IRENA
International Renewable Energy Agency

SULTANATE OF OMAN

Renewables Readiness Assessment

November 2014

About IRENA

The International Renewable Energy Agency (IRENA) is an intergovernmental organisation that supports countries in their transition to a sustainable energy future, and serves as the principal platform for international cooperation, a centre of excellence, and a repository of policy, technology, resource and financial knowledge on renewable energy. IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy, in the pursuit of sustainable development, energy access, energy security and low-carbon economic growth and prosperity.
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About RRA

A Renewables Readiness Assessment (RRA) is a holistic evaluation of a country's conditions and identifies the actions needed to overcome barriers to renewable energy deployment. This is a country-led process, with IRENA primarily providing technical support and expertise to facilitate consultations among different national stakeholders. While the RRA helps to shape appropriate policy and regulatory choices, each country determines which renewable energy sources and technologies are relevant and consistent with national priorities. The RRA is a dynamic process that can be adapted to each country's circumstances and needs. Experience in a growing range of countries and regions, meanwhile, has allowed IRENA to continue refining the basic RRA methodology.

In June 2013, IRENA published a guide for countries seeking to conduct the process in order to accelerate their renewable energy deployment.
For more information visit www.irena.org/rra

Acknowledgement

This Renewables Readiness Assessment report was prepared by IRENA in close collaboration with the Government of Oman, as represented by the Public Authority for Electricity and Water (PAEW). Under the guidance of Gauri Singh and Mustapha Taoumi, valuable support was provided by Erik Steen Sorensen, independent consultant, who assisted in the finalisation of the report, and Dr. Abdullah Al-Badi and Dr. Yassine Al-Charabi (Sultan Qaboos University, Muscat). Bilal Hassan (IRENA) also made a valued contribution. IRENA wishes to thank the following experts for their insights and constructive guidance during the peer review process: Fahad Hamad Al-Tamimi (Assistant Manager, Renewable Energy, Qatar Petroleum) and Bradley Jason Horn (Sr. Renewable Energy Analyst, Qatar Petroleum), Dr. Michael Knaus and Professor Peter Heck (Umwelt-Campus Birkenfeld, Germany), Dr. Anita Richter (Deutsche Gesellschaftfür Internationale Zusammenarbeit), Rod Janssen (Energy and Environment Consultant, Paris) and Frank Wouters (IRENA).

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Sultanate of Oman

Renewables Readiness Assessment

FOREWORD

from the Chairman of the Public Authority for Electricity and Water

The demand for energy in the Sultanate of Oman is increasing rapidly, due to a combination of a rising population and strong economic growth. In particular, annual electricity demand growth has reached a rate of 8-10%, reflecting the rapid expansion of industrial areas as the economy diversifies away from the oil and gas sectors. In the face of this rapidly swelling demand, and along with the inherently finite nature of hydrocarbon resources, the Government of Oman has started to examine the possible use of renewable natural resources for the production of electricity, with a view to diversifying the energy base of the Omani economy.

The Renewables Readiness Assessment (RRA) that forms the basis of this report is among a number of important initiatives undertaken by the Sultanate to enhance the deployment of renewable energy technologies. The study, conducted in collaboration with the International Renewable Energy Agency (IRENA), provides vital information to stakeholders in the field of renewable energy, including both governmental and private sector entities. It demonstrates the significant potential for renewable energy investment, as well as decision-making challenges in this area and the steps already in place to overcome them.

In parallel with this study, other initiatives are underway in cooperation with governmental entities and specialised international organisations such as the Japan International Cooperation Agency (JICA) and Germany's International Cooperation Agency (GIZ). These include an ongoing national energy study, the energy conservation master plan, a rooftop solar panel study and the development of a wind-resource atlas, as well as the implementation of several strategic pilot or demonstration projects. The Government of Oman seeks to achieve its short, medium, and long-term targets based on vast renewable energy resources, through the formulation of policies that bring together the findings of all of these valuable studies.

Finally, I would like to extend my enormous gratitude to the personnel of IRENA and the Public Authority for Electricity and Water who have worked together in conducting the RRA consultations and producing this report. I am certain it will be a valuable component as we seek to exploit all of our national resources effectively.

Mohammed Abdullah Al-Mahrouqi
Chairman
Public Authority for Electricity and Water
Sultanate of Oman

The Government of Oman seeks to achieve its short, medium, and long-term targets based on vast renewable energy resources.

FOREWORD

from the IRENA Director-General

The Renewables Readiness Assessment (RRA) conducted in the Sultanate of Oman marks an important step forward in the work of the International Renewable Energy Agency (IRENA) to promote the widespread adoption and sustainable use of all forms of renewable energy. This report – the culmination of a country-led process based on IRENA's methodology – is the first from a country belonging to the Gulf Cooperation Council (GCC), which represents a region characterised by heavy reliance on fossil fuels, both for export revenue and to drive national industrial development. Yet the GCC countries have also set out to achieve the sustainable deployment of renewable energy to enhance their long-term energy security.

Oman's power infrastructure and hydrocarbon reserves have come under pressure because of population growth, combined with rapid industrial development in cities such as Duqm, Sohar and Salalah. The country experienced severe power disruptions in 2009 and 2010, requiring major capacity additions for power generation that strained existing oil and natural gas resources. Fortunately, the Sultanate can employ renewable energy technologies, such as small or large solar, wind power and various hybrid power models to mitigate such fossil fuel shortages, stimulate further economic development, create new jobs and preserve a cleaner environment.

RRA pilot studies began in Africa in 2011. Since then, countries as diverse as Grenada, Kiribati and Peru have also completed the process, expanding the range of regions and economic-types available for comparison. All these studies strengthen IRENA's capacity to provide country-specific support and advice. More broadly, the RRA report series spreads the knowledge of good practices that is essential for a successful global energy transition.

While each country drives the process, IRENA helps to engage with all relevant national and regional stakeholders, in order to pinpoint the drivers, comparative advantages, enabling policies and technical measures that will ensure the successful scale-up of renewables. This report, therefore, provides the foundation for a concrete action plan.

I particularly wish to thank Chairman Al-Mahrouqi and his team at the Public Authority for Electricity and Water for their warm hospitality and energetic contribution to the process that resulted in this report. I hope the findings will enable Oman to significantly increase its deployment of renewables. IRENA stands ready to provide continuing support in implementing the actions identified.

Adnan Z. Amin
Director-General
IRENA

While each country drives the process, IRENA helps to engage with all relevant national and regional stakeholders, in order to pinpoint the drivers, comparative advantages, enabling policies and technical measures that will ensure the successful scale-up of renewables.

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ABBREVIATIONS

AER	Authority for electricity regulation
bbl/d	Oil barrel per day
Bcf	Billion cubic feet
CCGT	Combined cycle gas turbine
CDM	Clean development mechanism
CERs	Certified emission reductions
DPC	Dhofar power company
ED	Electro dialysis
EOR	Enhanced oil recovery
FIT	Feed-in-tariff
GCC	Gulf cooperation council
GCCIA	GCC interconnection authority
GDP	Gross Domestic product
GW	Gigawatt
K.A. CARE	King Abdullah City for Atomic and Renewable Energy
kV	kilovolts
kW	kilowatt
kWh	kilowatt-hour
LNG	Liquefied natural gas
Mcf/d	Million cubic feet per day
MED	Multi-effect distillation
MIS	Main interconnected system
mmBtu	Million British thermal units
MW	Megawatts
MWh	Megawatt-hour
MWth	Megawatt-thermal
NBP	National Balancing Point (virtual trading point for UK gas)
O&M	Operation and maintenance
OCGT	Open cycle gas turbine
OETC	Oman Electricity Transmission Company
OPWP	Oman power and water procurement company
PAEW	Public authority for electricity and water
PDO	Petroleum development Oman
PPAs	Power purchase agreements
RAECO	Rural Areas Electricity Company
RRA	Renewables Readiness Assessment
Tcf	Trillion cubic feet
TVC	Thermal vapour compression
TPES	Total primary energy supply
UAE	United Arab Emirates
UN	United Nations

EXECUTIVE SUMMARY

The Sultanate of Oman is a fast-growing country and has the fifth largest economy in the Gulf Cooperation Council region. The oil and gas sectors continue to be the most significant driver of Oman's economy. However the country's fossil fuel resources are insufficient to cater for a continuation of the current trends. A consensus is emerging to diversify from an oil and gas-based economy to one with enhanced energy and economic security.

Today renewable energy has no role in the country's energy supply, despite important wind and solar resources. A policy for developing renewable energy resources is therefore needed. If implemented, this could give renewable energy an important role in reducing Oman's dependence on oil and, in particular, natural gas.

In recent years, real total gross domestic product (GDP) growth has been between 4.5% and 5% annually. The industrial sector has become an important contributor to GDP, and significant large-scale industries have been developed, such as fertiliser, aluminium, cement and steel tubes. However, the oil and gas sectors continue to dominate Oman's economy. In 2010, they contributed 45% of Oman's GDP.

Meanwhile, economic growth, urbanisation and industrialisation have all contributed to continued rising domestic energy use. Oil consumption almost doubled over the past decade. Electricity use has grown in line with GDP, and domestic use of natural gas more than tripled from 2000 to 2012. Natural gas is primarily consumed in electricity generation and related water desalination, enhanced oil recovery, and large gas-intensive industries. The electricity sector is heavily dependent on natural gas, which accounts for 97.5% of total power production. Two separate grid areas, the Main Interconnected System (MIS) and the system in the Salalah region, serving the southern part of the country, are both based almost exclusively on gas-fired generation. Power production in rural areas, served by several relatively small, non-connected plants, is primarily from diesel engines.

Over the years, Oman has shifted from centralised power sector management to a more decentralised system, with electricity production opened to private investors. Power Purchase Agreements (PPAs) and Power and Water Purchase Agreements (PWPAs) with private investors have secured important capital needs in electricity and related water production.

Electricity tariffs in Oman are identical in all parts of the country, being politically determined, and heavily subsidised. Financial subsidies granted by the Ministry of Finance bridge the gap between the costs of producing and supplying electricity and low electricity tariffs. On average, the financial subsidy amounted in 2012 to almost 42% of the costs of producing and supplying electricity. The subsidy entails substantial costs to the government.

In addition to this direct financial subsidy, consumers also benefit from an indirect subsidy: the cost at which fuel is sold for electricity generation is far below the economic opportunity cost, which is the price of the same fuel in the international market. Low gas prices for domestic uses in the Sultanate have been a key policy instrument to promote economic growth and diversification.

Currently, Omani exports of Liquefied Natural Gas (LNG) benefit from high prices for the commodity in Asia. But Asian price levels are unlikely to be sustainable in the long run. For the analysis of the economic costs of electricity, current Asian prices are included as a "high gas price" scenario. The "medium gas price" scenario uses 2008 Asian prices, while pre-2008 Asian LNG prices are considered the "low gas price" scenario. The high price scenario implies an economic subsidy (financial plus gas-price subsidy) of about USD 150 per megawatt-hour (/MWh) on average for the production of electricity in the MIS and Salalah system. In the medium gas price scenario, the economic subsidy amounts to USD 112/MWh and in the low gas price scenario to USD 63/MWh. The price of diesel for electricity production in rural areas is also significantly lower than international prices. High subsidies remove the incentive to use electricity efficiently, add to the growth in demand for electricity, and yet hinder renewable energy deployment. Furthermore, they increase gas requirements. The result is a shortfall in future gas supplies compared to increasing demand.

Oman possesses important untapped renewable energy renewable energy resources. The level of solar energy irradiation in Oman is reckoned to be among the highest in the world, and high solar energy density is available in all regions. Wind is also a promising renewable energy resource for power generation, especially in the coastal and southern parts of Oman. Wind energy could be economically attractive as a supplement to gas-fired plants in the Salalah region. A comparison of the costs of producing thermal electricity with the costs of solar photovoltaic (PV) or wind energy shows viable business cases for solar PV and wind power in Oman. These renewable sources are cost-competitive, in particular in rural areas, with thermal power generation. Financial and indirect price subsidies to power generation distort the picture, but there is clear economic potential for renewables if subsidies are excluded.

In rural areas, diesel power generation can be complemented by solar and wind energy in a cost effective manner. However, only small-scale installations are feasible. Utility-sized solar PV plants, for which installation costs have also declined rapidly in recent years, are becoming a viable option as an alternative to gas-fired generation in the MIS and the Salalah system. Oman's economic case for exploiting renewable energy needs to be supported by a renewable energy strategy creating an enabling environment. A Renewable Energy Action Plan setting out the government's overall targets and key actions would underpin such a strategy. As a first step in this process, the Council of Ministers has asked the Ministry of Finance and the Public Authority for Electricity and Water (PAEW) to develop a future energy strategy for Oman.

Oman's sizeable renewable energy resource base offers an opportunity not only for energy diversification, but also for economic diversification. Research and development and high-technology services related to renewable energy could create new business and employment in Oman. Exploiting the synergies of renewable energy deployment and technology development would help to shift the Omani economy away from being primarily oil and gas based. Elsewhere in the Gulf region, Abu Dhabi's Masdar and Saudi Arabia's K.A.CARE are both geared to exploiting such opportunities.

Oman has already gained experience in attracting private investors to power and water production by offering PPAs. Similarly, these could be the basis for attracting investments to renewable energy projects. PPAs could also be combined with competitive tendering in order to secure the lowest possible electricity prices. Because of tendering costs, this procedure should be reserved for relatively large projects. Standard PPAs for renewable energy could drive small and medium-sized projects. A standard PPA has the advantage of reducing time and money spent on contract preparation and negotiation. Another system that has proven effective in many countries is the feed-in-tariff (FIT), which can be designed to accelerate investment in renewable energy technologies.

Based on all these elements, the Renewables Readiness Assessment (RRA) process has engaged local stakeholders in intensive consultations to develop an action plan for scaling up renewable energy in Oman. The RRA process identified five recommended actions for promoting renewable energy deployment:

ACTION 1: DEVELOPMENT OF POLICY AND REGULATORY FRAMEWORK FOR ALL RENEWABLE ENERGY APPLICATIONS

The Sultanate of Oman is developing a national energy strategy. As an integral part of this work, there needs to be a national renewable energy strategy, which sets the vision for the role of renewable energy in the future energy mix, as a contributor to energy diversification on an economic basis, and as a catalyser for new employment opportunities in the country. The national renewable energy strategy will set the general framework for policy instruments for the promotion of renewables.

OMAN'S NATIONAL ENERGY STRATEGY

The National Energy Strategy study will produce a detailed least-cost energy supply development plan and demonstrate the expected effects for the whole economy through a comprehensive energy-balance and macroeconomic model.

A key aspect of the study will be the evaluation and optimisation of the sources of energy for electricity generation, including alternatives to gas-firing and an in-depth investigation of the wider energy system.

The study will focus primarily on the long term — looking at the energy mix for Oman over the period to at least 2040 — and will identify both longer- and shorter-term targets in an integrated manner.

The National Energy Strategy will be used to guide the development of policies and will identify the required regulatory framework to implement the recommended strategy. Models outlined in the strategy can be used to test different policies during the strategy-development stage.

In addition to national energy strategy, Oman has started "Study for the Energy Conservation Master Plan in the Power Sector in the Sultanate", aimed at creating an energy efficiency and conservation (EE&C) master plan regarding electric power towards 2023, with objectives to institutionalise EE&C policy in the power sector and promote efficiency on the demand side as well as conserving electric power and fuel. Worldwide, it is recommended to link EE&C with renewable energy; most countries have started establishing policies for both under one institution.

Increased energy efficiency and renewable energy have become mainstream policy lines to enhance energy security and contribute broadly to sustainable development. There exists a wider scope for action on the demand side, *i.e.*, energy efficiency, compared with the supply side. Energy efficiency has thus become a cornerstone of energy policy for energy security and environmental protection. Energy efficiency and renewable energy policies are important to ensure sustainable and secure energy development.

OMAN'S MASTER PLAN FOR ENERGY EFFICIENCY and CONSERVATION (EE&C)

The EE&C master plan, conducted in collaboration with the Japan International Cooperation Agency (JICA) and concluded in March 2013, proposed the following prioritised measures for implementation:

- Energy Management System
- Minimum Energy Standards and Labelling System
- EE&C Building Regulation
- Demand-side Management Tariff System
- Smart Meter with Visualisation
- EE&C Dissemination Programme

ACTION 2: IMPLEMENTATION MODEL, TARGETS AND MARKET

The national renewable energy strategy should state the targets for renewable energy shares in the energy mix by sector and source, and outline the main policies planned for achieving these targets. The targets will set the scene and guide stakeholders and private investors. It is recommended that Oman builds on its experience with PPAs to purchase electricity generated from renewable energy and adapted to accommodate renewable energy investments. A FiT could be envisaged for relatively small installations.

A financial mechanism for the purchase of renewable energy generated electricity is needed. To attract investors it should be transparent and based on clearly defined funding principles. The prices offered to renewable energy generated electricity should reflect the economic costs of electricity generated by natural gas and for the rural areas by diesel.

ACTION 3: INSTITUTIONAL AND LEGAL FRAMEWORK

A renewable energy law is recommended to secure efficient implementation of the National Renewable Energy Policy. An important step would be the nomination of an authority having the prime responsibility and the decision powers needed to secure that renewable energy projects are prepared, contracted and deployed in line with the National Renewable Energy Strategy.

Institutional and local regulatory obstacles are considered to be major barriers for deployment of renewables in urban and industrial areas. Permitting requirements are complex and unclear and there are numerous restrictions regarding land use, zoning and interconnections of renewable energy power projects to the utility grid.

There is also a lack of inspectors and permit authorities with sufficient experience in renewable energy systems for urban areas. In addition, certified renewable energy entities, such as installers and maintenance companies, that meet the required technical, environmental, safety and performance standards are not easily available; purchasers, lenders, investors and insurance companies also have very little experience in this area.

ACTION 4: RESOURCE MAPPING OF RENEWABLE ENERGY SOURCES AND, RESEARCH AND DEVELOPMENT

There have been general studies and assessments of wind and solar resources. Assessments have been made by using both satellite mapping and measured data. They should be verified and as needed supplemented by more detailed and targeted studies (such as Oman Wind Atlas Resource Study). The availability of comprehensive and consistent (bankable data) will facilitate the drafting of a renewable energy strategy and is a prerequisite for future project development.

A database for renewable energy needs to be develped and to be centralised at an institution responsible for renewable energy.

ACTION 5: DEVELOPING CAPACITY BUILDING FOR RENEWABLE ENERGY

There is a need for capacity building on several levels. This could include creating a Renewable Energy Steering Committee composed of private and public entities, increasing financial support to the educational institutions for renewable energy research and developing renewable energy related programmes for both undergraduates and postgraduates. Offers should be launched by technical schools for training courses in design, execution, operation and maintenance of renewable energy installations. This could be taken further with the creation of a National

Industrial Training Centre, which would be funded by public and private companies.

OMAN'S RENEWABLE ENERGY STRATEGIC R&D PROGRAMME

The strategic R&D programme for renewable energy was established end 2012 and is steered by a committee chaired by PAEW in cooperation with the Research Council. The programme objectives are as following:

- Enhance the country's competence in the field of renewable energy and develop supportive programmes to that end;
- Take full advantage of the various platforms of international cooperation related to renewable energy, particularly those stemming from the International Renewable Energy Agency (IRENA);
- Develop strategic research programmes;
- Build up mutual cooperation between academic and industrial communities;
- Improve communication between the government and academic institutions in the country in respect to renewable energy development;
- Address the recommendations resulting from conferences held by various academic institutions in the country.

Fishing and agriculture formed the backbone of the economy until the shift to oil and gas.

I. Economic and energy background

INTRODUCTION

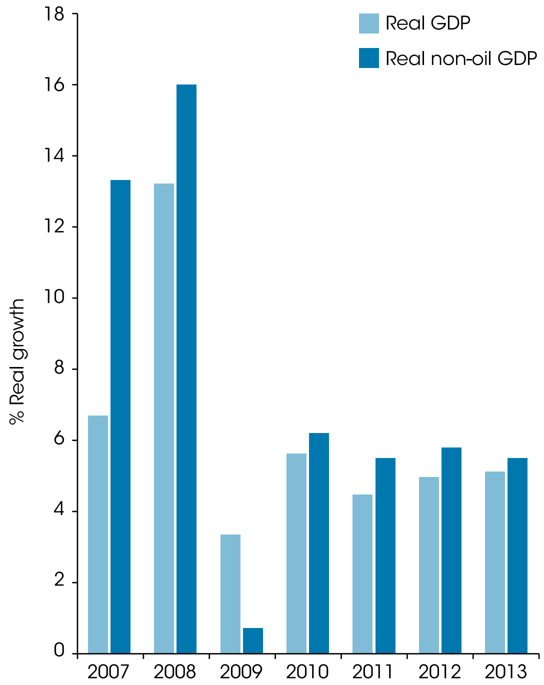
This chapter provides a general overview of Oman's economy and the energy background. The Sultanate of Oman occupies the south-eastern corner of the Arabian Peninsula, bordered by the Kingdom of Saudi Arabia and the United Arab Emirates (UAE) in the West and the republic of Yemen in the south. The population of Oman has grown from 2.34 million people in 2003 to 2.77 million people in 2010 (Ministry of National Economy, 2010) and which includes about 0.7 million expatriates.

Oman is a fast-developing country. The 2010 Human Development Report classified Oman in the "high human development" category showing rapid improvements in health, education and living standards. The majority of the population, roughly 75%, resides in densely populated urban centres. The overall literacy rate in 2003 for people over 15 years was 81%. In 2010, there were a total of 1.3 million formal jobs in Oman out of which public sector positions were 13%.

The rapid changes in living standards and infrastructure are primarily attributed to the discovery of oil and natural gas. Historically, fisheries and agriculture formed the backbone of Oman's economy. The discovery of oil and gas created a sectorial shift in the gross domestic product (GDP). As of now, Oman is the fifth largest economy amongst the Gulf Cooperation Council (GCC) countries. The oil and gas sectors in Oman have been and still are major contributors to job generation. According to International Monetary Fund (IMF), the unemployment rate is at 24% and rising (IMF, 2011).

In recent years, real GDP growth varied between 4.5% and 5% annually and the GDP level reached USD 23 731 per capita in 2011 (World Data Bank, n.d.). Non-oil GDP growth has in recent years been stronger than the total, see Figure 1. Large scale industries have been developed such as fertiliser, aluminium, cement and steel tubes, and the industrial sector has consequently become an important contributor to GDP. With the positive economic outlook, various rating agencies have given Oman high investment grade. Standard & Poor's credit rating for Oman ranges from A and A-1 for long-term and short-term bonds, respectively. Oman receives important foreign direct investments, which reached USD 788 million in 2011.

Figure 1: Economic growth in Oman, 2007 - 2013 (est.)



Source: International Monetary Fund, 2013

The Total Primary Energy Supply of Oman (Figure 2) is entirely dependent on natural gas and oil. In 2011, natural gas accounted for 71% of the country's energy supply with oil products accounting for the remaining 29%.

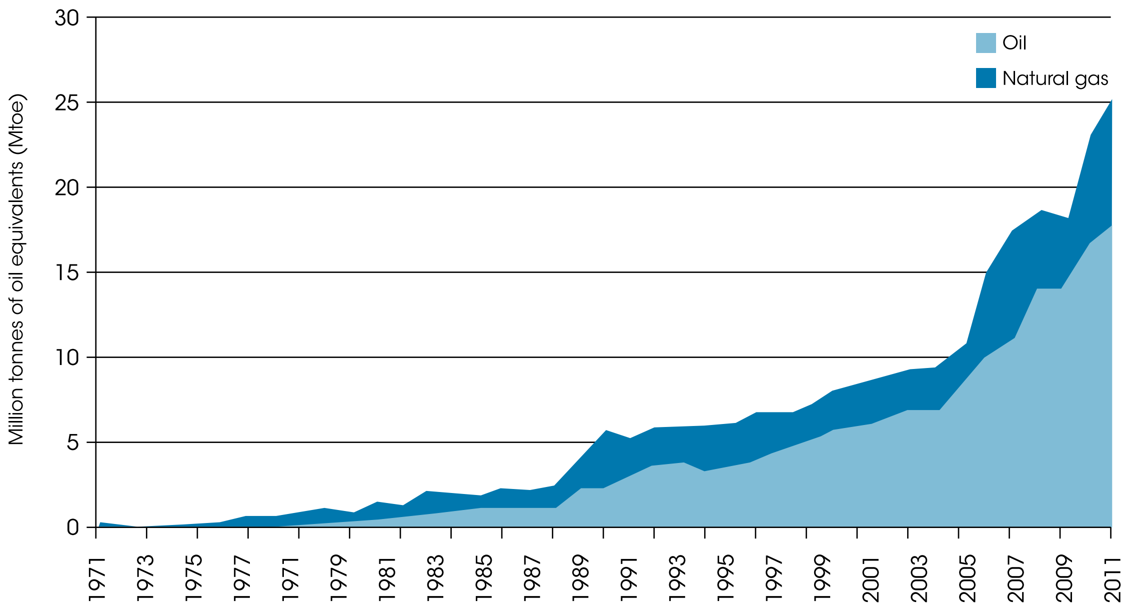
Domestic oil consumption has almost doubled over the past decade from 52 000 oil barrels per day (bbl/d) in 2000 to 98 000 bbl/d in 2011, due to an increased industrialisation processes and an expanding petrochemical sector together with a rapidly increasing vehicle fleet. Oil use in electricity generation is limited mainly to rural off-grid power generation plants and temporary peaking units. Main exports markets for crude and oil products are in Asia, primarily China, Thailand, South Korea and Japan.

The economic development of Oman has over the last three decades been driven by natural gas and oil. Natural gas will continue to have an important role in the economy, with exports in 2012 accounting for 38% of production. Liquefied Natural Gas (LNG) exports started in 2000 and were intended to play a critical role in diversifying the Sultanate's economy away from oil. Although natural gas exports have a low employment impact, they resulted in a number of beneficial opportunities for the deprived parts of the country. In 2012, revenues from natural gas exports were in excess of USD 4 billion (Oman LNG, 2012).

Domestic gas supplies are primarily used for electricity generation, desalination, industry and use within the oil & gas sector; particularly for enhanced oil recovery (EOR). The structure of domestic gas use changed considerably from 2000 and 2011; while the electricity sector's share remained fairly constant at around 19%, gas use by industrial areas and projects increased from 27% in 2000 to 58% in 2011. Gas use at oil fields, flared gas and other uses accounted for 22% of total gas use in 2011, significantly less than the 54% share in 2000 (see Panel C in Figure 4).

