values and growth rates of environmental technologies in the USA (1970–2010). (Source: http://www.docstoc.com/docs/54032745/Environmental-Market-Outlook-to-2010-Market-Development)

	1970	1980	1970–1980 Growth	1990	1980–1990 Growth	2000	1990–2000 Growth	2010e	2000–2010e Growth
Services	US$ Mn	US$ Mn	%	US$ Mn	%	US$ Mn	%	US$ Mn	%
Analytical services	0.1	0.4	300	1.5	314	1.6	7	1.9	20
Wastewater treatment works	4.3	9.2	116	19.8	116	30.0	52	44.5	48
Solid waste management	3.2	8.5	164	26.1	208	42.0	61	58.8	40
Hazardous waste management	0.1	0.6	550	6.3	921	8.0	27	9.7	21
Remediation/industrial services	0.1	0.4	550	8.5	1,813	10.0	18	13.7	37
Consulting and engineering	0.3	1.5	367	12.5	761	18.0	44	28.8	60
Equipment									
Water equipment and chemicals	3.2	6.9	117	13.5	95	20.0	48	32.6	63
Instruments and information systems	0.1	0.2	100	2.0	820	4.0	100	6.0	50
Air pollution control equipment	1.0	3.0	196	10.7	258	18.0	68	19.1	6
Waste management services	2.0	4.0	105	10.7	159	9.6	(8)	11.5	19
Process and prevention technology	0.0	0.1	259	0.4	418	1.2	200	2.0	70
Resources									
Water utilities	5.7	11.9	109	19.8	67	33.0	67	42.3	28
Resource recovery (recycling)	1.2	4.4	283	13.1	197	18.0	37	25.5	42
Environmental energy sources	0.3	1.5	420	1.8	15	15.0	733	38.3	155
USA total:	US$ 21	US$ 53	145	US$ 146	178	US$ 228	56	US$ 335	46

Table 5.3 Market value of environmental technology in rest of the world (US$ million). (Source: EBI (2011))

	China		Japan		Australia and NZ		Africa		MENA	
Market segment	1997	2000	2004	2008	2004	2008	2004	2008	2004	2008
Equipment	970	1,440	5.2	5	n.a.	1.2	0.8	1.3	0.8	1.4
Water equipment and chemicals	390	580	3	2.8	n.a.	0.5	0.1	0.2	0.6	1.2
Air pollution control	140	210	0.9	0.9	n.a.	0.1	0.1	0.1	0.2	0.3
Instruments and monitoring systems	100	150	7.5	6.8	n.a.	0.7	0.3	0.5	0.3	0.6
Waste management equipment	50	70	0.5	0.5	n.a.	0.1	0	0	0	0.1
Process and prevention technology										
Services	600	890	29.8	27.1	n.a.	2.3	0.7	1.2	1.4	2.6
Solid waste management	120	180	3.8	3.4	n.a.	0.4	0.1	0.1	0.4	0.7
Hazardous waste management	150	220	1.2	1.1	n.a.	0.9	0.3	0.4	0.4	0.7
Consulting and engineering	30	40	0.78	3.4	n.a.	1.1	0.3	0.5	2.4	4.5
Remediation	40	60	0.5	0.5	n.a.	0.1	0.1	0.1	0.1	0.1
Analytical services	540	800	9.9	9.1	n.a.	2	0.4	0.7	0.6	1.1
Water treatment works										
Resources	610	900	12.7	11.7	n.a.	2.2	1.85	3	2	3.9
Water utilities	10	10	10.2	10.5	n.a.	0.6	0.3	0.5	0.2	0.4
Resource recovery						0.5	0.3	0.6	0.2	0.4
Clean energy systems and power	3,750	5,550	85.98	82.85	n.a.	12.7	5.5	9.1	9.4	18
Total (US$ millions)										

MENA Middle East and North Africa, n.a. not applicable, NZ New Zealand

Japan's environmental investment, which is the largest in Asia and the third largest in the world, approaching US$ 100 billion annually' (EBI 2011).

The environmental markets in other regions of the world are miniscule but are growing rapidly albeit from a low base. For instance, in the Middle East and Africa regions, the size of the environmental market has nearly doubled between 2004 and 2008 (Table 5.3). Within the Middle East region, however, the market is largely dominated by Turkey, Egypt, UAE, and Saudi Arabia. The bulk of business activity in the Middle East is concentrated in water utilities and remediation, reflecting the overriding significance of water in the region.

5.4 Key Players in the Global Environmental Market

The global environmental technology business in all the key segments has been dominated by a handful of companies from the developed countries. This is not surprising since these countries are far ahead of their counterparts from the emerging and developing countries in terms of technological advancement. Table 5.4 shows the list of the top 70 companies that have physical presence in the global environmental technology market. Of these companies, 41 (58 %) are from the USA, followed by Germany with 9 firms (13 %), Japan with 8 (12 %), while France and the UK have 4 companies (6 %) each.

At the top of the league table of global environmental technology companies is *Vivendi Environnement SA* of France with environmental revenue of over US$ 17 billion in 2001 (latest available data), followed by yet another French company, *Suez*, with US$ 14 billion. Both Vivendi and Suez are predominantly in the water, water equipment, and solid waste management segments. They are followed closely by *Waste Management*, a US-based company that specializes in the solid waste and waste management equipment sectors, with US$ 11.3 billion.

5.5 Do Incentives Matter?

As Table 5.4 shows, there is considerable variation in revenues across the top 70 global environmental technology companies, but companies from the water utilities, solid waste, and waste management equipment business segments appear to have outperformed their rivals from the other environmental technology segments. The main reason for the huge gap in revenue outcomes could be attributed to the fact that water has highly inelastic demand and the technologies used in the water and related segments are well established, tried, tested, and highly diffused compared with the nascent technologies for other environmental business channels such as clean energy. This leads to a relatively high widespread application of the water technology, resulting in not only lower sunk and operational costs but also much more affordable tariffs compared with renewable energy, for instance.

Table 5.4 Top 70 global environmental technology companies, 2001. (Source: EBI (2011))

	Company	Country	Segment	Env'l Rev. (US$ Mn)
1	Vivendi Environnement SA	France	Water/SW/HW/WE&C	17,230
2	Suez (Ondeo, Sita)	France	Water/WE&C/SW	13,970
3	Waste Management	USA	Solid waste/WME	11,320
4	Allied Waste	USA	Solid waste	5,470
5	RWE Entsorgung AG	Germany	Solid waste/C&E	4,790
6	Bechtel Group Inc.	USA	EC/remediation	2,640
7	Severn Trent	UK	Water/WW/C&E	2,380
8	Ebara Corp	Japan	W/WW/APC/SW/RIS	2,300
9	Republic Services	USA	Solid waste	2,260
10	Mitsubishi Heavy Industries	Japan	Incinerator/APC/water equipment	2,160
11	Kubota (Ind'l Eq div.)	Japan	Equipment	1,830
12	Betz Laboratories Inc. (now GE Betz)	USA	Water treatment	1,820
13	Hochtief AG	Germany	EC	1,760
14	AWG plc (Anglian Water)	UK	Water	1,740
15	Shaw Group (IT Corp, S&W)	USA	C&E/remediation	1,610
16	Safety Kleen Corp.	USA	Hazardous waste/recycling	1,510
17	Earth Tech	USA	C&E	1,460
18	United Utilities	UK	Water/WW/equipment	1,440
19	CH2M Hill Cos.	USA	C&E	1,420
20	Vestas	Denmark	Wind power systems	1,280
21	Kurita Water Industries	Japan	Equipment	1,260
22	Noell Gmbh	Germany	APC/EC/SW/RR	1,100
23	Washington Group International	USA	C&E/EC	1,040
24	Fomento de Construcciones y Contratas	Spain	EC/solid waste	1,040
25	Hitachi Zosen	Japan	WME	970
26	Takuma (Envl Eq & M/M divs)	Japan	WME/biogas/WEC	920
27	Kelda Group (Yorkshire)	UK	WU/WTW/AS/medical waste	910
28	Philip Services	Canada	RR/industrial services/AS	810
29	Bilfinger + Berger	Germany	EC	810
30	NEG Micon	Denmark	Wind power systems	790
31	Babcock Borsig (Deutsche Babcock)	Germany	WME/APC	790
32	Black & Veatch	USA	C&E/EC	730
33	Foster Wheeler Corp. (now part of Tetra Tech)	USA	EC	730
34	Linde	Germany	Equipment/C&E	720
35	Fluor Daniel Inc.	USA	EC	720
36	Rethmann Entsorgungs	Germany	Solid waste	710
37	URS Corp	USA	C&E	700
38	Organo	Japan	Water equipment	700
39	Parsons Engineering Science	USA	C&E/CE	680
40	Philipp Holzmann	Germany	EC	600

Table 5.4 (continued)

	Company	Country	Segment	Env'l Rev. (US$ Mn)
41	Tsukishima Kikai	Japan	Water/sludge/incinerator equipment	590
42	MWH Global (Montgomery-Watson)	USA	C&E	570
43	Alstom	France	APC equipment	560
44	Tetra Tech Inc.	USA	C&E	550
45	Rhodia Eco Services	France	Hazardous waste	510
46	Casella Waste Systems Inc. (Rutland, VT)	USA	Solid waste	480
47	Battelle Memorial Institute	USA	C&E	450
48	Camp Dresser & McKee Inc.	USA	C&E	440
49	Jacobs Engineering	USA	C&E	410
50	Stericycle	USA	Medical waste	390
51	Waste Connections Inc. (Folsom, CA)	USA	Solid waste	380
52	Buderus	Germany	Construction/WEC	380
53	CalEnergy (MidAmerican Holdings)	USA	Geothermal power	370
54	AECOM Technology Corp	USA	C&E	370
55	Mactec Inc.	USA	C&E	370
56	Ionics	USA	Water/WW equipment	350
57	Norcal Waste Systems Inc.	USA	Solid waste	320
58	The ERM Group	USA	C&E	300
59	Rumpke Consolidated Companies Inc.	USA	Solid waste	290
60	Gundle Environmental	USA	Waste equipment	260
61	Waste Holdings Inc.	USA	Solid waste	260
62	Pall Corp	USA	Water equipment	260
63	Thermo Electron Corp.	USA	Instruments	240
64	Arcadis	Holland	C&E	230
65	Clean Harbors Inc. (Braintree, MA)	USA	Hazardous waste	220
66	Donaldson Company Inc.	USA	APC equipment	220
67	Heritage Environmental Services	USA	Hazardous waste	200
68	IESI Corp. (Haltom City, TX)	USA	Solid waste	190
69	Perkin-Elmer	USA	Instrumentation	180
70	BHA Group Inc	USA	APC equipment	170

However, with appropriate incentives for all environmental technologies, it is highly likely that many of the environmental business channels, including clean energy, will be profitable. The key question is: How would environmental technologies respond to government incentives, and which of the environmental business channels would be more receptive to such incentives? In other words, do environmental policy incentives matter for environmental technology businesses? Answers to these and related questions may be difficult to find especially on an ex ante basis in countries where such incentives do not exist. Even in those countries such as the

EU member states where such a policy has been in place for some time, the analysis may be constrained by data limitation.

In the presence of the appropriate data, however, answers to these questions could easily be ascertained through a quantitative analysis of the relationships between the incentives and environmental business channels. Such a procedure, involving a multiple regression analysis, would allow for estimation of the elasticities of environmental technology business channels with respect to government incentives and other controlled variables. The estimated elasticities would give a clue not only on the nature and magnitude of the impact of policy incentives on environmental technology business channels but also on the relative importance of the policy incentives. The stylised form of such the multiple regression equation can be written as follows:

$$\begin{aligned} \mathrm{ENV\_BUS} = {} & \mathrm{C} + \mathrm{b}_1\mathrm{FIT} + \mathrm{b}_2\mathrm{SUBSIDY} + \mathrm{b}_3\mathrm{QUOTA} \\ & + \mathrm{b}_4\mathrm{LOAN} + \mathrm{b}_5\mathrm{TAX} + \mathrm{b}_6\mathrm{CONTROL} + \epsilon, \end{aligned}$$

where

ENV_BUS	Environmental business
FIT	Feed-in tariffs
SUBSIDY	Subsidy and aid
QUOTA	Quota to be sourced from renewable energy sources
LOAN	Soft government loans and loan guarantees
TAX	Tax breaks
CONTROL	Control variables, such as income and demographic variables, that might influence environmental technology business

b_1, b_2, …., b_6 are the estimated elasticities for environmental business activity with respect to each of the six independent variables, while C is a constant term and ε represents error term which is supposed to be normally and independently distributed.

Thus, the above equation shows that environmental technology business depends on FITs, subsidy, mandatory energy quota to be sourced from clean (green) sources, soft loan and government guarantees, and tax rebates on environmental technology investments. It also depends on other non-incentive variables such as per capita income and population growth. A priori, the coefficient of each of the independent variables is expected to be positive, implying that an increase in each of the independent variables (policy incentives as well as control variables) would boost investments in environmental technologies, while a decrease in each of the independent variables would reduce environmental investments.

Ideally, the above regression equation should be applied to each of the 14 environmental technology businesses. However, lack of data on many of the incentives across the 14 environmental business channels precludes the estimation of the regression by environmental business segments for individual countries. In fact, only the EU has relatively detailed data on both environmental technology business and policy incentives. As a result, we confine our analysis here to 18 (out of the 27) EU countries where data on incentives, especially on renewable energy, are available for the period 2001–2010.[2]

5.5.1 Regression Results

Table 5.5 contains the results of the regression equations of environmental technology market data on the different types of incentives, including FITs, standard quota regulations, tax, subsidies, and research and development (R&D) for environmental activities. We also added non-incentive control variables such as per capita GDP in purchasing power parity terms and population growth rate as other determinants of environmental activity. Four different equations for environmental market in EU countries for the years 2001–2010 were estimated based on different combinations of the explanatory variables, including the following:

- A dummy variable for FITs, taking the value of unity (1) for the presence of FIT and zero (0) for the absence of a FIT policy.
- Percentage of power that is mandated to be sourced from renewable energy. This represents a policy incentive of 'Obligations and Mandates'.
- Public R&D for control and care of the environment both in absolute monetary terms (millions of dollars in constant purchasing power parity) and as a percentage of total government R&D budget.
- Environmental aid as a percentage of total allocable aid, representing a subsidy incentive policy.
- Environmental tax revenues (millions of dollars).
- Per capita real GDP in purchasing power parity terms.
- Growth rate of population.

As stated earlier, a FIT policy is expected to have a positive effect on environmental technology activity, so the estimated coefficient of this variable is expected to be positive. Similarly, an Obligations/Mandates policy is likely to encourage increased activity in renewable energy as is the case with increased environmental R&D and environmental aid. Real GDP per capita and growth rate of population are introduced to capture the effect of market size on environmental business, through increased purchasing power and demographic dynamics leading to increased demand for environmental goods and services. Both variables are also expected to impact positively on environmental business activity.

All variables, including the dependent and the independent (explanatory) variables, are expressed in logarithmic terms, which means that the results of the regression equations can be directly interpreted as elasticities (i.e. the degree to which environmental technology business responds to policy incentives, consumer purchasing power, and population dynamics). The explanations of the results are as follows.

[2] These EU countries are: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and UK.

Table 5.5 Regressions of environmental activity for EU countries, 2001–2010 (dependent variable: environmental market size in US$ millions)

Explanatory variables	Equation 1	Equation 2	Equation 3	Equation 4
Constant	0.874	−0.07	0.520	−2.358***
	(1.17)	(−0.10)	(0.55)	(−2.86)
Real GDP per capita	0.437***	0.703***	0.386***	0.980***
	(4.41)	(8.59)	(3.00)	(16.57)
Population growth rate	0.011	0.016	−0.014	0.009
	(0.55)	(1.00)	(−0.28)	(0.44)
Public environmental R&D expenditure	0.048***	–	0.038**	–
	(4.00)	–	(2.20)	–
Environmental R&D (% of total R&D budget)	–	0.011***	–	−0.014*
	–	(2.70)	–	(−1.90)
Environmental tax revenues	0.352***	0.224***	0.354***	0.052*
	(8.74)	(6.66)	(6.27)	(1.89)
% of power from renewable energy	−0.021***	−0.026***	−0.030***	−0.043***
	(−3.01)	(−2.64)	(−4.63)	(−2.90)
Dummy for feed-in tariffs	0.127	0.202	0.263	0.438
	(0.69)	(0.77)	(1.60)	(1.12)
Environmental aid (% of total allocable aid)	–	–	0.355*** (4.44)	0.444** (2.35)
No. of observations	140	140	100	100
Adjusted R-squared	0.88	0.91	0.88	0.95

Note: All independent variables are in natural logarithms; **, *** represent 5% and 1% significance level, respectively; figures in parentheses are absolute values of t statistics. Figures in parentheses are absolute values of t statistics.

In Eq. 1, we introduced all explanatory variables except R&D as a percentage of total R&D budget and environmental aid as a percentage of allocable aid, as both variables are expected to exhibit significant correlations that might bias the goodness of fit of the model.

As can be seen from the results, the estimated coefficients of the FITs, R&D, and environmental tax revenues are positive, suggesting that environmental business responds positively to these policy incentives albeit at varying levels of significance.

The implication of these results is that investment in environmental segments (equipment, services, and resources) will be boosted profoundly by introduction of these policy incentives. For example, an introduction of FITs can boost business activity in environmental resources by 12.7%. This implies that, by providing FIT incentives, the government could encourage private investors to increase their investment in environmental technology business by nearly 13%. Similarly, a 10%

increase in R&D subsidy on green technologies will attract investment into those activities by around 5 %. Thus, by providing financial incentives, such as FITs and R&D subsidies, policymakers would be able to boost investments in environmental technologies quite considerably.

The only exception to the results in Eq. 1 is the coefficient of the 'obligations' incentive which mandates energy suppliers to source a particular percentage of their power through clean energy sources. This explanatory variable is expected to have a positive impact on environmental investment, but its estimated coefficient is negative and statistically significant, implying that an increase in the percentage of power sourced from renewable energy will lead to a decrease in environmental activity. Puzzling as it may be, the result may perhaps suggest that there appears be a threshold level of the renewable energy obligatory requirement so that once the minimum requirement has been reached, there is no added value to be gained from incentives beyond the threshold level. The policy implication of this result is that policymakers should not increase the minimum regulatory requirement for sourcing power from renewable energy, since numbers beyond the threshold level could only serve to undermine investment in environment business segments. This calls for formulation of an effective mechanism for determining the appropriate range of values of the percentage of power to be sourced from clean energy in order to avoid overshooting the 'critical' level that incentivises investment in green business.

In the case of market size, proxied by per capita income and population growth rate, both of them have positive elasticities, implying that an increase in both variables would lead to an increase in environmental business activity, *ceteris paribus*. It is, therefore, instructive that policymaking initiatives that could boost the purchasing power of consumers could also boost investment in environmental business. The explanatory power of Eq. 1 is relatively high, as reflected by the adjusted coefficient of determination (adjusted R-squared) of 0.88, which means that the explanatory variables in the equation jointly explain around 88 % of the variability in environmental business activity.

Equation 2 is similar to Eq. 1 except that we replaced the absolute value of environmental R&D with the percentage share of environmental R&D in total R&D expenditure budget. Here again, all the incentive variables in the equation (except the obligations incentive) have the correct positive signs on their estimated coefficients. This implies that putting in place these policy incentives will increase the returns on environmental activity in each of the business segments. In the case of incentives relating to 'obligations', however, the threshold level quota must be taken into account to avert perverse outcomes. Similarly, the results show that an increase in per capita GDP and population growth rate will increase the market value of environmental business activities.

In Eqs. 3 and 4, we introduced the share of environmental aid (subsidy) in total allocable aid as an additional variable, which turns out to be a more potent incentive because it contributes positively to investments in environmental business channels, while at the same time it increases the impact of the FITs on environmental businesses.[3] For example, a 10 % increase in environmental subsidy as a percentage of total allocable aid can lead to a 4.4 % increase in investment in environmental business, but it also boosts the impact of FITs, suggesting that an introduction of US$ 100 million FITs along with a 10 % environmental subsidy will increase investment in environment business by US$ 44 million.

In sum, the statistical analysis suggests that incentives do matter in environmental technology investments. Unfortunately, however, it is not possible from the results to distinguish the relative responsiveness of each of the 14 business channels to incentives since the regression analysis applies only to aggregate environmental activities rather than to individual business channels. However, a review of recent developments and lessons of experience on investment opportunities relating to each of the environmental technology segments will help to shed light on their prospects. The following section is, therefore, devoted to undertaking such a review.

5.6 Environmental Investment Opportunities

The choice of where to invest in the environmental technology industry depends upon a number of factors, including demand conditions, incentive schemes, risk–return profile, accessibility of appropriate technology, emerging market niches, etc. Other selection criteria include: the potential to have a positive effect on environmental problems and challenges facing Saudi Arabia; the potential for exports; and the potential to provide the Kingdom with a leadership role in environmental initiatives, e.g. green building technology, solar power, recovery and recycling, etc.

In essence, environmental technology activities have a huge job creation potential, as confirmed by estimates from a number of recent studies. For instance, a study by Wei et al. (2010), cited in Bowen (2012), arrived at the following conclusions:

- The renewable energy and low carbon sectors generate more jobs per unit of energy delivered than the fossil fuel-based sector.
- Within the common renewable portfolio standard (RPS) technologies, solar photovoltaics (PVs) create the most jobs per unit of electricity output.
- EE and renewable energy can substantially contribute to CO_2 emission reductions and significant job creation. For instance, cutting the annual rate of increase in electricity generation in half and targeting a 30 % RPS in 2030 each generates about 2 million job-years through 2030 in the USA.

[3] Equation 3 is a replica of Eq. 1 but with environmental subsidy added to it, while Eq. 4 is a replica of Eq. 2 plus subsidy. In Eqs. 3 and 4, however, the number of observations has dropped to 100, from 140, as four countries did not offer environmental subsidy throughout the estimation period 2001–2010. In Eqs. 3 and 4, the estimated coefficient of the additional variable (environmental subsidy) is positive and statistically significant, implying that a 1 % increase in environmental subsidy would stimulate investment in green business by between 0.36 and 0.44 %, respectively.

- A combination of renewable energy, EE, and low carbon approaches such as nuclear and carbon capture and storage (CCS) can yield over 4 million job-years through 2030 in the USA with over 50 % of the electricity supply from non-fossil supply sources.

Similarly, Rutovitz (2010) conducted a detailed analysis of employment opportunities from 'green' activities, especially in renewable energy and EE sectors in South Africa, and found that an energy revolution scenario that reduces South Africa's emissions by 60 % by 2050 (relative to 2005 levels) would create 27 % more jobs than a 'business-as-usual' scenario.

Furthermore, Upadhyay and Pahuja (2010) also examined the employment potential of renewable energy, especially in solar and wind power in India, and found that solar power is more labour-intensive than wind power and better able to meet India's requirements for small-scale, off-grid power. Biomass, 'green' transport, and public works in water and forest management are also seen as attractive ways of achieving both employment and environmental objectives.

Undoubtedly, environmental technology business has the potential of creating wealth to investors as well as the potential to create jobs and economic opportunities that will help to address many of the development challenges facing the Kingdom of Saudi Arabia and other countries in the Gulf Cooperation Council (GCC) region. We shall evaluate the potential investment opportunities based on prognostic analysis and future projections for the various investment technology channels for the period 2012–2030 with a view to gaining a deeper insight into their long-term outlook.

5.6.1 Opportunities in the Environmental Resources Segment

As stated earlier, the environmental resources segment consists of clean energy (renewable energy and EE), water utilities, and resource recovery. It is the fastest growing segment of the environmental technologies, with huge business opportunities in each of its three main business channels. The clean energy business segment of the environmental resources industry is forecast to be the fastest growing environmental business channel, followed by water utilities, while resource recovery business is expected to grow sluggishly (Fig. 5.5).

5.6.1.1 Clean Energy

Clean energy is often used to describe environmentally friendly energy such as renewable energy and EE. Improving EE, which can be gained from both new and old facilities, including industry, buildings, and transportation systems, is one of the leading options for achieving energy security and improving industry profitability and competitiveness. It can also help to reduce the overall energy sector impacts on climate change (Taylor et al., 2008).

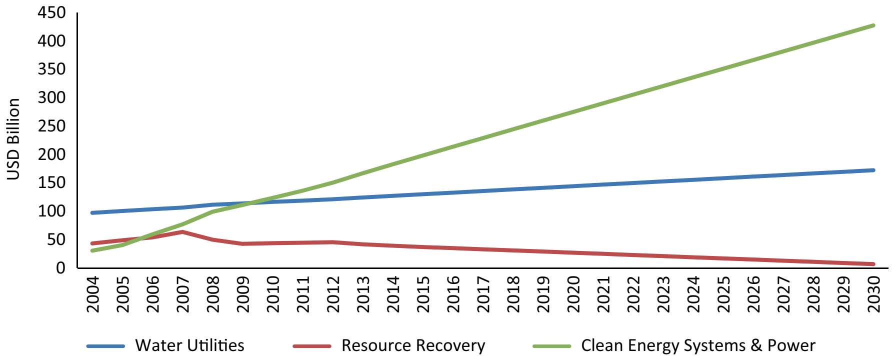


Fig. 5.5 Global environmental resources market forecast. (Source: EBI (2011))

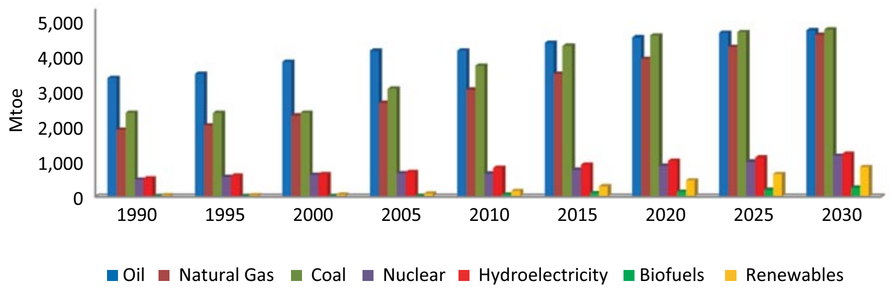


Fig. 5.6 Energy production by sector. (Source: BP (2012))

On the other hand, renewable energy business is a diverse activity consisting of solar power, wind power, geothermal energy, fuel cells, wave/tide power, and biofuels (Asplund 2008). Such a diversity provides profitable business opportunities within the renewable energy technology sector, which are largely driven by concerns about the negative environmental impacts of fossil fuels (known as fossil fuel negatives), peak energy, rising prices of conventional energy, and climate change issues.

Fossil fuel negatives

Fossil fuels have been powering the world economy for decades and it will continue to do so for decades more to come. For example, around 98 % of global energy production is from fossil fuels (oil, gas, coal, etc.), and fossil fuel is likely to remain the most dominant energy source by the year 2030 even though its proportion in global energy mix will continue to fall (Figs. 5.6 and 5.7). The problem with fossil fuel, however, is that it generates considerable pollution in the earth's atmosphere and creates other environmental problems that could affect sustainable economic

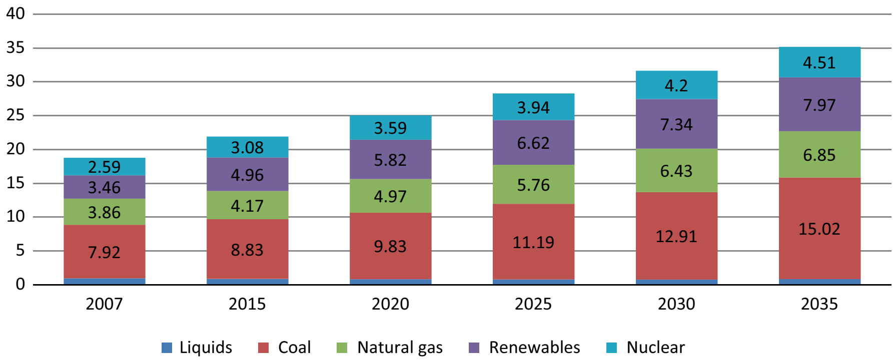


Fig. 5.7 World net electricity generation by fuel type (trillion kilowatt hours). (Source: BP (2012))

growth and development. In addition, the world economy is vulnerable to supply shocks and volatility in the price of fossil fuels with adverse consequences for both fossil fuel importing and exporting countries.

Peak Energy

The finite and exhaustible nature of conventional energy means that they will reach maturity and begin to decline, a process known as peak energy. For instance, oil which is the lifeblood of the modern economy has already started to peak, as the largest oil reservoirs called 'Super Giants', the easiest to find and most economical to develop, have already aged and started their decline (Asplund 2008).

Peak energy will create significant imbalances between energy demand and supply. For instance, since 2010, the gap between oil demand and supply has opened up, with oil demand outstripping oil supply. Such a gap is expected to widen considerably in the future with expected demand estimated at 4,720 million tonnes of oil equivalent (mtoe) by the year 2030 while oil supply is forecasted at 4,512 mtoe during the same period (Fig. 5.8). This will undoubtedly jerk up the prices of oil and enhance the attractiveness of clean energy.

Peak oil signifies the end of 'cheap oil' as extraction becomes more difficult leading to a sharp increase in oil prices. In addition, demographic dynamics in oil exporting countries, such as Saudi Arabia, will also increase domestic oil consumption, resulting in a sharp fall in oil exports and government revenues. Unless concrete actions are taken, by way of developing alternative energy sources or enhancing the efficiency of the conventional energy, this will lead to disruptive and devastating energy crises for the entire global economy.

Thus, the emergence of peak energy will present fantastic opportunities for clean energy business to flourish in the foreseeable future. A recent report by Al Masah Capital (2012) has provided a detailed analysis on renewable energy generation

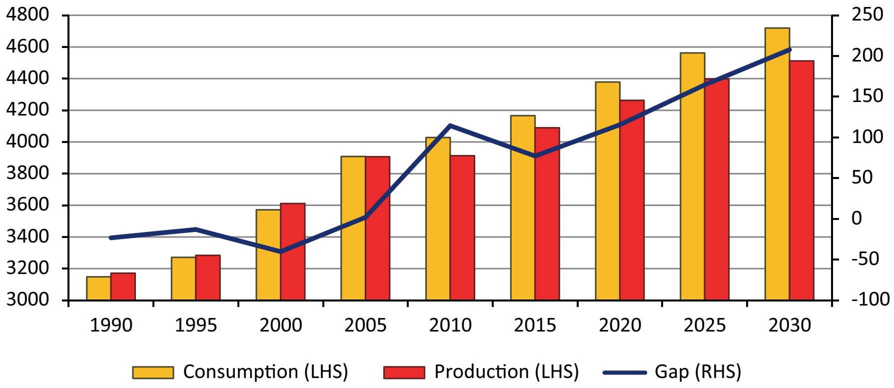


Fig. 5.8 World oil consumption and production (million tonnes). (Source: BP (2012))

in the Middle East region as a necessity for keeping energy exports steady and for powering our homes and industries in the face of dwindling oil reserves.

Shale Gas

Shale gas is an unconventional gas resource that is found in shale rock underground and is developed by special techniques including hydraulic fracturing known as 'fracking'. It is one of three types of unconventional gas resources, the other two being coal bed methane and tight gas. These three forms of unconventional gas differ from conventional gas in the sense that they are found in reservoirs with relatively low permeabilities and they cannot, therefore, be extracted via conventional methods.

Shale gas can be found in nooks and crannies of the world and could help to elongate the lifespan of global gas supply. An analysis by *The Economist* (2012) shows that global gas production could increase by 50 % between 2010 and 2035 and that 67 % of such growth will come from unconventional gas sources.[4] Estimates of the technologically recoverable global shale gas reserves vary across regions, but China appears to have the largest proven reserves, estimated at around 1,275 trillion cubic feet, followed by the USA with 862 trillion cubic feet (Table 5.6).

Despite having the largest world reserves of shale gas, China started to explore it as recently as 2010 as part of its strategic objective of meeting most of its energy needs from alternative energy sources by 2020. In contrast, companies in the USA have already unlocked access to shale gas reserves as the country has already started full-scale production of shale gas. On current trends, shale gas production has the

[4] *The Economist* (2012), 'Fracking Great: The promised gas revolution can do the environment more good than harm', 2 June.

Table 5.6 Global estimates of proven shale gas reserves, 2009. (Source: Energy Information Administration (2011))

	Trillion cubic feet	% of global shale gas reserves
World	6,622	100
China	1,275	19.3
USA	862	13.0
Argentina	774	11.7
Mexico	681	10.3
South Africa	485	7.3
Australia	396	6.0
Canada	388	5.9
Libya	290	4.4
Algeria	231	3.5
Brazil	226	3.4
Poland	187	2.8
France	180	2.7
Others	647	9.8

potential to transform the energy market in the USA, as recent analysis has shown that shale gas could provide up to half of America's gas supply by the year 2020.[5]

Canada, which is the world's third largest producer of natural gas, with an average annual production of 6.4 trillion cubic feet, is closely following the USA in terms of shale gas development.[6] Thus, given the rapidly declining rate of conventional natural gas in Canada and the rest of the world, it is likely that Canada will be increasingly shifting its attention to unconventional sources, including shale gas.

Sizeable quantities of shale gas and other unconventional sources of fuel have also been reported in many countries in Europe, including the UK, Germany, France, Holland, Norway, Poland, and those of Scandinavia. Ukraine and Turkey are also said to have substantial potential in shale gas. Shale gas development in these countries will pose a significant threat to Russia which is the dominant supplier of conventional gas in Europe. However, European investors are playing a 'wait-and-see' game with the USA to see if the American investors further develop their country's capabilities in exploration of shale gas before they could follow suit. Exploration activity in the shale gas sector in Europe is also being hampered by a wide range of issues, including economic, environmental, and regulatory considerations.

Needless to say, although shale gas is gaining traction around the world, it is surrounded by controversy on both sides of the debate. While proponents of shale gas have argued that it has the potential to turn the world's energy industry on its head as it is abundant and cleaner than fossil fuels, opponents of shale gas have argued that the environmental risks associated with the hydraulic fracking method of extraction of shale gas far outweigh the environmental benefits. The environmental risks

[5] http://www.renewables-info.com/drawbacks_and_benefits/shale_gas_advantages_and_disadvantages.html.

[6] KPMG (2011).

include groundwater contamination, minor tremor (earthquake), water usage risks, surface water and soil risks, and spills and blowouts (Box 5.1).

Box 5.1: Hydraulic Fracturing: What Are The Environmental Risks?

Natural gas is, in many respects, a clear and efficient burning fuel and has the potential to lower carbon emissions with fuel switching plays. However, risks remain since shale gas development around the world has met with fierce opposition from local residents and environmental groups due to environmental concerns over the hydraulic fracturing, or ‘fracking’, process.

Fracking involves drilling a well bore into the reservoir rock formation and then forcing water, sand, and chemicals into the well at high pressure to create fractures or fissures in the rock. Once the fracture is open, the released gas flows out of the fractures and into the well bore. In addition to shale gas, the process has recently been applied to extract gas from coal seam and tight sand deposits.

With the impact of fracking operations still under study, the jury is out on the extent to which the process may be harmful to the environment. Some specific concerns being raised by environmental groups, media, and regulated companies are as follows.

Groundwater Contamination

Some have asserted that fracking chemicals used in the process could leak into underground rivers and reservoirs and ultimately into drinking water supplies. The health effects of long-term exposure to chemicals commonly used in fracking are being evaluated by regulatory agencies.

Gasification

When gas migrates into groundwater, the build-up of pressure due to gasification may lead to tremors or explosions. Aquifer gasification due to shale gas development has been cited as a potential cause for recent minor seismic activity in the UK, though these claims are largely uncertain at this point and being investigated.

Water Usage Risks

Fracking can be water intensive depending on the water management methods used. This may pose risks in water-restricted areas.

Surface Water and Soil Risks

Risks may also arise from the volume of chemicals that need to be stored at the drilling site and from the liquid and solid waste produced during drilling and fracking.

Spills and Blowouts

Well blowouts can cause spills that could spread into the surrounding soil and into wetlands, streams, and waterways. There are also concerns that wastewater kept in storage ponds could overflow in high rains.

Source: KPMG (2011)

On the balance of the debate, it is likely that shale gas production would generally impose a larger environmental footprint than conventional gas, with huge implications for local communities, land use, and water resources. Addressing the key problems of the potential for air pollution, for contamination of surface and groundwater, and for greenhouse gas emissions both at the point of production and throughout the entire natural gas supply chain will require concerted actions from both policymakers and private sector participants.

Cost considerations

In addition to posing environmental risks, the costs of extraction of shale gas can be significantly higher than those for conventional oil and gas given the low permeability of the unconventional gas reservoirs. However, these costs have declined considerably over the past decade in North America (though still relatively high) due to efficiency improvements resulting from large-scale drilling programmes and the use of pad drilling and multilateral wells.[7]

Recent cost analysis of 13 companies producing shale gas in the USA revealed an average cost of US$ 5.34 per million cubic feet (mcfe) of gas. This is substantially higher than the current spot price of around US$ 4 per mcfe of natural gas. With such a low cost structure, most companies would not be able to operate a profitable shale gas business. However, the high rate of technical improvement and innovation will bring costs of shale gas down in the longer run, thereby enhancing its attractiveness. As Erismann (2011) has argued, the shale plays will develop further as more and bigger energy companies like Shell, Chevron, and BP enter the shale gas business, thereby reducing their drilling cost significantly, especially as substantial parts of the costs are carried by the big names acquiring stakes in smaller companies.

Regulatory Issues

There are regulatory issues that have to be sorted to mitigate the environmental impacts of shale gas production. New regulatory measures and disclosure requirements will have to be put in place not only with regard to water usage and chemical fracturing but also on air emissions. For instance, environmentalists in the USA have petitioned the Environmental Protection Agency (EPA) to regulate disclosure of chemicals used in the fracking process. The EPA is also in the process of drafting regulations for additional regulation of air emissions (KPMG Global Energy Institute, 2012). Thus, the global challenge revolves around designing and implementing a well-developed, stable regulatory regime for exploration and development of shale gas.

[7] 3 LEGS Resources (2011).

In sum, the future prospect of shale gas is not as unambiguous as many have painted it to be. While shale gas has the potential of complementing the existing energy sources, the high cost of extraction, coupled with the relatively low prices of gas, would make it unappealing for investors. The environmental risks associated with shale gas production are also colossal, thereby dwarfing whatever environmental benefits it may confer on the society.

Furthermore, in fossil fuel-producing countries, such as Saudi Arabia, the low price of conventional natural gas gives them a comparable advantage in the manufacturing of petrochemicals. A switch from natural gas to shale gas will make the feedstock for petrochemicals more expensive, thereby undermining the competitiveness of companies operating in the petrochemical sector. Excessive focus on shale gas is also likely to undermine Saudi Arabia's momentum on investments in clean technologies in the long run.

5.6.1.2 Renewable Energy

The renewable energy industry, consisting of solar, wind, geothermal, biomass, and fuel cell energy, has great potential for job creation as lessons of experience from the emerging countries illustrate. China, in particular, provides a classic example of policy-led growth in renewable energy that has created jobs, income, and revenue streams for nascent low carbon industries. The sector as a whole was estimated to have generated output worth US$ 17 billion and employed an estimated 1.5 million at the end of 2009, of which 600,000 were in the solar thermal industry, 266,000 in biomass generation, 55,000 in solar PVs, and 22,200 in wind power (Asplund 2008). So, which segment within the renewable energy business field holds the greatest promise in the future regionally and globally? We briefly review the future market potential of each of the renewable energy segments.

5.6.1.3 Solar Power

It is estimated that, if tapped properly, solar energy is sufficient to meet the energy needs of the earth's nearly seven billion inhabitants for 27 years (US National Renewable Energy Laboratory, cited in Asplund 2008). This is particularly useful for Saudi Arabia and other GCC countries with unlimited supplies of sunshine. The Middle East region receives 3,000–3,500 hours of sunshine per year, with more than 5.0 kg/W per square metre of solar energy per day. Egypt, Oman, Jordan, Saudi Arabia, and the UAE all have on average over 9.3 hours of sunshine each day (ESCWA 2011).

Solar energy has the potential to equip the Middle East with sufficient sustainable, clean electricity, but not all electricity production needs to be large scale though, so there are multiple opportunities for SMEs in the supply, fitting, and maintenance of small-scale solar-power electricity and heat-exchange devices. As technology for renewable energy develops, there are major opportunities for the GCC countries to use solar and other forms of renewable energy to offset their energy requirements, to export surpluses, and to stimulate SME development. Solar heaters are an obvious example of renewable energy business that could reduce the overwhelming dependence on oil.

Globally, it is estimated that by 2030 new power generation capacity of 4,700 G/W will be built at an estimated investment of about US$ 4 trillion investment. One third of this capacity will be built in the emerging economies of Asia (Asplund 2008). This means that there is a big opportunity for solar power to supply a significant portion of this new electricity-generating capacity, since it currently accounts for less than 0.1 % of global electricity production.

Types of Solar Power

There are two main approaches to solar energy production: thermal solar power and solar PV power. While thermal solar power uses the sun's energy to heat fluids, solar PV uses semiconductor materials to convert the sun's energy directly into an electrical current. Both have comparative advantages and disadvantages but one of the main strengths of the thermal solar power is that it is less expensive than solar PV. Even so, the costs of solar PV have declined quite considerably over the years and will continue to decline in the future as oil price continues to fall due to developments in unconventional oil, thereby enabling PVs to achieve cost parity. In fact, solar PV in the USA is already economically competitive in states where electricity is expensive, including Hawaii, MA, and New York, and states with good solar exposure and lots of land, like California, Nevada, and Arizona.