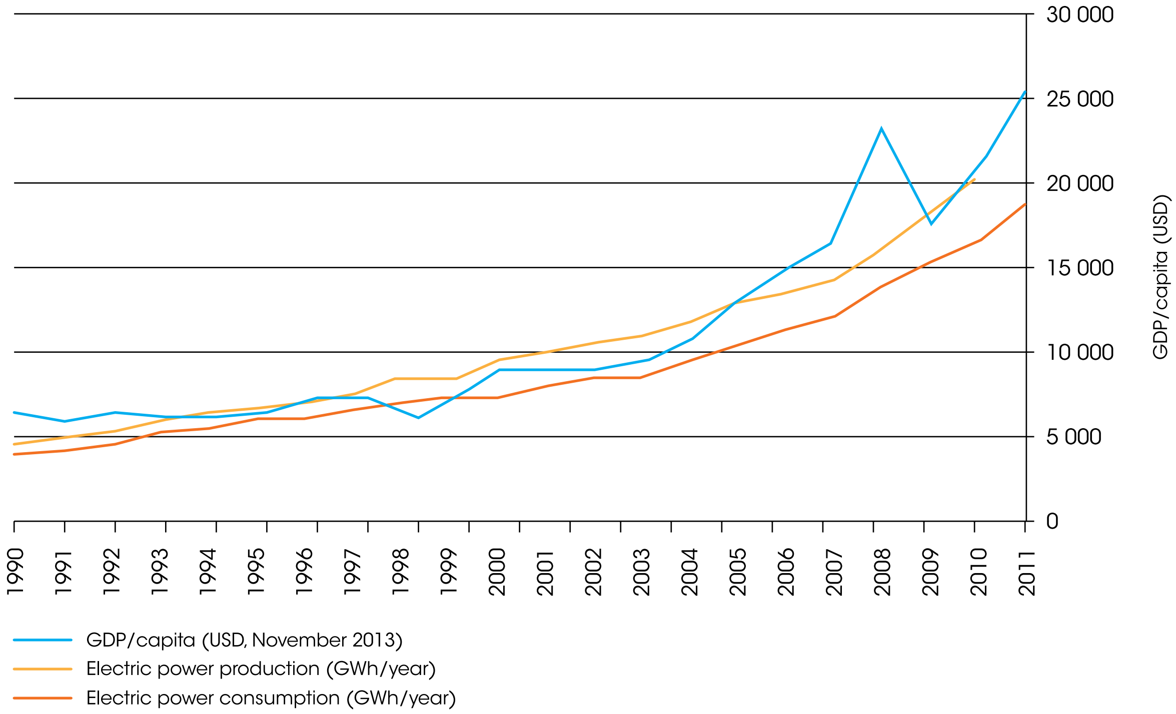
Electricity use in Oman has grown closely in line with GDP, see Figure 3. As shown in Panel D of Figure 4, 97.5% of electricity production in 2011 was from natural gas, with diesel generation accounting for just 2.5% of total electricity production (US Energy Information Administration (EIA), 2012).

Figure 2: Total primary energy supply for Oman



Source: International Energy Agency (IEA) 2013

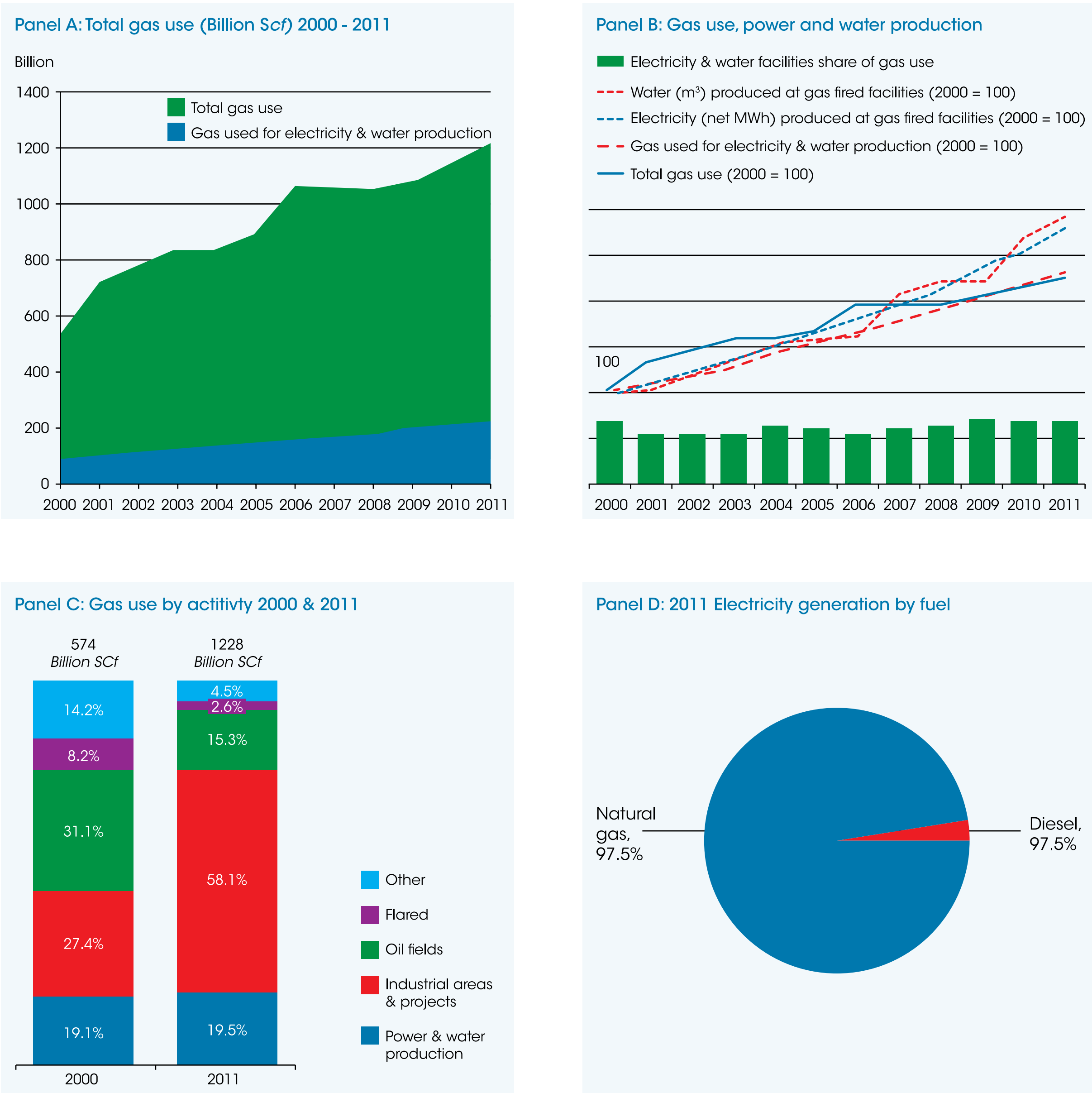
Figure 3: Relationship between GDP, electricity production and consumption for Oman



Source: World Bank, 2013

Oman has seen significant improvements in the efficiencies of gas based power generation. As indicated in Panel A in Figure 4, natural gas produced 7.2 terawatt-hour (TWh) of electricity and 52 million cubic metre (m^3) of desalinated water in 2000 accounting for 19% of total Oman gas use. Between 2000 and 2011 electricity and desalinated water production increased by 180% and 190%, respectively, whereas total gas use increased by only 124%, see Panel B, Figure 4.

Figure 4: Analysis of natural gas use in Oman: 2000 - 2011



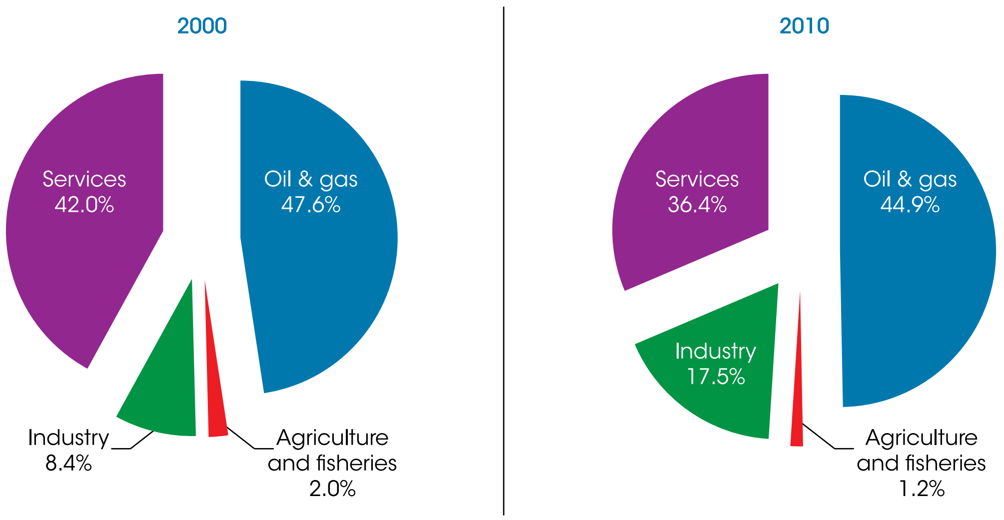
Source: Authority for Electricity Regulation (AER), 2011

ENERGY IN THE SOCIO-ECONOMIC CONTEXT

Oman's economic policy is formulated in the context of 5 year planning cycles for short-term policies and 25 year cycles for long-term policies. The first long-term policy plan (1970-1995) aimed at exploiting oil and gas resources, planned high levels of government expenditure and investment, and the employment of a large number of expatriates to provide a skill base. The government's second long-term economic policy plan (1996-2020) aims at consolidating the gains from the first policy plan and sustain growth by focusing on the development of local human resources to reduce dependence on foreign manpower. The plan also promotes the active involvement of the private sector, optimal utilisation of natural resources, the development of new industries and expanded downstream oil operations, such as petrochemicals, in order to reduce the country's economic dependence on crude oil exports and to create jobs.

With the objective of integrating with the international economy Oman became a full-fledged member of the World Trade Organisation in 2000. Also, as a founding-member of the GCC, Oman is leading progress towards implementation of the Common Market initiative launched in 2008 and is playing an active role in the formation of the Greater Arab Free Trade Area of the Arab League.

Figure 5: GDP shares per sector in 2000 and 2010.



There has been some progress in moving away from an oil-based economy to one that is more diversified (Figure 5). Oil and gas's share of GDP remained almost constant between 2000 and 2013, but, industries share of GDP more than doubled, from 8% to about 18% over the same period. However, the oil and gas sector continues to dominate Oman's economy.

Enhanced oil recovery has reversed the decline in oil production, resulting in a 30% increase since 2007

THE OIL SECTOR

Oman has total proven reserves of 5.5 billion barrels of oil, see Figure 6 for a comparison with other countries in the Gulf (Authority for Electricity Regulation (AER), 2008). Oman's oil reserves are mainly in the north and central onshore areas and are composed of many separate clusters of smaller fields. Oman oil is highly viscous and only a fraction of the reserves are recoverable using traditional production methods. The geology results in production costs being some of the highest in the region.

Oman has implemented an extensive programme that deploys sophisticated methods of EOR has and succeeded in reversing the decline in crude oil production. Since 2007, Oman's crude oil production has increased by almost 30% reaching 920 000 bbl/d in 2012 (IEA, 2013). EOR makes it possible to extract more of the reserves from the ground, mainly by steam injection, which requires natural gas. Natural gas use for EOR amounts to almost 20% of total domestic gas use in the Sultanate. Although, the country's solar energy resources offer a technical potential for replacing an important part of this gas.

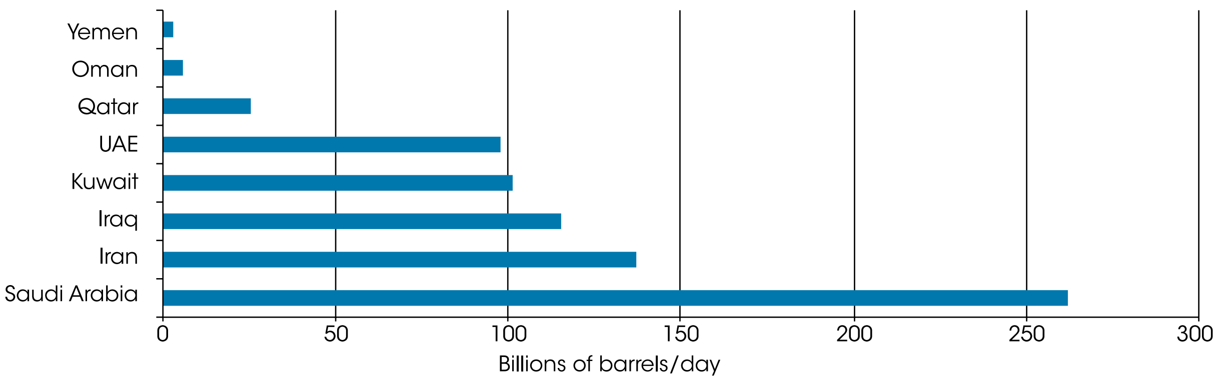
Oman consumes currently about 15% of its oil production (IEA, 2012). The refineries are primarily used to meet internal requirements for refined oil products that previously were imported. In 2010, Oman had a refining capacity of 222 000 bbl/day (EIA, 2012) split between two refineries. Oman plans a new large refinery and petrochemical complex at Duqm in southern Oman, which will be geared to supply the export markets.

THE NATURAL GAS SECTOR

Oman has significant reserves of natural gas and it is a leading regional exporter of LNG. Proven gas reserves amount to 30 trillion cubic feet (Tcf) as of January 1, 2011. Figure 7, illustrates the top Middle East natural gas exporters in 2010; Oman produced a total of 937 billion cubic feet (Bcf) of natural gas in 2011.

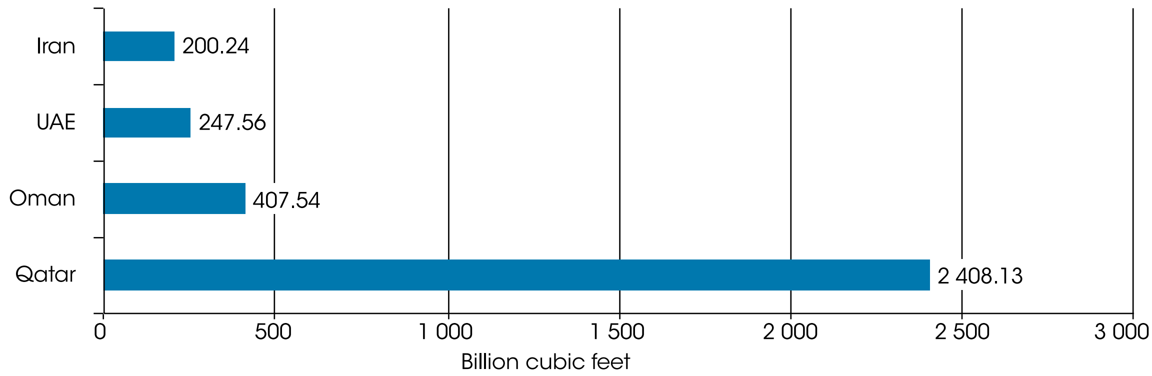
Natural gas exports started much later than oil exports. The Oman LNG Company was formed in 1994. Two gas liquefaction trains at Sur were commissioned in 2000. A third liquefaction train was added in 2006. LNG has contributed to the diversification of Oman's economy and has reduced the dependency on oil. The LNG sector is the second major income source and contributes 12%-15% to Oman's GDP. The LNG plant is connected with the gas gathering plant at Saih Rowl part of the central Oman gas field complex through a 360 km long pipeline with a capacity of 424 Bcf/year. Major long-term overseas buyers of Oman LNG are Korea Gas Corporation, Osaka Gas and Itochu Corporation, both of Japan (Oman LNG, 2012).

Figure 6: Proven oil reserves of Oman in comparison to other Middle East countries



Source: EIA, 2012

Figure 7: Top Middle East natural gas exporters, 2010



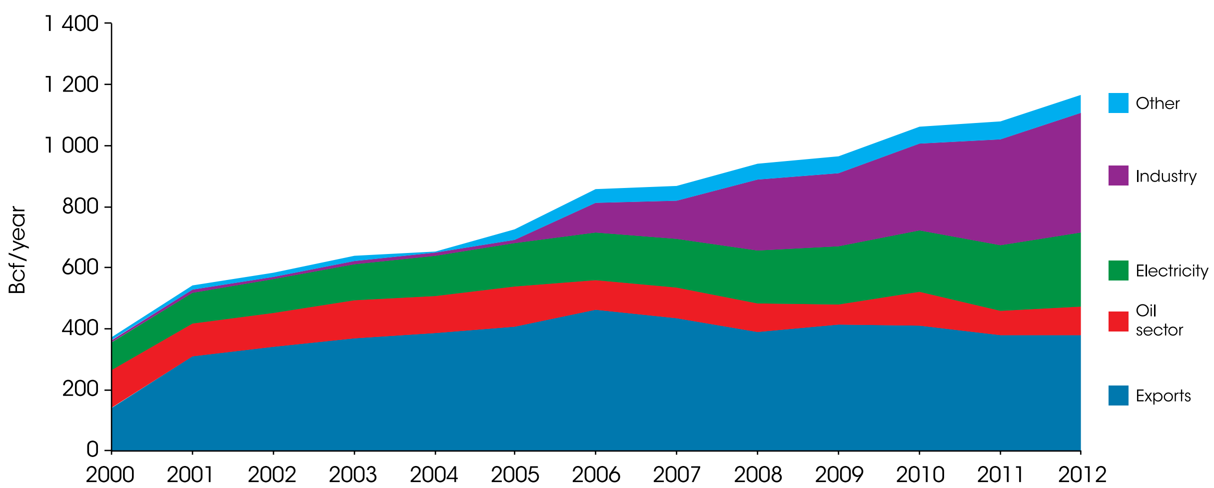
Source: IEA, 2012

Natural gas consumption rose more than 200% between 2000 and 2012

Within Oman, natural gas is primarily used for industry, electricity generation, water desalination and EOR. Domestic consumption tripled from 2000 to 2012 (Figure 8). Whereas total exports and gas use in EOR has declined slightly, since 2006 there have been continued increases in gas use for electricity generation and in industry. Economic growth and an increasing population are driving the growth in the use of electricity generated primarily by gas. The increase in industrial gas use is largely attributable to the economic diversification policy favouring large scale industrial gas use.

In recent years, the demand for natural gas for local consumption and exports has outpaced supply. Oman imports relatively small volumes of natural gas from Qatar, via the UAE, through the Dolphin Pipeline. The Dolphin Pipeline is currently Oman's only means for importing natural gas, providing approximately 200 million cubic feet per day (Mcf/d). Despite of facing a gas shortage and increasing domestic demand, Oman exported in 2012 34% of its gas production because of long-term contracts, the first of which expires in 2020. The government is recognising that in the future, it may face constraints in meeting gas demand and has initiated the development of new gas fields and is also considering new gas import options, such as from Iran.

Figure 8: Oman natural gas use, only dry gas, 2000 - 2012



Source: IEA, 2013

THE ELECTRICITY SECTOR

The electricity sector in Oman is primarily based on natural gas; 97.5% of the installed electricity capacity is fuelled by natural gas and the remaining 2.5% by diesel.

During the last decade, sustained economic growth, population growth and the expansion of heavy industry in cities such as Sohar and Salalah, have in combination with low electricity prices put a strain on Oman's power infrastructure. Oman is subject to harsh summer weather conditions, which results in a dramatic peak loads, occasionally resulting in power cuts. In the summers of 2009 and 2010, the country witnessed several power cuts in particular in the most heavily populated areas of the Sultanate, reflecting its difficulties in bringing sufficient production capacity to the grid in line with the growth in demand.

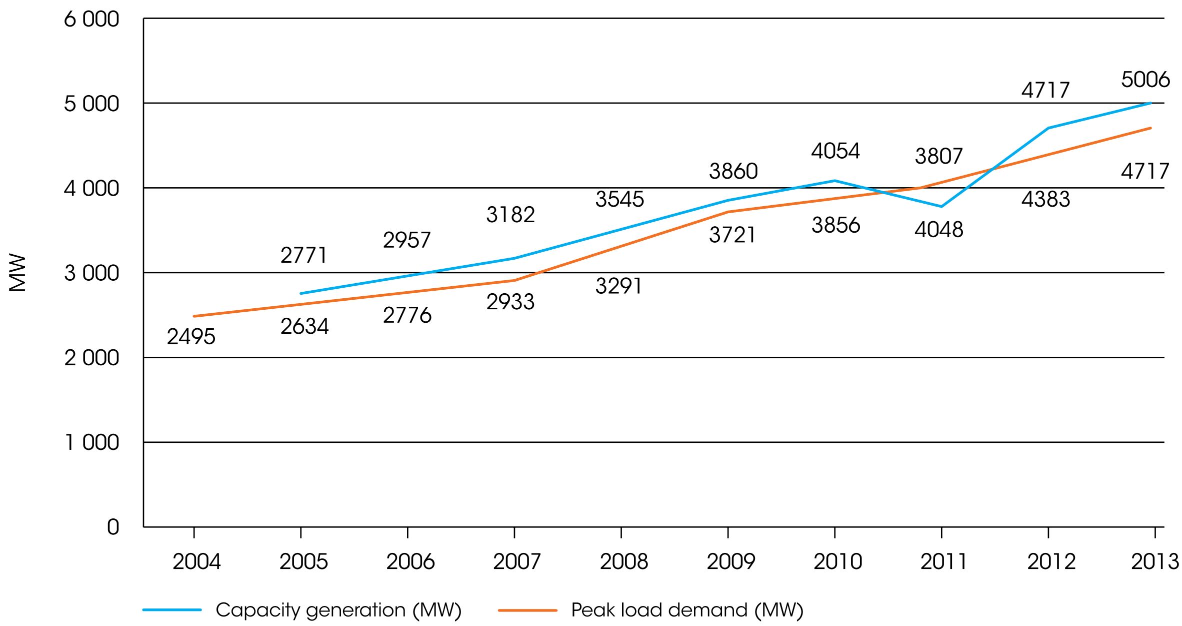
OVERALL DEMAND AND SUPPLY

Continued growth in electricity demand requires building new power plants. So far all of the decided and mid-term prospective power plant additions are gas-based. Hence, there is an open window for investing in renewable electricity generation, as well as exploiting the potential for end-user renewable energy appliances, reducing the demand for electricity such as air conditioning by absorption.[1] Renewable energy would contribute to easing the constraints on gas supplies, free more gas for possible exports, increase the skills base in Oman, and create new employment opportunities.

Power demand reflects the climate in Oman and is highly dependent on the seasonal weather variations. Power peak demand is in the summer, typically recorded in June- July is coincident with highest summer temperatures and is usually more than double the average winter demand primarily due to the intensive use of air-conditioning. According to Oman Power and Water Procurement Company (OPWP), the single buyer of electricity and water in Oman, peak power demand reached 4.7 gigawatt (GW) in 2013, representing an 89% increase compared to 2004, see the figure 9.

1 Air conditioning by absorption is in particular suited for use in spaces with high day cooling needs.

Figure 9: Electricity capacity and peak load in Oman, 2004 - 2013



Source: OPWP, 2014

ELECTRICITY GRID NETWORKS

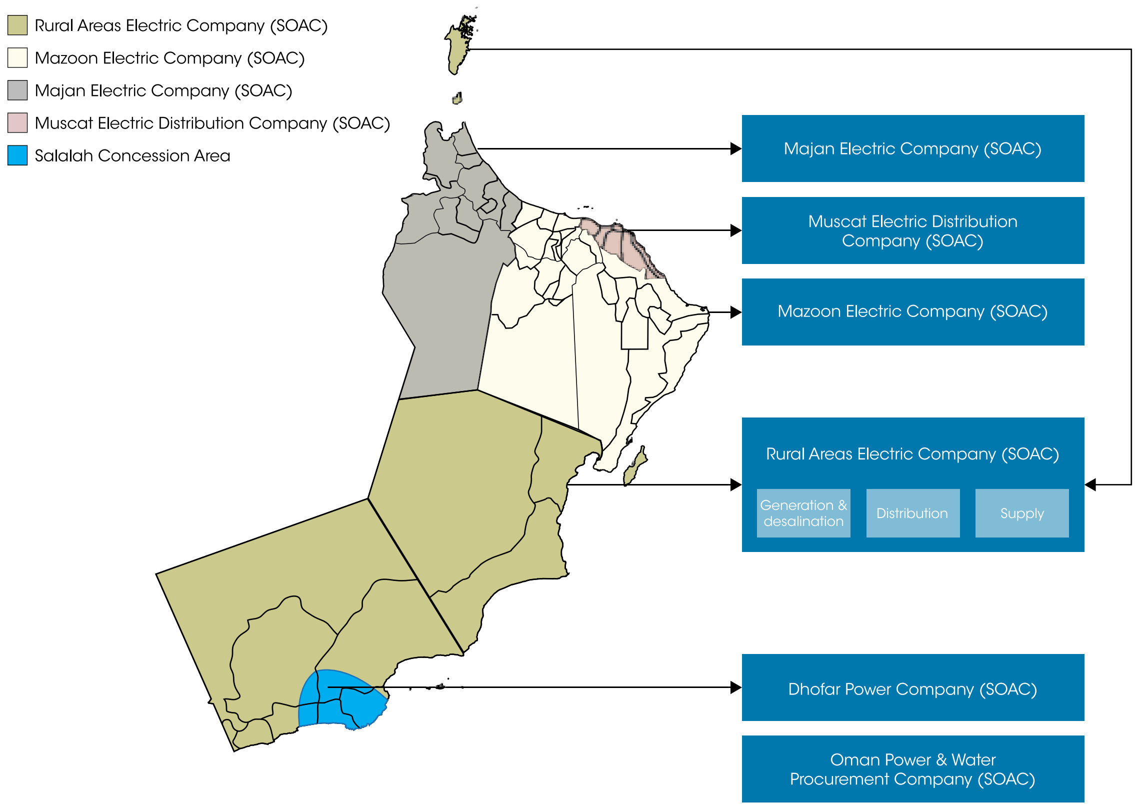
Oman does not have an interconnected national grid; rather the electricity grid comprises the Main Interconnected System (MIS) in the north and the Salalah power system in the south. The government plans a future interconnection of the two systems. The service areas of the key companies are shown in Figure 10.

MIS is the main electrical network Oman, covering the majority of the population (around 0.6 million electricity customers). It covers the Governorates of Muscat, North Al-Batinah, South Al-Batinah, Al-Dhahirah, Al-Buraimi, Al-Dakhliyah, North Al-Sharquiya and South Al-Sharquiya. Oman Electricity Transmission Company (OETC) is the owner of the MIS grid and is licensed to undertake all regulated activities of electricity transmission and dispatch in northern Oman (Rural Areas Electricity Company (RAECO), 2011).

The existing MIS transmission has two operating voltages, 220 kilovolts (kV) and 132 kV and with the commissioning of the 2 000 megawatts (MW) Sur power plant in 2014, MIS will operate at 400 kV as well. It extends across the whole of northern Oman and interconnects bulk consumers and generators of electricity. There are three distribution companies connected to the MIS: Muscat Electricity Distribution Company, Mazoon Electricity Company and Majan Electricity Company.

MIS is interconnected with the transmission system of UAE (Abu Dhabi Transco) at 220 kV from the Al Wasit grid station in Mahadah. Through this interconnection it forms part of the GCC Grid providing increased security of supply and cost savings from the sharing of reserve capacity and energy resources.

Figure 10: Oman power system companies and areas



Source: Al-Badi, Malik and Gastli, 2011

The OETC transmission system is also interconnected at Nizwa through the transmission network of Petroleum Development Oman (PDO) via a single 132 kV overhead line, whose present exchange capacity is limited to 60 MW for security reasons. It is connected to Salalah system through the PDO network.

The Salalah power system covers Salalah and adjacent areas in southern Oman (Dofhar governorate) and serves around 70 000 customers. The overall system is owned by Dhofar Power Co. (DPC). The system is interconnected with the PDO system via 132 kV link between Thumrait and Harweel, whose power exchange is presently limited to 40 MW. The generation capacity of the Salalah system is 718 MW.

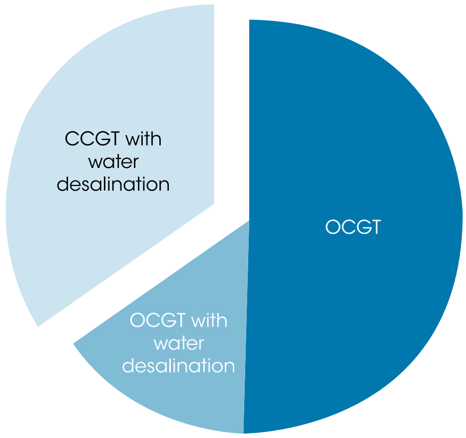
In the other more rural parts of the country, the electricity is supplied in relatively small isolated distribution systems built up around local diesel engine plants.

MAIN POWER PLANT CHARACTERISTICS

MIS and Salalah

In both the MIS and Salalah systems the majority of the installed capacity is open cycle gas turbines (OCGT), most of them being configured to run without desalinating seawater, see Figure 11. The more energy efficient, but equally more expensive, combined cycle gas turbines (CCGT) have in the past been designed for combined electricity production and water desalination. Most of the desalination plants in the MIS area are combined with electricity production, whereas Salalah's water supplies are from stand-alone plant. Electricity capacity additions in MIS, decided during 2013 and 2014, are to be commissioned as CCGT plants without being combined with water desalination.

Figure 11: MIS and Salalah main generation technology



Source: OPWP, 2012

Rural areas

The rural areas of Oman are supplied with electrical power by diesel generators. RAECO is responsible for generating, transmitting and distributing power in rural areas. As of 2013, the rural system has 41 diesel plants in operation. They supply separate mini-grid networks over a wide area of the Sultanate of Oman. RAECO is responsible for electrification of rural areas and is funded through a special mechanism provided for by the sector's law. Water supplies to the rural areas are from wells supplemented by a number of relatively small desalination plants run on locally produced electricity.

The PDO network

PDO, the main oil and gas exploration, and production company in Oman owns and operates a dedicated power system of around 1.2 GW capacity. This system is interconnected with the MIS and Salalah systems, providing reliability benefits through the sharing of generation reserves between them.

Industrial power production

In addition to the power plants supplying the public networks, large energy intensive industries have their own power plants supplying their own needs. Several of these captive power plants are connected to the MIS, including from industries, such as Oman Mining Company, Oman Cement Company, Sohar Refinery, Sohar Aluminium Company (SAC), Occidental of Oman, etc. is the most active of these is the 1 000 MW SAC power facility. SAC's demand is only 650 MW during summer months and SAC delivers up to 300 MW to the grid, while during winter months the grid delivers a similar amount of energy to SAC.

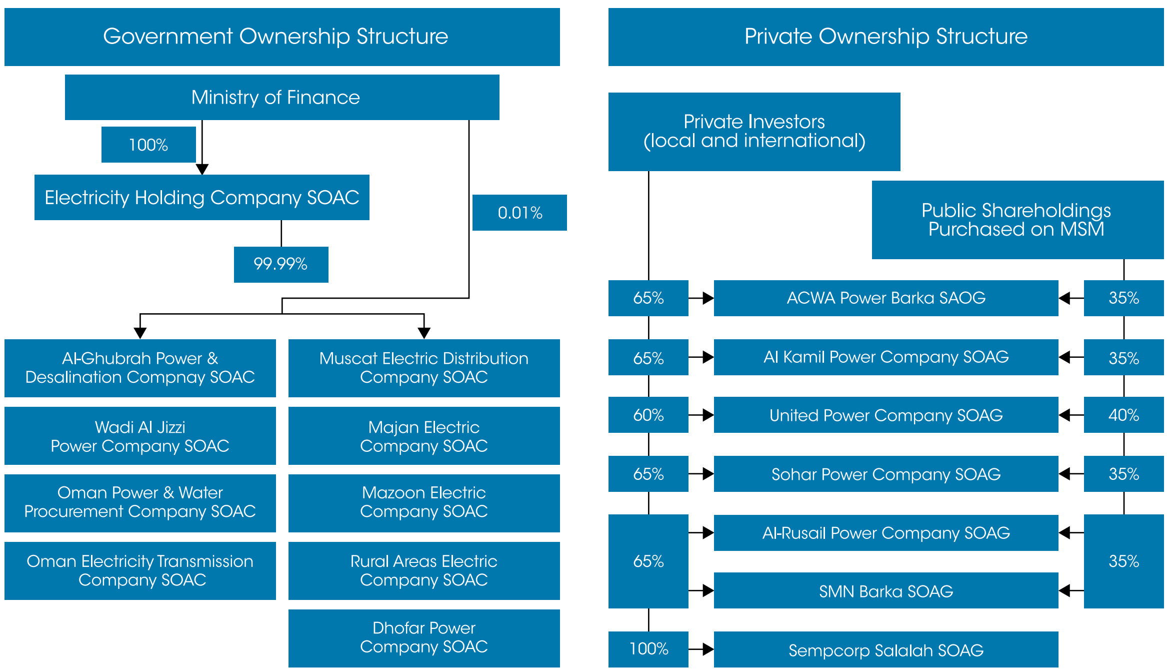
POWER-SECTOR INSTITUTIONS

Over the years, Oman has shifted from a centralised power-sector management system to be more decentralised, with electricity production opened to private investors. Up until the 1990s, power plants in Oman, as in the whole GCC region, were exclusively financed and operated by governments and were government backed corporations.

Oman pioneered the independent power project model in the Gulf. The Al-Manah power plant, commissioned in 1996, became the first plant to be completely financed, built and operated by a privately owned company. Since then the private sector has played a leading role in the construction of new power and desalination capacity and from 2000 Oman has awarded a total of 10 Power Purchase Agreements (PPAs) and Power and Water Purchase Agreements (PWPAs), as well as the region's first independent water project at Sur. As of May 2012, PPAs had been signed with private developers for just over 7 000 MW of capacity (MEED Insight, 2012).

The success of this initiative eventually led to the creation of a more decentralised power sector. In 2005, the Ministry of National Economy implemented a Transfer Scheme whereby the electricity and related water assets, liabilities and staff of the Ministry of Housing, Electricity and Water were transferred to the successor companies as shown in Figure 12. With the exception of the Electricity Holding Company, the successor companies are now responsible for most of the electricity functions previously undertaken.

Figure 12: Electricity and related water ownership, 2011



The electricity sector now comprises a mix of government and privately owned companies. The Electricity Holding Company holds the government's majority interest in the successor companies, and is itself 100% owned by the Ministry of Finance. As of now, the Ministry of Finance and the Electricity Holding Company hold 0.01% and 99.99%, respectively, of the shares of the successor companies.

The Public Authority for Electricity and Water (PAEW) is a governmental institution supervised by the State Audit Committee. The Authority has its own juridical personality, in addition to financial and administrative independence. As well as being the water utility serving most of the population, its key role is to secure production of potable water not related to electricity production. PAEW also implements the government's electricity and water supply policy. It encourages the private sector to invest in both the water and electricity sectors.

The OPWP is a wholesaler of electricity and water (produced in combination with electricity). It purchases electricity and water under PPAs and PWPAs and provides bulk supplies of electricity to the Muscat, Majan and Mazoon distribution companies, and bulk supplies of desalinated water to Water Departments (OPWP, 2012). OPWP is responsible for the long term generation planning and publishes seven year statements. These statements identify new Independent power producer/ independent power and water producer projects to be tendered to private sector development in order to meet the future power generation and water desalination requirements. A brief description of the water sector is provided in the box below.

AER was established by the "Sector Law".[2] According to the law the key duties of the AER are to:

- promote competition;
- ensure safe, efficient and economic operation of the electricity sector;
- protect the interests of the end-users, in particular the poorer members of the population;
- secure compliance with government policy, especially in relation to environmental protection, the number of local Omani staff employed and Omani Content;ensure that the licensees are financially and technically capable;
- ensure transparency in tenders for new capacity issued by OPWP; and
- assist the privatisation of the electricity and related water sector in Oman and review the scope for further liberalisation.

2 A Law for this sector was promulgated by Royal Decree 78/2004 on 1 August 2004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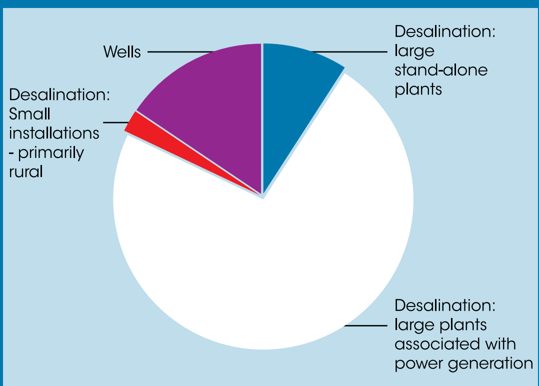
OMAN'S WATER SECTOR

With its limited water resources, Oman is, like other GCC countries, highly dependent on large- scale desalination for its water supplies. Currently sea water is desalinated in seven large plants, of which five are combined power and desalination plants, and the remaining two are stand-alone plants only producing water. The large plants supply urban and industrial regions. Rural areas are served by more than 30 small desalination plants, which serve isolated areas and only account for 2.5% of total water supplies in the Sultanate (see the Water Supply Sources figure in PAEW, 2012).

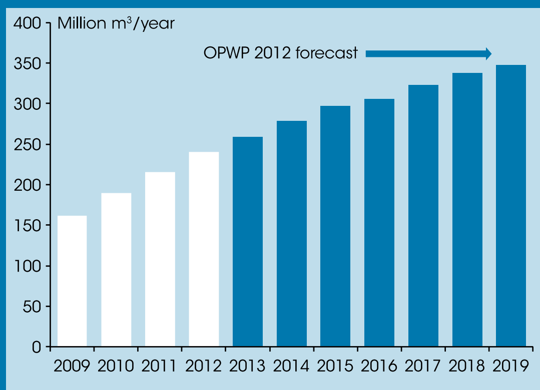
Water supplied from wells is declining, with a reduced role in the total supply of water. In 2012, wells only contributed about 15% to total supply and this is primarily reserved for irrigation.

In recent years total water demand has grown at a rate of 10% per year. Future demand for water is expected to grow at a slower rate. According to OPWP's forecast, water demand will grow with 8% per year over the 2013 to 2019 period. All of this growth will be met by new desalination plants.

Water supply sources



Water production, actual and forecast



CCGT plants associated with desalination provide heat to the water production. Co-generated heat and electricity entails an energy efficiency gain of about 20% compared to separate heat and electricity production (Othman, 2013). All of the desalination plants in Oman associated with power plants are Multi Stage Flash (MSF) processes, *i.e.*, seawater is distilled under pressure in several stages. Energy for this process is first of all heat supplemented with electricity for pumping.

Other thermal processes include Multi Effect Distillation (MED) and Thermal Vapour Compression (TVC), which have lower energy requirements than the MFS because they avoid recycling the water. MED and TVC have become the leading technologies in new thermal installations in the Gulf region.

Another technology, the reverse osmosis, is applied in all other installations operating in Oman. Reverse osmosis plants separate the sea salt by pumping sea water through a series of membranes. Energy for this process is exclusively electricity. Other non-thermal technologies are Electro Dialysis (ED) and Mechanical Vapour Compression. ED separates the salt by ionisation of the water and mechanical vapour compression uses electrical power to compress vapour to condensate.

REGIONAL INITIATIVES

ELECTRIC GRID INTERCONNECTION PROJECT

The GCC Interconnection Authority (GCCIA) has been created to pave the way for economic and technical optimisation of the interconnected member states' power systems (Al-Ebrahim, Al-Shahrani and Tabors, 2012): The strategic objectives of the Authority are:

1. Interconnection of the networks for power exchanges in emergency situations;

2. Reduce the national generation reserves;

3. Improve the economic efficiency of the electricity power systems;

4. Promote power exchanges between the member states to gain economically and strengthen the supply reliability;

5. Interact with electricity companies and authorities in charge of the sector in the member states and elsewhere to coordinate and strengthen the operational efficiency;

6. Monitor international technology developments in the field of electricity with a view to applying the best available technologies.

The interconnection project was composed of several phases: Phase I involved the interconnection of Kuwait, Saudi Arabia, Bahrain and Qatar (the Northern System); Phase II the interconnection of UAE and Oman (the Southern Systems); and Phase III interconnection of the Northern and Southern Systems. All three phases are completed and the interconnected grid system is fully operational. The connection between Oman and UAE is through a 220 kV line and currently a maximum of 200 MW of power can be exchanged between the two countries.

ELECTRICITY TRADE

The GCC countries have approved a Power Exchange and Trade Agreement that sets the basic rules and mechanisms for facilitating and regulating power trade between GCC countries through the Interconnector. The GCC countries are well positioned to diversify their energy sources and consumption patterns and there is government backing for an efficient utilisation of the interconnected grids through an appropriate power market arrangement.

The commissioning of the GCC Interconnection comes at a time when the electricity supply industry in the countries is rapidly transforming. The current dynamic transformation of GCC utilities combined with the long-awaited GCC Interconnection project open for a transformation of the electric industry in the region, particularly the creation of competitive electricity markets in the Middle East (Al-Ebrahim, Al-Shahrani and Tabors, 2012).

According to a study commissioned by GCCIA there are a number of issues that will shape the development of the regional electricity market. They include:

- Existing legislation, laws and commercial codes of GCC power sectors;

- Dissimilar market structure in the GCC member states;

- Existing PPAs with IPPs;

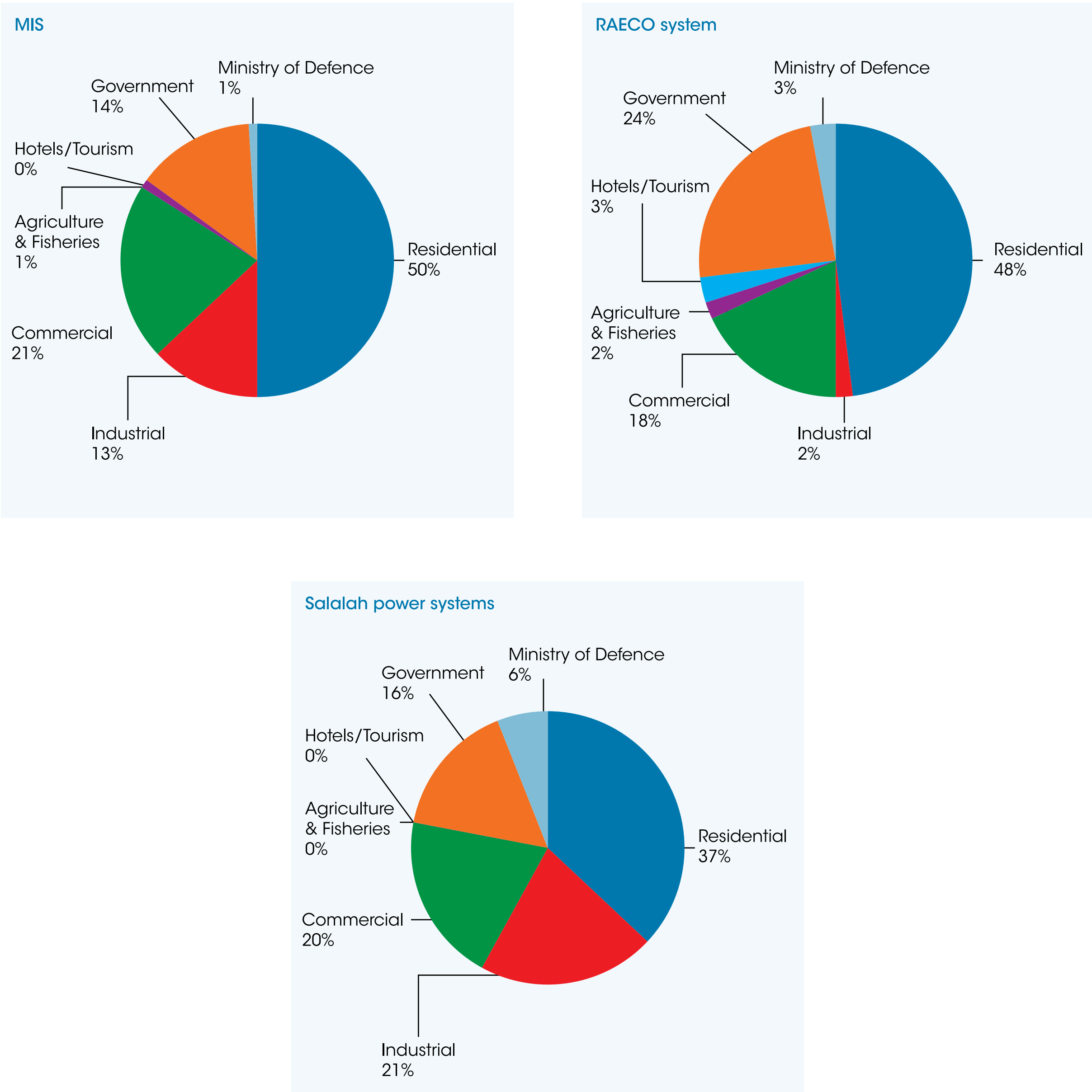
- Transmission system congestion; and

- Cross-border tariffs.

POWER CONSUMPTION

In all three electricity systems, the residential sector is the largest consumer category, see Figure 13. The rural system, RAECO, has by its very nature only a small share of industrial electricity demand compared to the other two systems. MIS has a smaller share of industrial demand than the Salalah system, although the region covered by the MIS is more heavily industrialised than the rest of the country. However, as noted previously the large and energy intensive industries are supplied with electricity from their own captive power plants.

Figure 13: Electricity supply by system and tariff category, 2011

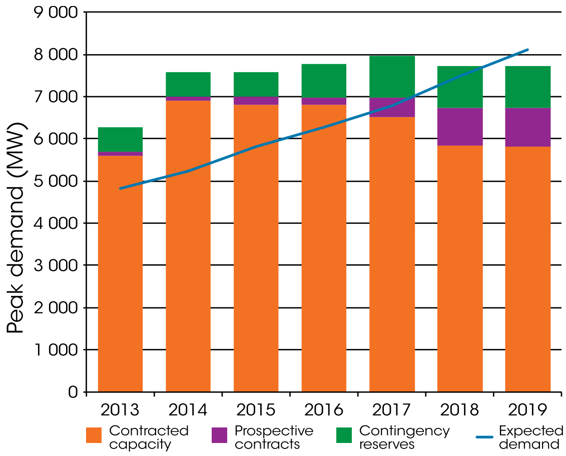


Source: OPWP, 2012

ELECTRICITY DEMAND FORECASTS

OPWP publishes annually a seven years statement with an outlook for electricity and desalinated water demand (both average demand (OPWP, 2014), *i.e.*, energy, and peak demand) for the MIS and Salalah Power System and the capacities required to meet the forecasted demand. These projections are official and are the reference for the electricity sector. They include a Low-case, a High-case and an Expected-demand case. The forecasted expected case is a continuation of the trends observed over the last decade. The main trends in peak demand and generation capacities in the Expected case are shown in Figure 14 for MIS and Figure 15 for the Salalah system.

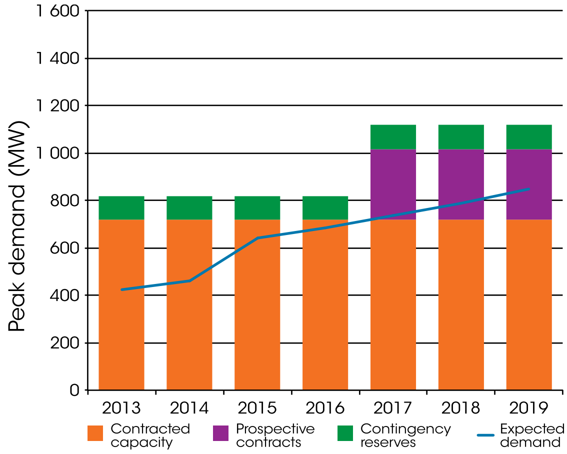
Figure 14: MIS: Exp electricity demand and supply 2013 - 2019



Source: OPWP, 2014

In the Expected case, MIS peak demand is projected to grow at 9% per year to reach 8.1 GW in 2019. Without including the contingency reserves, but including prospective contracts, which all consist of extensions of existing PPAs and PWPAs, the MIS has sufficient capacity to meet demand growth until 2017. According to this forecast new contracts for additional capacity should be signed no later than in 2014 assuming three years of lead time for capacity additions. The Low-case for MIS has a 7% per year growth in peak demand whereas the High-case projects a growth of 11% per year.

Figure 15: Salalah: Exp electricity demand and supply 2013 - 2019



Source: OPWP, 2014

In the Expected case for Salalah, peak demand grows at 12% per year reaching 848 MW in 2019. Without including contingency reserves, but including prospective contracts consisting of a tender for one new plant to be commissioned in 2017, demand is covered to 2019.

The Low-case for Salalah, projects a 7% growth per year in peak demand. The High-case allows for more rapid industrialisation and has peak demand increasing at 14% per year to 2019.

There are no official forecasts published for the rural areas, supplied by RAECO. In the past in this area electricity consumption increased significantly. Annual demand growth from 2008 to 2012 was 16%, which is considerably more than in the MIS and Salalah system. Improved electricity supply coverage has played and will continue to play a role in this area having in most parts a very scattered population. Demand for electricity in the RAECO area will, in addition, increase considerably when the development projects in the Duqm area and Masirah Island take off.

All decided and planned new plant capacities in the MIS and the Salalah system will be gas-fired. Neither nuclear nor coal power are currently considered as options and there are no firm plans for supplementing the expansion of the thermal electricity production capacity with renewable sources apart from relatively small pilot plants. In the rural areas served by RAECO the majority of the plants are diesel engines.

Several small renewable energy projects have been considered by RAECO and the electricity regulator, AER, see Chapter 2, Section 3 for details. Additionally, from 2012 RAECO has been obliged by AER to include an evaluation of potential renewable options when applying for financial support to new electrification projects. If renewable energy is not included as an option RAECO is required to justify the reasons why.

ELECTRICITY PRICES AND SUBSIDIES

Regulated tariffs in the GCC countries for the main service sectors are shown in Figure 16, which also for comparison includes average US electricity prices. Omani retail electricity prices are closed to the industrial sector of Saudi Arabia and are almost doubled compared to other sectors, but still are much lower than in Dubai, Abu Dhabi and Sharjah. Figure 16 shows higher electricity prices in the US than in Oman, but also significant differences in the structure of the tariffs.

In the US, as in other OECD countries, the price paid for electricity by small electricity consumers, such as in the residential sector, is higher than the price paid by the larger electricity users in the commercial sector and industry. Cost-reflective electricity prices normally decline with the size of subscribed capacity and annual consumption. Residential electricity consumers have generally a more "peaky" demand than commercial and industrial users implying higher supply costs in addition to the higher residential distribution costs. Having a lower price for residential users as is the case in Oman is obviously not cost-effective.

Table 1: Electricity tariff to consumers

A: Permitted aariffs for electricity supply

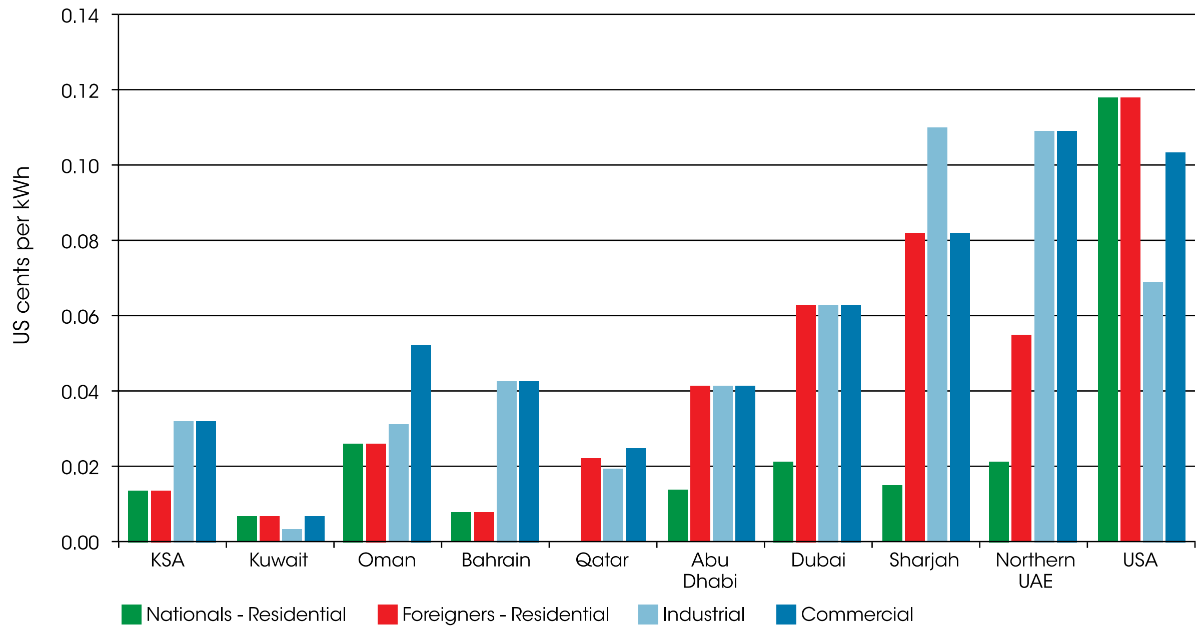
Permitted Tariff Category	Tariff Structure				
Industrial[3]	All Regions except Dhofar			Dhofar Region	
	September to April: 12 Baiza / kWh (Bz / kWh)			August to March: 12 Bz / kWh	
	May to August: 24 Bz / kWh			April to July: 24 Bz / kWh	
Commercial	Flat rate @ 20 Bz / kWh				
Ministry of Defence	Flat rate @ 20 Bz / kWh				
Residential	0-3 000 kWh	3 001-5 000 kWh	5 001-7 000 kWh	7 001-10 000 kWh	above 10 000 kWh
	10 Bz / kWh	15 Bz / kWh	20 Bz / kWh	25 Bz / kWh	30 Bz / kWh
Government	0-3 000 kWh	3 001-5 000 kWh	5 001-7 000 kWh	7 001-10 000 kWh	above 10 000 kWh
	10 Bz / kWh	15 Bz / kWh	20 Bz / kWh	25 Bz / kWh	30 Bz / kWh
Agriculture and Fisheries	0-7 000 kWh			7 001 kWh & above	
	10 Bz / kWh			20 Bz / kWh	
Tourism[4]	0-3 000 kWh	3 001-5 000 kWh	5 001-7 000 kWh	above 7 001 kWh	
	10 Bz / kWh	15 Bz / kWh	20 Bz / kWh	20 Bz / kWh	

B: Permitted tariffs fees for disconnection and reconnection of accounts

Disconnection fee (all types of metered accounts): 7.500 Rial Omani (OMR);
Reconnection fee (all types of metered accounts): OMR 7.500;

Where: kWh - kilowatt-hour OMR 1= 1000 Baiza (Bz); OMR 1 = USD 2.6, (September, 2014)
3 Customers require written confirmation from MOCI of eligibility for this tariff and must maintain a power factor of at least 0.9
4 Subject to Ministry of Tourism regulations and approval.