Solar thermal power

The solar thermal power consists of two main elements: solar hot water/heat and concentrating solar power (CSP). The first category uses the sun's rays to provide hot water to a building, to heat a building, or to heat a swimming pool whilst the second category (CSP) concentrates the sun's rays to create high-temperature water or other liquids which, in turn, run turbines to generate electricity.

The technology for the solar hot water/heat system is simple as it is made up of a series of thick panels containing water tubes or air baffles under a sheet of blackened, heat-absorbent materials. The panels are then positioned towards the sun so that they receive the maximum amount of the sun's rays. The water or air absorbs the heat and the heated water or air is then piped to where it is to be used. The solar hot water system can have an electric backup for use at night when the sun is not shining so that it can continue to provide hot water. According to the US Department of Energy (2003), the utility bill for consumers with solar water heaters is 50–80 % lower than for consumers who have traditional electric water heaters. China accounts for over 63 % of the installed world capacity of solar hot water systems, followed by Europe with nearly 13 %. Box 5.2 provides a success story of a solar thermal power programme in Tunisia.

Box 5.2: Solar water heating systems: the PROSOL programme in Tunisia

The Tunisian Programme solaire (PROSOL)—a joint initiative of the Tunisian Agence Nationale Pour la Conservation de L'energie (ANME), the state utility Société Tunisienne de l'Electricité et de Gaz (STEG), the United Nations Environment Programme and the Italian Ministry for the Environment, Land and Sea—provides an example of solar thermal market development.

Financial and fiscal support combines a capital grant qualifying for a value added task (VAT) exemption, customs duty reduction, and a bank loan with a reduced interest rate. Repayment of the loan is organized through the regular utility bill of the state electric utility STEG, with local banks receiving support that allows them to finance solar water heating (SWH) projects with reduced interest rates.

This arrangement has generated direct financial benefits for the end users, when comparing the size of the monthly instalments for a SWH system to the earlier electricity bills. A complementary interest rate subsidy was available during the first 2 years (2005–2006) of the programme, reducing the interest rate of the loan to 0 % to the final end user. This support was removed in 2007 and annual interest rates for loan repayment have been 6.5 %.

The government provides a subsidy of 20 % of the system cost or US$ 75 per square metre, while customers are expected to finance a minimum of 10 % of the purchase and installation costs.

Over 50,000 Tunisian families now get their hot water from the sun based on loans amounting to more than US$ 5 million in 2005 and US$ 7.8 million in 2006—a substantial leverage to PROSOL's initial cost of US$ 2.5 million. With installed surface of the programme reaching 400 000 m^2, the government has now set a more ambitious target of 750,000 m^2 for the period 2010–2014, a level comparable to much larger countries such as Spain or Italy. As of 2008, PROSOL helped avoid 214,000 tonnes of cumulative CO_2 emissions. Jobs have been created as 42 technology suppliers were officially registered and at least 1,000 companies installed the systems.

In conclusion, the experience in Tunisia demonstrates the potential returns on investing in renewable energy, creating new jobs, and reducing dependency on fuel imports.

Source: UNEP (2010)

In the case of concentrating solar power systems (CSPs), they use mirrors to concentrate solar energy by 50–10,000 times on the solar thermal panels, thereby creating fluid temperatures high enough to generate steam for turbines that, in turn, run electricity generators (Asplund, 2008). Three types of mirror configurations are in vogue: trough systems, dish/engine systems, and power towers. The trough technology is the most common CSP solar thermal system which uses long parabolic-shaped mirrors to concentrate the sun's rays on a tube that runs down the centre of the mirror. CSP is gaining momentum due to the comparatively low power generation costs and the large scale of electricity that can be generated in remote, desert-type locations. The World Bank is using its Solar Initiative to introduce CSP to developing countries using funding from the Global Environmental Facility.

Solar PV Power

As stated earlier, the solar PV system is relatively expensive but R&D has helped to reduce the historical costs by about 5% per annum and it is expected to be competitive in 50% of the developed world by the year 2020 (Asplund, 2008). Despite its cost disadvantages, solar PV system has several advantages, including the following (Asplund, 2008):

- It is carbon neutral and electricity generated from it satisfies government-imposed renewable energy mandates placed on power utilities around the world.
- It produces no waste by-products; equipment lasts 25–30 years on average with virtually no maintenance.
- It uses free fuel (sun) and generates electricity even on cloudy days.
- User-installed solar systems provide distributed electricity to the owner and protect the owner from grid problems such as blackouts, brown-outs, and electricity price hikes.

Home and commercial building installations constitute the main target market for solar PV power. The system power capacity for home installation ranges from 2 to 10 kWh, while for office buildings and schools it ranges from 10 to 100 kWh. The benefit for homeowners and businesses is that besides the upfront capital cost for the equipment, there are no additional charges for the electricity produced during the life of the solar power equipment (typically 25–30 years). In addition, the owner of the solar PV system is protected from electricity price hikes from the local utility company.

Solar power is particularly attractive in developing countries for electricity generation in remote areas as it requires no fuel and little maintenance. China is one of the countries in the world that actively uses the solar PV system for rural electrification. Box 5.3 illustrates the success story of potential returns on investment in solar energy in China and its ability to create new jobs and reduce dependency on energy imports. Solar power is also well suited for instrumentation devices in remote off-grid locations such as pipelines and bridges; remote water pumps; and transportation signalling devices where it is too expensive or even impossible to run power lines.

In spite of the growing importance of solar PV energy in emerging economies, growth in the solar industry over the past decade or so has been driven largely by Germany and Japan, which currently account for 55 and 17%, respectively, of global demand for new solar installations (Asplund, 2008). In both countries, growth in solar PV has been driven by aggressive government support programmes,

Box 5.3: Solar Power Success Story from China

Being the largest solar PV manufacturer in the world, China produced 45 % of global solar PV in 2009. The domestic solar market has started developing more recently, with about 160 MW solar PV installed and connected to grid in 2009. But with more than 12 GW of large projects in the pipeline, it could rapidly become a major market in Asia and the world. For solar PV, the government has also indicated that the target for installed capacity in 2020 could be increased from 1.8 to 20 GW.

China is now the world's largest market for solar hot water, with nearly two thirds of global capacity. More than 10 % of Chinese households rely on the sun to heat their water with more than 160 million square metres as total collector area. The rapid development of the solar water heater sector is due to its basic profitability for both business manufacturing the units and households that install them. There are also considerable health and sanitation benefits afforded by the improved availability of hot water, made more feasible and economic with solar water heater systems. Within the context of the Eleventh Five-Year Plan for New and Renewable Energy, an Implementation Plan on Promoting Solar Thermal Utilization in China was adopted in 2007. Under this national policy, the installation of SWH systems is given priority for major hot water consumers, such as hospitals, schools, restaurants, and swimming pools.

Source: UNEP (2010)

especially through a robust FIT policy. Germany, in particular, has offered a guaranteed FIT of 0.50 € per kilowatt-hour for 20 years for electricity fed into the utility grid. The FIT guaranteed price, however, falls by 5 % per annum for new projects to ensure that the solar power providers are receiving benefits only if solar equipment costs fall 5 % per year. In the case of Japan, it provided Roofs programme which offered a 50 % cash subsidy for 3–4 kilowatt grid-connected residential systems. Besides Germany and Japan, solar PV is now growing rapidly in other industrialised parts of the world especially many EU countries such as Spain, Italy, Greece, Portugal, France, and Belgium. The UK is now starting to play catch-up in the field of solar PV systems.

5.6.1.4 Wind Power

Wind energy is a renewable resource that is plentiful, clean, widely distributed, and does not produce greenhouse gas emissions during operation. Although the wind

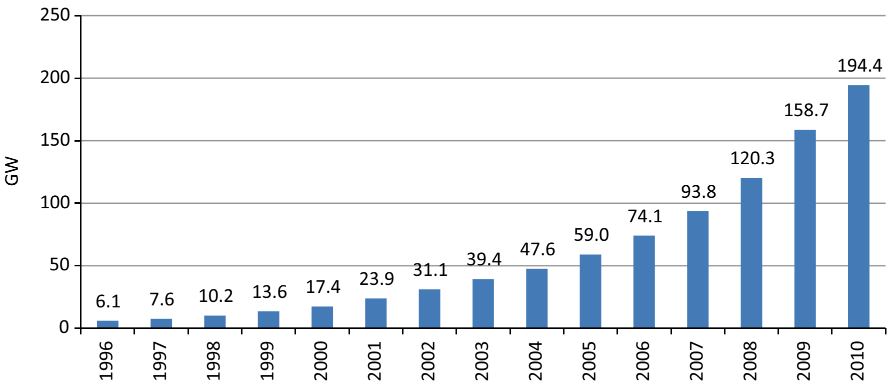


Fig. 5.9 Global wind power cumulative capacity. (Source: GWEC)

farms do not constitute pleasant scenery because of their visual impact, their effects on the environment are generally less problematic than those of any power sources.

In addition, wind power has negligible fuel costs but has a high capital cost consisting of sunk cost (cost of the turbine and transmission facilities and O&M expenditure). The useful life of the equipments can be at least 20 years, which is a good candidate for private–public partnership (PPP) schemes and for FIT arrangements. The global wind power capacity has increased dramatically over the past decade or so, reaching 194 gigawatts in 2010, from just 6 gigawatts in 1996 (Fig. 5.9).

The global wind turbine industry is worth US$ 23 billion growing at an average rate of 20 % per annum over the past decade. China tops the world table of wind power with installed capacity of 45 gigawatts, closely followed by the USA where wind power is the fastest growing electricity industry, with an annual growth rate of 27 % per annum. Wind power provides a significant part of electricity supply in some EU countries, such as Germany, Spain, Italy, France, and Denmark (Table 5.7).

Wind power requires a relatively high initial investment cost, but O&M costs are relatively low since no fuel is needed to be purchased to power the turbines. In essence, the financing costs for wind power projects are becoming comparable with those of fossil fuels (Table 5.8).

However, the global wind power industry still continues to depend heavily on government subsidies for uptake and growth. For instance, in the USA, the government provides wind operators with a 10-year production tax credit that is indexed to inflation and is currently set at around 2 cents per kWh. The government also provides them with a 5-year accelerated depreciation schedule for wind turbines, but the wind power industry is pushing for a longer term extension of the credit beyond 5 years (since the useful life of a wind turbine is normally 20 years) to give the industry some stability and prevent the stop–go government policies of the past (Asplund, 2008).

Box 5.4: Success Story of Wind Power in China

The additional generating capacity from wind power has exhibited an annual growth rate of more than 100 % from 2005 to 2009. With new installations of 13.8 GW coming on line in 2009, China led the world in added capacity and is second in terms of installed capacity, after the USA. To reflect increasing ambition in the industry, the government has indicated its intention to increase its previous target of 30 GW of installed capacity by 2020 –100 GW.

To directly encourage local wind turbine manufacturing, China has implemented policies to encourage joint ventures and technology transfers in large wind turbine technology and mandated the use of locally made wind turbines. The Ministry of Science and Technology has subsidized wind energy R&D expenditures at varied levels over time, beginning most notably in 1996 with the establishment of a renewable energy fund. Domestic wind turbine makers, such as Sinovel Wind, Goldwind Science and Technology, and Dongfang Electric, have contributed an increasing share of total new installations.

Together, they accounted for at least half of a market dominated by foreign firms until 2008. China's National Development and Reform Commission issued the Interim Management Measures for Renewable Power Tariff and Cost Allocation in 2006 and the Interim Measures on Renewable Power Surcharge Collection and Allocation in 2007. Together with the Renewable Energy Law, the regulations aim to encourage a reduction in the price of wind power by stipulating that a competitive pricing bidding model be used for the majority of wind power development in China.

Source: UNEP (2010)

In the EU countries, they have FITs to support wind farm operators with a guaranteed fixed price for electricity generated by wind power, thereby guaranteeing them a minimum return on investment and making it easier for the wind farm operators to have access to financing. Countries with popular FITs on wind power are Germany, Spain, Italy, and Denmark.

Outside the developed countries, China provides a classic example of an emerging country that provides government support for wind power operators. Initially, China started with FITs but later moved to a tendering or competitive bidding process. The importance of policy incentives for investment in the wind power sector in China is illustrated in Box 5.4.

Advantages of Wind Power

There are a number of advantages that can be had from wind power operations. These include the following (Asplund, 2008):

- Inexhaustible source of power with no pollution or greenhouse gas emissions, as the wind turbines run exclusively on wind which is a renewable source of energy.

Table 5.7 Wind power countries in the world (February 2011). (Source: Kahn (1995))

Country	Wind power capacity (MW)
China	44,733
USA	40,180
Germany	27,215
Spain	20,676
India	13,066
Italy	5,797
France	5,660
UK	5,204
Canada	4,008
Denmark	3,734

Table 5.8 Financing cost comparisons. (Source: Kahn (1995))

Technology	Debt/equity (%)	Debt cost	Equity cost	WACC	CRF
Wind	65/35	0.100	0.180	0.104	0.150
	50/50	0.100	0.180	0.122	0.163
Conventional fossil	80/20	0.095	0.120	0.072	0.111

CRF Capital Recovery Factor, *WACC* weighted average cost of capital

The wind turbines do not generate any pollution because they produce electricity via a purely mechanical process involving no chemicals or combustion.

- Low operation and maintenance costs as no fuels are needed.
- Wind farms can be located onshore or offshore. Most wind power is currently installed onshore as building offshore wind turbines is relatively expensive. Even so, a few wind turbines are installed at sea in Europe.
- Usability of surrounding land. Wind turbines are large, tall structures that need lots of space between one another and wind farms, therefore, occupy extensive geographical areas. However, the land between them can be used for other purposes such as farming or livestock grazing. Farmers can lease their lands to wind energy operators, thereby obtaining extra incomes.
- Job creation. It is estimated that every megawatt of installed wind capacity creates between 15 and 19 jobs directly or indirectly, and 60 person-years of employment (European Wind Energy Association).

In spite of these advantages, wind power suffers from a number of limitations, including the following:

- Intermittent power supply due to dependence of electricity on wind speed
- Wind turbines operate at less than full capacity as they depend on wind speed
- High installation costs
- Danger to wildlife
- Noise and visual nuisance to communities

5.6.1.5 Energy Efficiency

Renewable energy, such as solar and wind power, is a great idea and should be sought after by Saudi Arabia and other GCC countries, but it is currently among the more expensive options. Thus, in the absence of renewable energy, EE projects appear to be the most appealing options because they are cheaper, more proven, and easier to implement than solar power or wind energy. In addition, EE investments can reduce greenhouse gas emissions while at the same time saving money for the consumers. A former US Secretary for Energy, Samuel Bodman, once said: 'The cheapest and most available source of energy is the energy we waste' (U.S. Department of Energy, 2007). This quote could not be further from the truth as it summarises why efficiency and conservation should be the first place to look to solve our energy challenges.

The outlook for EE business or projects is bright, as the International Energy Agency (IEA) has estimated that investment in improved electricity generation, transmission, and distribution infrastructure to meet rising global electricity demand will be US$ 10 trillion during the period 2003–2033 (IEA, 2003). In essence, the effectiveness of EE investments is highlighted in a recent World Bank study (Box 5.5).

Thus, the huge financing gap for global electricity provision offers profitable investment opportunities in EE, while at the same time it provides the following benefits in the case of power efficiency (Asplund, 2008):

- Lower energy bills, greater customer control, and greater customer satisfaction
- Lower than supplying new generation from new power plants

Box 5.5: EE Investments Are Very Cost Effective

The cost effectiveness of EE investments can be seen from results of a World Bank survey of 455 EE investments implemented in 11 developed and developing countries. The results suggest that the cost per unit of energy saved (present value over lifetime of the investment of 10 years) is on average US$ 76 per toe or US$ 11 per barrel of oil (in year 2006 US dollars). This compares favourably with the prevailing market price of energy, for example, more than US$ 60 per barrel of oil (in 2006 US dollars). The survey reveals that more than 80 % of the projects surveyed recovered their investment costs through energy cost savings within 30 months. Even one of the least cost-effective types of EE investments from the sample, in buildings, has life-cycle costs (8.6 US cents per kWh over a 10-year lifetime) that are substantially below the costs that most final consumers have to pay for electricity. Not surprisingly, investments in countries such as India or China tend to be far more cost effective than in industrialised countries.

Source: World Bank (2008)

- Modular and quick to deploy, as opposed to building new power plants
- Environmental costs (savings in pollution and greenhouse gas emissions)
- Economic development
- Energy security

Besides power efficiency, there is a huge potential for EE business in other fields, such as efficient appliances, efficient lighting, and efficient buildings (green buildings). Home appliances, such as laundry and kitchen appliances, are a fertile area for power conservation as they account for a sizeable proportion of electricity usage. Thus, there is huge potential for improving appliance efficiency by manufacturing more energy-efficient appliances.

EE can also be gained in lighting, which is one of the objects that consume significant amount of electricity. A shift away from incandescent bulbs (highly inefficient source of light) to compact fluorescent bulbs and light emitting diode (LED) represents a step forward in terms of EE in lighting, but there is scope for improvements through investment in R&D in the lighting area. For example, the USA is encouraging R&D in this field through the so-called solid state lighting (SSL) programme, aimed at the development of energy-efficient solid-state lighting technologies.

Green Buildings

Green buildings provide another important mechanism for promoting EE. The term 'green building' may connote several definitions, but the most widely used definition encompasses the whole area of reducing the environmental footprint of buildings (Asplund, 2008). More specifically, the US EPA defines green building as the practice of creating healthier and more resource-efficient models of construction, renovation, operation, maintenance, and demolition.[8] In addition, the term also refers not only to the efficient use of electricity but also to the efficient use of cooling/heating, natural gas, and water. It also includes measures to reduce exposure of humans in buildings to toxic materials and fumes (Asplund, 2008).

The USA is a leading country in terms of green buildings, where the Green Building Council has established a widely accepted set of buildings standards known as *Leadership in Energy and Environmental Design* (LEED). Such standards provide architects and builders with a common set of tools to use for designing new buildings and renovating existing ones. Buildings that meet the LEED standards are designated as LEED certified.

EE approaches may differ between new and existing buildings, so a distinction must be made in addressing EE in the building sector. The World Bank (2008) has identified the following key components for ensuring EE in new buildings:

- Building design and orientation
- Ventilation and lighting system design

[8] US Environmental Protection Agency, 'Green Buildings', http://www.epa.gov/greenbuilding.

- Thermal integrity, including insulation and energy-efficient windows and doors
- Proper construction methods
- Efficient heating, cooling, and lighting equipment

These components are the responsibility of designers, developers, and construction companies, but public policy should seek to encourage them to implement energy-efficient choices. Thus, policymakers endeavour to introduce and implement mandatory EE codes for new buildings as well as to embark on public education and awareness campaign to end users that could lead to the uptake of EE investments in the building sector.

In the case of existing (old) buildings, however, the most profitable EE projects are those that relate to renovation of energy service systems in commercial and public buildings, including public health and education facilities and government offices. Such energy service systems include lighting; heat, ventilation, and air conditioning (HVAC); and water pumping. The World Bank (2008) argues that 'similar system replacement projects exist in residential buildings, but are often more difficult to package attractively'. Even so, the financial viability of major projects to improve the thermal integrity of buildings is highly site specific, and investment payback periods for such projects are often longer than for efficiency measures in new buildings.

EE in buildings versus other facilities

Promoting greater EE in the building sector may require different approaches than in other sectors such as industrial and transportation infrastructure. Table 5.9 provides a summary of the principal policy interventions required to improve EE with regard to new and existing facilities across economic subsectors, including the building sector.

It is apparently clear from the table that the EE policies for new structures in all sectors involve policy and planning as well as equipment-regulating standards while those pertaining to existing structures require direct energy-efficient investments. The World Bank (2008) has identified the following policy and regulatory tools to promote EE in new facilities:

- Strengthening attention to long-term EE issues as part of the planning process, especially in urban and transportation planning
- Implementation of mandatory EE codes and standards for key types of energy-consuming equipment, motor vehicles, and new buildings (especially buildings where heating is required)
- Facilitation of energy-efficient technology transfer, and adaptation and demonstration of key technological innovations in new plants in local markets
- Provision of information on the demonstrated performance and cost effectiveness of energy-efficient technologies
- Development of voluntary EE agreement schemes with industry and EE benchmarking programmes

Table 5.9 Energy efficiency interventions by economic sector. (Source: World Bank (2008))

Key sector	Subsector	Principal energy efficiency interventions
Industry	A. New plant	Policy and planning Equipment regulating standards
	B. Existing plant	
	1. Energy supply industries	Restructuring investment
	2. Industrial energy consumers	EE investment
Buildings	A. New buildings	Building codes and standards Policy and planning
	B. Existing buildings	EE investment
Transportation	A. Motor vehicles	Vehicle regulating standards
	B. Other	Policy and planning Restructuring investment

EE energy efficiency

- Provision of fiscal or direct incentives for implementation of new and innovative EE schemes
- Taxation of energy inputs (most governments are loathe to tax energy where trade competitiveness may be affected, but taxation of vehicle fuels is common)

However, in the case of existing facilities, including old buildings, substantial EE improvements can be achieved through investment in technological upgrading and renovation as well as improved operational management.