Figure 16: Electricity prices by sector in the GCC and the US in 2011



Source: Hertog, 2013

ELECTRICITY SUBSIDIES

Electricity prices for the end-users in Oman are identical in all parts of the country, are politically decided, and are heavily subsidised.

The so-called financial subsidies granted by the Ministry of Finance bridges the gap between the costs of producing and supplying electricity and established electricity tariffs. These financial subsidies are paid by the government directly to the licensed suppliers in the electricity sector on an annual basis. Government financial support is also granted to electrification projects in rural areas. The financial subsidies promote the use of electricity by keeping consumer electricity prices significantly below the costs of production, transmission and distribution.

In addition to these direct financial subsidies there are in Oman substantial indirect subsidies to electricity production, by way of the political decision to have low prices on natural gas and diesel fuel used in electricity generation.

Financial Subsidy

The average level of financial subsidisation varies considerably between the three systems, MIS, Salalah, and the RAECO reflecting the differences in the costs of producing and supplying electricity between the systems.

In both the MIS and Salalah systems most of the electricity production is contracted with investors by PPAs or PWPAs and these agreements cover in principle the costs of electricity generation.

The financial subsidies involve substantial amounts, see Table 2. The principle of identical electricity tariffs across the Sultanate results in relatively high financial subsidy being paid to Salalah and in particular to RAECO. The Salalah system requires a higher financial subsidy than MIS because Salalah serves a less densely populated area and also because Salalah has a quite important surplus production capacity compared to MIS.

Table 2: Financial subsidies for electricity

Subsidy	Bz/kWh	USD/MWh	USD Million	% share of total subsidy	% share of electricity market	% of electricity price
MIS	10.0	26.0	479.6	66.8%	88.4%	39.2%
Salalah system	25.4	66.0	113.7	15.8%	9.1%	52.7%
RAECO	81.1	210.6	125.2	17.4%	2.6%	79.0%
Total/ Average	13.3	34.6	718.5	100.0%	100.0%	41.5%

Source: AER, 2012

In 2012, the average subsidy amounted to almost 42% of the overall costs of producing and supplying electricity and the subsidy involves substantial costs to the government. In the rural areas the subsidy is on average almost 80% of the costs, whereas it is lower in both Salalah and in particular in the MIS. However, given that MIS with its 88% of total public electricity supply has the highest share in the total electricity market, the MIS companies account for 67% of the total financial subsidy.

Per kWh the subsidy is the highest in rural areas. RAECO is relying on supplies from plants operating as “island” systems primarily fuelled by diesel, which in itself is an expensive energy input to electricity generation. In fact, the financial subsidy to electricity in the rural areas is higher than the projected generation costs of solar PV, see the discussion in Chapter 2, Section 5.

In addition to the direct financial subsidy from the Ministry of Finance consumers also benefit from indirect subsidy: the price for the fuel sold to electricity generation is below the opportunity cost, which is the netback price of the fuel in the international market. Foregoing opportunities to export domestically produced natural gas and diesel imposes real costs on the Omani society. Failing to include these opportunity costs understates the true level of the subsidies provided to consumers. The AER, since 2012, has been publishing numbers for the electricity subsidy on two bases: one for the financial subsidy, another adjusting fuel prices to reflect their opportunity costs. Previously the AER only published data for the financial subsidies and the new methodology provides a transparent picture of the substantial economic subsidies granted to the electricity users.

Indirect Price Subsidy – the case of gas

Over 99% of electricity produced by the MIS and the Salalah Power Systems is produced at gas-fired power plants. The price of gas to the power and water desalination sector is fixed by the Government. Currently the price is USD 1.5 per million British thermal units (mmBtu) for gas delivered at the plant. Although the Omani gas price for electricity generation is higher than the average of the GCC countries, it is still very low by international standards.

Low gas prices for domestic uses in the Sultanate have been a key policy instrument in the promotion of economic growth and diversification. Not only is gas sold at low prices to key sectors, such as electricity generation and water desalination, but energy intensive industries also benefit. These include industries important to the construction sector, such as cement, steel, and aluminium, and large scale production of base chemicals primarily destined for the export markets such as urea and methanol. Omani gas policies have focused on investing in an extended gas grid, selling gas domestically at advantageous prices and investing in an important LNG export capacity. Gas policy has succeeded in promoting an industrial development in gas intensive activities, which again has triggered activity and employment in other much unrelated sectors.

For the electricity sector the gas price subsidy is the difference between the politically decided domestic gas price for electricity generation and the opportunity value of the gas, *i.e.*, the value which could be obtained if gas was redirected from electricity generation to an alternative use having a higher value than in electricity generation. Currently the highest value is the one obtained in LNG exports.

Exporting to neighbouring countries is not an attractive option for Oman despite the inherently low transportation costs. Qatari gas is much better placed for supplying this market having larger reserves and lower gas production costs than Oman.

Prices on the international LNG markets are attractive despite the price volatility and the opportunity value for supplies to the electricity sector – as to other domestic sectors – is the net-back value of LNG, *i.e.*, the sales price of LNG in the foreign market minus costs of transportation and liquefaction costs.

Since starting the LNG exports, Oman has sold practically its entire LNG production on long-term contracts to customers in Spain, Japan, and South Korea. Prices in long-term LNG contracts are traditionally partly linked to the price of crude or oil product prices, but the regular re-negotiations of these long-term contracts have often changed the relation between LNG prices and oil prices, partly by de-coupling the LNG prices from oil prices, see Figure 17.

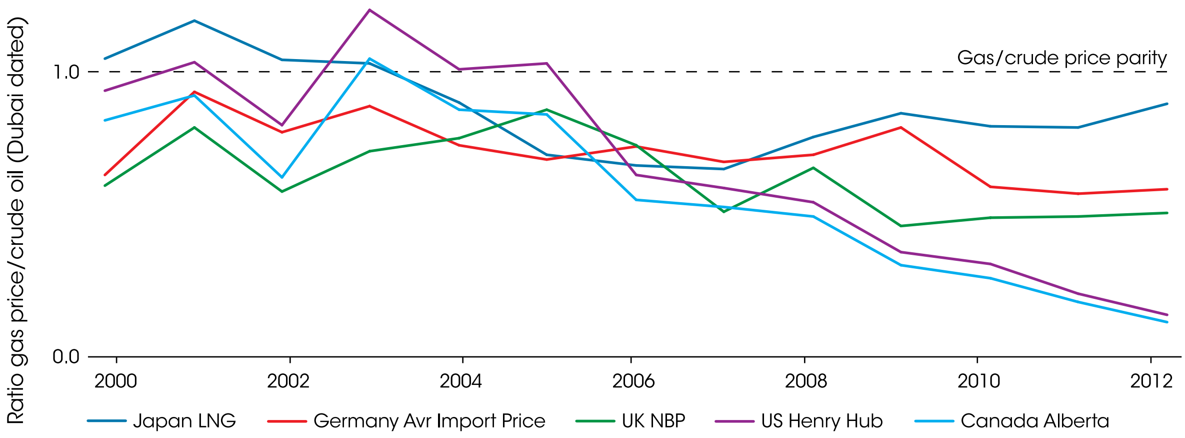
LNG prices have to some extent, but not fully, followed the trend observed in the main markets for pipeline gas. North American gas prices have fallen to historically low levels in the wake of the boom in shale gas production. In Europe gas prices have been under pressure as illustrated by the UK market price (National Balancing Point (NBP) (virtual trading point for UK gas)) and the average German gas import price, where the latter is all pipeline gas, in both cases prices have fallen. Pressure on European gas prices was originally triggered by national and EU wide market liberalisation and has in recent years increased due to a number of factors of various strengths: slow economic growth, industrial recession in several countries, spill-over from the low prices in the North American gas market, low electricity prices, and low international coal prices. As a result wholesale and import prices are increasingly being determined in market places instead of by oil prices in long-term contracts.

The result of this multitude of changes has been the emergence of important and persistent price differentials between the main World gas markets, see Figure 18. Natural gas markets are by their very nature regional. There is no market integration securing a worldwide natural gas price. High transportation costs, strong variations in production costs, and long distances between markets are all barriers to market integration and price alignment. Also national energy and regulatory policies contribute to splitting the markets.

Since 2008, Asia has become a high price region. Demand for LNG in the region has been fuelled by economic and industrial growth in China and India as well as by the Fukushima nuclear plant accident. Development of new LNG capacities for supply to the region is relatively costly and has long lead times. Although the US have turned from being a net-importer of gas to having together with Canada a large exportable surplus, LNG capacities on the North American Pacific coast are limited, but are expected to be supplemented by LNG exports from the US Gulf routed through the Panama Canal.

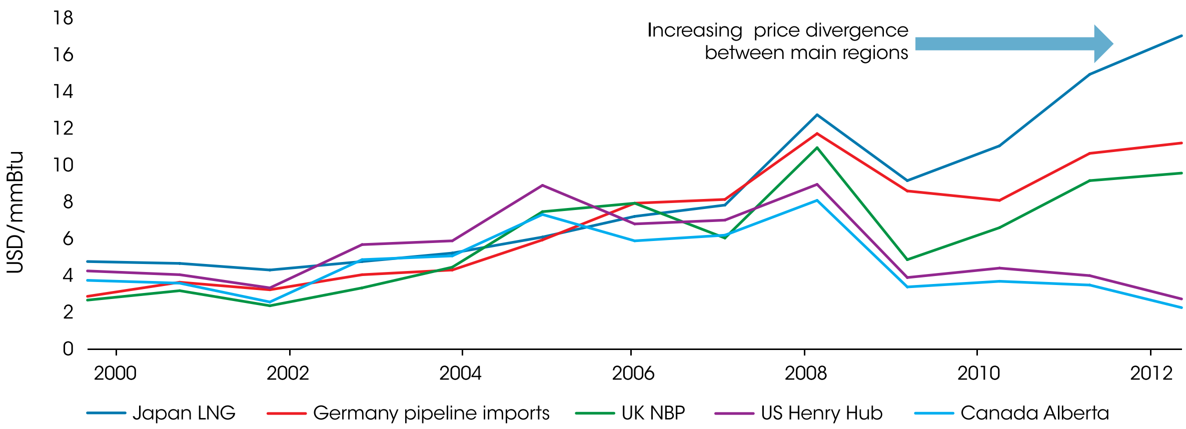
Current prices for LNG under long-term contracts to Japan are in the range of USD 16/mmBtu to USD 18/mmBtu. Prices for delivery to Japan, China and South Korea tend to align and Japan's import price is considered a benchmark for Asian prices.

Figure 17: World prices: Natural gas compared to crude oil



Source: BP Statistical Review of World Energy, 2013

Figure 18: World natural gas prices – regional divergence



Source: BP Statistical Review of World Energy, 2013

In 2012 Oman sold the majority of its LNG exports to only two markets, Japan and South Korea. Previously, LNG was also shipped to Spain on a regular basis, together with minor volumes to other markets. It is highly likely that the Omani LNG under long-term contract with the Spanish client, was probably re-directed to Asia and their high-paying market. Similar transfers to Asia have been seen from other countries, for example for Qatari LNG originally contracted for European markets.

Market dynamics will erode some of the Asian price premium over time. But with energy and gas price volatility in general and the Asian LNG price premium in particular, any evaluation of the sustainable medium- and longer-term opportunity costs of gas for Oman is fraught with uncertainties. In this report three LNG price scenarios have been chosen:

- A “high gas price” scenario corresponding to the current high Asian prices;
- A “medium gas price” scenario, which corresponds to the 2008 Asian prices. Although 2008 saw peak gas prices compared to earlier years, the 2008 Asian price is considerably lower than the 2012 and 2013 prices;
- A “low gas price” scenario at the 2007 Asian LNG price level.

The three price scenarios are summarised in Table 3.

Table 3: LNG price scenarios

Asian Price (fob Japan before regasification)	USD/mmBtu	
High Case	16.8	Av. 2012
Medium Case	12.6	Av. 2008
Low Case	7.7	Av. 2007

Table 4 shows a simplified breakdown of the costs in the LNG chain and Table 5 the corresponding net-back value of exported LNG *i.e.*, the value to Oman after deduction of the costs in the LNG chain. In Oman the estimate standard costs and actual liquefaction costs may differ. Variable costs are also shown *e.g.*, for using the existing installation with spare capacity, and for fixed capital costs, which for example, are calculated for the new LNG train added to the existing three trains at the Sur plant. The current spare capacity on the existing LNG plant could be absorbed in the medium term, dependent on whether more Omani produced gas becomes available for export.

Table 4: Standard costs in the LNG chain

Asian Price (fob Japan before regasification)	USD/mmBtu
Variable LNG Costs	
1. Liquefaction in Existing Plant (OPEX plus own gas use)	0.6
2. Transportation	1.0
Total Variable LNG Costs	1.6
Capital Costs, Additional LNG Train on Existing Plant	0.9
Total Variable and Capital Costs	2.5

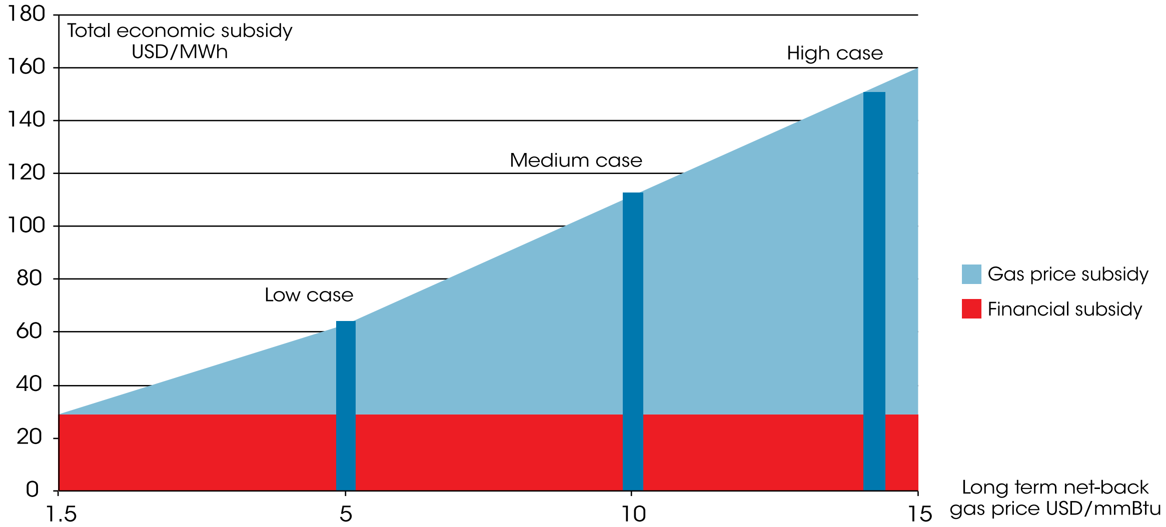
Source: Jensen, 2013

Table 5: Net-back Asian prices to Oman

LNG Price Scenarios, USD/mmBtu	International gas price	Net-back short term	Net-back long term
High Case	16.8	15.2	14.3
Medium Case	12.6	11.0	10.1
Low Case	7.7	6.1	5.2

The indirect subsidies to power generation are the differences between Table 5's net-back values and the current Omani price of USD 1.5/mmBtu for gas use in power generation. As shown in Figure 19 the High Case implies an economic subsidy (financial plus gas price subsidy) of about USD 150/MWh on average to the production of electricity in MIS and the Salalah system. In the Medium Case the total economic subsidy amounts to USD 112/MWh and in the Low Case to USD 63/MWh. In fact for every USD 1/mmBtu change in opportunity gas costs, the economic subsidy to power generation is equivalent to USD 10/MWh of electricity.

Figure 19: Total economic subsidy to gas-generated electricity, MIS and Salalah 2012 average, 2012



Source: AER, 2012

Indirect Price Subsidies – the case of diesel

RAECO has 40 production facilities that are "island" systems *i.e.*, the individual facilities supply the local customers connected in a local distribution grid and the individual production facilities are not interconnected.

The regulated tariffs for electricity supply in the rural areas are, because of Omani policies, identical to prices in other areas of Oman, although total supply costs are much higher. Consumer prices are consequently heavily subsidised. In addition diesel fuel is supplied to the power plants at a price that is out of line with market conditions. Similar to gas supply to electricity generation in the MIS and Salalah systems, the low price on diesel is an indirect subsidy financed by the oil sector and probably for the major part financed in the form of reduced earnings for the 100% state owned Oman Oil Company.

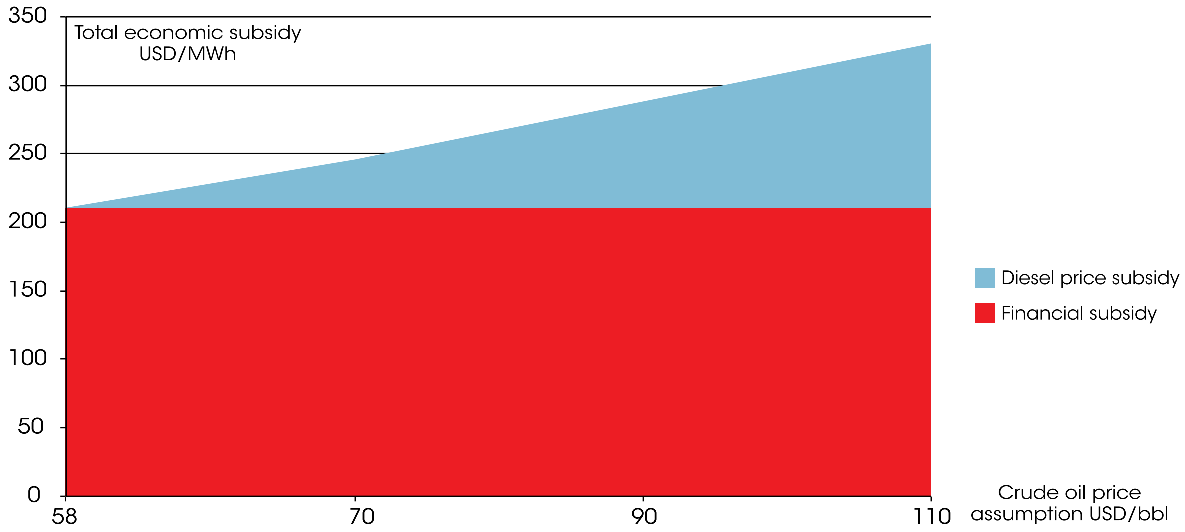
The estimated opportunity costs of diesel delivered by RAECO for electricity production are shown in Table 6. In this table the estimation of the diesel opportunity costs in 2012 is made by applying the average 2012/2013 observed spread between the crude oil and bulk diesel prices in the Gulf. Figure 20 shows the calculated total economic subsidy as a function of the international crude oil price level.

Table 6: Opportunity costs of diesel in Oman, 2012

	Crude Oil Price	Diesel/Crude Oil Refinery Spread	Delivery (transport)	Diesel Price	
	USD/bbl	%	USD/bbl	USD/bbl	Bz/Litre
Regulated diesel price 2012 for RAECO	58	8.3%	Included	62.8	0.151
Opportunity Costs					
2012 Crude Oil Price and Spread, estimated Delivery Costs	109	15.5%	1.4	127.3	0.308

Source: BP Statistical Review of World Energy, 2013; Government of India, 2013

Figure 20: Total economic subsidy to diesel-generated electricity, RAECO, 2012



Source: AER, 2012

Total Economic Subsidies

Total economic subsidies to electricity production, which are the sum of financial subsidies and the indirect price subsidies, amount to USD 2.6 billion in the medium case for international natural gas prices of USD 12.6/mmBtu and at a crude oil price of USD 109/bbl, see Table 7. The gas price subsidy accounts for 65% of the total economic subsidy.

At the medium case for international gas prices, the value of Oman's current net-exports of natural gas amounts to a little less than USD 4 billion/year. With the projected continued growth in electricity demand and production in Oman (see Section II of this Chapter) subsidies will increase in parallel, unless policies are adjusted. In a scenario of unchanged policies, the total economic subsidies would exceed the value of the Omani gas exports by 2018.

Table 7: Total electricity subsidies

Million USD	Financial Subsidy	Gas and Diesel Price Subsidy	Total Economic Subsidy
MIS	480	1 522	2 002
Salalah system	114	188	302
RAECO	125	196	322
Total	719	1 906	2 625

THE RENEWABLES READINESS ASSESSMENT METHODOLOGY

The Renewables Readiness Assessment (RRA) process is a comprehensive assessment tool for the promotion and deployment of renewable energy, which has been developed by IRENA. The present RRA process was configured to assist the Sultanate of Oman for the necessary transition towards a renewables-based energy future.

IRENA became a full-fledged international organisation in April 2011, with a mandate to promote increased adoption and sustainable use of all forms of renewable energy. With its 135 members and 34 countries in the process of accession, IRENA has the global reach to act as the focal point for international cooperation and to underpin the effort to increase the inclusion of renewables within the energy mix of countries around the world. Through its work programme, IRENA aims to position itself as a platform for stimulating policy dialogue and developing strategies to assist countries for their necessary transition to a renewable energy based future

RRAs are now an integral component of the IRENA Work Programme and are included in the "Promotion of regional consensus to adopt renewable energy through strategic intervention". The RRA process is designed to provide inputs to national and regional renewable energy action plans and bring together partners who can support the implementation of action plans.

Renewables Readiness Assessment

IRENA has developed the RRA as a comprehensive tool for assessing key conditions for renewable energy technology development and deployment in a country, and the actions necessary to further improve these conditions. Unlike other assessments, the RRA is a country-initiated and led process that identifies short- to medium-term actions for rapid deployment of renewables The RRA consists of four main phases: initiation and demonstration of intent; country assessment and action plan; RRA country validation and finalisation; and follow-up. Various stakeholders are engaged during each phase to ensure that the process achieves its intended purpose of compiling relevant information, establishing networks and promoting renewable energy deployment.

The RRA provides a comprehensive analysis of the enabling conditions for the development of renewables. Most importantly, this analysis takes into account how the renewables policy of the country in question contributes to other policy objectives. The RRA process also facilitates comparisons and case studies enabling the useful matching of attributes of renewable energy with opportunities for deployment.

The RRA comprises a process that includes completing a set of templates and a final report. The RRA methodology covers all forms of energy services (transport, heat, electricity and motive power) and all renewable energy sources, with countries selecting those of particular relevance. The RRA also encourages strong engagement by country stakeholders, as the process is designed

RRA

- **rapid assessment**

  The RRA highlights the requirements for the installation and on-going operation of renewable energy facilities in a country

- **comprehensive**

  It covers all renewable energy sources and services

- **national product**

  The RRA report, along with the insights and recommended actions, arise from a country-led process.

to be conducted by national governments, thereby allowing countries to obtain a comprehensive overview of the conditions for renewable energy from their own national perspective. All processes and documentation are led by the country and inputs derived from discussions with stakeholders, facilitated by the country focal point with assistance from IRENA. Therefore, the resulting report has a national focus, developed and owned by the country.

This sets the methodology of the RRA apart from other assessment processes led by international organisations. IRENA offers its support, but action points and insights are developed through a country-owned process, resulting in greater ownership, responsibility and ease of deployment of renewable energy.

RRAs facilitate a coordinated approach and the set priorities that can inform discussion with bilateral and multilateral cooperation agencies, financial institutions and the private sector, with regard to implementing actions and initiatives that emerge out of the RRA process. IRENA's backing of the RRA process enables countries to access a global network with the capacity to follow-up on actions and facilitate an exchange of experiences. IRENA can facilitate follow-up actions, where necessary, after a specific request from country or regional entity.

The development of the RRA methodology entailed an intensive literature review of the various assessment methodologies in renewable energy sector and interaction with key experts in this field. A draft methodology was developed and presented to country officials, experts in a workshop in Abu Dhabi in November 2012. The feedback from this workshop was used for updating and fine-tuning the methodology before it was applied to the assessment in Oman from December 2012 to July 2013. The methodology adopted for the country-level RRA has a number of distinct stages, as shown in the chart.

RENEWABLES READINESS ASSESSMENT METHODOLOGY

1. SCOPING

Step 1a: Preparatory Work

- Setting up of a RRA team initiated and lead by National Government
- Contextualisation of the RRA
- Identification of key stakeholders, renewable energy projects and programmes
- Roadmap and timeline for assessment

Step 1b: Planning the Process

- Identification of appropriate service–resource pairs
- Preparation of list of interviewees, appointments and tentative questionnaire for bilateral meetings

2. ASSESSING

Step 2a: Initial Plenary Session

- Introductory session led by high-level government official
- Discussion on status, potential and barriers to scale up renewable energy
- Description of how to conduct the RRA
- Refining and selection of key renewables applications

Step 2b: The Assessment

Filling out of RRA templates with regards to:

- Policy & strategy
- Business models
- Institutional, regulatory & market structure
- Resources, technologies & infrastructure
- Finance, building, operations & maintenance

Step 2c: Validation Workshop

- National workshop to present and validate preliminary findings

3. FINALISING

Step 3a: Final Report

- Final report-writing drawn on preparatory materials, completed RRA templates and list of actions
- RRA Director comments and approves work on behalf of the country

Step 3b: Follow-Up Actions

- Working with IRENA
- RRA Director and Government Focal Point identify areas for subsequent collaboration and action

CONDUCTING THE ASSESSMENT IN THE SULTANATE OF OMAN

The RRA implementation in Oman was initiated with an extensive literature review of studies and reports relevant to the national context of the energy sector and the current renewable energy status. A preliminary background report was prepared in accordance with IRENA guideline.