5.6.2 Water Utilities

Water utilities constitute another segment within the environmental resource business. Indeed, water scarcity is the most overarching problem in the GCC region. This provides unique opportunity for investors not only in water supply but also in wastewater treatment works as well as water storage and water harvesting technologies. In essence, water wastage poses a real challenge globally, as water withdrawal rate outstrips water consumption rate, and the gap between the two is estimated to continue for the foreseeable future (Fig. 5.10).

In the case of the GCC countries, the ratio of groundwater withdrawal to total renewable water resources is huge, ranging from 200 % in the case of Bahrain and Qatar to 1,000 % for Kuwait. Only Oman has a relatively low ratio (40 %) (Table 5.10).

Although the proportion of the GCC population with access to water is high, the coverage for potable water is low, thereby providing investment opportunities in this subsector of the water industry. The scarcity of conventional water, including both freshwater and renewable groundwater, in the GCC region has led to increased reliance on wastewater reclamation and desalination activities. As a result, the GCC region has become home to the largest water desalination activities in the world, accounting for 57 % of global water desalination schemes, estimated at around

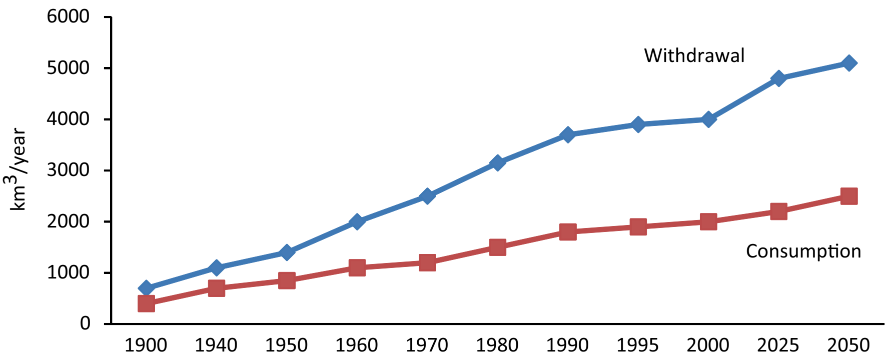


Fig. 5.10 Trends in total water withdrawal and consumption. (Source: UNEP (2011))

Table 5.10 Selected water indicators. (Source: Global Water Intelligence)

	Ratio of groundwater withdrawal to renewable resources (%)	Potable water coverage (%)	Treatment capacity (litre/person/day)	Total treatment ('000 m^3/day)
Bahrain	200	100	291	200
Kuwait	1,000	80	225	525
Oman	40	65	12	35
Qatar	200	70	145	125
Saudi Arabia	600	85	24	625
UAE	800	80	351	900

31 million cubic metres (Fig. 5.11). In terms of individual countries, Saudi Arabia is the world's leading desalination country, followed by the USA, UAE, Spain, and Kuwait, while Qatar, Bahrain, and Oman ranked 8th, 12th, and 18th in the world. In fact, the average annual increase of demand for desalinated water in the Middle East and North Africa (MENA) region, at 6% per annum, doubles the 3% global average. Around 40% of the increased demand for desalinated water in the MENA region is on account of industrial and municipal sectors.

With the largest desalination capacity in the world, the GCC region has a significant role to play in the global water industry. But this requires investment in appropriate water technologies to enhance the competitiveness of local water operators. The success story of existing world water barons lies in tapping their local markets first before embarking on international expansion. Thus, the region should aim at becoming the global leader in water technology through investment in R&D. Such a move would help to broaden and differentiate GCC water operators and, thereby, enable them to enhance their local and global competitiveness.

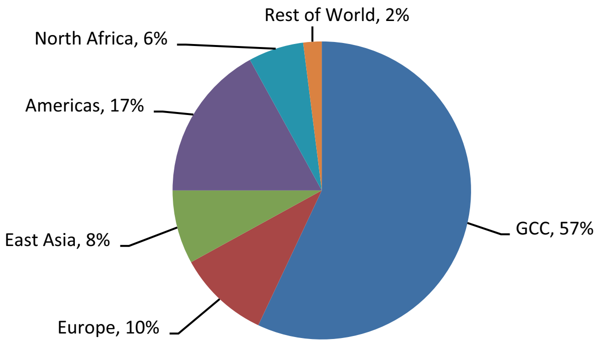


Fig. 5.11 Global desalination capacity (31 million m^3/day). (Source: Global Water Intelligence)

5.7 Opportunities in the Environmental Services Segment

Within the environmental services business segment, two business channels hold significant promise for growth: solid waste management and wastewater treatment works (Fig. 5.12). Waste management is a very important environmental and health issue for all countries in the GCC and other MENA regions due to the high proportion of organic materials in the solid waste stream. This, undoubtedly, provides huge business opportunities for recycling activities.

5.7.1 Waste Management

Available statistics show that the GCC region generated 80 million tonnes of waste in 2009. Of this, 53 % is construction and demolition waste, 33 % is municipal solid waste, and 14 % is industrial waste (Fig. 5.13). Saudi Arabia alone accounted for 64 % of the municipal solid waste in the region, followed by the UAE (19 %), and Kuwait (5 %), while Bahrain, Oman, and Qatar each accounts for 4 %.

During the last decade, GCC countries have made tremendous progress towards addressing their solid waste management problems from several angles: policy, legal, institutional, operational, and financial levels. At the policy level, many countries already have put in place strategies and national programmes for managing municipal solid waste, even though a lot more needs to be done. Legalistically, there are still flaws in environmental legislation, which is beset by legal inconsistencies and missing rules and regulations, making this an uncertain area for private investors, especially SMEs, to invest in. At the operational level, however, there is a marked improvement in the level of cleanliness of most major cities, resulting from better collection and street sweeping. However, despite efforts to establish sanitary landfills, municipal waste in some countries is generally being disposed of at open dumps, a practice that has major environmental and health implications. Finally, at the financial level, governments in the region remain the major financiers of

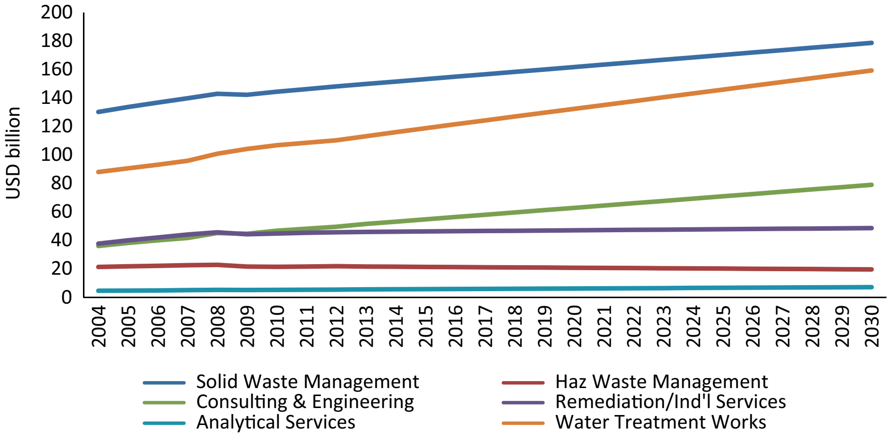
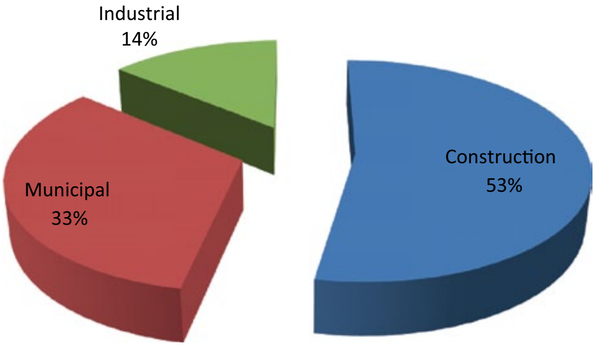


Fig. 5.12 Global environmental services market forecast. (Source: EBI (2011))

Fig. 5.13 Composition of waste in the Gulf Cooperation Council (GCC) region, 2009. (Source: http://arabia.msn.com/Business/News/GF/KSA/2011/April/4460861.aspx)



municipal waste sector, but private sector could easily be attracted if appropriate incentives are guaranteed.

The issue of hazardous industrial and medical wastes has not received adequate policy attention. This is an area that deserves urgent action due to the growing volumes of hazardous waste which occur mostly in urban and suburban areas where the population is concentrated and where water and land resources are scarce. There are opportunities for private sector intervention here, as has been illustrated by Jordan's recent privatization of disposal of medical waste.

The Economic and Social Commission for Western Asia (ESCWA) (2011) has argued that the essential actions for moving towards sustainability will involve multiple investors to develop communications strategies and piloting community interaction in specific cities; complete and update municipal waste management plans; develop missing policies, laws, and regulations; and design a solid waste management information system.

Opportunities may also exist in the following waste management services:

- Site management and cost recovery
- Specialized services, such as industrial or medical waste servicing
- Financing investment priorities for expanding waste management coverage
- Establishing waste facilities that are affordable and technologically proven, rehabilitating old dumps, and collecting and disposing of hazardous health-care waste
- Recycling and biodegradable plastics activities

The GCC waste management services industry has grown into a multibillion dollar venture, with governments in the region infusing substantial investments into it. With the escalating awareness about sustainable environmental business practices, Saudi Arabia and other GCC countries are resorting to advanced waste management solutions for treating both domestic and industrial waste. With the rapid urbanisation and industrialisation, coupled with high population and economic growth rates and evolving consumption patterns in the region, the demand for waste management services in the region is expected to soar. This would generate higher volumes of waste, which will increase the demand for waste management facilities in the region (Sullivan and Frost 2010).

Of course, GCC countries have a penchant for state-of-the-art waste management solutions for recycling, composting, and even waste-to-energy. This eagerness to adopt green practices has already attracted a number of domestic and international companies to the sector. And the sheer scale of construction activities in the GCC countries could create substantial prospects for the waste management companies that can offer effective disposal, transportation, and recycling services for construction and demolition waste.

5.7.2 Recycling Waste Energy

The recycling of industrial waste energy, especially in the largely untapped area of combined heat and power (CHP), provides yet another fertile area for environmental investment in Saudi Arabia and other GCC countries. Four types of job opportunities are associated with energy recycling (Lowe and Gereffi, 2009):

- Jobs in manufacturing the waste energy recovery equipment
- Jobs in creating the 'energy islands' where industrial hosts' waste energy is recycled into power
- Jobs in operating and maintaining the on-site energy islands
- Jobs resulting from higher energy productivity and increased competitiveness

Recycling industrial waste energy offers considerable potential to save energy, increase productivity, reduce greenhouse gases, and create jobs. Recently, the US government has provided crucial support for the development of CHP, including waste energy recycling. Such an incentive provides unique opportunities for ex-

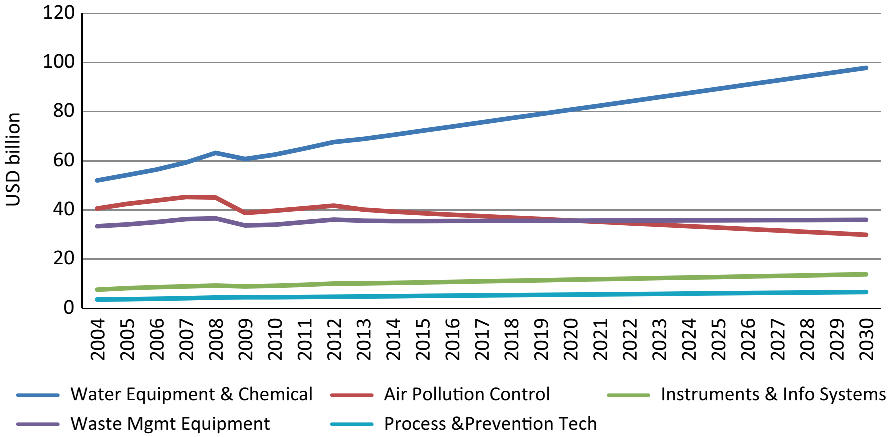


Fig. 5.14 Global environmental equipment market forecast. (Source: Environmental Business International; Gulf One)

panding industrial waste energy recycling activities. Saudi Arabia and other GCC countries should borrow a leaf from the US experience.

5.8 Opportunities in the Environmental Equipment Segment

Environment equipment constitutes the third segment of the environmental technology business channels. Within this particular business category, the market for water equipment and chemicals appears to have the greatest potential for long-term growth as Fig. 5.14 illustrates.

5.8.1 Water and Wastewater Treatment Equipment

The importance of clean water and effective treatment of wastewater to sustainable development cannot be over emphasised. As a result, governments and organizations around the world are investing substantial amounts of money in water and wastewater improvements, creating ample opportunities for water and wastewater treatment equipment technology. This includes treatment facilities at the municipal and industrial levels, water sampling, water testing and analysis equipment services, manufacture and sale of equipment, and services related to the testing and treatment of water through chlorination, ozone, and ultraviolet (UV) systems.

According to the World Health Organization, it is estimated that only 21 % of wastewater in developing countries is treated. The principal constraints to the de-

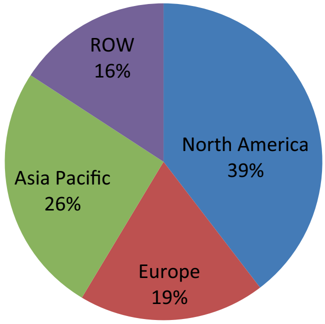


Fig. 5.15 Global water recycling market by region (% of revenues, 2008). (Source: Frost & Sullivan (2008))

velopment of the water supply and sanitation sector in these countries include inadequate funding, inadequate cost recovery, and inadequate operation and maintenance. Thus, the global market for water and wastewater treatment equipment is expected to grow tremendously due to the rising water requirements associated with industrialisation, demographic dynamics, including rapid rate of urbanisation, strict laws, and stringent discharge limits, and increased awareness about the benefits of water recycling. These factors can be ranked in order of importance as follows (Frost & Sullivan, 2009):

- Strict wastewater discharge limits driving the market.
- Increasing water scarcity and growing population.
- Inability of Publicly Owned Treatment Works (POTWs) to treat industrial wastewater is encouraging industries to take up water recycling.
- Upgrading of municipal facilities.
- Corporate social responsibility and economic benefits associated driving industries to take up water recycling.

The major end users of the water-recycling equipment market are municipal and industrial facilities. Stringent wastewater discharge limits or requirements could boost market sales as much as upgrading and building of municipal facilities. Similarly, sales could also be bolstered by filters used as a complementary technology.

Nearly 40 % of the global water and wastewater treatment is in North America, followed by Asia Pacific (26 %), and Europe (19 %), as Fig. 5.15 illustrates.

There are several technologies used in the water recycling treatment equipment but the most popular one is the membrane system, which accounted for 69 % of the total world water recycling equipment market in 2008, and is predicted to account for nearly three-quarters by 2015 (Table 5.11).

The high growth of the membrane technology can be attributed to the high quality of water that is produced by this system. The membrane bioreactor (MBR) technology is in a high growth phase due to its exceptional performance and ability to combine the two stages of filtration and biological treatment into a single process. The major market drivers are (Frost & Sullivan, 2009): high quality of effluent produced by membrane systems; growing popularity of MBRs boosts sales; membranes used as pretreatment for systems using reverse osmosis (RO) aiding growth;

Table 5.11 Global water recycling treatment equipment market by technology (% of revenues). (Source: Frost & Sullivan (2009))

	Activate carbon	Media filtration system	Membrane system	Zero liquid discharge system
2005	7.8	15	61.7	15.5
2006	7.6	14.8	62.2	15.4
2007	7.4	14.5	62.9	15.2
2008	7.2	14.2	63.7	14.9
2009	6.9	13.7	65	14.4
2010	6.6	13.3	66.2	13.9
2011	6.3	12.8	67.6	13.3
2012	6	12.3	68.9	12.8
2013	5.7	11.8	70.2	12.3
2014	5.4	11.3	71.5	11.8
2015	5.1	10.8	72.7	11.4

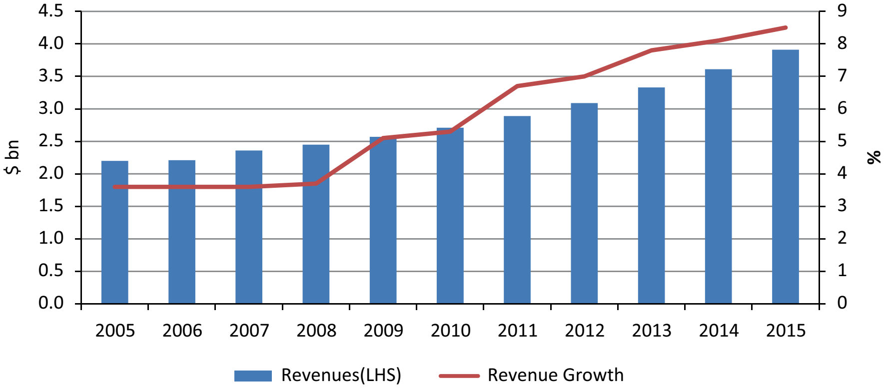


Fig. 5.16 Global water recycling equipment (revenue forecasts). (Source: Frost & Sullivan (2009))

growing green awareness among various sections of the society; and relative ease of maintenance of membrane systems aiding growth.

Going forward, the water recycling equipment market by revenue is forecast to grow from around US$ 2.5 billion now to around US$ 4.0 billion by 2015, with estimated annual growth rate of around 8.5 % (Fig. 5.16).

5.9 Conclusion

Based on the foregoing analyses, it is apparent that the business channels in the environmental resources technology have the potential to yield the most profitable investment outcomes. These business channels include EE, renewable energy, and water utilities. It is noteworthy that investment in EE provides the most practical, easiest, and profitable form of business for addressing environmental challenges in the short run. In the long run, however, this could be complemented by investment in water, solar energy, wind power, smart power generation, and other forms of renewable energy business activities.

Although investments in environmental resources are more appealing in terms of growth prospects and profitability, other environmental business channels, especially in environmental services, also offer profitable business opportunities. On top of the list in the environmental services segment are wastewater treatment, solid waste management, and recycling business channels.

The findings from the analyses in this chapter are broadly in line with the results from a recent survey conducted by the United Nations (UN) ESCWA (ESCWA, 2011) on business and opinion leaders in West Asia, including the GCC region. In this survey, respondents were asked to rank the various environmental business segments (resources, services, and equipment) in terms of their importance in addressing environmental challenges, having substantial export potential, and providing regional leadership in promoting environmental technology business. The following environmental technology business channels were ranked as the most important for countries in the region, including the Gulf States: water supply and wastewater treatment; solar and wind power; natural resource-based enhanced geothermal system (EGS); green building technology and green transport; waste management, recovery and recycling; and green agricultural products.

With the exception of green agricultural products, all these environmental business channels, largely dominated by resources and services, are in line with the findings and analyses in this chapter, and should form the nucleus of future environmental technology businesses in Saudi Arabia and other GCC countries.

Chapter 6
The Way Forward

6.1 Overview

Environmental concerns pose a serious threat to sustainable development in both developing and developed countries. But the environmental challenges facing the oil-rich economies of the Gulf are especially dire because of their excessive dependence on conventional energy sources to power electricity, transportation systems and water desalination activities. Decades of domestic oil subsidies have encouraged inefficient production and consumption of conventional energy, thereby contributing to high and rising pollution and environmental degradation with significant social and economic consequences. At the same time, more than 90 % of government revenue comes from oil, which is currently the major source of financing development programmes, which cannot be sustained due to the exhaustible nature of oil as well as its increased usage in domestic consumption. Even so, increased reliance on oil has lulled policy makers into a false sense of complacency, with little or no efforts being made to diversify the economy away from hydrocarbon and towards manufacturing and services. Equally, these economies are yet to pursue a more balanced approach to energy policy.

Saudi Arabia, in particular, has all the ingredients for developing substantial comparative advantages in clean technologies. The Kingdom is awash with abundance of sunshine suitable for solar power generation; it has huge wind resources appropriate for generating wind energy; and it has the largest desalination operations in the world without owning the desalination technology. The Kingdom's current financial reserves and sovereign wealth funds could be heavily invested, in addition to attracting top intelligent funds towards investing in the green business sector in Saudi Arabia. Thus, the abundance of oil resources in the Kingdom could provide it the wherewithal to acquire appropriate environmental technologies to achieve both social and business objectives. Yet, Saudi Arabia and the wider Gulf Cooperation Council (GCC) region lag behind the rest of the world in terms of clean technology projects, including renewable energy and energy efficiencies. The world is at a crossroads where 'the demand for new and cleaner forms of energy comes not only from environmental considerations, but also from the sheer amount

N. Taher, B. Hajjar, *Energy and Environment in Saudi Arabia: Concerns and Opportunities,*
DOI 10.1007/978-3-319-02982-5_6,

of new energy generation that will be needed to satisfy the world's fast-growing energy needs' (Asplund, 2008). Demographic dynamics, fossil fuel negatives and the existence of peak oil will continue to put untold pressures on conventional energy, such that future generations will be deprived of the benefits from these resources, and government revenues from hydrocarbons will be put at great risks as domestic demand for these resources outweighs foreign demand. The mismatch between demand and supply will also drive up prices of conventional energy, thereby creating additional pressures on domestic prices through imported inflation pass-through.