The stakeholder mapping exercise identified key entities in public sector bodies, financial institutions, research bodies, and the private sector. A series of visits to Oman were conducted between October 2012 and July 2013, and included the following activities:

1. An introductory meeting with the PAEW focused on the RRA initiation and information sharing with key stakeholders.

2. A series of fact-finding interviews with stakeholders relevant to the renewable energy sector.

3. Working sessions with stakeholders to fill in RRA templates for different renewable energy resources and services.

4. An Inception workshop with stakeholders aimed at presenting the RRA template information, eliciting further feedback on the findings, and developing the action agenda which is the key RRA outcome document

5. A consultation process involving the key governmental bodies to identify the key elements and priorities of the action plan and give guidance on the direction that the future renewable energy strategy should take.

AIMS AND OBJECTIVES

The key objectives of this report are:

1. To assess the energy issues Oman currently faces and review the current status of the energy policy, specifically regarding renewable energy;

2. To critically review employed and planned approaches for developing institutional structures for deployment of renewables;

3. To review the framework for providing access to renewable energy as well as the current status of technology and infrastructure to deliver it;

4. To critically assess the opportunities and barriers for developing viable business models for renewable energy projects; and

5. To suggest a set of actions to address the identified barriers.

Oman RRA Implementation

- Introductory meeting with PAEW (October 2012)
- Fact-finding interviews with key stakeholders (November 2012)
- Working sessions with stakeholders to fill out RRA templates (December 2012)
- Consultations with keys stakeholders (June – July 2013)
- Analysis and drafting of the RRA report (September 2013 - January 2014)

OBJECTIVES

ASSESS & REVIEW

THE STATUS AND ISSUES
for energy and renewable energy in Oman

THE APPROACHES
for developing institutional structures for renewable energy

THE FRAMEWORK
for providing access to renewable energy

THE TECHNOLOGY AND INFRASTRUCTURE
for delivering energy and renewable energy

THE OPPORTUNITIES AND BARRIERS
for viable business models for renewable energy

RECOMMEND

A SET OF ACTIONS TO ADDRESS IDENTIFIED ISSUES

II. Business case for renewables in Oman

In Oman, as in some other GCC countries, highly subsidised and cheap natural gas based electricity competes with renewable energy based power sources. The business case for renewable energy deployment in Oman should be based on real costs to society of thermal electricity production, *i.e.*, the costs of renewable energy should be compared to the full economic costs of thermal electricity production. As demonstrated in this Chapter, renewable energy technologies are viable options for Oman, and will help reduce the constraints on gas supply, thereby providing overall economic advantages.

The level of solar energy density in Oman is among the highest in the world and there is significant scope for developing solar energy resources throughout Oman. There is also significant wind energy potential in coastal areas and in the mountains north of Salalah. Wind speeds in these areas are comparable to recorded wind speeds at inland sites in Europe where large numbers of wind turbines are installed and operational. Wind speeds are highest in summer months which coincide with peak periods of electricity demand in Oman (AER, 2008). However, renewable energy resources such as solar and wind energy are currently limited to niche applications in Oman.

This Chapter will first discuss the limits to continued increases in gas use for power generation in Oman and the very important potential for solar energy and wind resources. It is technically possible to substitute part of the natural gas and diesel used in power generation by renewable sources and in this manner alleviating the gas supply constraints. A comparison of the costs of producing thermal electricity with the costs of solar PV or wind energy, show that solar PV and wind power in Oman are both viable business cases in the most favourable locations. These renewable sources are competitive in particular in the rural areas with the economic costs of thermal power generation. Financial and indirect price subsidies to power generation distort the picture, but there is an economic potential for renewable energy when disregarding the subsidies.

CONSTRAINED SUPPLY OF NATURAL GAS

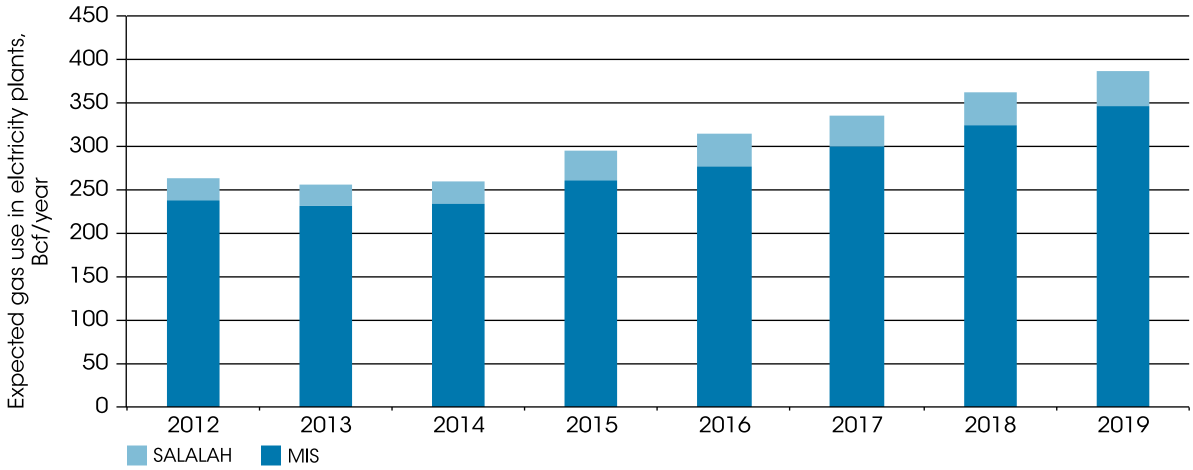
Oman's economy is entirely fuelled by natural gas and oil. Therefore, the availability of a sufficient supply of natural gas is vital for economic progress, especially given substantial export commitments and rising domestic gas use. As of January 2011, Oman's proven reserves of natural gas amounted to 30 Tcf. According to the EIA, Oman's natural gas reserves have remained almost constant at this level since 2006. Oman's natural gas production capacity has remained close to 900 Bcf per year. The Omani government has actively supported exploration and development of new gas production.

Apart from indigenous production of natural gas, Oman imports gas from Qatar through the 200 million Mcf/d Dolphin pipeline, via UAE. Other new supplies could come from Iran. A memorandum of understanding was signed in 2013 between the governments of the two countries for the construction of a pipeline crossing the Straits of Hormuz and for delivery of gas.

However successful in supporting economic development and growth, the Omani gas policy is not sustainable in the longer term. A low gas price for electricity generation results in a low electricity price, which in turn does not provide the needed signal to consumers to use electricity efficiently.

According to the current government strategy, all power generation expansion projects in the foreseeable future will be fuelled by natural gas. This will result in further substantial increases in gas use in power plants. Figure 21 shows the expected demand for gas in power generation plants according to OPWP's seven-year statement 2013-2019 as discussed in Chapter 1, Section 5, and Table 8 shows a future gas balance in a scenario that corresponds to the Expected demand forecast developed by OPWP.

Figure 21: Oman's expected natural gas use in electricity plants



Source: OPWP, 2014

Table 8: Oman's natural gas supply and demand

Oman's Future National Gas Scenario	Bcf/year
Natural Gas Supply	
Oman Production	950
Imports (Dolphin Pipeline from Qatar via UAE)[5]	73
Total Supply	**1023**
Natural Gas Demand	
Exports (LNG)[6]	375
Local Consumption (2011)	500
Enhanced Oil Recovery (20% of consumption)	125
Natural Gas Requirements for Sur Plant (2 GW, Commissioning in 2014)[7]	101
Natural Gas Requirements for further addition of 2.0-2.5 GW (2018-2019)	131
Total Demand	**1232**
"Shortfall": Total Demand minus Total Supply	**209**

5 Maximum Natural Gas Imports through Dolphin Pipeline at 200 Mcf/d for 365 days/year.
6 Oman's total natural gas exports in 2012.
7 Natural gas requirements are calculated with a capacity factor of 75% and 7980 cubic feet of natural gas per MWh.

Even without any increase in non-power use of natural gas, total domestic gas uses are expected to increase to 886 Bcf/year driven exclusively by gas requirements in new natural gas fuelled power plants. The result is a shortfall in supplies of 209 Bcf/year, when including possible but not contracted imports through the Dolphin pipeline, and excluding potential imports from other sources.

Oman has cut exports of LNG, only fulfilling long-term contracts that were locked in years ago. As a result, despite of the economic attractiveness of exporting to the international LNG markets the currently installed LNG capacity in Oman is underutilised. Currently the gas liquefaction plant in Sur is operating at 2 million tons (MT) below its LNG capacity. This capacity of 2 MT of LNG, corresponds to 7%-8% of the total Omani natural gas production.

The shortage of natural gas is not restricted to Oman. The entire GCC region faces an extraordinary challenge in maintaining and increasing gas production at a level needed to meet demand. Gas use in the region increased during 2002-2011 at an annual rate of about 7%. With GDP growth and economic diversification, the demand for electricity grew at 7.5% per year (Booz and Co., 2010a).

A move towards exploiting Oman's wind and solar resources on a large scale would contribute to reducing the growth in demand for gas. Renewable energy could reduce the demand for electricity; reduce the need for gas in EOR and in the production of electricity and water. Renewable energy deployed on a large scale would help to meet the shortfall in electricity supplies by freeing up gas for process use and exports. Major renewable energy projects have been witnessed across the region such as the Masdar City and Dubai Solar city in UAE, and King Abdullah City for Atomic and Renewable Energy in Saudi Arabia. UAE has developed targets for renewable energy with Abu Dhabi striving to attain 7% of its domestic power from renewable energy by 2020, while Dubai will achieve 5% by 2030

RENEWABLE ENERGY RESOURCE POTENTIAL

IRENA has initiated and leads the Global Atlas for Renewable Energy, which is supported by a high-profile international consortium. This tool is an online Geographic Information System (GIS) linked to a number of data centers around the world. The GIS interface enables users to visualise information on renewable energy resources, and to overlay additional information, for example, population density, topography, etc. (IRENA, 2014a).[8] The Global Atlas assists users in identifying areas of opportunity for developing projects and supporting policy formulation. It is an instrument for planning and stimulating investment in pre-feasibility studies for renewable energy projects.

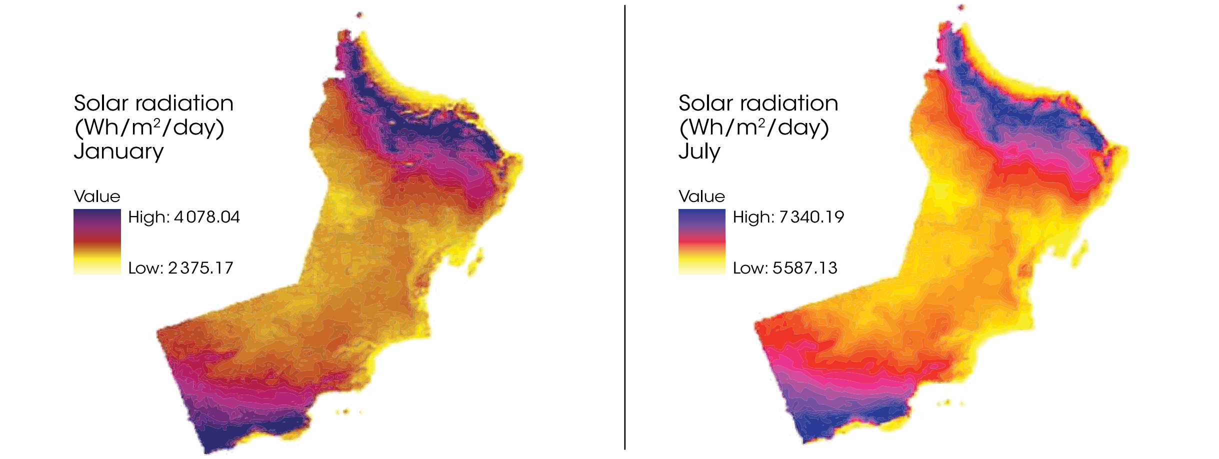
Oman is in discussions with IRENA on how to benefit from this initiative as the Global Atlas does not yet include data for Oman. This report therefore presents national renewable energy resource assessments, which are based on various sources, such as academic scientific literature, numerical weather prediction models and dataset from the Omani National Meteorological network (managed by the Directorate General for Meteorology and Air Navigation, for the quantitative assessment of solar and wind energy resources), with the level of solar energy potential in Oman is estimated to be among the highest in the world. High solar energy density is available in all regions of Oman as shown in Figure 21 (Gastli and Charabi, 2010).

SOLAR ENERGY IN OMAN

Evaluations of spatial and temporal availability and variability of the solar energy potential are essential for site assessment, technology selection, market potential and optimum design of solar power plants.

8 The Global Atlas is accessible at: http://globalatlas.irena.org

Figure 22: Solar radiation in Oman during January and July

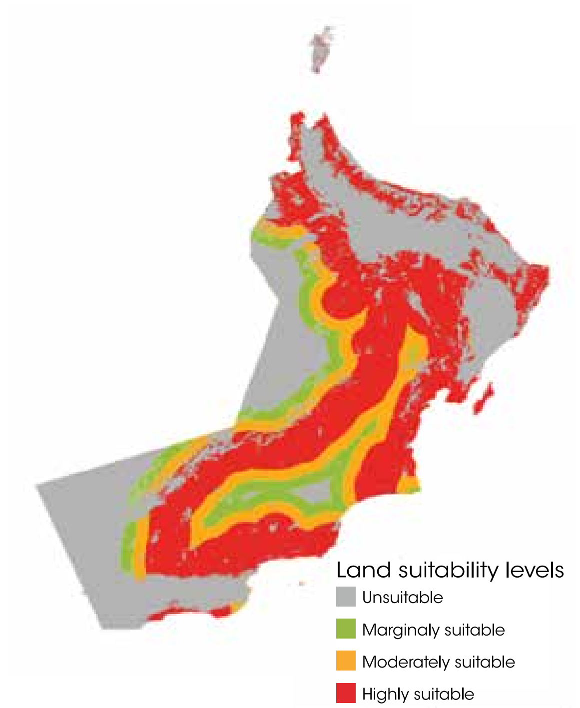


Source: Gastli and Y. Charabi, 2010a

The global average daily sunshine duration and solar radiation values have been studied in detail for 25 locations in Oman. Marmul is considered to have the highest solar radiation in Oman followed by Fahud, Sohar and Qairoon Hairiti. The remaining cities in Oman have almost the same solar radiation values except Masirah Island, Salalah and Sur, which have the lowest values. Salalah and Sur have significantly lower insolation compared with other stations due to the summer rain period in Salalah and the frequent periods of fog in Sur. Generally the highest insolation is in the desert areas, see Figure 23, and the lowest is at the coastal area in the southern part of Oman (Booz and Co, 2010b).

In conclusion, given the vast unused land available with high solar resources, Oman has clearly excellent potential for their large scale solar exploitation. However, specific resource assessments are needed in order to determine the market potential for solar energy and to formulate targets for solar energy, as part of a national renewable energy policy, see the discussion in Chapter 3, that illustrates the steps in the target setting process.

Figure 23: Spatial distribution of land with suitable levels for solar photovolatic energy projects



Source: Gastli and Y. Charabi, 2010b

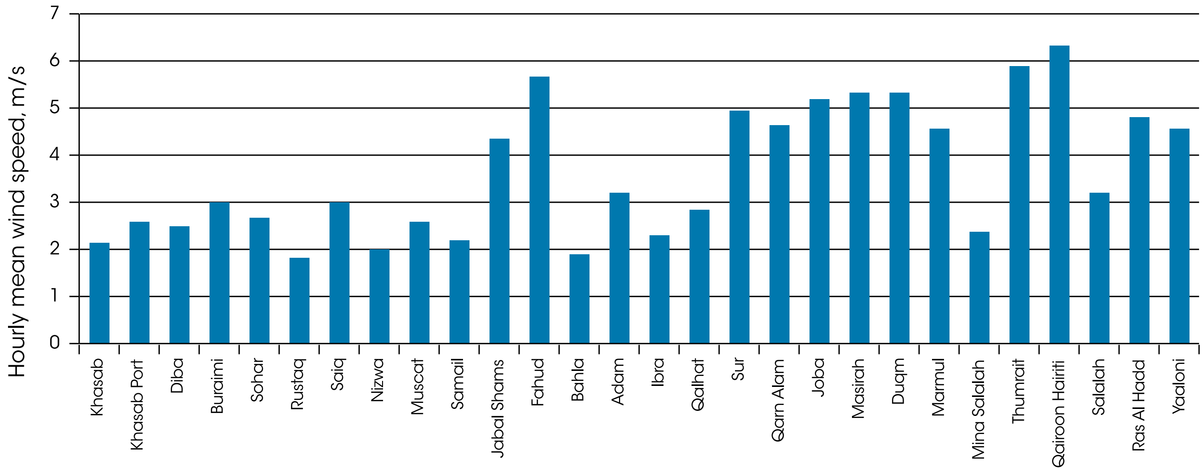
WIND ENERGY IN OMAN

Several studies have been conducted for assessing wind energy resource in Oman. These studies confirm wind power as a promising renewable energy resource for power generation, especially in the coastal and southern parts of Oman as demonstrated in Figure 24 (Al-Badi, 2011). The most promising sites are those located in the southern and eastern regions of Oman, primarily Qairoon Hairiti (Figure 25) (Charabi, Al-Yahyai and Gastli, 2011). These locations have similar wind speeds to European sites where commercial wind power successfully operates.

The technical and economic viability of utilising different configurations of hybrid systems (Wind, PV, diesel), to electrify Al Hallaniyat Island in Oman, has been investigated.

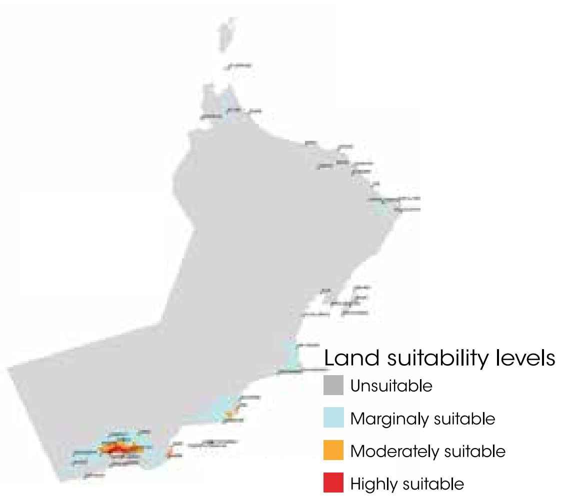
An economic feasibility study of wind incorporated into an existing diesel power plant in the Duqm area, showed that with the current diesel price of USD 0.368/litre, the hybrid system would provide the lowest cost of energy with wind speeds close to the average wind speed in Duqm area. Wind data from Duqm meteorology station and the actual load data from Duqm were used in the simulation model (Al-Badi and Bourdoucen, 2009).

Figure 24: Hourly measured mean wind speed at 10 m above ground level at 28 meteorological stations



Source: Al-Badi, 2011

Figure 25: Land suitability index for wind energy at 50 m for the Sultanate of Oman



Source: Charabi, Al-Yahyai and Gastli, 2011

In conclusion, Oman has considerable unexploited potential for wind power. However, as for the solar energy, specific resource assessments are needed in order to determine the market potential for wind energy and to formulate targets for wind energy's contributions to supply as part of a national renewable energy policy, see the discussion in Chapter 3, Section 2.III, of the steps in the target setting process.

PILOT PLANTS, RESEARCH AND DEVELOPMENT

Solar and wind energy resource assessments have been key areas of research in Oman. Most of this research has been carried out in the universities, particularly the Sultan Qaboos University and the Dhofar University. The Research Council declared in 2009 that renewable energy was a priority topic and the Council has since funded nine academic research projects in this field. These research projects have had an important role in the dissemination of knowledge about renewable energy in Oman.

In addition to solar PV, combined electricity and desalination plants using concentrated solar power technologies (CSP) have been evaluated for Wilayat Duqum in Oman. For wind power, a multi-criteria research project assessed and detailed wind power potentials based on five years of hourly wind data from 29 weather stations. The project also assessed costs per kWh of electricity for different types of wind turbines.

For the development of larger solar projects, 23 locations have been identified and tested. Out of these 23 locations, four, Adam, Manah, Al Khaboura and Ibri have been identified as being feasible for solar power projects. Land for the power plants at two of these locations has been allocated and tenders are being developed and awaiting final official approval. The projects in Adam and Manah would be large-scale, in the 100 MW-200 MW range.

In 2012, rules were decided for the evaluation of applications of renewable energy in electricity production in rural areas. RAECO is committed to evaluate the possibility for incorporating renewable energy in rural areas when submitting an electrification request to AER. In its request RAECO shall determine the share of the new capacity that could be supplied as renewable energy. Electrification requests are to be accompanied by a detailed assessment of solar and wind resources, together with a project economic analysis and an evaluation of the implications for security of supply arising from intermittency.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RENEWABLE ENERGY PILOT PROJECTS IN OMAN

RAECO agreed to implement some renewable energy projects. These include 4 700 kilowatts (kW) of wind power projects in Masirah, and Sharqia and Saih Al Khairiat in the Dhofar region. Additionally, roughly 2 000 kW of solar projects were also identified in the Dhofar and Al-Wusta regions. Although RAECO and AER have finalised the preparation of the PPAs, and the engineering, procurement and construction agreements for the pilot projects, the development in this sector has been fairly slow.

Several small scale renewable energy pilot projects are in the pipeline. The AER has confirmed a shortlist of six renewable energy pilot projects of which four are solar projects as follows:

- 100 kW PV solar project in Hiji;
- 292 kW solar project in Al Mazyonah;
- 1 500 kW project at location to be confirmed;
- 28 kW solar project in Al Mathfa incorporating battery storage capability;
- 500 kW wind project in Masirah Island; and
- 4 200 kW wind project in Saih Al Khairat, Wilyiat of Thumrait.

Amongst these shortlisted projects the Al Mazyonah project is the first to go ahead. A 303 kW solar PV pilot project will supply RAECO with power after the company signed a 20-year purchase agreement with the investors. Private investors will construct a hybrid diesel-solar plant, the first of its kind in Oman. The project is expected to be operational by June 2014.

Among the pilot projects, is the first roof top solar PV project initiated by Majan Company in Oman. The company installed around 50 kW of PV on the building roof of their head office in Sohar together with another 3 kW installation for the car park in front of the main office. In May 2010, a 6 kW concentrated PV (CPV) on-grid system was installed in The Knowledge Oasis Muscat. CPV was also installed and tested in the desert areas of Oman. In May 2012, a 1 kW PV system was installed in desert areas that are prone to high temperature and dusty environments. The system was installed by renewable energy research lab of the College of Engineering in Sultan Qaboos University and the operational results were presented to the PAEW.

In December 1996, Oman's first 10 kW wind-powered water-pumping system was installed to assess the role of wind power in pumping.

Recently PDO, the largest producer of oil and gas in Oman, in partnership with US company has built the Middle East's first solar EOR project, see the separate information box.

RAECO signed in 2013 a PPA with U.S.-based solar company to install a pilot solar PV project in Al Mazyunah, which will have a capacity of 303 kW. Local company Multitech will work in cooperation with Aston field in order to plan, construct and operate the solar plant. Two types of PV, thin film and polycrystalline modules, will be installed and tested at the pilot plant.

THE MIDDLE EAST'S FIRST SOLAR ENHANCED OIL RECOVERY PROJECT

With abundant oil reserves underground and some of the world's best solar resources, Oman has seized the opportunity to integrate the two. PDO, the largest producer of oil and gas in Oman, partnered with the US company to bring solar-fuelled EOR to the Middle East. PDO is a world leader in innovative EOR technologies. Over the past three decades, they have pioneered a range of EOR techniques, contributing to the growth of the Omani economy.

In Thermal EOR (the most widely used method of tertiary recovery); steam is injected into the formation, to heat the oil and increase its mobility. Steam injection increases the rate of oil production and can also extend the lifetime of an oil field. However, thermal EOR requires important volumes of natural gas to produce the steam. Today, thermal EOR consumes a significant share of Oman's natural gas production.

PDO realised it could increase production of heavy oil and conserve Oman's natural gas resources, by harnessing solar energy to produce steam for EOR. The natural gas saved can then be applied to higher-value uses within the Sultanate, such as industrial development. After an extensive evaluation of concentrating solar thermal technologies, PDO has chosen Enclosed Trough solar steam generators.

The solar EOR project produces a daily average of 50 tonnes of steam that feeds directly into existing thermal EOR operations at PDO's Amal West field in Southern Oman. The 7 MW plant is in operation and has passed its first performance acceptance test since being commissioned in May 2013.

Enclosed trough design encloses parabolic mirrors inside an agricultural glasshouse structure, protecting the solar collectors from harsh conditions of high wind, dust, dirt, sand and humidity common to Middle East oilfields. The glasshouse enclosure enables the use of ultra-light, low-cost reflective materials. The installation maintains a high optical efficiency through an automated washing system, which eliminates the need for manual cleaning and minimises water use, recapturing nearly 90% of the wash water. The steam generators are designed to use low-quality boiler water, eliminating the need for costly water pre-treatment.

ECONOMIC VALUE OF RENEWABLE ENERGY: THE CASE OF ELECTRICITY GENERATION

In general terms, the economic value of renewable energy in electricity generation is the avoided costs in the electricity sector. More specifically, in Oman renewable energy will replace electricity generation by gas plants in MIS and the Salalah system and diesel plants in the rural areas. The avoided costs are therefore determined by the costs of these plants, which have two main elements: variable costs and fixed costs. Variable costs include fuel costs and variable operation and maintenance (O&M), whereas fixed costs are capital costs and fixed O&M.

Fuel costs are determined by the plant efficiencies and the value of the gas and diesel used in electricity generation. As discussed in Chapter 1, both gas and diesel prices for electricity generation are subsidised in Oman so that the prices actually paid by electricity producers are significantly below the real value of these fuels. The real value being the opportunity costs of the fuels.

The value of renewable energy generated electricity is estimated based on standard costs and parameters of new thermal plants. The representative thermal plant is a CCGTs for MIS and the Salalah system, whereas the representative plant for the rural areas is a diesel-fired engine.