As discussed in the preceding chapter, the global clean energy industry is expected to experience a double-digit growth between now and the next two decades to reach 800 million tonnes of oil equivalent by the year 2030 (EIA, 2012). Such a phenomenal growth is to be largely driven by strong and expanding government support programmes worldwide and by declining costs of clean energy due to improved technology. In essence, even if government support for renewable energy fizzles out in the future, most of the renewable energy sectors are expected to become competitive with conventional fuels. Within the renewable energy sector, solar energy will be the rising star, as solar photovoltaic power, for instance, is already competitive with retail electricity in places like Japan and is expected to become competitive in many countries around the world in the near future. Indeed, analysts have forecasted that pre-tax returns for solar energy business are expected to remain strong in the region of 33–38 % during the next couple of decades (Asplund 2008). This robust outlook for solar energy business presents Saudi Arabia with ample opportunities to acquire and develop solar energy capabilities since it has all the ingredients (abundant sunrays) for developing a profitable solar energy business. After all, investment in solar energy is increasing rapidly in emerging economies as well as in developed countries, as there is more desire on the part of the industrialized world to get rid of the existing nuclear energy plants following the Japanese earthquake in March 2011, which destroyed its nuclear plants and unleashed catastrophic consequences. Thus, Saudi Arabia should pursue its policies based on its competitive advantages in alternative and renewable energy resources, rather than on nuclear energy.

This chapter discusses the way forward for Saudi Arabia towards a green economy in light of the outlook for global economy, demand for conventional and unconventional oil, developments in renewable energy sources and demographic dynamics. The aim is to produce a sustainable energy roadmap that explicitly identifies a pathway for Saudi Arabia to achieve its full potential for optimal energy mix through the acquisition and development of capabilities in clean energy technologies and environmental businesses. Section 6.2 looks at the global and regional economic outlook for the next three decades with implications for Saudi Arabia. Section 6.3 discusses the outlook for energy demand for the same time period with implications for investment and policy. Section 6.4 provides appropriate options for promoting clean technology business in Saudi Arabia. Section 6.5 concludes the chapter.

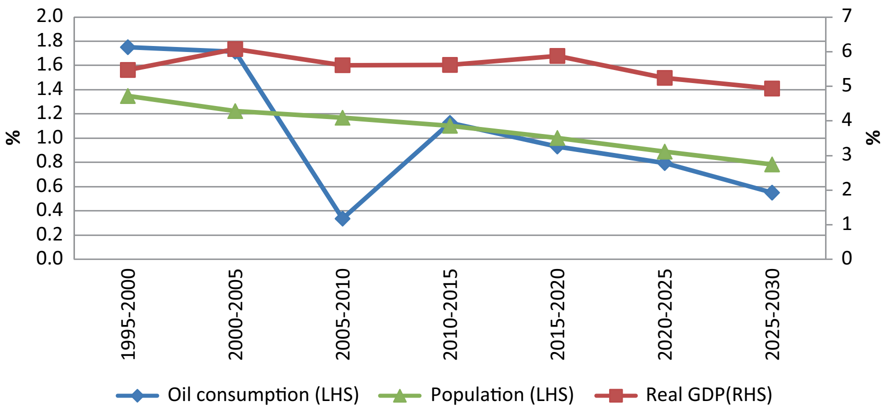


Fig. 6.1 Growth rates of world gross domestic product (GDP), oil consumption and population. (Source: IMF (2012); UN (2011))

6.2 Global and Regional Economic Growth Outlook

Global population and income will continue to remain the key drivers of global energy demand, hence the need to analyse the outlook of these important indicators. Over the past 20 years, the global population has increased by 1.6 billion people, but the growth rate is slowing down. It is projected that the world population will grow by another 1.4 billion over the next 20 years, equivalent to an annual growth rate of 0.9 %, and could even reach 9.3 billion by 2050 (UN 2012).

Although population growth is trending down, income growth is trending up as the world's real income is projected to double between 2010 and 2030. Other studies have suggested that world output will treble due to anticipated growth acceleration in emerging economies. For instance, by 2050, economic output in the emerging world will have increased fivefold and will be larger than that in the developed world. It is anticipated that by that time, China and India will be the largest and third largest economies in the world.[1] As a result, and as will be discussed later, energy consumption per capita in 2030 is likely to grow at a sizeable rate, but energy intensity (i.e. energy per unit of gross domestic product (GDP)) will continue to improve globally and grow at an accelerating rate. Most of the growth both in income and in population is predicted to be coming from the emerging economies of Brazil, Russia, Indonesia, China and South Africa (BRICS).

The connection between growth rates of world GDP, population and oil consumption can be vividly seen from Fig. 6.1. With few exceptions, the growth of GDP appears to be the main driver of growth in oil consumption.

[1] HSBC (2011), The World in 2050: Quantifying the Shift in the Global Economy. HSBC Global Research. January.

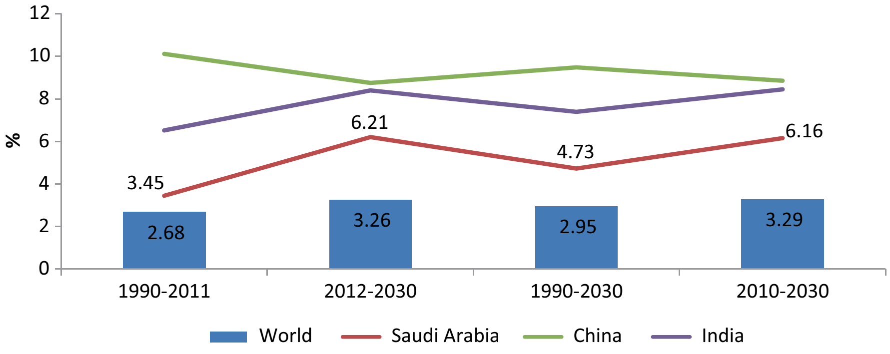


Fig. 6.2 Growth rates of real gross domestic product (GDP). (Source: IMF (2012))

Barring serious global financial crisis, the long-term economic growth outlook for the global economy is expected to be much brighter than the observed growth in the preceding two decades, as the world economy is projected to expand at an annual average rate of 3.3 % during the period 2012–2030 compared with the 2.7 % recorded in the past 20 years (Fig. 6.2). China and India will be the key drivers of global growth over the next two to three decades, and with their insatiable demand for energy to achieve their ambitious industrialization targets, both countries will see huge increases in their national incomes, which will put them at the helm of the global GDP league table.

Economic growth in the Saudi Arabia over the next two decades will be well above the global average of 3.26% and nearly double its own historical growth record for the past 20 years. This will have significant growth for energy demand in the Kingdom, as domestic oil consumption currently accounts for nearly 25 % of total oil production of more than 11 million barrels per day (mbpd). Recent study by Citibank (2012) shows that oil and its derivatives account for approximately 50 % of Saudi Arabia's electricity production, with more than half of it being used for residential purposes, and that peak power demand is growing by around 8 % per annum. Thus, given the rapidly rising incomes, coupled with the fact that Saudi Arabia has one of the fastest population growth rates in the world and its per capita energy consumption exceeds that of the most advanced countries, it is likely that Saudi Arabia may have little oil to export by 2030 if no actions are taken during this period, as the bulk of it will go towards satisfying domestic consumption. Figure 6.3 clearly shows the close correlation between changes in income and changes in domestic oil consumption in Saudi Arabia.

This calls for a more proactive policy that takes a balanced approach to energy mix, including fossil fuel and clean energy in addition to energy efficiency initiatives. Such a policy will not only compensate for the increased domestic demand for oil but also elongate the lifespan of the existing fossil fuel while at the same time enabling the Kingdom to gain comparative advantage in clean energy technologies.

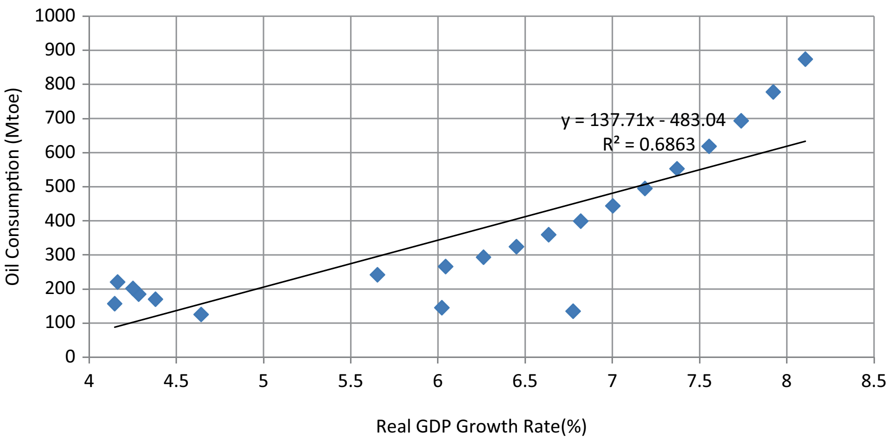


Fig. 6.3 Real gross domestic product (GDP) growth rate vs domestic oil consumption in Saudi Arabia. (Source: IMF (2012); BP (2012))

6.3 Global Energy Demand Forecasts

As discussed earlier, global energy demand is heavily dependent on demographic dynamics and changes in incomes. These factors, along with the exhaustible nature of fossil fuel, will drive a wedge between energy production and consumption. World primary energy consumption is projected to grow by 1.6 % per annum during the period 2010–2030, adding 39 % to global consumption by 2030. Even so, the growth rate of energy consumption has decelerated over the past couple of decades and will continue to decline in the future. For instance, during the past decade global energy consumption grew by 2.5 % per annum. However, it is expected to grow by 2 % per annum over the next decade and by 1.3 % per annum between 2020 and 2030.[2] As a result, starting from 2025, total global energy production will lag behind global energy consumption by around 15 mtoe, and this figure will nearly double by the year 2030 (Fig. 6.4).

The mismatch between energy production and consumption will be largely caused by oil, which has already past its peak, but ongoing geopolitics will have a disruptive effect on supply. As Fig. 6.5 shows, global demand for oil had for long exceeded production, but the excess demand had amplified over the years and is projected to reach 208 mtoe by 2030.

Similarly, coal will also experience acute shortages despite the fact that there will also be a gradual shift away from it in favour of gas and non-fossil fuel as Fig. 6.6 suggests.

In essence, the emerging and developing economies (non-OECD countries) will be the main drivers of growth of energy consumption as the fuel mix gradually

[2] According to BP's 2012 World Energy Outlook 2030 based on a background paper prepared by Ruhl et al. (2012).

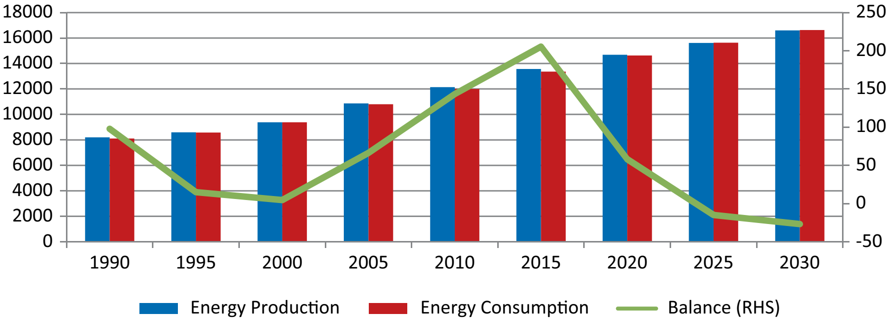


Fig. 6.4 Global energy production and consumption (mtoe). (Source: Ruhl et al. (2012); BP (2012))

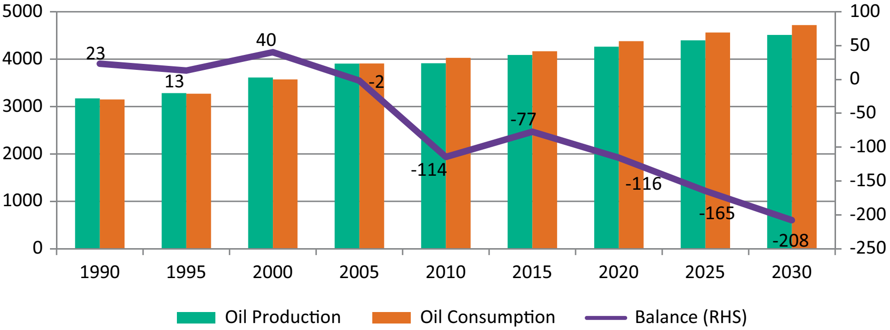


Fig. 6.5 Global oil production and consumption (mtoe). (Source: BP (2012))

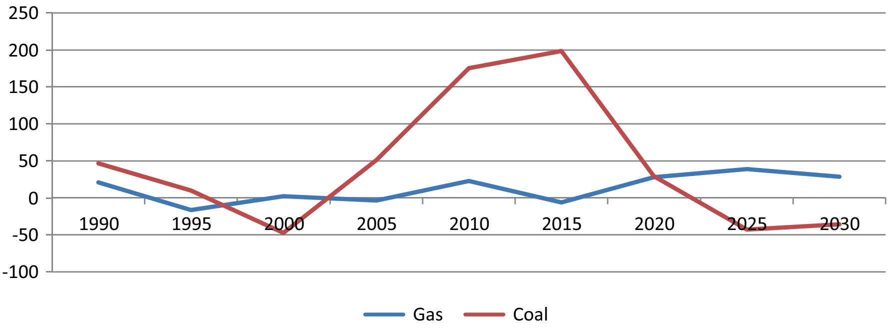


Fig. 6.6 Excess demand for gas and coal (mtoe). (Source: BP (2012))

shifts away from oil and coal in favour of gas and non-fossil fuel (Fig. 6.7). By 2030, it is projected that the energy consumption of the non-OECD countries will be nearly 70 % above the 2010 level, with the growth averaging 2.7 % annually (or 1.6 % per annum on a per capita basis). In terms of absolute consumption levels, the emerging economies outside the Organisation for Economic Cooperation and

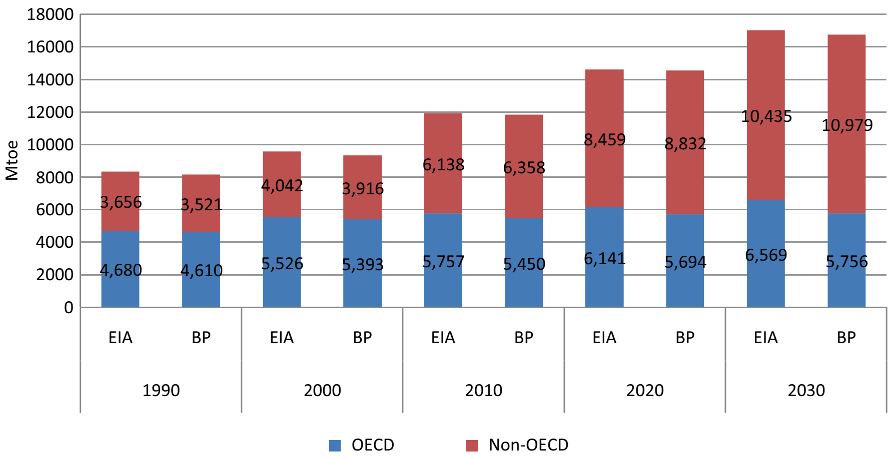


Fig. 6.7 Total global energy consumption by region. (Source: EIA (2012); BP (2012))

Development (OECD) area will account for 65 % of world energy consumption by the year 2030, compared with 54 % in 2010 (EIA, 2012; BP, 2012).[3]

In contrast, the energy consumption of the OECD countries (developed nations) in 2030 is projected to be only 4 % higher than in 2010, with the growth averaging 0.2 % per annum in 2030. OECD energy consumption per capita, however, is expected to continue its declining trend, at −0.2 % per annum during the period 2010–2030.[4]

It is noteworthy that despite the gradual shifts in energy mix over the coming decades, fossil fuel will still remain the most dominant type of energy. In particular, oil and coal will account for the bulk of energy consumption although the demand for non-conventional fuel will continue to increase (Fig. 6.8). Within the fossil fuel, the largest single fuel contribution to the projected growth in global energy will come from gas, which is expected to account for 31 % of the forecast growth in global energy. Overall, gas is projected to grow by 2.1 % per annum from 2010 to 2030, whilst oil will grow at the slowest pace of 0.7 % per annum.[5]

However, non-fossil fuels will experience the fastest growth due to the determined efforts of the developed countries to substitute oil with alternative sources

[3] There are a number of authoritative bodies that engage in periodic updates of global energy outlook, including the Paris-based International Energy Agency (IEA), the US Energy Information Administration (EIA), the Vienna-based Organization for Petroleum Exporting Countries (OPEC) and the UK-based British Petroleum (BP). Although estimates provided by these agencies slightly differ from time to time due to differences in assumptions used in forecasting models, the BP's 2030 world energy outlook has benefitted from a highly acclaimed background paper whose model does not simply rely on trend extrapolation and is not constrained by any given policy scenario (Ruhl et al., 2012).

[4] Calculated from information in Fig. 6.7.

[5] Derived from data in Fig. 6.8.

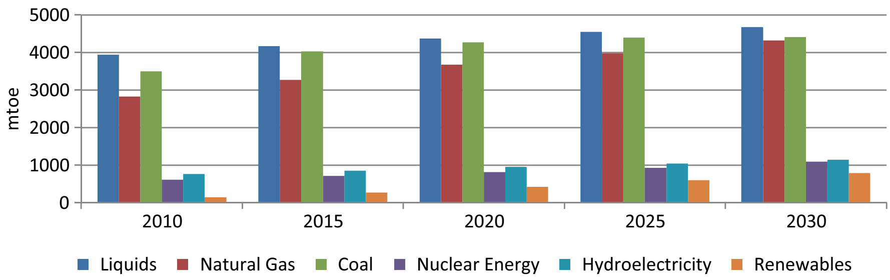


Fig. 6.8 Global energy consumption by type of fuel. (Source: BP (2012))

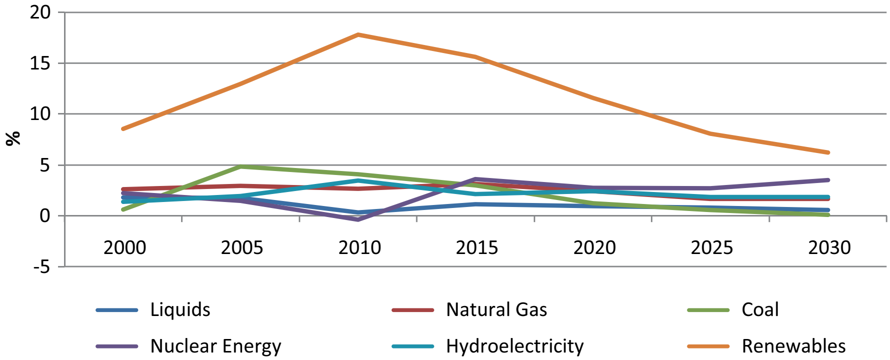


Fig. 6.9 Average annual growth rates of energy consumption by type. (Source: Ruhl et al. (2012))

of energy. In particular, renewable energy will be the fastest growing fuel, which is expected to increase by an average annual growth rate of 8.2 % over the period 2010–2030 (Fig. 6.9).

It is projected that non-fossil fuel as a whole (renewable energy, nuclear and hydro) will account for 34 % of the global growth in energy consumption, and, for the first time, this aggregate non-fossil contribution is larger than the contribution of any single fossil fuel. This is not surprising because fuel substitution is the overarching objective in the developed countries as they gradually explore alternative sources of energy to reduce dependence on fossil fuel from the oil-producing countries, especially from the Middle East. In particular, renewable energy will substitute oil in transport and coal in power generation in the OECD countries, while gas is likely to gain at the expense of coal in power generation. These shifts are driven by a combination of the relatively high fuel prices, technological innovation and policy interventions.

In contrast, the emerging and developing countries will continue to see all types of fuels expanding. The economic development programmes of these countries will continue to create an appetite for energy that can only be met by expanding all fuels. In fact, for many developing countries, securing affordable energy, regardless of its source, to underpin economic development is the imperative goal.

6.3.1 Sectoral Assessment

The growth of energy consumption by sector is dominated by power generation, transportation and industry and will continue to be dominated by these sectors for the coming decades. Energy used to generate electricity remains the fastest growing sector, accounting for 57 % of the projected growth in primary energy consumption in 2030 compared to 54 % for 1990–2010.[6] Indeed, the power sector is also the main driver of diversification of the fuel mix, with non-fossil fuels, led by renewable energy, accounting for more than half of the growth. It is projected that world electricity demand is to grow more rapidly, at around 2.6 % per annum, than total energy over the next 20 years. Thus, efficiency gains in power generation mean that the fuel inputs are likely to grow less rapidly than power output, averaging 2.1 % per annum over the period 2010–2030.[7] This means that even under the assumption of zero growth in oil demand globally, the Kingdom of Saudi Arabia still has to work hard to develop alternative energy resources internally to lessen oil consumption for local usage in electricity, water and transportation.

Coal is likely to remain the largest contributor to the growth of power fuels, accounting for 39 %, but non-fossil fuels are rapidly catching up. It is expected that, in aggregate, non-fossils such as nuclear, hydro and other renewables will contribute as much as coal. It is estimated that, by 2030, renewables will supply 11 % of the world electricity. The European Union (EU) leads the way, with 26 % of power coming from renewables by 2030, followed by the rest of the OECD with a lag, and then the developing countries increasing the share of renewables in power consumption. Thus, the growing role of non-fossil fuels becomes even clearer in the following decade to 2030, with 75 % of the growth coming from these sources and very little from coal. Thus, the rate at which renewables penetrate global energy markets bears remarkable similarity to the emergence of nuclear power in the 1970s and 1980s.

Industry leads the growth of final energy consumption, particularly in rapidly developing economies, accounting for 60 % of the projected growth of global final energy demand in 2030. The non-OECD nations are expected to account for around 6.5 mbpd of oil demand growth in industry, largely for petrochemicals.[8]

The transport sector is expected to exhibit the slowest growth in demand for energy, with the demand from the OECD bloc projected to decline due to energy diversification measures. Such measures are largely driven by policy which is facilitated by technological progress and innovation, and energy efficiency developments. In essence, biofuels are projected to account for 23 % of transport energy demand growth, while gas and electricity will account for 13 and 2 %, respectively, of the transport energy demand growth.[9] However, environmentalists are sceptical

[6] Based on data obtained from both the EIA (2012) and BP (2012).

[7] Ibid.

[8] Derived from data contained in BP's 2012 World Energy Outlook for 2030.

[9] Ibid.

about biofuels due to its dependence on burning food for energy, and, more importantly, scarcity of food is a major concern for the whole globe.

Therefore, much of the growth in liquid (especially oil) demand in the transport sector over the next two decades is expected to come from non-OECD countries which are projected to account for 14 mbpd. In the case of the OECD countries, declines in oil consumption will be initially concentrated outside the transport sector where gas and renewables could easily displace oil. Beyond 2015, however, improved engine efficiency is likely to play a key role in the fall in demand for oil in the transport sector of OECD countries. Renewables face a tougher challenge penetrating the transport fuel market, as only 7 % of world transport fuels will come from renewable sources by 2030 (BP 2012).

6.4 Options for Promoting Clean Technology Business

From the foregoing analysis, it is apparent that the global economy will undergo significant changes over the coming decades which will undoubtedly affect the interfaces between the environment, demography, wealth of nations and energy mix. These changes will undoubtedly present potential opportunities and threats to all countries as they will have both policy and investment implications. Saudi Arabia is not an exception, so the Kingdom's ability to sustain long-term economic growth and prosperity would crucially depend on its willingness and ability to formulate and implement appropriate energy-mix policies, including clean energy technologies that will enable it to take full advantage of the opportunities and minimise the risks associated with global shifts. Thus, going forward, actions need to be taken by both the government and the private sector.

The government should formulate a robust policy framework that should go beyond the 'business-as-usual' mantra; rather, it should be far-reaching, all-encompassing and far-sighted in nature, including adequate incentives towards addressing industrialization and environmental challenges. The private sector must also partake in national policy issues by lending support to government policy initiatives and scaling up investments in clean energy technologies. In other words, a strong public–private partnership (PPP) in all aspects of energy issues (policy, financing and social responsibility) should be encouraged and pursued. We enumerate a number of action points that should be undertaken by both parties and conclude with lessons of experience from around the world.

6.4.1 Government Policy Actions

Saudi Arabia and many emerging and developing economies do face a number of challenges that are impeding the promotion of environmental businesses. These include lack of a coherent medium- to long-term government plan targets and incentives, which combine to diminish the bankability of environmental investments;

fragmented, short-term and overly prescriptive approaches to public sector procurement which prevent longer term signalling to innovators about future purchasing requirements, thereby acting as a barrier to private investment; inadequate capacity and skills in some environmental business sectors to develop and manage more complex supply chains and technologies; difficulties for innovators to obtain adequate commercial funding at the demonstration and near-market stages of new technologies; and insufficient incentives to adopt and innovative environmental services in business and the broader economy. These problems are largely market failure issues, which call for decisive policy responses around the following broad areas:

- Formulating a comprehensive national energy-mix plan and mainstreaming it into the Kingdom's long-term national development plans to align overall energy goals and targets with industrial development objectives
- Introducing a special financing mechanism via the 'green sukuk' to facilitate incubation of entrepreneurial ideas in clean energy technologies
- Developing an appropriate architecture on incentives (legal, regulatory, financial, advocacy, etc.) to accelerate the growth of clean energy businesses
- Formulating a robust strategy for PPPs in clean energy investment and development
- Linking centres of research excellence (or research and development (R&D) hub), including the widely acclaimed King Abdullah University of Science and Technology (KAUST) with industries and entrepreneurs
- Setting up an environment czar to provide oversight function on broad-based environmental and energy issues, including monitoring, assessment, enforcement and management of key environmental objectives

We discuss subsequently the modus operandi of each of these policy action points.

6.4.1.1 Mainstreaming national energy-mix policies into national development plans

There is a need for a comprehensive national energy plan that should be mainstreamed in the Kingdom's long-term national development plans. The government's national energy policy at the moment is rather fragmented among various authorities. We believe the ministry of petroleum should formulate a national plan for energy called 'National Plan for Energy Mix', tailored to the domestic and global needs, while employing different international experiences. This plan should determine clearly the future vision of the Kingdom in the energy world with all its components and details, including goals, policies, programmes and timetable for execution. It should also have effective mechanisms to ensure compliance, with periodical performance reports that have clear performance indicators, to clarify achievements and overcome obstacles. The targets of this plan should include reducing the consumption of oil locally and increasing the renewable energy contents in total energy mix. It also has to create a solid and attractive investment environment in renewable energy and energy efficiency, with all the related laws, rules and regulations required.

The presence of a plan on the national strategic level will pave the way to resolve all the conflicts and duplications that are now observed among the various agencies. For example, the electricity and cogeneration regulatory authority (ECRA), in collaboration with a top international consulting firm, had put a development plan for renewable energy. Meanwhile King Abdullah City for Atomic and Renewable Energy (KA CARE) has also put a renewable energy strategic plan for the Kingdom, while the Ministry of Petroleum and King Abdulaziz City for Science and Technology (KACST) have both worked separately on developing energy efficiency initiatives. Therefore, there has to be only one high-level authority that sets, overviews and regulates the national plan especially if there was a serious restructuring of the ministry of petroleum and minerals (as will be discussed later). Such a single authoritative agency should become a reference or focal point for approving any other sub-plans coming from related parties to ensure that these efforts are mainstreamed and aligned with national priorities as expressed in the national energy plan. The plan itself should be for the long term but will be subjected to continuous short- and medium-term reviews to achieve a sustainable green economy.

6.4.1.2 Policy Instruments to promote environmental business

Promoting investments in clean energy technology in Saudi Arabia will require a vast amount of policy incentives and instruments, many of which have been used by different countries around the world. These instruments could be classified into the following broad categories:

- Enabling a policy environment for the promotion of resource efficiency and raising the profile of resource efficiency within the government
- Promoting renewable energy services
- Enhancing research, development and technology demonstration efforts
- Strengthening institutional frameworks and procurement processes
- Improving capacity and skills in environmental goods and services business
- Engaging in increased information dissemination and capacity building
- Creating market ‘bankability’ in environmental goods and services
- Providing greater support for innovation implementation

6.4.1.3 Promoting resource efficiency

According to the World Energy Council (2011), energy efficiency is widely recognised as a key mechanism to achieve progress towards a lower carbon economy, as it can also contribute to social equity by reducing energy prices and increasing energy availability. After all, promoting energy efficiency is the largest, cheapest and fastest option for tackling key energy problems. TERI (2009) has identified a number of policy instruments for the promotion of resource efficiency, including regulatory, financing and market development mechanisms. Saudi Arabia could adopt some of these policies to promote resource and energy efficiency. These include the following:

- Providing financial incentives
- Promoting industry support institutions
- Promoting standards and labelling
- Strengthening public procurement policy for resource-efficient products
- Raising the profile of resource efficiency within the government

One of the major barriers to the takeoff of environmental businesses in Saudi Arabia relates to higher initial cost of clean energy products and technologies. Lessons from around the world, especially the EU, show that financial and non-financial incentives have played a key role in promoting clean technology businesses. Some of these incentives include tax rebates on energy-efficient devices and technologies; accelerated depreciation; feed-in-tariffs (FITs); capital subsidies; tax rebates; investment credits; public investment and guarantees; and low interest rate loans for investments in clean energy.

Examples of successful FIT incentive policy abound from most European countries. Such schemes were aimed at encouraging private sector investment in renewable energy generation with a view to developing sustainable energy supply to lower the costs of energy supply and to provide energy security by reducing their reliance on imported energy. For example, in Germany, fixed FITs are production subsidies given to renewable energy producers to guarantee prices for electricity production usually set at a premium. The policy was successful because it guaranteed grid access; it is customized to promote even development of renewables by setting differential tariffs for areas depending on wind resources; and differentiated tariffs to reflect costs of various renewable energy technologies at certain developmental stages to support the development to commercial scale (German Institute for Economic Research, 2009). Despite its success, however, there are key challenges associated with the FIT policy, including the following: It requires an organised governing system along with supporting institutions in place; setting appropriate tariffs to avoid 'bubbles' and inefficient electricity generation at high costs; ensuring system can integrate renewable energy (e.g. grid expansion, power storage systems to help with the integration of renewable energy into the grid); and ensuring demand-side management programmes to help balance intermittent renewable energy electricity production.

In addition to financial incentives, there is a need to strengthen the legal and regulatory framework, including institutions and agencies responsible for environmental issues. Thus, efforts must be made to strengthen industry support institutions so that they could play a critical role of providing technical support for development and implementation of resource efficiency and cleaner production. Similarly, labelling programmes, such as Energy Star labels for equipment and Eco Mark for products, should be encouraged and advocated so that manufacturers developing such products adhere to the rules. There is a need for advocacy to educate the consumer on such eco-friendly products and labels with regard to durable consumer goods and equipment such as refrigerators, air conditioners, water heaters and products made from recycled materials, for example, recycled paper. In the Western world, the law demands that all new domestic refrigerators, freezers, washing machines, etc. display the energy label.

But successful standards and labelling schemes must include provision of suitable incentives for manufacturers of energy-efficient appliances, development of appropriate standards and informed decision making by bulk consumers. Thus, the government should introduce incentives to encourage manufacturers of energy-efficient products and/or put in place disincentives to dissuade them from producing energy-inefficient products. In essence, the policy of standards and labelling could open up a very lucrative market for environmental services in Saudi Arabia, including opportunities for scientists, engineers, technicians and marketing professionals engaged in the entire life cycle—from R&D and testing to manufacturing and selling of the green product or equipment (TERI, 2009).

Raising the profile of resource efficiency within the government must be the focus of policy in the Kingdom to deliver optimal resource efficiency within the economy. There is, therefore, the need for not only better collaboration between key agencies but also the creation of a new 'game-changer' (Resource Efficiency Implementation Agency) to provide leadership, communication, data management, strategic direction, planning and capacity building. The aim of such a body is to sufficiently raise the profile of resources and environmental issues within the government and to achieve the political 'clout' which is needed to ensure that actions are taken promptly. The following potential benefits could be derived from raising the profile of resource efficiency within the government, as the lessons of experience from the UK demonstrate (UKCEED, 2007):

- 'Increasing the credibility of plan initiatives in this field by demonstrating that there is a powerful voice within Government that is committed to their long-term implementation;
- Providing an alternative perspective to those with mandates for environmental protection;
- Helping to develop more 'joined up' support for resource efficiency related innovation;
- Helping to develop the supportive socio-technical networks which are required to support the radical innovations that appear to be possible within the overall resource efficiency sector;
- Making a potentially important contribution to the Government's climate change targets by highlighting the connections between waste minimisation and resource recovery on the one hand, and reductions in greenhouse gas emissions on the other'.

A number of policy lessons on energy efficiency could also be drawn from successful countries around the globe. In China, for instance, the government introduced a policy dubbed 'China's 1000 Enterprise Programme', whose goal is to improve energy efficiency of the 1,000 most energy-intensive industrial enterprises in China, clustered in nine industries with a target to reduce energy consumption per unit of GDP by 20% between 2005 and 2010 (World Energy Council, 2011). The mechanisms for achieving the targeted goal include negotiated agreements between the government and large-scale enterprises in major energy-consuming industries that require companies to formulate energy efficiency goals; establish an energy utilisation reporting system; conduct energy audits; formulate an energy conservation plan; adopt energy conservation incentives; and invest in energy efficiency improvements. The success story of such a policy initiative derives from the fact that it is based on simple and preliminary guidelines which offer financial carrots and sticks to encourage compliance and phase-out inefficient enterprises. In parallel, the government provided hierarchical guidelines and education/training to industrial workforce to assist enterprises (World Energy Council, 2011).

Policy lessons with regard to standards and labelling could be borrowed from Brazilian and US energy-labelling programmes. In Brazil, the government introduced a labelling programme for energy-efficient household and energy-consuming equipment with the aim of increasing national production of energy-efficient equipment and household appliances; transforming market for energy-efficient products through technological development; and informing consumers on how to purchase more energy-efficient appliances (World Energy Council, 2011). The mechanism for achieving these policy objectives consisted of ensuring that labelling scheme is based on 'a five-point scale against government-set minimum energy performance standards (MEPS); best performing products awarded; and products are tested by independent testing organisations' (ibid). The programme works well because it is focused first on products that contributed most to domestic electricity consumption; it requires mandatory labelling for common household appliances; and a creation of a domestic market for low-energy appliances.

In the case of the USA, the government introduced an Energy Star programme aimed at reducing air pollution, green house gas emissions and energy consumption by encouraging purchase of energy-efficient products. It is also aimed at providing reliable information on energy efficiency and transforming market for energy-efficient products as well as substantially increasing market share of energy-efficient products over time. To achieve these policy objectives, the mechanism allows special labels to be attached to products that are 10–25 % more energy efficient than minimum federal standards (World Energy Council, 2011).

6.4.1.4 Creating Market Bankability

Government's signalling of expectations about future targets, regulatory regimes, market circumstances and technical trends can have a powerful impact on environmental business innovation by motivating investment in the expectation of future rewards. A desirable means of signalling is for government to establish a long-term vision in key environmental innovation areas, identify innovation pathways towards it and establish targets to monitor and drive progress. Additional measures which would increase the credibility and effectiveness of government policies and measures, as was the case of the UK, are (UKCEED, 2007) as follows:

- Tax breaks for recovered materials;
- A more favourable tax regime for 'servicing' approaches;

- Enhancing co-ordination between government policies and investments at regional and local level in order to achieve better optimisation of energy and resource outcomes, e.g. with regard to current initiatives on 'zero carbon homes' and 'sustainable eco-cities'; and
- A ban on disposal of all recoverable materials to landfill.

6.4.1.5 Improving Government Procurement Policy of Environmental Products

In Saudi Arabia and other Middle East countries, environmental innovation is constrained by both demand and supply factors. On the demand side, there is a lack of credible articulated demand for environmental goods and services, while a lack of R&D is a key source of supply-side constraints. Addressing these issues will require the government to take appropriate actions to encourage R&D activities and to mobilise the supply chain to deliver environmental innovations.

In fact, all over the world, government-funded R&D activities have helped in advancing a number of energy-efficient and resource-efficient technologies including renewable energy technologies such as wind turbines and high-efficiency appliances. There is also the need to encourage intelligent supply chain management. One key action of this kind, which could also help to provide more bankability, would be greater support for Forward Commitment Procurement, similar to what obtains in the UK (Environmental Innovation Advisory Group, 2006; and the Sustainable Procurement Task Force, 2006), with the latter arguing that: 'Government must lead the public sector in setting forward commitments to purchase innovative solutions and establish clear routes to public sector market for suppliers of innovative solutions'. Forward Commitment Procurement has the potential to provide greater market visibility for innovators and better and more sustainable solutions for buyers since it focuses on outcomes rather than specific products, and vendors are more willing to invest to achieve economies of scale. According to TERI (2009), policy initiatives that encourage the procurement of green technologies (e.g. CFLs (Compact Fluorescent Lamps) and solar photovoltaics modules) by the public sector will increase the demand for such products and help to create a market base. This will also help to bring down the cost of manufacture of green technology products, and, thereby, help to bring down the prices of such products to affordable levels for the end users.

6.4.1.6 Strengthening Institutional Frameworks

As discussed in this book, the existing institutional structure for environmental business in Saudi Arabia is weak in terms of manpower, technical know-how, resources and supply chain. It is, therefore, crucial that the existing institutional apparatuses are strengthened to effectively and efficiently provide oversight functions of regulating, monitoring and facilitating delivery of environmental services in the Kingdom. For example, the success of PPP models of collection, storage and disposal of municipal solid waste may depend on the credibility and capability of the institutions that are directly responsible for crafting such initiatives. Similarly, efficient delivery of energy efficiency and renewable energy services at the local level is of paramount importance and this requires strong institutional frameworks to ensure that the end users do not have to depend upon outside support for regular maintenance and upkeep of the technologies. Lack of effective administrative and delivery systems will affect the sustainability of energy-efficient practices in the long run, hence the need to strengthen institutional structures associated with clean energy technologies.

6.4.1.7 Improving Capacity and Skills

Shortages of skills and human capital constitute a major barrier to environmental business innovation in Saudi Arabia. These relate to both technical skills (e.g. software or environmental technology) and business-related skills which are needed to transform a largely contractor-based sector into a more proactive and higher value-adding sector. Improving the capacity and skills of citizens will strengthen the Kingdom's infrastructure and capacity for undertaking innovation and R&D on green technology business. This will require a multi-pronged approach including technical training programmes on energy-efficient technologies, building and strengthening the capabilities of engineering and science-related universities to train and impart knowledge to the students in the field of energy and environmental technologies. The universities system must equip the students with not only knowledge and skill sets in renewable energy technologies and other related fields but also in-depth understanding of the social and economic aspects of energy and environment policy. The pedagogical tools should include lectures, tutorials, workshops and field visits to industrial, municipal and landfill sites. External collaborations with universities in both developed and developing countries should be encouraged to facilitate the sharing of knowledge, lessons and experiences on acquisition and delivery of clean energy technologies.

Related to capacity and skills development is information dissemination, given the apparent lack of awareness about clean energy technologies and the potential gains arising from improved energy efficiency in the Kingdom. The type of information that needs to be disseminated will be different for different sets of stakeholders (industries, general public, etc.). It is pertinent to develop comprehensive databases, websites, manuals and case studies regarding efficient energy utilisation equipment and practices, as this will help new and expanding firms to evaluate available options before deciding on the use of new equipment and technology.

In the Europe, the Energy and Utilities Skills Sector Council is the leading organ for skills development in most environmental services sectors, which has undertaken a number of initiatives, including proposals to change the regulatory requirements for the operation of waste management facilities in order to reflect the changed nature of the industry and to provide greater operational flexibility. As a result, this created changes in training requirements based on the recommendations of the Chartered Institute of Waste Management (CIWM) and the Waste Management Industry Training and Advisory Board (WAMITAB), both of which provide accreditation routes for meeting more flexible regulatory standards.

6.4.1.8 Greater Support for Innovation Implementation

The greatest need for government support for clean technology innovation is at the demonstration and early market stages. As a result, policy effort should focus on assisting the development of low-cost early-stage innovation assessment approaches which could provide some validated information to investors, customers and other stakeholders. There is also the need to help establish a business-mentoring scheme specifically aimed at the environmental goods and services sector. This support is imperative given that it is difficult for small and medium-sized enterprise (SME) innovators to find risk capital for the demonstration and near market stages of new technologies and skills in many developing countries.

6.4.1.9 Better Information on Resources and Environmental Services

Environmental resources business channels (such as renewable energy and energy efficiency) have attracted considerable debates in recent years. In contrast, environmental services business, such as environmental consultancy, has received a relatively low profile in the debates about environmental policies and technologies due to lack of information about their size and characteristics. Thus, efforts must be scaled up to collect and store data on such environmental services to provide the right kind of policy support to potential investors. Better information on the innovation performance of environmental services would also be useful for monitoring and problem identification.