In addition to variable costs savings, renewable energy may also reduce the need for thermal capacity and thereby reduce the fixed costs in thermal production. Capacity savings in thermal systems depend inter alia on the availability of renewable energy and the coincidence between the renewable energy availability and the system demand load. Only a detailed analysis of the power sector allows a precise determination of possible capacity savings in thermal systems. This chapter will point to the possibilities for renewable energy power plants in Oman to displace capacity in the thermal system.

RENEWABLE ENERGY VALUE COMPARED TO GAS-FIRED POWER

Table 9 below shows standard costs of new gas-fired plants based on international data. Parameters for both CCGT and OCGT are included in this table, but for gas prices higher than USD 1.5/mmBtu the CCGTs is the economic choice for new gas plants.

The current predominance of the less energy efficient OCGT plants in the Omani electricity systems is partly a consequence of the gas price policy. At the low gas price of USD 1.5/mmBtu, there have been insufficient economic incentives for electricity producers to construct the more capital expensive, but also more energy efficient CCGT plants. In Oman, the most recent gas capacity additions for electricity production only are CCGTs, whereas the CCGT technology earlier was only chosen for combined electricity and water production.

Table 9: Techno-economic parameters of new gas-fired power plants

Main Assumptions	CCGT	OCGT
Investment, USD/kW	1100	750
Operation and Maintenance, USD/kW	44	36
Efficiency	58%	34%
Load Factor	60%	60%
Required Real Rate of Return	10%	10%

Source: UK Department of Energy and Climate Change, 2011

Table 10 shows the costs of gas-fired power plants in the three price cases for LNG exports as discussed earlier. These international LNG prices have been netted back with the full costs of the LNG chain to prices for delivered gas at the electricity plant in Oman as discussed in Chapter 1, Section 6. The full costs includes the capacity value of renewable energy for the system, which are determined by the capital costs of thermal plants. The energy value is determined by the variable costs of producing thermal electricity, *i.e.* it is the replaced use of gas and variable O&M costs.

Table 10: Levelised electricity generation costs in CCGT plants

	Electricity Generation Costs (USD/MWh)	
	CCGT	
International LNG Price (USD/mmBtu)	Full Costs	Variable Costs
High Case: 16.8	108.3	84.1
Medium Case: 12.6	83.6	59.4
Low Case: 7.7	54.8	30.6
Current Omani Price: 1.5	33.0	8.8

On a full cost basis renewable energy would have an economic value of USD 108.3/MWh in the High Case for LNG prices. Of this value the "capacity payment" is USD 24.2/MWh, *i.e.* the difference between full and variable costs. The "capacity payment" is independent of the gas price level. In the Medium Case for LNG prices, the economic renewable energy value would be USD 83.6/MWh on a full cost basis.

It is important to take into account that conditions in Oman, especially higher temperatures in the summer, the efficiency and capacity declines rapidly; this deducts at least 6% from capacity and efficiency on average with it reaching 10% at peak hours.

RENEWABLE ENERGY VALUE COMPARED TO DIESEL GENERATION

The Omani population that has settled in rural areas with poor accessibility, have their electricity and water supplies secured by RAECO. As stated before, RAECO manages 41 diesel based power stations across the Sultanate of Oman with a total rated capacity in 2012, of 222 MW. RAECO also operates the desalination plants in these same rural areas of the Sultanate and supplies desalinated water in bulk to PAEW.

The current stock of RAECO diesel plants is very heterogeneous in terms of capacity and age. Over time, the total capacity has increased and the thermal efficiency of the diesel plants improved. However, the actual generation costs in the RAECO area vary across the locations. In time renewable energy will compete with electricity production from new diesel plants and the long-term value of renewable energy is therefore determined by the costs of new plants as shown in Table 11. The resulting levelised production costs are shown in Table 12. The diesel prices underlying the values in Table 12 are the "opportunity" costs of diesel for a range of international crude oil prices as discussed in Chapter 1, Section 6.

Table 11: Techno-economic parameters of a new diesel engine

	Diesel Engine and Generation
Investment (USD/kW)	450
Operation and Maintenance (USD/MWh)	29.1
Efficiency	30%
Load Factor	40%
Required Real Rate of Return	10%

Table 12: Levelised generation costs of a new diesel engine[9]

Diesel Plant Electricity Generation Costs (USD/MWh)	4.8 MW Diesel Engine	
Crude Oil Price (USD/bbl)	Full Costs	Variable Costs
80	233.7	216.9
90	257.1	240.1
109 (2012 av.)	301.3	284.5
120	327.0	310.1

9 The levelised costs are calculated based on the parameters as in Table 11.

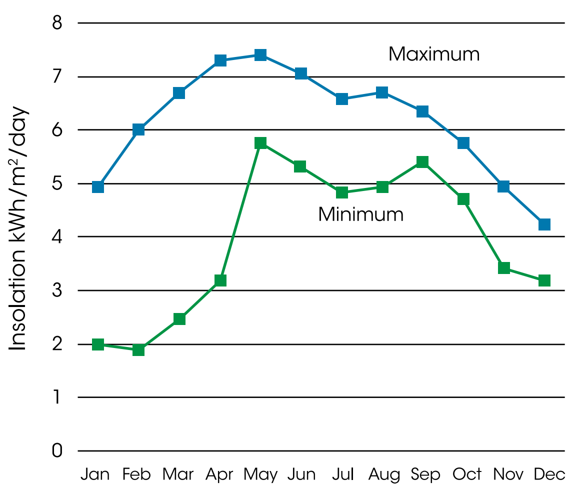
On a full cost basis renewable energy would have an economic value of USD 301.3/MWh in the rural areas, at a crude oil price (from 2012) of USD 109/bbl. Of this value the "capacity payment" is USD 16.8/MWh, *i.e.*, the difference between full and variable costs. The "capacity payment" is independent of the oil price level. At a crude oil price of USD 109/bbl the economic value of renewable energy in the rural areas is more than three times higher than the economic value in the other areas of Oman, where the value is determined by the cheaper CCGT plants.

RENEWABLE ENERGY VALUE: POTENTIAL CAPACITY VALUE

Electricity generated from renewable energy has a capacity value equivalent to the amount used during peak demand hours that results in a saving of energy generated by other means, *i.e.,* the thermal system.

Oman possesses in most of its regions a statistical high predictability of insolation during the summer, which coincides with the peak demand period for electricity. As illustrated in Figure 26, the summer has a relatively small difference between the observed maximum and minimum insolation that means solar power has a high availability factor in the day.

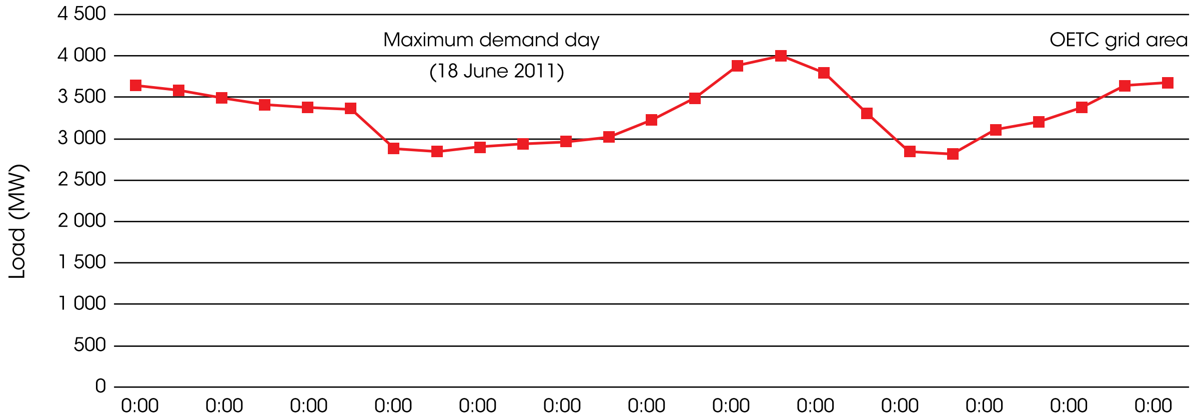
Figure 26: Insolation patterns over the year, example Fahud, 1987 - 1992



Source: AER, 2008

For example, in MIS solar power is available during the hours of peak demand, which is in the early afternoon see Figure 27. However, solar power is not available at night, unless it is combined with battery storage in the case of PV plants, therefore its capacity value for the electricity system is limited to the difference between the night peak and the day peak at the height of the summer day, The difference

Figure 27: Hourly load on the high-load day in MIS



Source: OPWP, 2012

between maximum day and maximum night demand in MIS is about 10% of the maximum load. In this load range solar power would have a capacity value, but there is a potential for significantly increasing this range. Battery storage would allow solar power to meet night-time electricity demand. Also, combining solar power and water desalination with water storage allows the utility to meet night water use through solar power. In fact, intra-day water storage could be designed as a form of electricity storage.

Wind is intermittent and there is no guarantee that the wind will blow on the day and time when electricity demand is high. Generally, the value of wind power for the electricity system is therefore determined by the variable costs of producing electricity, but the GCC Interconnector offers the potential for a higher value of wind power by optimising the power exchanges as planned between the member states.

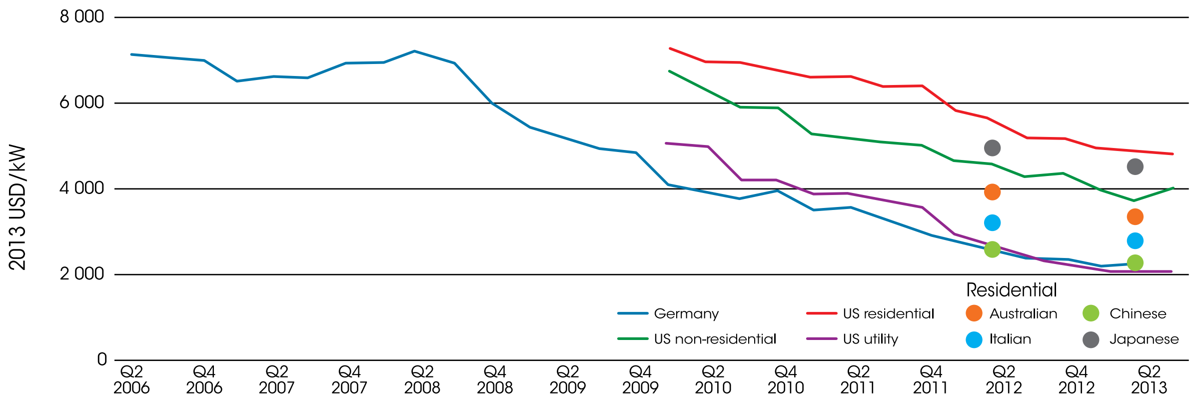
These are general considerations and a precise evaluation of the capacity value of both solar and wind power in Oman requires a system analysis related to a specific renewable energy project. It should be taken into account that the diurnal variation of insolation – 1500-1600 insolation is probably 30%-40% less than peak which will reduce the capacity benefit.

ECONOMIC RENEWABLE ENERGY OPTIONS

Renewable energy is in a position to compete with the existing sources of electricity production in Oman when evaluated at their full economic costs. Renewable energy costs are by their very nature much more site specific than the costs of mainstream thermal generation, such as the CCGT or diesel plants, which have been the options available to Oman. Any comparison of costs of renewable energy with those of fossil fuel based energy is therefore only indicative. Such cost comparisons provide, however, useful guidance as a first step in the process of formulating a renewable energy strategy.

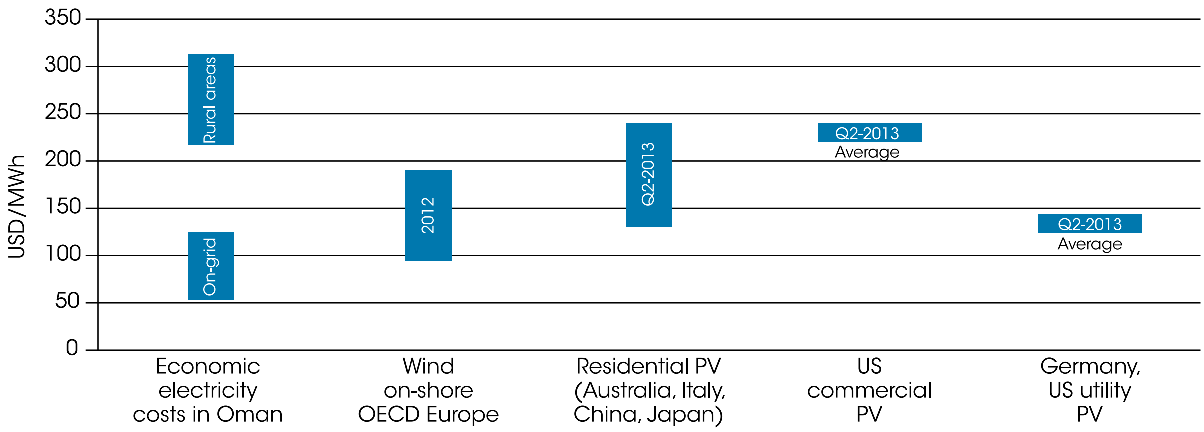
The costs of solar PV continued their decrease in 2013, see Figure 28. For installations in Germany (average of all PV types) and for US utilities, investment costs declined in second quarter of 2013 to about USD 2 000/kWp and there were parallel declines in the costs of residential installations from 2012 to 2013 in all the countries included in this graph.The estimated full economic costs of electricity generation as discussed in the previous Section are summarised and compared to indicative levelised costs of solar PV and wind energy in Figure 29. Wind power costs shown are the observed in 2012. In 2013 wind power costs have not changed significantly. Wind power and solar PV costs are calculated as the levelised costs over the lifetime of the installations.

Figure 28: Investment costs of solar PV, 2006 - 2014



Source: IRENA, 2014b

Figure 29: Levelised costs of solar PV and wind power compared to economic costs of electricity in Oman[10]



10 Assumptions:
Wind power costs as in IRENA, Renewable Power Generation Costs in 2012, Figure 2.3.
Solar PV costs: Germany, US Utility USD 2000/kW, US Commercial USD 4 000/kW, Residential (Australia, Italy, China, and Japan) USD 2 000-4 300/kW. **Levelised costs** calculated assuming 10% p.a. real rate of interest, lifetime 20 years, six months of construction, replacement of inverter after 10 years (USD 110/kW), O&M USD 20/kW/year for utility scale, USD 30/kW/year for other, capacity factor 27.5%. PAEW noted that assumed capacity factor is very high. **Economic electricity costs** in Oman: Rural Areas as variable costs in Table 12 of this report (assumed no capacity payment), On-Grid as full costs in Table 10 of this report (assumed full capacity payment).

ON-GRID RENEWABLE ENERGY (MIS AND SALALAH)

For utility sized solar PV plants, the impressive declines in recent years for total installation costs have made solar PV increasingly attractive economically and therefore competitive with gas-fired generation at the best sites in the MIS and Salalah areas, where there are very high insolation levels. As shown in Figure 29 the levelised average costs of solar PV in Germany and in the US (utility scale) were in the second quarter of 2013 in the high end of the economic costs range in both MIS and Salalah. Levelised costs of wind power are on par with the economic costs of on-grid gas-fired plants and wind power is economically attractive in the Salalah region. As shown in Section 2 of this Chapter, available wind data shows a wind power potential in Salalah and less so in the region covered by MIS. The high wind speeds are found in the north and western parts of Oman.

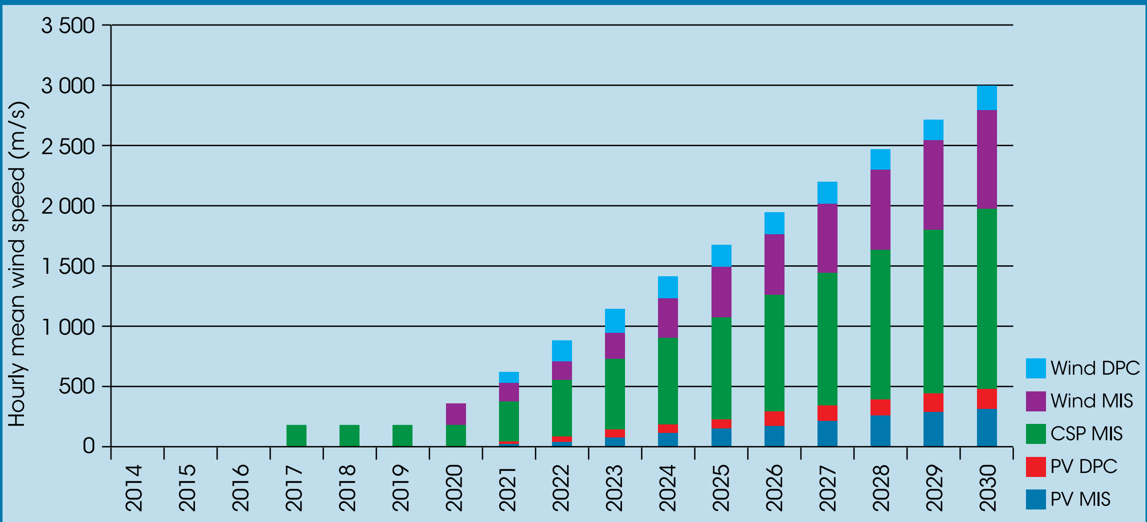
Oman has taken an important step in regard to grid tog expansion with the development of the Transmission Master Plan for Oman (2014-2030) (The Development of Transmission Master Plan for Oman, n.d.) based on a study undertaken by OETC. This study will serve as a basis for conducting feasibility studies of renewable energy potential at several locations where the grid is not available.

OMAN'S ELECTRICITY TRANSMISSION SYSTEM MASTER PLAN

The objective of the study is to build the long term (2017-2030) Transmission System Master Plan to determine the future transmission infrastructure investments over the planning horizon. This study prolongs the short-to-mid-term vision of network developments stated in the Five-Year Annual Capability Statement of Oman Electricity Transmission Company as the Transmission Master Plan reflects the mid-to-long term vision for the network development in Oman. This Master Plan is designed so that the electricity demand is supplied in a least-cost approach, while ensuring the power system security and reliability.

The study considered a scenario assuming 15% of renewable energy share in energy mix by 2030 and shows that the development of renewables up to 15% of the total installed capacity (expected 3 000 MW) allows substituting around 1 000 MW conventional plants by 2030.

Renewable plant site distribution according to technologies - 15% Renewable Energy Scenario



OFF-GRID RENEWABLE ENERGY IN RURAL AREAS

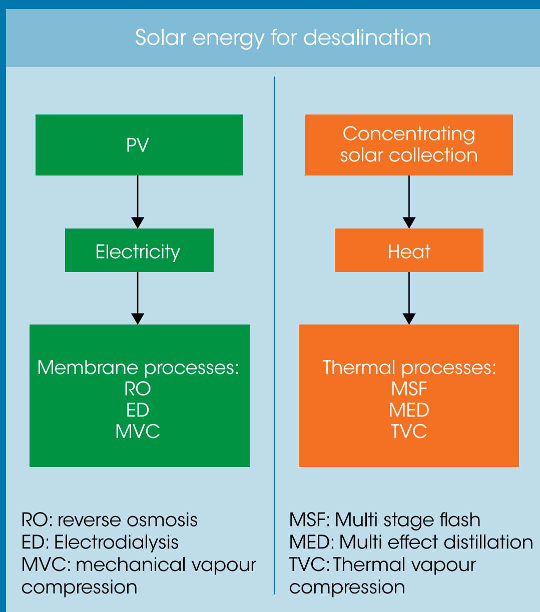
In the off-grid rural areas, the scattered diesel plants have significantly higher economic costs than the on-grid gas-fired plants in MIS and the Salalah system, see Figure 29. Renewable energy offers an economically attractive alternative to diesel generation in off-grid installations. This conclusion is based on internationally observed renewable energy costs. Renewable energy costs in rural areas may be higher than observed internationally because the installations are scattered geographically and are relatively small, but possible additional renewable energy costs in these areas should be compared to the relatively high economic costs of supplying power from the diesel-fired plants.

In the rural areas diesel power generation could be supplemented or replaced by small-scale solar PV in a cost effective manner. In these areas, dominated by small island systems, small scale PV installations linked up to a diesel plant are feasible unless combined with battery storage.

Also small scale wind farms could be competitive in off-grid applications, see Figure 29, but the potential is limited to coastal areas and the wind farms would need to be located close to existing local grids to avoid costly grid connections.

SOLAR ENERGY FOR DESALINATION

With the decline in installed PV costs solar energy has become an attractive option for water desalination. The figure below gives a simplified view of the main technology choices. For the reverse osmosis process, which is already in widespread use in Oman, electricity supplies from solar PV are strongly competitive in rural areas compared to diesel generated electricity, and has also become an economically attractive solution for power production in MIS and the Salalah system replacing gas-fired power. Water storage capacity could be added to cover the water demand at night and would have the value of "storing" electricity produced in daytime replacing or supplementing battery storage.



Another option is solar thermal desalination, where the heat is supplied by concentrating solar collectors. The two currently available techniques are parabolic trough systems and solar towers. Both systems may be combined with heat storage. Solar thermal desalination processes are being tested in pilot projects and are not yet available as commercial solutions.

There is potential in implementing pilot desalination plants that use solar energy in rural areas (North Oman, Musandam-coastal areas) where the demand for water is very low and the water supplied through ships transport from desalination plants, is economically feasible considering diesel price and cost of O&M of the ships.


FIVE RIALS
CENTRAL BA

III. Barriers to renewable energy deployment and enabling measures

The RRAs that are being rolled out by IRENA provide a template for the identification in each of the countries of the primary barriers to renewable energy and strategies and keys actions to address them.

The RRA process for Oman used a three-step framework to develop an enabling framework for renewable energy:

Step 1. Identifying key barriers to technology diffusion;

Step 2. Determine appropriate policy mix and institutional set up to create an enabling policy environment; and

Step 3. Define a renewable energy strategy and action plan to be implemented to reach the goals that have been fixed.

This Chapter describes the main barriers for renewable energy deployment in Oman identified in the RRA process and the enabling environment for renewables including the overall policy framework and institutional setup. Possible models which could facilitate renewable energy deployment are presented and the need for a transparent financial support system is discussed. The recommendations for Oman's renewable energy strategy are presented in the following Chapter 4.

BARRIERS TO RENEWABLE ENERGY DEPLOYMENT

There are two main sets of barriers to renewable energy deployment: financial and economic barriers and non-economic barriers. Financial and economic barriers are not only due to the costs of renewable energy compared to competing fossil fuel technologies. The financial attractiveness of renewable energy is also influenced by the relatively high capital cost compared to most conventional fuels, perceived risks linked to policy and technology, and obstacles for renewable energy to access the power market.

International experience points to four broad categories of non-economic barriers (United Nations, 2010). They are general and not specifically linked to the situation in Oman:

- Policy barriers: the absence of a well-defined national renewable energy strategy and action plan.

- Administrative barriers: institutional and bureaucratic challenges adding transaction costs to renewable energy projects or delaying project development.

- Technical and infrastructure barriers: weak grid capacity and insufficient knowledge about existing infrastructure.

- Capacity barriers: lack of the expertise needed for the renewable energy development, including insufficient training and capacity building of developers and installers, business managers, financiers, government officials and regulators.

- Insufficient resource knowledge: incomplete mapping of solar and wind resources prevent an optimal planning of renewable energy investments.

Each of these non-economic barriers may pose a significant obstacle to renewable energy market growth and add costs to renewable energy project development and may be "showstoppers" if overlooked.

ENERGY AND RENEWABLE ENERGY POLICIES IN OMAN

In Oman, as in many other oil producing countries in the Gulf, energy governance is organised around the oil and gas sectors. Currently, the Ministry of Oil and Gas and the Ministry of Finance share the responsibilities for energy sector policies in the country, assisted primarily by the PAEW and the AER. The Ministry of Environment and Climate Affairs leads the international dialogue and issues such as climate change and mitigation.

CURRENT SITUATION

The focus by Omani economic and energy policies on the oil and gas sectors, satisfying rising electricity and water demand, and the promotion of new industries are anchored in the natural gas resource base. Strong government institutions and oil, gas and electricity companies have secured the success of these policies, and large investment needs have been met by forming public-private partnerships in key sectors.

Oman is in the process of creating a basis for the formulation of a national energy strategy. See the box below.

> The Council of Ministers has asked the Ministry of Finance and PAEW to study the options to be included in a future energy strategy for Oman.
>
> The study will be an important element in guiding the development of Oman's energy policy. It will be focussed on the expected development of the oil and gas sector, but it will also provide an opportunity to examine the role that renewable energy could have in Oman's future energy economy. It will have a number of important deliverables such as an energy-economy model, which will allow the government to examine the implications of potential interventions (taxes, new sources of fuel, performance standards, etc.) on the whole economy of Oman. The report will conclude by recommending a National Energy Strategy and will be completed by the end of 2014.

The current governance structure would need a dedicated institution focused on developing renewable energy and implementing the accompanying legislative and administrative measures. In fact, renewable energy projects have been dispersed, as they are not part of an overall renewable energy strategy. It would better support renewable energy and related issuing, by clarify the decisions and powers between the ministries and agencies. Many of the non-economic barriers faced by renewable energy generators are the result of fragmented governmental responsibility for renewable energy and the symptoms of this fragmentation include multiple contact points across agencies and a lack of coordination among governmental departments.

Locally in urban and industrial areas, there are administrative and regulatory obstacles for renewable energy deployment. Permit requirements are complex and unclear and that there are numerous restrictions regarding land use, zoning and interconnections of renewable energy power projects with the utility grid. There is also a lack of sufficient inspectors and permitting authorities with experience in renewable energy systems for urban areas.

A NEW POLICY CONTEXT

The National Energy Strategy to be formulated, offers an opportunity for also establishing a National Renewable Energy Strategy. In fact, a renewable energy strategy needs to be placed in the context of the economic, social, and political factors of the society and there should be consistency between the renewable energy strategy and the National Energy Strategy.

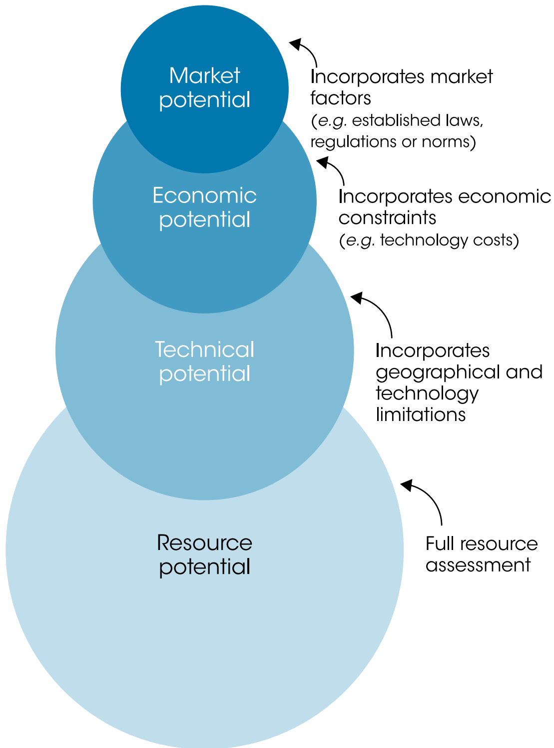
Renewable energy deployment on a significant scale requires the formulation of a National Renewable Energy Strategy to be followed by a Renewable Energy Action Plan, setting the targets for renewable energy by technology and application, the envisaged instruments, and the governance structure foreseen for the renewable energy sector.

SETTING RENEWABLE ENERGY TARGETS

Targets for renewable energy contribution to energy supplies are indispensable benchmarks for the design, implementation, and administration of renewable energy programmes and for adapting policy instruments over time to changes in market conditions. Absence of targets may result in renewable energy initiatives becoming uncoordinated, which in turn could increase the perceived risks associated with renewable energy investments. Setting targets therefore contributes to enabling renewable energy technology deployment and is recommended as an integral part of Oman's national renewable energy strategy. However, for targets to fulfil this role they need to be consistent with the policy visions of the national renewable energy strategy and reflect a realistic assessment of the renewable energy resource base and of what is obtainable economically.

Figure 30 outlines the four steps to be taken when defining the market potential for renewable energy. The market potential is a sound starting point for ultimately setting policy targets (A Framework for State-Level Renewable Energy Market Potential Studies) (National Renewable Energy Laboratory (NREL), 2010)

Figure 30: Renewable resource – market assessment stages



Source: NREL, 2010

The four steps are:

Step 1. Resource potential: determination of the resource potential in regard to availability, timing of availability, and location for relevant renewable energy resources, which in Oman is solar and wind.

Step 2. Technical potential: determination of the technically exploitable resource potential taking into account both technical and land use limitations, but disregarding economics and market barriers.

Step 3. Economic potential: estimation of the part of the technically exploitable resources that is economic taking into account the cost parameters of the technologies.

Step 4. Market potential: estimation of the potential left after incorporating factors such as market acceptance, regulations, incentives, barriers, consumer response, and others.

SOLAR POTENTIAL ASSESSMENT: A KEY ACTION TOWARDS THE ESTIMATION OF SOLAR MARKET POTENTIAL

Solar radiation and wind potential are variable in time and space, dependent on multiple factors, and due to these reasons they are difficult to predict.

In order to obtain relatively reliable information about wind and solar parameters, many years of observations are needed at specific spots, with good renewable energy resources. The existing methods of measuring solar and wind potential are basically using meteorological stations measurements, geographical and satellites observations, airplanes observations and probes.

The data is gathered and compiled in order to be used to develop solar and wind maps, estimate the market potential and determine the project feasibility. Although these data have a certain level of reliability, they should be used tentatively and specific measurement campaigns in the project selected site should be undertaken to correlate the available data.

In the case of UAE, the Research Center for Renewable Energy Mapping and Assessment (ReCREMA) - Masdar Institute, in response to UAE's renewable energy drive, has developed a solar mapping tool to meet the country's prospecting and resource assessment needs.
The developed tool utilises a robust satellite-based model to map the solar potential across the country. Most of the existing models, developed elsewhere, typically overestimate solar irradiance in this region. The bias is primarily due to the models' inability to adequately account for the attenuation and scattering of solar irradiance by predominantly airborne dust. The UAE solar mapping tool was specifically developed considering the local conditions and upon validation is revealed to be reasonably accurate for UAE climate and has the potential to be reliably used for similar arid environments.

The model produces direct normal irradiance (DNI), diffuse horizontal irradiance (DHI) and global horizontal irradiance (GHI) maps at a 3 km spatial resolution and in a near real-time manner, *i.e.*, updated each 15 min. While DNI is used as a key input in all Concentrated Solar Power (CSP) applications, the latter two components are of immediate interest in PV simulations. Hourly, daily, monthly and yearly irradiation values for all three components can also be derived. One of the primary objectives of the solar atlas project is to bridge the gap between restricted number of existing ground measurement sites and regional demand for rapid solar technology deployment by providing reliable and readily available solar irradiance data. The UAE Solar Atlas is accessible here: *http://atlas.masdar.ac.ae/*

NEED FOR CLEARER GOVERNANCE STRUCTURE

Oman should designate an institution to have the primary responsibility for the national renewable energy and energy efficiency policies. To fill this type of gap, some countries have created a dedicated state renewable energy agency competent in implementing the national renewable energy strategy. Other countries have placed the prime responsibility for executing the renewable energy policy with an existing major ministry or a government controlled market actor.

A national renewable energy entity could be entitled with the responsibility to:

- Develop and implement the national renewable energy strategy and action plan.

- Coordinate and align the activities of ministries and other government agencies related to or impacting renewable energy deployment.

- Serve as the focal entity for recommending, designing and implementing financial incentives for renewable energy deployment.

- Coordinate closely with AER to streamline regulations and procedures for procurement including contracting, PPAs, permits, and grid access for renewable energy electricity.

- Formulate the R&D priorities and coordinate with the scientific institutions in order to manage research, development and demonstration programmes for renewable energy.

- Organise activities related to renewable energy resource assessment, renewable energy research and development, and training.

- Initiate a streamlining of local regulatory requirements, planning rules, and procedures, and the introduction of fast track permits.

- Develop the data base for renewable energy related data and information, be the reference for renewable energy data in Oman that is accurate and updated.

Amongst the companies OPWP and PAEW have the organisational capacities needed to implement, monitor, and operate energy projects. These two organisations have pivotal roles in the development of PPAs and PWPAs for the gas plants and their experience and know-how in this domain is of vital importance for advancing renewable energy deployment. Both organisations work with AER and liaise with other government bodies.

FINANCIAL FACILITATION

The rapid growth in energy demand in Oman continues to require significant new generating capacity additions. A key challenge will be to ensure that a part of the new capacity will be renewable energy plants instead of being as in the past primarily gas-fired plants. Because of the low electricity prices in the market Oman needs to create a financial mechanism for providing price support to renewable energy in order to attract domestic financial resources and international investments in renewable energy.

RENEWABLE ENERGY PRICE SUPPORT

Under the current single buyer system in the electricity and water sectors phasing in renewable energy will increase OPWP's average power purchase price for resale in MIS and the Salalah system and RAECO's production costs will increase. Renewable energy will replace low-priced gas or diesel in power generation.

Possible ways of financing these additional costs could be in the form of a "renewable energy levy" added on the regulated consumer prices or by simply increasing the regulated prices corresponding to the additional purchase costs. Knowing that OPWP already use a shadow "market" gas price in evaluating bids for generation under their economic purchasing obligation and so – in theory – already buy capacity that has a higher cost than when considering the contract gas price. These costs are passed through in the Bulk Supply Tariff.

In any case, to attract private investments to renewable energy it is needed to clarify the policy on how the additional costs are absorbed financially. Any ambiguity on the policy level in this regard risks reducing renewable energy project attractiveness for investors.

SECURING INVESTMENTS

An important challenge to securing renewable energy investments is the renewable energy projects relatively high upfront capital costs and long pay-back horizons. Financing renewable energy projects could be handled by consortia of local banks or by a mix of local banks and foreign banks. There has been no difficulty in securing finance for large scale projects and smaller scale renewable energy projects could also tap into the growing local banking market – including Sharia-compliant financing. Oman has a good standing in attracting foreign investments. According to Ernst & Young's 2012 Country Attractiveness Survey, Oman had a strong foreign direct investment position. Overall, the country emerged as the 32nd most competitive nation in the world. Similarly, the survey "Doing Business 2013" ranks Oman number 47 and has improved its position over the years. This owes, in particular, to the efforts by Oman for provision of a business friendly business environment. The financing of renewable energy investments could benefit from this status, which has assisted Oman over the year to attract important flows of foreign investments to the energy sector.

A possibility for Oman is to supplement these financial sources by drawing on international climate funds. Climate finance refers broadly to international public and private capital targeting low-carbon development. Climate finance funds derive from a range of sources, including national budgets, foundations, carbon offset sales, and global capital markets, and is provided directly to projects or through international development channels.

The climate finance landscape is complex and dynamic. It takes many forms, including commercial finance, equity investment, risk management instruments, grants, and concessional loans. In 2009/2010, there was an estimated USD 97 billion in climate finance, of which two thirds derived from the private sector (Buchner, *et al.*, 2011) . It is difficult to determine precisely how much of these funds were directed towards renewable energy investment.

In the multilateral landscape, the Clean Development Mechanism (CDM) was developed as part of the 1997 Kyoto Protocol. CDM allows projects that reduce greenhouse gases in non-Annex I countries to earn Certified Emission Reductions (CERs) for each tonne of CO_2-equvalent of GHG reduced. Those CERs are then traded or sold to entities in Annex I countries. Renewable energy projects have benefited from CDM revenues, but it is seems unlikely that CDM will be a significant driver of renewable energy markets. Some of the reasons for this are

- Every CDM project has to be approved by the CDM Executive Board and project developers face high up-front transaction costs, an average processing time of up to two years, and a high degree of uncertainty;

- CERs are delivered after the project is developed, and future revenue from CERs sales is uncertain.

As a result, CERs have not been driving renewable energy and other projects. Instead, they create an additional revenue stream for already viable projects, a feature which could also benefit renewable energy projects in Oman.

It is recognised internationally that there is a need for the development of climate finance mechanisms supporting broader programmatic or sectorial approaches rather than supporting individual projects. Programmatic approaches could create opportunities to support renewable energy flexibly and avoiding the transaction costs encountered under CDM.

A key concept related to sectorial approaches to climate finance is the development of Nationally Appropriate Mitigation Action

(NAMAs), which are specific actions that could be used to meet national low carbon development strategies. NAMAs were introduced at the COP13 in 2007 and are envisioned as a new vehicle for developing countries to engage in mitigation activities.

The new focus on programmatic funding is a significant development for climate and renewable energy finance. A key component could be the Green Climate Fund, which was announced after the United Nations (UN) Climate Change Conference in Copenhagen in 2009. Developed countries committed to make USD 10 billion in "fast start" finance available from 2010 to 2012 per year increasing to USD 100 billion annually by 2020. However, the details of the Green Climate Fund have yet to be defined. Depending on how it is capitalised and implemented, the Green Climate Fund could be a significant and important source of new funds for renewable energy.

IMPLEMENTATION MODEL

A clear and transparent implementation model is needed for renewable energy take-off. The model should define main procedures for renewable energy projects and assure developers that renewable energy generated electricity will be purchased at the long-term price conditions agreed. It is an offer to private investors securing a reasonable return on the investment. For the government it is an instrument to ensure that renewable energy develops in line with Oman's national policy targets and keeping costs under control.

PPAs could be adapted to attract investments in renewable energy. Compared to gas-fired plants, renewable energy electricity projects are much more capital intensive and the costs of renewable energy produced electricity is mainly dependent on capital costs. To secure the financial backing a renewable energy investment requires a guaranteed electricity price over the project time horizon, typically over 20 years. Often the guarantee is in the form of a base electricity price wholly or partly indexed to inflation.

Competitive tendering of solar and wind power projects is widely used across the world. When tendering the Omani renewable energy, the entity would have the task to prepare the ground by identifying the site for the project and undertaking an in-depth assessment of the renewable energy resource at this site. Competitive tendering has costs for all parties involved and is time consuming. Time is needed for preparing the bids, for the Omani renewable energy entity to consider the bids, for negotiating bid details, and finally negotiating and agreeing the PPA for the project. Competitive tendering could therefore be reserved for relatively large renewable energy projects. In the early stages of the Omani renewable energy programme, competitive tendering could for example be reserved for wind or solar projects larger than 10 MW. Launching key projects on that scale would offer the possibility for capacity building in Oman. The size limit for projects under competitive tendering could be revised in light of the practical experiences.

For smaller renewable energy investment projects there are other options, which could be included in the Implementation Model. A standard PPA for renewable energy could drive small and medium sized business projects. This would provide big opportunities for the small and medium institutions. Offering a standard PPA has the advantage of reducing time and money spent on contract preparation and negotiation. Signing a standard PPA could be open for a certain period or/and for up to a certain maximal accumulated capacity of a particular renewable energy. During such an "open season" interested investors could launch project proposals accompanied by their asking price for electricity delivered to the grid. Asking prices could be negotiable. Investors would be responsible for proposing sites and for undertaking the renewable energy resource assessments at the sites.

A standard PPA would have the benefit of being faster to conclude than in competitive tendering, but bids might become less cost reflective. In Oman it could possibly be a means for attracting private investments in renewable energy to rural areas in addition to on-grid applications in MIS or Salalah.

Another system used in many countries is the feed-in-tariff (FIT). For each renewable energy source to be promoted, FIT offers a non-negotiable electricity price fixed with inflation indexation for a long period. Investors would be guaranteed to sell all of their production to the grid at the FIT and the owner is the sole responsible for obtaining permits, license and verifications. FITs have been successful in many countries resulting in quick off-takes. Promoting also small installations FITs have created local jobs in installation and maintenance and have contributed to increasing public awareness of renewable energy.

A variant of a FIT is net-metering, where independent renewable energy producers only sell surplus electricity to the grid after having covered their own needs. In fact, net-metering systems are first of all designed to meet the producer's own needs for electricity in homes, offices and industry. Because of low electricity prices, net-metering would not be attractive in Oman unless supported financially as part of a specific policy.

R&D, CAPACITY BUILDING, AND EXPLOITING SYNERGIES

Currently R&D efforts in Oman related to renewable energy are conducted at the university level and the national renewable energy strategy for Oman should strengthen the R&D activities. There is also a need to improve the mapping of wind and solar resources in the Sultanate. Currently, there are no specific programmes in place for renewable energy capacity building targeting industry and creating a skilled work force. A comprehensive capacity building policy should seek to exploit the potential synergies between renewable energy development, job creation, and economic diversification.

R&D COORDINATION AND STEERING

Creating a steering committee for renewable energy related R&D activities would add value by securing prioritisation of projects and coordination between the actors in line with the national renewable energy strategy. A major task will be to secure that R&D efforts focus on technologies having the highest potential in Oman and to benefit from similar R&D efforts in other Gulf countries and wider internationally. Cooperation with the other research organisations, especially in the region, is imperative if Oman wants to maximise the effectiveness of public spending on R&D.

For a R&D programme to be efficient it needs to be focussed and selective. An area which a priori offers prospective success would be adaptation and improvement of technologies already functioning in commercial environments to the specificities of the Omani situation, including the climate conditions.

Also needed is a comprehensive mapping of the wind and solar resource base in Oman taking as point of departure the results of earlier initiatives in this area. With a view to improving the efficiency of the mapping activities there is a case for exchange of information and pooling of resource mapping data.

A R&D steering committee could also have a role in the prioritisation of pilot renewable energy projects, whereas investments in commercial sized demonstration projects in the electricity sector should by coordinated be the renewable energy entity to be created as part of the institutional set-up for executing the renewable energy strategy, see Section 2 of this Chapter.

The leverage of R&D steering committee could be enhanced if supported by a R&D fund for renewable energy technologies and system analysis. Obligatory contributions from the energy sector in addition to voluntary contributions from bilateral and multilateral donors could secure the budget of such a fund.

CAPACITY BUILDING AND EXPLOITING SYNERGIES

It is suggested at an early stage in the implementation of the national renewable energy strategy to initiate training programmes for designers, installers, managers, and service companies of solar and wind plants drawing on the experiences of other countries in relevant areas.

For Oman exploiting a large renewable energy resource base, there are potential benefits in the synergies between renewable energy developments and the economy at large. Renewable energy deployment demands new skills at many levels: R&D, project design and development, construction management, O&M. In addition, a local market for renewable energy applications opens for new business opportunities in manufacturing renewable energy equipment, in commercial banking for the financing of renewable energy projects, in insurance, in consultancy services, and in installation and maintenance.

Developing renewable energy in Oman could become a driver for not only diversification of energy supplies but also for a broader economic diversification by moving into renewable energy related high-technology activities. Ambitious policies directed at changing the economy from being primarily resource based to become knowledge based are the driving forces for two major initiatives in the GCC region: the Abu Dhabi Masdar initiative and also the K.A.CARE initiative in Saudi Arabia as described in the boxes below.

THE MASDAR INITIATIVE: A SUSTAINABLE DEVELOPMENT MODEL IN THE UNITED ARAB EMIRATES AND BEYOND (MASDAR, 2013)

The Abu Dhabi Masdar initiative to create a high-tech city combining education, R&D, services and manufacturing is an example of the possibilities opened to the private sector by clustering activities and providing support to take-off by public investments. This is underpinned by the funding and construction of a series of solar plants in Abu Dhabi and an active renewable energy investment policy in various parts of the world.

Established in 2006, Masdar is a commercially driven renewable energy company based in Abu Dhabi, UAE. As a strategic government initiative — and a subsidiary of the Mubadala Development Company—Masdar has a mission to invest, incubate and advance the establishment of a clean energy industry in Abu Dhabi and around the world. Masdar operates through three integrated business units, complemented by an independent, research-driven, graduate-level university. With an initial commitment of USD 15 billion from the Abu Dhabi government, Masdar is a university, a renewable energy developer, an investor and a clean tech cluster in one of the world's most sustainable urban developments. Through these platforms, Masdar is contributing to the Abu Dhabi Economic Vision 2030, which is focused on transitioning the emirate to a knowledge-led economy.

Masdar operate currently two investment funds with international partners. The most recent, DB Masdar Clean Tech Fund was established January 2010, raising USD290 million for investments in renewable energy with a focus on North America and Europe.

Masdar is an important investor in renewable energy both in Abu Dhabi and internationally. In total Masdar has invested in nearly 1 GW of renewable energy generated electricity with wind and solar projects in Spain, United Kingdom, Mauritania and elsewhere. In Abu Dhabi Masdar owns and operates the Shams 1 CSP facility (100 MW).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A similar holistic approach has been used in Saudi Arabia to construct the King Abdullah City for Atomic and Renewable Energy, the K.A. CARE (Al Ghabban, 2013).

SAUDI ARABIA MOVES TOWARDS A SUSTAINABLE ENERGY MIX

K.A.CARE engages in broad range of activities promoting nuclear power and renewable energy. It is responsible for policy formulation, legal and regulatory implementation. It is also an investor and undertakes company creation and is responsible R&D and human capacity development. K.A.CARE is a state agency vested with the authority to initiate renewable energy deployment and create new institutions as required for policy implementation. As in the Masdar project, K.A.CARE is building a high-tech city designed to cluster academic R&D with private sector capacity and product development.

K.A.CARE has published a draft Renewable Energy Competitive Procurement paper (Al Ghabban, n.d.), which outlines the institutional structure for the promotion of renewable energy in line with the national renewable energy strategy. According to this, all PPAs for electricity produced by renewable energy and nuclear power will be administered by one single entity, SEPC, which is a company outside the existing electricity sector structure.

K.A.CARE is planning renewable energy investments in the Kingdom on a large scale. In 2013 it issued calls for tender of an initial procurement of 500-800 MW renewable energy and has stated the intention to launch two more tenders within three years for 7 GW of installed capacity.

In regard to capacity building the Clean Energy programme includes two funds, one for sustainable energy research and the other for training in this subject area. Both funds will be financed through levies on gross revenues of developers, as for example independent power producers (IPPs). Supervisory bodies will have an advisory role to secure that the funding activities are adequate and relevant.

IV. Strategy and action plan for deployment of renewables

Preparing the ground to formulate a renewable energy strategy and action plan in the Sultanate of Oman is the main objective of the RRA and this report. The RRA seeks not only to identify barriers and challenges to renewable energy deployment, but also to develop a targeted programme of actions through a comprehensive participatory approach and consultation process. The targeted programme was developed through the following processes:

1. Synthesis of information related to Oman's renewable energy sector:

This synthesis is based on an intensive literature review process. The literature review covered a broad range of publications and consultations, including national-level reports from PAEW, the AER, The Research Council, academic papers and IRENA reports on viability and comparative costs of renewable energy technologies. The documents were synthesised into a background report providing an overview of Oman's energy economy, the gas and electricity sectors, academic research activities and best practices for renewable energy.

2. Stakeholder Engagement:

An inception workshop for stakeholders from private and public sectors relevant to renewable energy was held in Oman on 2-3 December 2012. The workshop was organised by PAEW in collaboration with IRENA to prepare for the RRA action plan for Oman. The objectives of the workshop were to:

- Introduce the scope of work and the RRA methodology;
- Organise a brainstorming where stakeholders voiced their views on the promotion of renewable energy in Oman and filled in the RRA templates.

The stakeholders were introduced to the framework of the overall project through a series of interviews before the workshop and presentations made by IRENA representatives and local consultants. Following this, the stakeholders formed four working groups: On-Grid Electricity; Off-Grid Applications; Industry and Urban applications; and Capacity Building and Public Awareness. Each of the groups discussed the current situation, identified barriers and gaps, and developed a consensus on the key areas of action.

A number of consultation meetings were conducted with key stakeholders: Ministry of Commerce and Industry; Royal Estates; Ministry of Oil and Gas; Ministry of Agriculture; The Supreme Council for Planning; Ministry of Environment and Climate Affairs; Ministry of Manpower and The Research Council. They provided feedback on the potential for introducing renewable energy as a key contributor to the energy mix in Oman and also their evaluation of the current actions promoting renewable energy and explored proposals for changes. These consultation meetings led to the elaboration of the promotion of renewable energy action plan.

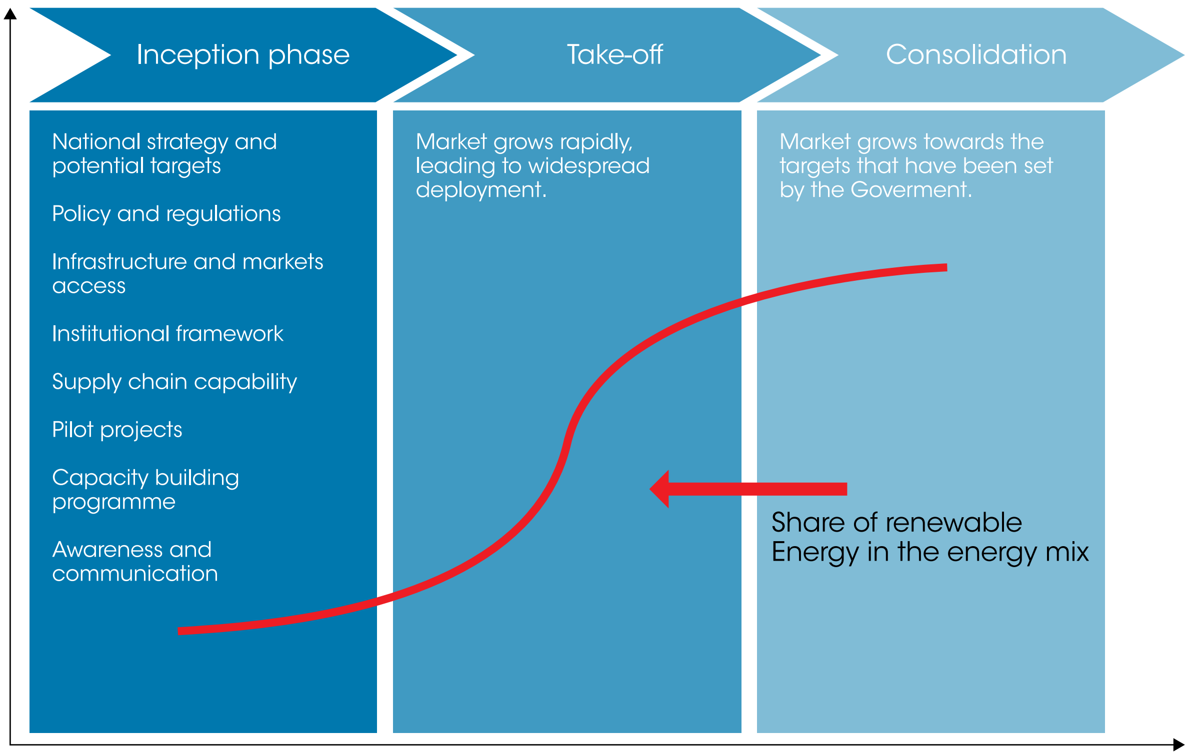
STRATEGIC DIRECTION AND IMPLEMENTATION MODEL

The key drivers for integrating renewable energy in the energy mix are clear and there is political support from H.M. The Sultan Qaboos bin Said. The consulted ministries reaffirmed their support for the implementation of a national renewable energy policy and strategy based on national circumstances and development aspirations. There was consensus to diversify the energy mix, in particular through increased use of renewable energy sources and more efficient use of energy and more integration of advanced energy technologies. The government entities supported PAEW's initiatives on access to energy, energy efficiency and renewable energies. However, developments in the renewable energy sector are held back by some key obstacles: (1) a need for a clear strategy and policy for renewable energy in Oman and (2) and no clear plan for diversification of the energy mix. Any launch of a national strategy and policy for renewable energy in Oman must involve key stakeholders.

The deployment of renewable energy can be segmented into three main phases (Müller, Brown and Ölz, 2011) (Figure 31), starting with the Inception phase, where the policies and initial projects are being developed and deployed. This is followed by the Take-off phase where the market grows rapidly, leading to widespread deployment and finally the Consolidation phase during which the market grows towards the targets that have been set by government. In all stages the maturity of the renewable energy technologies is an important aspect to take into account in the policy making. Across the three phases, challenges evolve as the renewable energy market grows and penetration levels increase. Policy priorities will change as deployment levels increase.

Incentive programmes for encouraging investments in renewable energy should be part of the strategy. Capacity building programmes should be linked to key renewable energy initiatives to be launched in the country. In particular, the research and development strategy should be aligned with renewable energy strategy and targets. To facilitate financing of renewable energy projects, a dedicated renewable energy fund could be developed to support renewable energy deployment in Oman and the government representatives called for specific shares for local equipment manufacturers when tendering renewable energy projects.