6.4.2 Financing issues

In addition to financial incentives, the government should endeavour to facilitate environmental investments through two innovative financing mechanisms: green sukuks and PPP on green technologies. The green sukuk is analogous to green bond that the World Bank has pioneered over the past decades to raise funds to finance a wide variety of green projects in developing countries. Since then other multilateral development institutions, such as the Asian Development Banks, the African Development Bank and the Inter-American Development, have followed suit. Following the 2008 global financial crisis, the US Government too started to embrace the green bond philosophy to support investments in clean technology as a means to tackling infrastructure and environmental challenges as well as creating jobs for the unemployed youths.

In the same way, the Saudi Arabian Government should introduce a special green sukuk to act as an incubator for green technology programme in the Kingdom. Proceeds from the green sukuk will then be distributed in the form of grants, loans, incentives, cooperative agreements and awards to enterprises, especially SMEs, involved in clean energy activities. The *Green sukuk* programme, which can be used for the 10-year maturity of the bond, will have the capacity to sustain a high level of investment in green ventures after the green sukuk programmes come to an end, as revenues to sustain and grow the scheme over time will be generated from a number of key sources, including loan repayments and return on shares of profit realised from products/processes developed with grant support.

The World Bank is currently exploring the possibilities of introducing green sukuk in a number of developing countries to fund low carbon development or environmental projects. The Saudi authorities should explore ways of collaborating with the World Bank, the Islamic Development Bank and the International Monetary Fund (IMF) on such an innovative financing mechanism to promote the development of clean energy technologies in the Kingdom.

PPPs also constitute another innovative instrument for financing green technologies in Saudi Arabia. The Kingdom has experimented with PPP on a limited scale on infrastructure developments but the success of such schemes has been mixed due to a number of institutional and regulatory issues as well as inadequate support structures. The government should address these issues, highlighted in Chap. 3 of this book, and apply the principle to finance green technology investments.

6.4.3 The role of the private sector

Strictly speaking, entrepreneurial activities everywhere are largely the prerogative of the private sector, but the government can play a key role by providing conducive environment for the private sector to operate without undue hindrances. Thus, while the government should endeavour to provide adequate support to promote business activities in clean energy technologies in the Kingdom, the private sector should also take a more proactive role in green investments through a wide range of financing mechanisms, including setting up of green venture capital, private equity, environmental funds and green development banks.

Such private sector funding mechanisms for clean technologies are already widespread and popular in the developed countries and some emerging economies due to regulatory changes and policy incentives being offered to green energy activities, thereby enhancing the bankability of such investments. A wide range of private sector initiatives on green technologies around the world have been highlighted in this book; efforts must be made to encourage the private sector in the Kingdom to take up the gauntlet towards embracing such innovative financing mechanisms to give Saudi Arabia a first mover advantage in clean energy technologies in the Middle East and North Africa region.

6.5 Conclusion

Crafting a national energy investment policy is a multifaceted task which includes a range of approaches, and there are many lessons and insights for regulators as they draw lessons from other countries on what works and what does not work. The following, however, is a checklist of critical factors that policy makers may consider in designing an optimal national energy plan:

- Efforts must be made to provide a clear, well-defined and stable energy policy to reduce the risk of long-term investments by the private sector. Energy infrastructures take decades to develop and most energy-related investments will continue to come from private sources. But private investment needs a stable policy framework and reasonable predictions of financial outcomes if it is to invest at the scale necessary to meet the growth in global energy demand.
- Attempts must be made to learn and apply lessons from other comparator countries, especially among resource-rich emerging countries, and periodic policy revisions should be undertaken to keep national energy policy on track. Ineffective policies or those with unintended consequences must be adjusted without creating disincentives to long-term investment.
- Applications of a range of mechanisms to stimulate investment are key to accelerating the development of clean energy technologies. In some instances, direct government spending is an option, either through state-owned firms or through the provision of subsidies to private firms (e.g. as grants and tax breaks). In many other cases, more effective mechanisms may be policies that provide incentives for the private sector and other actors to invest in competitive markets. These include incentives such as FITs in the case of renewable energy, low interest loans and financial guarantees.
- Government support and policy intervention in markets and other activities will be needed to acknowledge and tackle key environmental challenges, especially the climate change-related problems. The government should, therefore, take a proactive role in the design and implementation of rules and market arrangements as well as providing conducive environment for attracting private sector investment in clean energy business activities.
- Government should take appropriate measures to facilitate a dialogue with the private sector on environmental policy formulation and implementation, especially with regard to the crafting and mainstreaming national energy policies into long-term national development plans of the Kingdom. Such policy dialogues will also ensure that public funding is sustainable and perceived to be equitable by all stakeholders. In essence, inputs from the private sector will enhance the quality of public policy support systems.
- Government can help to foster innovation in both the environmental services sector and service industries in general through a number of channels, including: creating greater long-term certainty about policy implementation and levels of financial incentive to stimulate greater interest and investment in innovation as well as modifying procurement mechanisms to provide greater encouragement

for innovation. Efforts must also be made to provide greater support for the demonstration and near market stages of innovative environmental services and to improve the information base on environmental services and resource efficiency.

- In terms of financing mechanisms, there is a need for the government to introduce green sukuks to act as a catalyst for green technology incubation. Such a scheme will boost confidence of the private sector, especially for the SMEs, thereby enabling them to increase their participation in environmental businesses in the Kingdom.
- PPP is also identified as an innovative mechanism for financing clean technology businesses as it helps to allay the potential concerns of the private sector, the main providers of finance in most such schemes. With the right kinds of incentives and political will, PPP schemes can act as a springboard for the acceleration of environmental investments in Saudi Arabia and the Gulf region. Governments in the region should use sovereign wealth funds as vanguards for PPPs and to facilitate the PPP process and help manage risks by providing guarantees often required by the private sector. With planned public expenditures on infrastructure lagging behind 'required' infrastructure financing, increased private and public investment in green technology infrastructure is a desirable and profitable proposition.
- In order to take the above factors into account, with many other details to be considered, we believe it is crucial to restructure the government energy authorities in the Kingdom to cope with the new trend and facilitate effective implementation of the Kingdom's energy strategies and plans. At the moment, the Ministry of Petroleum and Mineral Resources is responsible for all energy-related policies, including geological surveys and activities. For an efficient and effective realisation of the Kingdom's energy potential, we recommend that the existing Ministry of Petroleum and Mineral Resources should be restructured fundamentally. Under the whole new dimension and critical issues discussed before in the whole book, there should be what is called the Ministry of Energy which encompasses both petroleum and clean energy issues. Rather than inventing the wheel, all the current renewable energy institutions and research centres should also be redirected and relinked to the Ministry of Energy for more clear and effective collaborations, with a professional guidance on monitoring and reporting regulations from the ministry. Meanwhile, this restructuring should include a spin-off for all the mining activities into a separate ministry or authority. The Mining Ministry should concentrate exclusively on all mining issues, including geological surveys. Restructuring the current petroleum and mineral resources ministry in this way will undoubtedly allow for forward and backward linkages between the ministry and research institutions, thereby facilitating the acquisition and diffusion of appropriate energy efficiency and renewable energy technologies which will in turn boost industrial development and empower the private sector to play a key role in the Kingdom's economic growth and development process.
- It is noteworthy that some of the largest oil companies in the world such as British Petroleum, Chevron and Shell have had a huge move in focusing on

renewable energy in their corporate strategy especially in the aftermath of the oil spill in the Gulf of Mexico. In their plans and implementation, they took into consideration various internal and external factors including climate change, energy security and home country resources and factors, in addition to firm specific elements. They have also identified various risk parameters in their energy business with worldwide renewable targets. In other words, each company has its unique strategy. Therefore, the concept of the Ministry of Energy in Saudi Arabia is a suggestion that should be further studied and modified accordingly to sustain and unleash the Kingdom's potential as a global energy market leader in a green approach.

Appendices

Appendix A: Saudi Arabia's General Environmental Law and Rules for Implementation

Chapter One: Definitions and Goals

Article One In the implementation of this regulation, the following expressions shall have the meaning set forth below.

1. The Competent Agency: Meteorology and Environmental protection Administration (MEPA).
2. The Competent Minister: Minister of Defense and Aviation and Inspector General.
3. The Public Institution: Any Ministry, Department or Government Establishment.
4. The Licensing Institution: Any Institution In-charge of licensing projects with potential negative impacts on environment.
5. The Concerned Institution: The Government Institution In-charge of environment-related projects.
6. Person: Any private natural or judicial person. This includes private establishments and companies.
7. The Environment: All that surrounds man such as water, air, land and outer space and all the contents of these milieus such as inanimate objects, flora, fauna, various forms of energy, systems and natural processes and human activities.
8. Environmental Protection: Preservation of the environment and prevention of its contamination and deterioration.
9. Environmental pollution: Presence of one or more materials or factors in quantities or quality for periods of time that directly or indirectly lead to harming public health, bio-organisms, natural resources, property or adversely affect quality of life and human welfare.
10. Environmental Deterioration: The negative impact on environment that changes its general nature or characteristics or the balance among its elements or loss of its beauty and appearance.

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11. Environmental Disaster: An incident which causes damage to the environment and requires greater capabilities to deal with than those required for normal incidents or exceeding the local capabilities.
12. Source Standards: Maximum allowable limits or percentages of the concentration of various pollutants discharged to the ambient environment. This includes identification of the necessary controlling techniques to comply with these limits.
13. Environmental Quality: Limits and percentages of concentrations of Standards pollutants that are not allowed to be exceeded in the air, water and land.
14. Environmental Standards: Both environmental quality and source standards.
15. Environmental Criteria: The environmental specifications and criteria to control pollution sources.
16. Projects: Any facilities, installations or activities with potential impact on the environment.
17. Major Change: Any expansion or change in design or operation of any existing project that might negatively affect the environment. For the purpose of this definition, any equivalent substitution of quality and capacity shall not be deemed a major change.
18. Environmental Assessment: The study carried out to identify the potential of the project or consequential environmental impacts, the procedures and appropriate methods to prevent or reduce the negative impact and increase or achieve positive outputs of the project on the environment in accordance with the environmental standards in force.

Article Two This Law and Its Rules for Implementation are aimed to achieve the following:

1. Preserve, protect and develop the environment and safeguard it from pollution.
2. Protect public health from activities and acts that harm the environment.
3. Conserve and develop natural resources and rationalize their use.
4. Include environmental planning as an integral part of overall development planning in all industrial, agricultural, architectural and other areas.
5. Raise awareness of environmental issues and strengthen individual and collective feelings of the sole and collective responsibility for preserving and improving the environment and encourage national voluntary efforts in this area.

Article Three The Competent Agency shall be entrusted with the duties of preserving the environment and preventing its deterioration, which comprise the following:

1. Review and evaluate the condition of the environment, develop observational means and tools for the collection of information and conduct environmental studies.
2. Document and publish the environmental information.
3. Prepare, review, develop, interpret and issue environmental protection standards.
4. Prepare environmental regulations relevant to its areas of responsibility.

5. Ensure that public agencies and individuals abide by the environmental regulations, standards and criteria, as well as adopt necessary procedures thereof in coordination and cooperation with the concerned and licensing agencies.
6. Review the latest developments in the field of the environment and its management at the regional and international levels.
7. Promote environmental awareness at all levels.

Article Four

1. Each public agency must adopt appropriate actions to ensure that the Rules set forth herein are applied on their projects or projects under their supervision or those licensed by the public agency, and ensure commitment to environmental regulations, criteria and standards stated in the General Environmental law and its Rules for Implementation.
2. All public agencies responsible for the issuance of standards, specifications or rules relating to the practical implementation of activities that may impact the environment must coordinate with the Competent Agency before their issuance.

Article Five Licensing agencies must verify that the Environmental Impact Assessment (EIA) studies for projects that may cause negative effects on the environment are conducted at the project feasibility stage. The agency in charge of implementation of the project shall be responsible for conducting the EIA studies in accordance with the environmental fundamentals and standards specified by the Competent Agency in the Rules for Implementation.

Article Six The party executing new projects, making major modifications to existing projects, or owning projects whose specified terms of investment have expired must utilize the best possible and most suitable technologies for the local environment and use materials which introduce the lowest possible level of pollution to the environment.

Article Seven

1. Agencies in-charge of education must include environmental concepts in curricula at various stages of education.
2. Agencies in-charge of mass media must sustain environmental awareness in various mass media and support the concept of environmental protection from the Islamic perspective.
3. Agencies in-charge of Islamic Affairs, Da'wah and guidance must enhance the role of mosques in encouraging the community to preserve and protect the environment.
4. Concerned agencies must establish appropriate training programs to increase capabilities in the field of preserving and protecting the environment.

Article Eight Taking into consideration the General Environmental law and its Rules for Implementation, public agencies and persons shall:

1. Rationalize the use of natural resources to preserve and prolong the reserve life of non-renewable resources and to develop renewable resources.

2. Achieve coherence between the bearing capacity of the resources and utilization levels of the various resource categories.
3. Apply recycling technologies and reuse of resources.
4. Develop conventional technologies and traditional systems that are coherent with the local and regional environmental conditions.
5. Promote the technologies associated with traditional building materials.

Article Nine

1. In coordination and cooperation with the concerned agencies, the Competent Agency shall develop an environmental disaster management plan based on an inventory of local, regional and international capabilities.
2. Concerned agencies shall establish and enhance emergency plans, as required, to protect the environment from pollution hazards resulting from emergencies caused by their projects during the performance of their activities.
3. Each person who supervises a project or a facility, which has the potential for causing adverse impacts on the environment, shall prepare emergency plans to prevent or alleviate the hazards of such impacts and have sufficient means to implement these plans.
4. In coordination with the concerned agencies, the Competent Agency shall conduct periodical reviews of the suitability of emergency plans.

Article Ten Environmental aspects must be taken into consideration in planning for projects and programs, in the development plans for the various sectors and in the General Development Plan.

Article Eleven

1. Each person responsible for designing or operating any project or activity shall ensure that such design and operation is in compliance with the applicable regulations and standards.
2. Any person engaged in an activity with potential adverse environmental impacts shall take the appropriate actions to limit such impacts or minimize the probability of their occurrence.

Article Twelve

1. Anyone performing digging, demolition, construction, or debris and earth transportation works must take necessary precautions for safe storage and transportation of any waste, as well as the proper treatment and disposal of such waste.
2. All smoke, gases or vapours and solid or liquid residue resulting from the burning of any kind of fuel or similar, whether for industrial, power generation or other activities, must be within allowable limits as permitted in the environmental standards.
3. The owner of the facility must take all necessary precautions and measures to ensure that there is no leaking or emission of air pollutants to the work place beyond the allowable limits of the environmental standards.
4. Adequate ventilation requirements must be applied in enclosed and semi-enclosed public places according to the size and space capacity of the place and the kind of activity carried out in the place.

Precautions, measures, methods and environmental standards must be set forth in the Rules for Implementation.

Article Thirteen All persons engaged in production, servicing or other activities shall take the necessary precautions to achieve the following:

1. Prevent direct or indirect contamination of surface, ground and coastal waters that may be caused by solid or liquid residues.
2. Preserve the soil and land and curb its deterioration or contamination.
3. Limit noise pollution, particularly when operating machinery or other equipment or using horns or loudspeakers. Noise levels shall not exceed allowable environmental standard limits set forth in the Rules for Implementation.

Article Fourteen

1. Hazardous, poisonous or radioactive wastes are prohibited from entering the Kingdom of Saudi Arabia or its territorial waters and exclusive economic zone.
2. Persons in-charge of the production, transportation, storage, recycling, treatment and final disposal of poisonous, hazardous or radioactive materials must comply with the procedures and controls set forth in the Rules for Implementation.
3. Any harmful pollutants, poisonous, hazardous or radioactive wastes are prohibited from being disposed of, or discharged from vessels or alike in the Kingdom's territorial waters or its exclusive economic zone.

Article Fifteen Projects existing at the time of the issuance of the General Environmental law shall be given a maximum term of 5 years as grace period before enforcement, so that these projects can organize themselves accordingly. If the said term is not sufficient for projects of a special nature then an extension may be granted by a decision from the Council of Ministers based on the proposal of the Competent Minister.

Article Sixteen Commitment to environmental protection regulations and standards must be a conditional pre-requisite for receiving loans for projects from lending agencies.

Article Seventeen

1. When it is confirmed to the Competent Agency that any of the environmental criteria and standards have been violated, it shall coordinate with the agencies concerned and obligate the violator to do the following.
   a. Eliminate any negative impacts and stop them. Rectify their effects, within a specified time, as required by the environmental criteria and standards.
   b. Submit a report showing the steps taken by the violator to prevent future recurrence of the violations of the criteria and standards. The proposed steps must meet the approval of the Competent Agency.
2. If the situation is not rectified according to what is mentioned here-above, the Competent Agency shall in coordination with the concerned agencies or the licensing agencies, take necessary actions to force the violator to correct his situation in accordance with the provisions of this Regulation.

Article Eighteen

1. Subject to Article (230) of UN Marine Convention ratified by the Royal Decree No. (M/17) dated 11 Ramadan 1416, and without prejudice to any severe penalty imposed by Islamic laws or provided for in other regulations, whoever violates the provisions of Article fourteen of the General Environmental law shall be punished by imprisonment for a term not to exceed 5 years, by a fine not to exceed SAR 500,000 or both. An appropriate compensation shall be ordered and the violator shall be obligated to eliminate the violation. The facility may be closed or the vessel detained for a period not exceeding 90 days. In case of recurrence, the maximum limit of imprisonment shall be raised but may not exceed double the initial term, or the maximum limit of the fine shall be increased but may not exceed double the initial fine or both. An appropriate compensation shall be ordered and the violator shall be obligated to eliminate the violation. The facility may be temporarily or permanently closed or the vessel temporarily detained or confiscated.
2. Without prejudice to any severe penalty imposed by other regulations, the one who violates any of the provisions of other articles of the Rules for Implementation shall be subject to a fine not to exceed SAR 10,000, and the violator shall be obligated to remove the violation. In case of recurrence, the violator shall be punished by increasing the maximum limit of the fine but not to exceed double this limit, and shall be required to remove the violation. The facility may be closed for a period not exceeding 90 days.

Article Nineteen The Competent Agency shall designate staff to report violations to the General Environmental law and the rules issued for its implementation. The Rules for Implementation shall specify procedures to be followed in reporting and documenting violations.

Article Twenty

1. The Grievance Bureau shall have the jurisdiction to apply penalties set forth in paragraph (1) of Article (18) on violators of the provisions of Article (14) of this Regulation.
2. Subject to paragraph (1) of this Article, one or more committees shall be formed by a decision of the Competent Minister comprising three members each, with at least one member specialized in the Regulation to review the violations and apply penalties set forth herein. Decisions of the committee shall be decided by majority vote of its members and approved by the Competent Minister.

Whoever is penalized by the committee shall have the right to file a petition to the Grievance Board within 60 days from the date of notification of the penalty.

Article Twenty One The committee set forth in paragraph (2) of Article Twenty may order, if necessary, an immediate elimination of the violation without awaiting issuance of a decision from the Grievance Bureau in respect to the petition or the case, as per the circumstances.

Article Twenty Two The Competent Agency shall establish the Rules for Implementation of this Regulation in coordination with the concerned agencies. The Rules for Implementation shall be issued by a decision from the Competent Minister within a year from the date of publication of this Regulation.

Article Twenty Three Current regulations, rules, decisions and instructions related to the environment in force at the time of publication of this Regulation shall remain valid provided there is no contradiction.

Article Twenty Four This Regulation shall be published in the official Gazette and go into force after 1 year from the publication date.

Source: PME (2001), General Environmental Law and Rules for Implementation, Kingdom of Saudi Arabia, 15 October.

Appendix B: Environmental Funds

Table B.1 Environmental Funds: Location, Size, Inception Date and Sector. (Source: Tresvista)

Name	Domicile	Total Asset USUS$ (M)	Inception Date	Sector Allocation
Pictet-Water-Pc€	Luxembourg	3,064.61	11/7/2008	Water, Environmental Control, Miscellaneous Manufacturing, Machinery—Diversified Electric, Building Materials
Pioneer Fds-Glbl Ecolg-I€	Luxembourg	1,194.22	10/15/2007	Electronics, Machinery—Diversified, Chemicals, Transportation, Electrical & Equipment, Food
Dws Zukunftsressourcen	Germany	827.54	2/27/2006	Chemicals, Electrical Compo & Equipment, Energy—Alternate Sources, Water, Machinery—Diversified, Miscellaneous Manufacturing
Allianz Glb Inv Glb Eco Tren	Taiwan	824.11	10/4/2006	Stock market
Impax Environmental Markets	U.K.	621.71	6/2/2006	Technology-based systems, products or services in environmental markets, particularly those of alternative energy.
Jupiter Ecology-I Acc	U.K.	520.13	6/15/2009	Environmental Control, Food, Transportation, Commercial Services, Energy—Alternate Sources, Electronics
Powershares Wilderh Clean En	U.S.A.	501.19	3/3/2005	Electrical & Equipment, Semiconductors, Energy—Alternate Sources, Electric, Chemicals, Miscellaneous Manufacturing

Table B.1 (continued)

Name	Domicile	Total Asset USUS$ (M)	Inception Date	Sector Allocation
Unigarantplus: Klimawndl2014	Luxembourg	397.39	4/3/2008	Banks, Municipal
Alliianz-Dit-Glb Ectr-Rcm It	Luxembourg	367.54	6/4/2007	Electrical Compo & Equipment, Semiconductors, Environmental Control, Miscellaneous Manufacturing, Energy—Alternate Sources, Electronics
Prof Managed Portfolio 21-Is	U.S.A.	340.94	4/2/2007	Pharmaceuticals, Electric, Healthcare Products, Telecommunications, Internet, Transportation
Swisscanto Ch Eq Green Inves	Switzerland	338.71	7/6/1999	Electrical Compo & Equipment, Building Materials, Cosmetics/ Personal Care, Electronics, Telecommunications, Transportation
Jupiter Green Investment Tr	U.K.	325.49	6/22/2007	Equity
Unigarantplus: Klimawndl2013	Luxembourg	286.76	12/12/2007	Banks
Deka-Umweltinvest-Cf	Germany	282.47	12/27/2006	Electrical Compo & Equipment, Electronics, Commercial Services, Energy—Alternate Sources, Semiconductors, Machinery—Diversified
Winslow Green Growth Fund-In	U.S.A.	269.23	5/9/2006	Building Materials, Electrical Compo & Equipment, Environmental Control, Miscellaneous Manufacturing, Semiconductors, Engineering & Construction
Swisscanto Lu Eqty Climate-J	Luxembourg	190.17	2/22/2007	Transportation, Semiconductors, Electrical Compo & Equipment, Energy—Alternate Sources, Chemicals, Electronics
Delta Lloyd-Wate & Cli Fd-Ic	Luxembourg	189.88	11/15/2007	Miscellaneous Manufacturing, Environmental Control, Electrical Compo & Equipment, Semiconductors, Energy—Alternate Sources, Electronics
3 Banken Nachhaltigkeitsfond	Austria	154.31	10/1/2001	Computers, Oil & Gas, Healthcare Products, Banks, Water, Retail
Jbm Sam Sustai Climate-Chf B	Luxembourg	140.13	5/31/2007	Energy—Alternate Sources, Electrical Compo & Equipment, Electric, Buliding Materials, Engineering and Construction, Auto Parts & Equipment

Table B.1 (continued)

Name	Domicile	Total Asset USUS$ (M)	Inception Date	Sector Allocation
Samsung Gl Water Eq-Master	South Korea	118.78	4/13/2007	Water, Environmental Control, Machinery—Diversified, Miscellaneous Manufacturing, Electronics, Engineering and Construction
Blackrock New Energy Investm	U.K.	83.63	N.A.	N.A.
Danske Invest Klima Trends	Denmark	75.89	11/9/2009	Chemicals, Oil & Gas, Electrical Compo & Equipment, Electric, Electronics, Retail
Oeko-Aktienfonds	Luxembourg	68.94	5/13/1991	Stock and equity securities
Dws Invest Climate Chang-Ds1	Luxembourg	60.26	12/21/2007	Electrical Compo & Equipment, Chemicals, Electric, Semiconductors, Energy—Alternate Sources, Miscellaneous Manufacturing
Espa Wwf Stock Umwelt-Huf-Vt	Austria	60.21	1/10/2008	Environmental Control, Energy—Alternate Sources, Water, Electrical Compo & Equipment, Transportation, Commercial Services
Sgam Fd-Eq Europ Environmt-B	Luxembourg	58.75	6/29/2006	Pharmaceuticals, Oil & Gas, Commercial Services, Water, Electric, Electrical Comp & Equipment
Fidelity Select Env & Alt En	U.S.A.	55.53	6/29/1989	Electric, Miscellaneous Manufacturing, Chemicals, Electrical Compo & Equipment, Aerospace/ Defense, Environmental Control
Ecosphere Europe-E	France	47.45	4/14/2008	Stock market
Goldman Sachs Sus Port-Pas€	Luxemb'g	45.3	9/16/2008	N.A.
Jih Sun Anti-Global Warming	Taiwan	44.84	1/17/2008	Stock market
Dws Climate Change-C	U.S.A.	40.66	9/5/2007	Electrical Components, Chemicals, Energy—Alternative Sources, Semiconductors, Water, Forest Products & Paper
Ing Global Climate Change Fu	Taiwan	37.69	1/18/2008	Environmental industries
Hsbc Gif-Climate Chg-IUS$-Acc	Luxembourg	35.07	11/9/2007	Electric, Electrical Components, Miscellaneous Manufacturing, Engineering & Construction, Environmental Control, Water

Table B.1 (continued)

Name	Domicile	Total Asset USUS$ (M)	Inception Date	Sector Allocation
Cra Clean Resources Fund—A	Cayman Islands	34.9	8/7/2006	Clean technology solutions, water, waste and environmental technology businesses.
Bnp P L1 Fund-Green Tigers-I	Luxembourg	32.85	7/31/2008	Banks, Diversified Financial Services, Electrical Components, Miscellaneous Manufacturing, Machinery—Diversified, Engineering & Construction
Cathay Global Ecology Fund	Taiwan	32.63	3/14/2008	Environment protection, alternative energy and agricultural and bio-technology around the world.
Kbc Eco Fund World-C	Belgium	29.36	5/4/1992	Banks, Pharmaceuticals, Oil & Gas, Telecommunications, Food, Miscellaneous Manufacturing
Cra Clean Water Fund—A	Cayman Islands	25.2	5/1/2007	Water infrastructure, pollution abatement, waste management nad waste to energy fuels.
Allianz Rcm Glbl Ecotrends-C	U.K.	21.64	2/14/2008	Electrical Components, Energy—Alternative Sources, Semiconductors, Environmental Control, Miscellaneous Manufacturing, Electronics
Planete Bleue-I	France	17.14	4/15/2008	Energy—Alternative Sources, Electrical Components, Chemicals, Miscellaneous Manufacturing, Building Materials, Water
Quest Cleantech Fund-C	Luxembourg	11.46	3/31/2008	Cleantech

Table B.2 Performance of environmental funds by type of investment. (Source: Tresvista)

Type of Investment	Standard Deviation	Risk Adjusted	YTD Returns (%)
Equity[a]	23.69	0.39	4.77
Derivative[b]	16.60	0.63	6.03
Equity & Derivative[c]	18.73	1.16	5.85

[a] Average of 11 environment funds that have positive returns
[b] Average of 8 environment funds that have positive returns
[c] Only one environment fund

Appendix C: Cumulative Sums of Regression Residuals

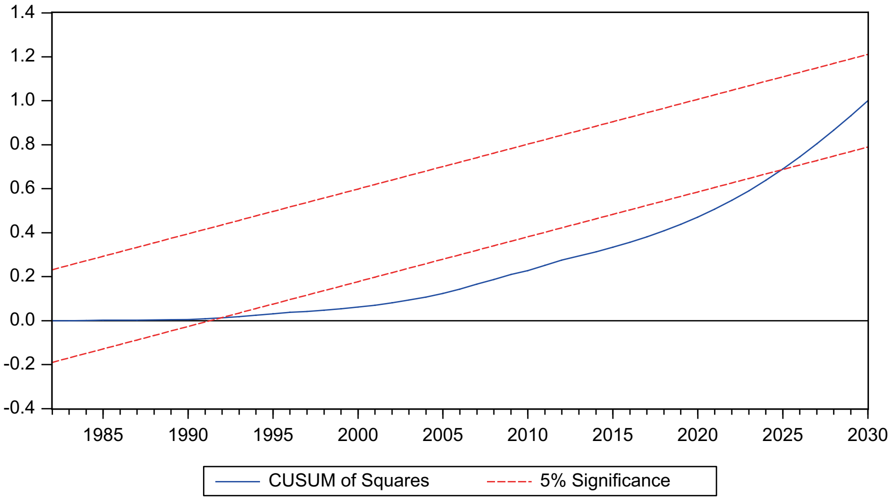

Fig. C.1 CUSUM-SQD of regression of CO_2 emissions on real per capita GDP (baseline case)

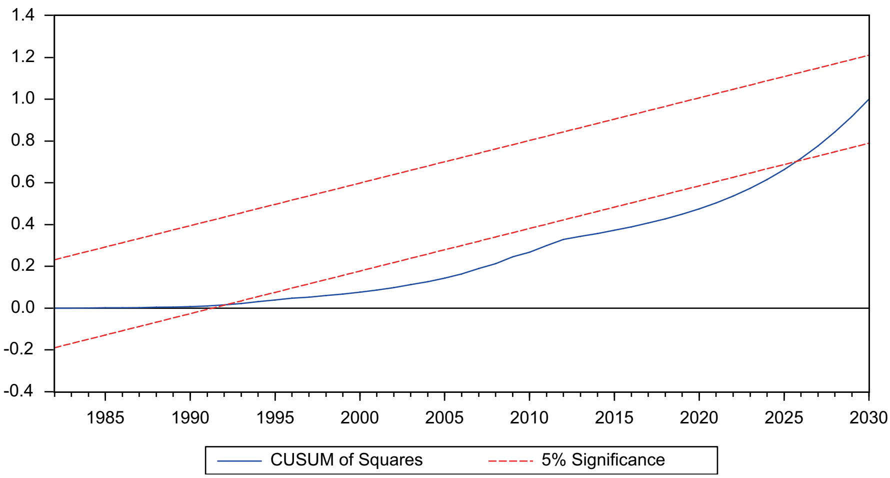

Fig. C.2 CUSUM-SQD of regression of CO_2 emissions on real per capita GDP (Pessimistic Case)

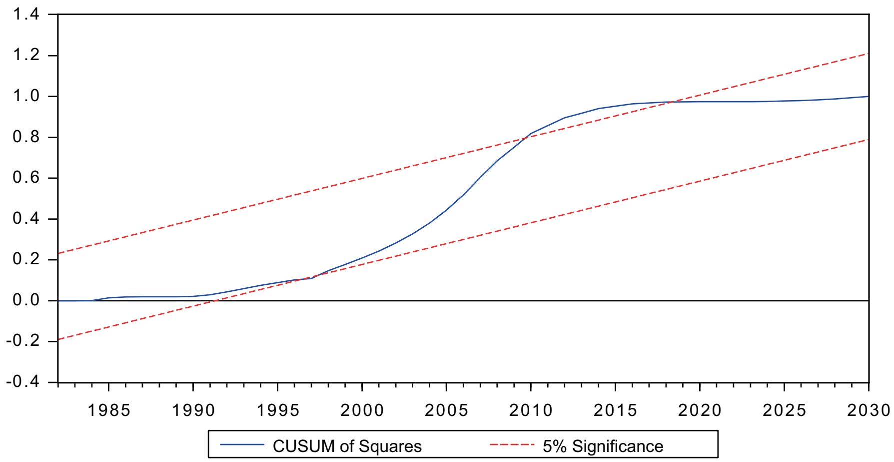

Fig. C.3 CUSUM-SQD of regression of CO_2 emissions on real per capita GDP (Optimistic Case)

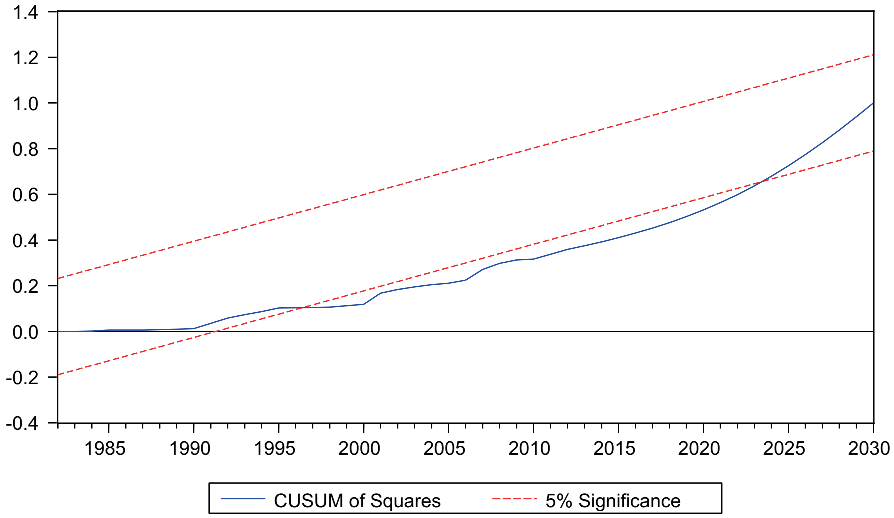

Fig. C.4 CUSUM-SQD of regression of waste on real per capita GDP (Baseline Case)

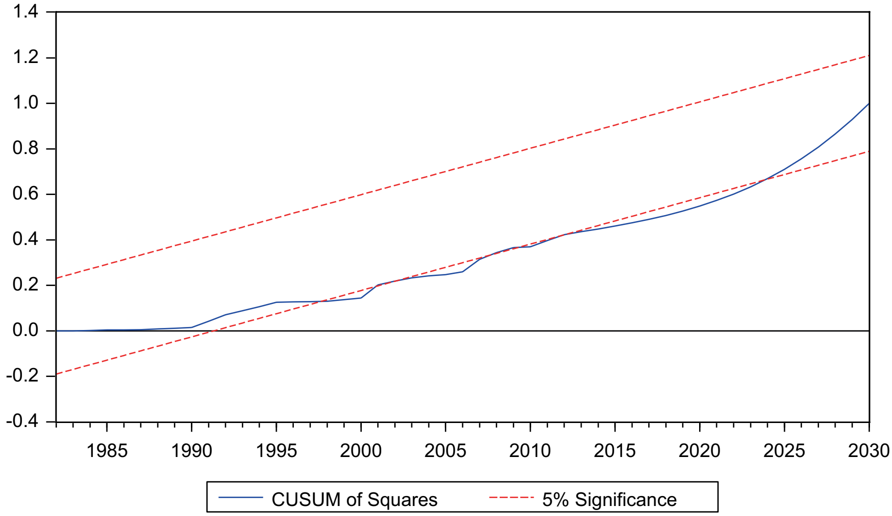

Fig. C.5 CUSUM-SQD of regression of waste on real per capita GDP (Pessimistic Case)

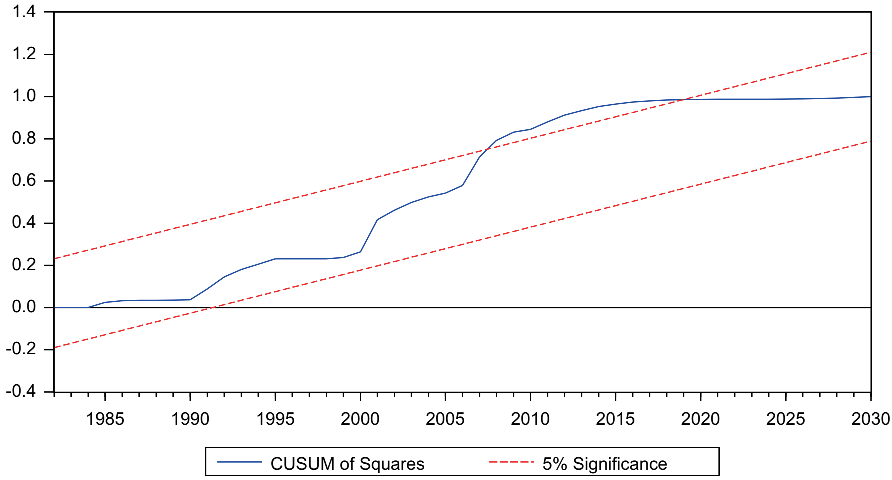

Fig. C.6 CUSUM-SQD of regression of waste on real per capita GDP (Optimistic Case)

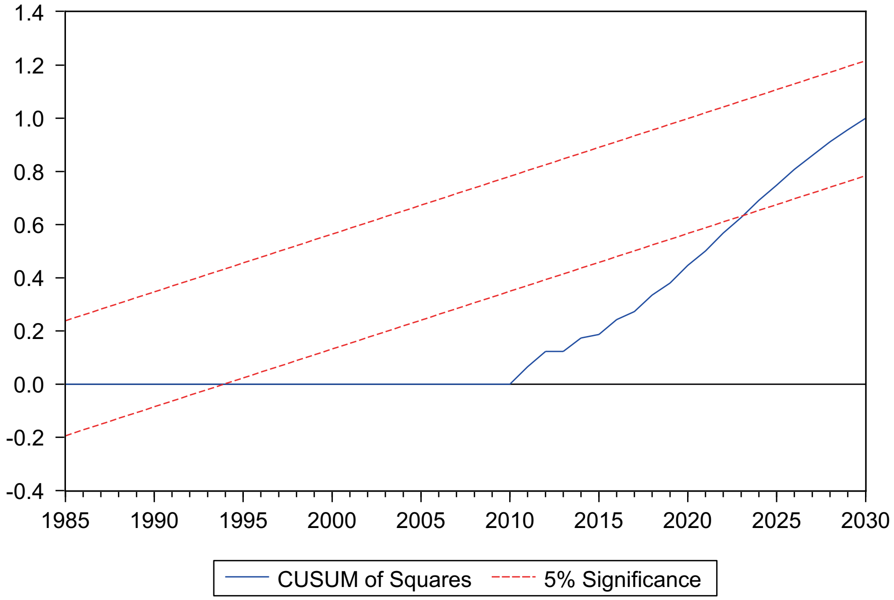

Fig. C.7 CUSUM-SQD of regression of production function (baseline case)

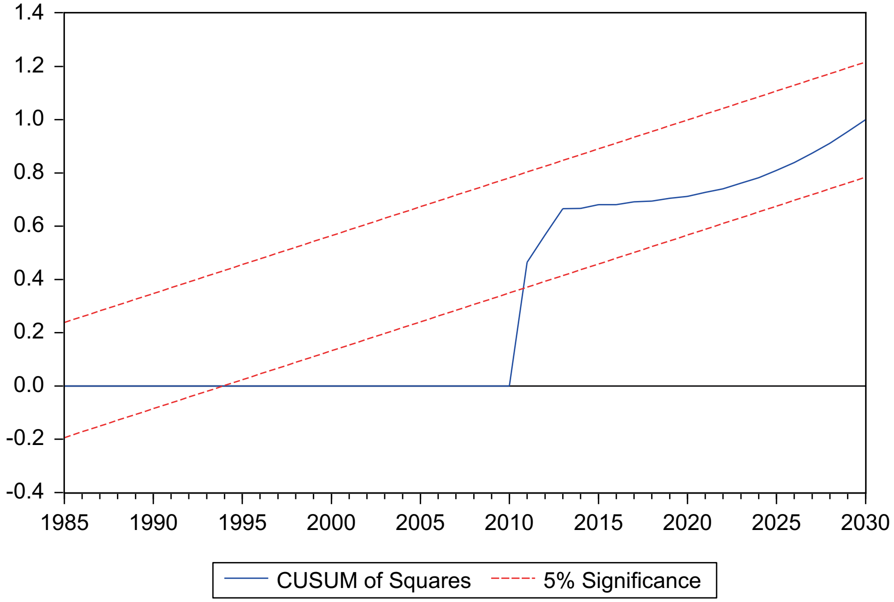

Fig. C.8 CUSUM-SQD of regression of production function (pessimistic case)

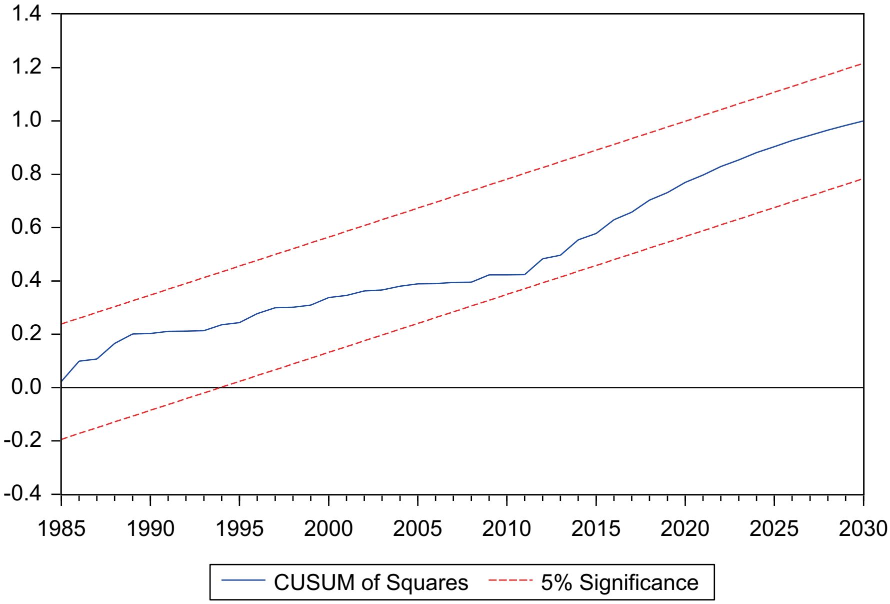

Fig. C.9 CUSUM-SQD of regression of production function (optimistic case)

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