Figure 31: Illustration of the three main renewable energy deployment phases



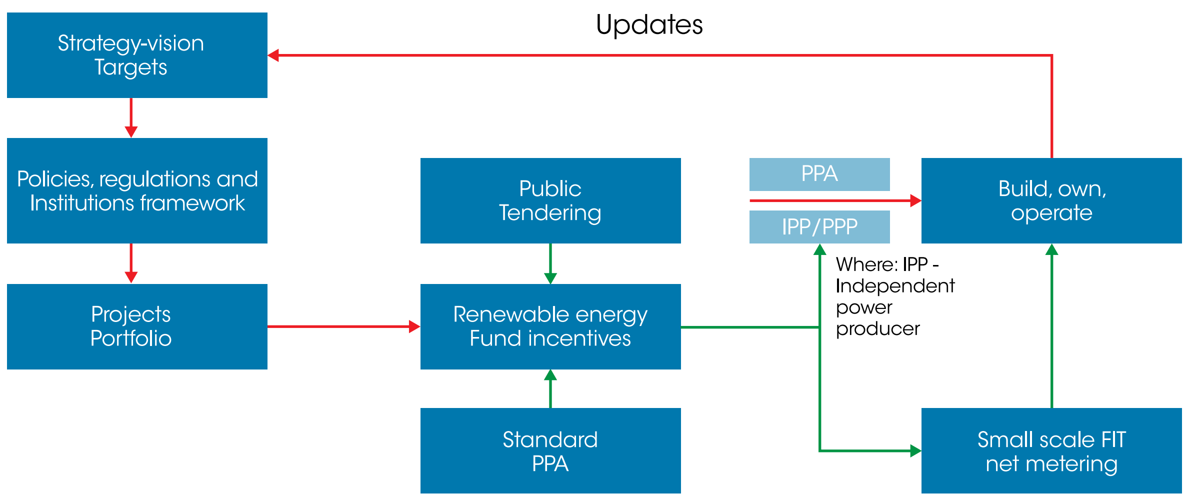
Source: Müller, Brown and Ölz, 2011

As shown in Figure 31, in the Inception phase the potential of renewable energy technologies should be determined in order to set reasonable targets; adopt policies and regulations enabling the penetration of renewable energy and ensuring renewable energy market access; develop the institutional capacity; establish the supply chain capability (O&M, local content and other services); identify and tackle other institutional, legal and administrative barriers to renewable energy; and install pilot projects to test wind and solar technologies and for the main actors to develop their skills. This critical phase could take between two to three years.

In Oman, it would be advantageous to start with a relatively simple policy involving public tendering and PPAs for deployment of renewable energy projects. The public tendering process offers the opportunity to compare technology costs and provides a basis for developing other renewable energy support mechanisms.

The Inception phase is an important learning phase, during which renewable energy policy targets and instruments are tested and possibly adjusted in the light of the reactions in the market (see Figure 32). Experiences from the market reaction to public tendering of wind or solar energy projects, standard PPAs, and support mechanisms such as a Feed-in Tariff should be closely monitored in order to have a basis for an updating renewable energy deployment targets, support mechanisms, and the regulatory framework. Such an interactive process is essential for a successful outcome of the Inception phase of a National Renewable Energy Strategy. The general institutional landscape in Oman does not support renewable energy, due to an overlap between the overall missions of the authorities; lack of stakeholder involvement in policy and decision making; and the absence of well-defined and transparent regulations for renewable energy. Stakeholders suggested the designation of one body to be responsible for all issues related to the renewable energy sector. This body should have the authority to establish renewable energy regulations following consultations with stakeholders and cultivate better coordination between the existing authorities.

Figure 32: Tentative model for renewable energy deployment in Oman during the inception phase



With respect to renewable energy resource and technology assessment the stakeholders proposed a programme including the following: detailed renewable energy wind and solar resource assessments using ground measurement and modelling tools; evaluation of renewable energy technologies suitable for Oman and testing the technologies via small pilots with involvement of local researchers; evaluation of grid codes facilitating integration of renewable energy sources; determining the quality of existing grid infrastructure and its ability to support intermittent renewable power resources; and evaluating effect of renewable energy deployment on grid design and operational management.

Regarding awareness and capacity building it was highlighted that the most pressing need is to build the capacity of staff to develop and apply new knowledge management approaches with the goal of increasing renewable energy deployment. As a way ahead, the participants proposed the creation of tailored capacity development programmes for academia, industry, skilled labour force, and research and development.

For the development of knowledge capacity, skills and expertise to in the field of renewable energy, it was proposed to increase the support to educational institutions for renewable energy research and develop new renewable energy related programmes at both undergraduate and postgraduate levels. In this regard, IRENA and other development partners can facilitate training in policy development and project financing for renewable energy projects in Oman and establish "peer-to-peer" learning through sharing of experiences with other countries.

To enhance renewable energy education in the academia, it was proposed to introduce an undergraduate programme with courses in renewable energy and develop a multi-disciplinary programme for the post graduate level (Master and PhD). The final year project was considered as an opportunity for students to gain hands-on renewable energy experience.

With regards to industries, the creation of National Industrial Training Centre was suggested. It could be funded by private and/or public companies. The stakeholders noted the opportunity to cooperate with international institutions to develop operators with the relevant skill base, who can run and maintain renewable energy installations. Capacity building activities could be coordinated by a renewable energy steering committee with representatives from private and public entities.

It was suggested to create a dedicated R&D institution for renewable energy undertaking not only research, but also contribute to raising public awareness through events such as an annual national renewable energy event, media advertisements and possibly a mobile bus for demonstration of renewable energy technologies.

SPECIFIC ACTIONS FOR OFF-GRID, URBAN AND INDUSTRIAL RENEWABLE ENERGY

OFF-GRID APPLICATIONS:

AER issued for rural areas in 2013, a regulation that stated any new power project should have a renewable energy component, unless resource limitations prevent the integration of renewable energy in such a project. To ensure further progress it was recommended to set renewable energy targets for off-grid applications and establish policies to facilitate the achievement of the targets. It was also recommended to consider a specific mechanism for enabling renewable energy penetration in the rural market and the governments should help in acquiring land for renewable energy project development in off-grid areas. It is important to review the current market structure to facilitate bilateral contacts between RAECO and private investors.

In the off-grid rural areas a large majority of the plants have a maximum load lower than 5,000 kW and a successful renewable energy penetration would be facilitated by the development of standard renewable energy packages adapted to the particulars of the Omani rural situation.

Stakeholders considered several applications as being important for integrating renewables in the rural areas, such as renewable energy technologies for water pumping and off-grid housing; remote desalination systems; PV lighting system for roads in off-grid areas; and renewable energy based cooling for off-grid areas. Similar to on-grid, the stakeholders called for a mandate to ensure contributions from local manufacturer in renewable energy projects in rural areas.

Representatives from the agricultural sector suggested that the high electricity consumption by the greenhouses and water pumps, could provide an opportunity to use renewable energy technologies. The agriculture researches centre confirmed the need to look for alternative forms of energy used in agriculture especially in the rural areas where there are limited connections to the grid. Pilot projects in agricultural activities using renewable energy technologies (desalination plants, pumps, greenhouses) are feasible. However, there is a need for awareness programmes, government support, and implementation of pilot projects in this sector.

URBAN AND INDUSTRIAL APPLICATIONS

Oman is experiencing a rapid urbanisation and energy demand is increasing rapidly. The economic diversification has triggered important industrial activities during the last decade resulting in an increasing power demand. However, the deployment of renewable energy in urban and industrial areas has been impeded by numerous policy and institutional barriers.

In the consultation process the stakeholders considered these institutional and local regulatory obstacles to be the major barriers for renewable energy deployment in urban and industrial areas. In particular, it was emphasised that the permitting requirements are complex and unclear and that there are numerous restrictions regarding land use, zoning and interconnections of renewable energy power projects with the utility grid. There is a lack of inspectors and permitting authorities with sufficient experience in renewable energy systems for urban areas. Additionally, actors such as power purchasers, lenders, investors, and insurance companies have not the required renewable energy insight and competence.

The stakeholders emphasised the need to develop a roadmap for renewable energy deployment in urban areas and industries, which would involve an assessment of the impact on the national energy market; development of a plan of action; establishment of appropriate rules and regulations; resolving technical issues such as interconnection with grid; facilitate access to financing; and increasing awareness through campaigns.

RECOMMENDATIONS

Oman has built up the electricity and associated water sector in a successful interaction between private investors and strong publicly owned companies. Economic growth and urbanisation has been accompanied by a rapid increase in electricity demand and production fuelled primarily by natural gas.

The use of electricity is heavily subsidised, which stimulates demand and thereby increases natural gas use in electricity generation. A financial subsidy covers the span between the costs of supplying electricity and the regulated consumer prices. In addition the costs of producing electricity are kept artificially low. The prices of gas and diesel for electricity generation are politically decided and are far lower than the international prices, which are benchmarks for the opportunity value for the society of these fuels.

The subsidisation of electricity is one of the main barriers to the deployment of renewable energy in Oman. As demonstrated in the next Chapter, there is a business case for introducing renewable energy in Oman on the condition that the renewable sources are allowed to compete against gas and diesel valued at their economic opportunity costs.

ON- AND OFF-GRID POTENTIAL

On an economic basis, even apart from any environmental benefit - Oman has the potential for developing renewable energy for electricity production in both on-grid and off-grid applications:

- Utility-scale solar PV at the best sites in MIS and the Salalah system (under high gas prices);
- Wind energy produced from wind farms connected to the Salalah system;
- Wind energy produced along the coast in relatively small capacities connected to nearby diesel generation plants in rural areas;
- In addition, the introduction of renewable energy would provide protection against increasing costs of subsidy as fuel prices remain high or rise further.

In the off-grid rural areas a large majority of the plants have a maximum load lower than 5,000 kW and a successful renewable energy penetration would be facilitated by the development of standard renewable energy packages adapted to the particulars of the Omani rural situation.

In all cases, these renewable sources are not profitable at the current Omani electricity tariffs, this would change, but only if remuneration was to occur at the equivalent full economic costs of production in Oman. Consequently, introduction of these renewable sources would not involve any direct economic costs to the society, but would provide benefits by extending the lifetime of Omani gas resources, by freeing up domestic diesel use, which could then be exported, and by opening new business opportunities and employment possibilities in Oman.

BARRIERS AND OPPORTUNITIES

There are two main sets of barriers to renewable energy deployment: financial and economic barriers and non-economic barriers.

Removing non-economic barriers first requires the formulation of a well-defined national renewable energy strategy and action plan, which includes setting realistic and coherent targets for renewable energy deployment. It is also necessary to review the governance structure. Currently, the responsibility for promoting renewable energy is split between several ministries. Some countries have created a dedicated institution or department as the responsible actor for renewable energy deployment. This model is recommended for Oman. The dedicated entity would have a wide range of responsibilities within the national renewable energy strategy and action plan. It should in particular coordinate activities of ministries and other government agencies; serve as the focal entity for recommending, designing and implementing financial incentives for renewable energy deployment; coordinate closely with AER; and initiate a rationalising of local regulatory and planning requirements.

To secure equity finance for renewable energy projects requires establishing a consistent and transparent mechanism, and handling the additional costs of purchasing renewable energy produced electricity. Otherwise, concerns about the financial mechanism would constitute a barrier to investments. Financing a transition to renewable energy in Oman could draw on the multitude of available international "green" finance" opportunities. Amongst these CDM offer a possibility for an additional revenue streams, but are not a drivers for renewable energy project development.

A model for renewable energy deployment could include competitive tendering for large installations, whereas projects with medium sized capacity could benefit from a standard PPA. Small installations could be remunerated by a FiT.

Currently, R&D efforts in Oman related to renewable energy are conducted at the university level and the national renewable energy strategy for Oman should strengthen the R&D activities. There is also a need to improve the mapping of wind and solar resources in the Sultanate. Creating a steering committee for renewable energy related R&D activities would add value by securing prioritisation of projects and coordination between the actors in line with the national renewable energy strategy. A major task will be to secure R&D focus on technologies that have the highest potential in Oman and to benefit from synergies from R&D efforts in other Gulf countries and wider internationally. Cooperation with the other research organisations, especially in the region, is imperative if Oman wants to maximise the effectiveness of public spending on R&D.

Developing renewable energy in Oman could become a driver not only for diversification of energy supplies, but also for broader economic diversification by moving into renewable energy-related high-technology activities. Ambitious policies directed at changing the economy from being primarily resource based to become knowledge based are the driving forces for two major initiatives in the GCC region: the Abu Dhabi Masdar initiative and also the K.A.CARE initiative in Saudi Arabia.

NEED FOR RENEWABLE POWER SOURCES

Several studies have emphasised solar and wind power as having the greatest commercial-scale potential for Oman, and surveys and assessments demonstrate the presence of such important potential. The electricity sector in Oman is primarily fuelled by natural gas and oil. In 2012, 97.5% of the installed electricity capacity was fuelled by natural gas and the remaining 2.5% by diesel. At the same time the energy sector is facing several continuing and emerging constraints.

Over the last decade, the sustained growth of the population, economic growth, higher living standards, and the expansion of heavy and energy intensive industry have put a strain on Oman's power infrastructure and gas supplies. The Sultanate of Oman has developed an important gas based petrochemical and refining sectors. These sectors are natural gas intensive and require a reliable and continued gas supply. However, with rapidly increasing natural gas requirements for power generation, gas supply to these industries could be constrained. In addition to the power sector, EOR from depleted oil fields and has developed as another major source of gas use. The combination of gas resource and supply constraints, continued increases in electricity demand, and spectacular increases in government subsidies for electricity has triggered a remarkable shift in the attitude in Oman towards favouring the development of the Sultanate's renewable energy resources. Energy being the engine of the economy with strong interlinks between all sectors, a participatory approach involving all relevant stakeholders was launched through the PAEW initiative in collaboration with IRENA. The objective was to map the barriers to deployment of renewable energy, identify the challenges they face, and develop a targeted programme of actions.

The participatory approach created a consensus that there is now an urgent need to develop and implement appropriate national policies and measures to create an enabling environment for the development, utilisation and distribution of renewable energy sources. Such policies should clearly improve the functioning of national energy markets in such a way that they support renewable energy, overcome market barriers and improve accessibility. Further, renewable energy sources could replace the oil or gas currently used for power generation and the surpluses created could become available for more profitable downstream applications and export. In the same direction, the renewable energy industry could drive economic diversification, create jobs and in so doing create wealth and added value to the local economy.

There should be established reasonable and achievable targets for renewable energy and policies and regulations should be formulated. Policy actions should also:

- establish models to ensure transparency and sustainability of the adopted strategy, and attract and secure investments;
- develop the institutional capacity required to manage and monitor the progress;
- help to establish a supply chain capability and deploying the first solar and wind projects, of reasonable size, to demonstrate the feasibility and credibility of the technologies;
- increase the support to educational institutions for renewable energy research and develop new renewable energy related programmes at both undergraduate and postgraduate levels, and enhance renewable energy education in the academia;
- create a dedicated R&D institution for renewable energy research and raising public awareness;
- create a specific mechanism for enabling renewable energy penetration in the rural market;
- develop a roadmap for renewable energy deployment in urban areas and industries.

IRENA's role in cooperating and assisting in the Country's efforts to integrate renewable energy in the energy mix was noted. In particular, international and regional cooperation can be effective in capacity building, education, technology transfer, information sharing, research and development, and the mobilisation of resources.

The RRA process identified and recommended the actions laid out in the Annex. The five points, which apply to all the priority resource-service pairs, are not given in any order of importance. A list of actions points from a rapid assessment is unlikely to be exhaustive. A more detailed list is contained in the Annex.

Summary of Policy Recommendations	
Development of Policy and Regulatory Framework for all renewable energy applications	• Build an efficient policy and regulatory framework • Establish rules and regulations for on-grid, off-grid and urban areas renewable energy applications. • Evaluate the overall quality of the grid infrastructure • Review the grid code to facilitate the integration of renewable energy sources. • Develop sector-based renewable energy implementation models, including models for desalination and PV applications in cities. • Draw on international experience and organisations, such as IRENA, for the development of a renewable energy policy framework and regulations.
Strategic Development of renewable energy Implementation Target and Market	• Set medium- to long-term renewable energy targets taking into consideration the value added and benefits of renewable energy (energy security, energy access, climate change mitigation, job creation, creation of SMEs,.....) • Set up comprehensive programmes for renewable energy implementation target and market including technology and financing mechanisms • Create evolving market-based support instruments such as competitive tendering • Strengthen private capacity and encourage private sector to invest in renewable energy • Assess manufacturing potential and develop a medium- to long-term strategy, taking into account regional markets opportunities • Monitor environmental, economic, energy markets and social impacts of implementing the strategy • Facilitate access to financing by promoting public and private funds and renewable energy investments • Promote Public-Private Partnership • Draw on international experience in the development of renewable energy policies and markets inter alia as conveyed by IRENA
Institutional and Legal Framework	• Improve the governance structures in order to promote renewable energy and to regulate their exploitation • Define and refine the mission and role of the actors • Establishing an entity having the lead responsibility in renewable energy policy implementation
Mapping of renewable energy Sources and R&D	• Undertake a comprehensive mapping of all renewable energy resources based on the concept of bankable data/projects • Conduct studies on grid capacity to uptake variable renewables sources • Test renewable energy technologies via small pilots with involvement of local researchers • Build a national programme to promote R&D activities in renewable energy • Develop or create a database for renewable energy data and related information
Developing Capacity Building for Renewable Energy	• Assess capacity building needs • Develop and fund training programmes to address capacity gaps • Identify training and education requirements for the building of the necessary local skills • Draw on international experience and IRENA in capacity building and its links with organisations around the world

REFERENCES

AER (Authority for Electricity Regulation) (2008), *Study on Renewable Energy Resources in Oman*, AER, Muscat.

AER (2012) *Annual Reports,* AER, Muscat.

Al-Badi, A.H., and H. Bourdoucen (2009), "Economic analysis of hybrid power system for rural electrification in Oman", the 2nd International Conference on Adaptive Science & Technology, DOI: 10.1109/ICASTECH.2009.5409712.

Al-Badi, A.H. (2011), "Wind Power Potential in Oman", *International Journal of Sustainable Energy*, Vol. 30, No. 2, 2011, pp. 110–118.

Al-Badi, A.H., A. Malik and A. Gastli (2011), "Sustainable energy usage in Oman—Opportunities and barriers", *Renewable and Sustainable Energy Reviews,* Vol. 15, pp. 3780–3788.

Al-Ebrahim, A.A., N. Al-Shahrani, and R.D. Tabors (2012), *'Launch Pad' of GCC Electricity Market,* Gulf Cooperation Council Interconnection Authority.

Al Ghabban, A. (2013), *Saudi Arabia's Renewable Energy Strategy and Solar Energy Deployment Roadmap,* Presentation, KA CARE (King Abdullah City for Atomic and Renewable Energy).

Booz & Co, (2010a), "Gas Shortage in the GCC-How to Bridge the Gap", *www.strategyand.pwc.com/media/uploads/Gas_Shortage_in_the_GCC.pdf.*

Booz & Co. (2010b), "The Future of IPPs in the GCC: New Policies for a Growing and Evolving Electricity Market", *www.strategyand.pwc.com/global/home/what-we-think/reports-white-papers/article-display/future-ipps-policies-growing-evolving.*

BP (British Petroleum) (2013), "BP Statistical Review of World Energy", *www.bp.com/content/dam/bp/pdf/statistical-review/statistical_review_of_world_energy_2013.pdf.*

Buchner, B., *et al.*, (2011), "The Landscape of Climate Finance", CPI (Climate Policy Institute) report, Venice, *http://climatepolicyinitiative.org/wp-content/uploads/2011/10/The-Landscape-of-Climate-Finance-120120.pdf.*

Charabi, Y., S. Al-Yahyai, A. Gastli (2011), "Evaluation of NWP performance for wind energy resource assessment in Oman", *Renewable and Sustainable Energy Reviews*, Vol. 15, No. 3, pp. 1545-1555.

EIA (U.S. Energy Information Administration) (2012), "Background on Oman", *www.eia.gov/countries/country-data.cfm?fips=MU, accessed August 2013.*

ESMAP (Energy Sector Management Assistance Program) (2009), "Study of Equipment Prices in the Power Sector", ESMAP Technical Paper 122/09, *www.esmap.org/sites/esmap.org/files/TR122-09_GBL_Study_of_Equipment_Prices_in_the_Power_Sector.pdf.*

Gastli, A. and Y. Charabi (2010a), "Siting of Large PV Farms in Al-Batinah Region of Oman", *Proceedings of the IEEE (Institute of Electrical and Electronics Engineers) International Energy Conference*, 18-22 December, Manama, Bahrain, pp. 548 - 552.

Gastli, A. and Y. Charabi (2010b), "Solar Electricity Prospects in Oman Using GIS-Based Solar Radiation Maps", *Renewable and Sustainable Energy Reviews*, Vol. 14, No. 2, pp. 790-797.

Government of India, (2013), Report of the Expert Group to advice on Pricing Methodology for Diesel, Domestic LPG and PDS Kerosene submitted to Dr. Moily, Press Information Bureau, Government of India, Ministry of Petroleum & Natural Gas, New Delhi, 30 October, *http://pib.nic.in/newsite/PrintRelease.aspx?relid=100333.*

Hertog, S. (2013), "The private sector and reform in the Gulf Cooperation Council Countries", Kuwait Programme on Development, Governance and Globalisation in the Gulf States, No. 30, London School of Economics and Political Science, *www.lse.ac.uk/middleEastCentre/kuwait/documents/The-private-sector-and-reform-in-the-GCC.pdf.*

IEA (International Energy Agency) (2012), "World Energy Outlook 2012", *www.worldenergyoutlook.org/publications/weo-2012/.*

IEA (2013), "World Energy Outlook 2013", *www.worldenergyoutlook.org/publications/weo-2013/.*

IMF (International Monetary Fund) (2011), "Article IV Consultation Concluding Statement of the IMF Mission", December 19, *www.imf.org/external/np/ms/2011/121911.htm.*

IMF (2013), "Economic Prospects and Policy Challenges for the GCC Countries", Annual Meeting of Ministers of Finance and Central Bank Governors, Staff Presentation to the Gulf Cooperation Council, Riyadh, 5 October 2013.

IRENA (International Renewable Energy Agency) (2012), "Renewable Power Generation Costs in 2012, An Overview", *http://costing.irena.org/media/2769/Overview_Renewable-Power-Generation-Costs-in-2012.pdf.*

IRENA (2014), "Solar PV module prices and installed costs graph 2009 to 2014", *www.irena.org/costs.*

IRENA (2014), "Global Atlas for Renewable Energy", *http://globalatlas.irena.org/.*

Jensen, J.T. (2013), "The Outlook for Gas Demand in East Asia by source of supply" Presentation to the Conference on US Shale Gas and Pacific Markets, May 2013, slides 42-46, *http://energypolicy.columbia.edu/sites/default/files/energy/home-sliderUSShaleGasandPacificGasMarketForum_May2013.pdf.*

MEED Insight (2012), "GCC Power & Desalination Projects 2012", *www.meed.com/research/gcc-power-and-desalination-projects-2012/3139692.article.*

Müller, S., A. Brown and S. Ölz (2011), "Renewables Energy, Policy considerations for deploying Renewables", Information Paper, OECD (Organisation for the Economic Co-operation and Development)/IEA, Paris, *www.iea.org/publications/freepublications/publication/Renew_Policies.pdf.*

Oman LNG (2012), "Annual Report, 2012", *http://omanlng.com/en/Media/Documents/AnnualReport/LNG_AR_2012_eng.pdf#search=annual%20report%202012*

OPWP (Oman Electricity and Water Procurement Co.) (2012), OPWP's 7-Year Statement (2012 – 2018), Issue 6, OPWP, Ruis, *www.transco.ae/media/pdf/Final-2012%207YPS-MainReport.pdf.*

OPWP (Oman Electricity and Water Procurement Co.) (2014), *OPWP's 7-Year Statement (2014 – 2020)*, Issue 8, OPWP, Ruis, pp. 54.

Othman, A.H. (2013), "Evolution of Thermal Desalination Processes", Saline Water Conversion Corporation, SWDRI (Saline Water Desalination Research Institute), Riyadh, Saudi Arabia, 2013, *www.sawea.org/pdf/waterarabia2013/Session_A/Evolution_of_Thermal_Desalination_Processes.pdf.*

PAEW (Public Authority for Electricity and Water) (2012), *Annual Report*, Muscat, pp. 76. PAEW, Muscat.

RAECO (Rural Areas Electricity Company) (2011), *Annual Report,* RAECO, Muscat.

RAECO (2012), *Annual Report,* RAECO, Muscat.

UK Department of Energy and Climate Change (2011), "Electricity Generation Cost Model – 2011. Update Revision 1", *https://www.pbworld.com/pdfs/regional/uk_europe/decc_2153-electricity-generation-cost-model-2011.pdf.*

United Nations (2010), "Energy for a Sustainable Future", The Secretary-General's Advisory Group on Energy and Climate Change (AGECC), Summary Report and Recommendations, 28 April, New York .

World Bank (2014), "World Development Indicators- Oman", *http://databank.worldbank.org/data/views/variableselection/selectvariables.aspx?source=World-Development-Indicators.*

ANNEX: DETAILED DESCRIPTION OF RECOMMENDED ACTIONS

ACTION 1 Development of Policy and Regulatory Framework for all Renewable Energy Applications	
Resource-Service pair(s)	Wind and solar, all applications
Description	The Sultanate of Oman is in the process of developing a national energy strategy. The national renewable energy strategy will set the general framework for the policy instruments for the promotion of renewable energy As an integral part of this work it is necessary to develop an efficient policy and regulatory framework based on the vision for the role of renewable energy in the future energy mix as contributor to energy diversification on an economic basis and as a catalyser for new employment opportunities in the country. The framework includes in particular: • rules and regulations for on-grid, off-grid and urban areas renewable energy applications • an adapted Grid Code to facilitate the integration of renewable energy sources • sector-based renewable energy implementation models including models for desalination and PV applications in cities • draw on international experience and organisations, such as IRENA, for the development of a renewable energy policy framework and regulations • the institutional setup envisaged for promoting renewable energy deployment and management when in place • initiatives for building renewable energy capacity in Oman • the strategy for local content • the principles for the remuneration of renewable energy in electricity generation, on-grid and off-grid This process should be supported by drawing on international experience and organisations, such as IRENA, for the development of a renewable energy policy framework and regulations
Actors	Supreme Council for Planning, Ministry of Finance, AER, PAEW, OPWP
Timing	Preparation during 2014 and implementation by mid-2015
Keys for Success	Nomination of one key Omani actor to drive the process, setting and respecting a timeframe for stakeholder consultations and inputs

ACTION 2 Strategic Development of renewable energy Implementation and Market	
Resource-Service pair(s)	Wind and solar, all applications
Description	The national renewable energy strategy should state the targets for renewable energy shares in the energy mix by sector and source, and outline the main policies planned for achieving these targets. The targets will set the scene and guide stakeholders and private investors. The targets should take into consideration the value added and benefits of renewable energy, such as energy security, energy access, climate change mitigation, value added for the economy and job creation. It is recommended that Oman builds on its experience with PPAs to purchase renewable energy generated electricity, adapted to accommodate renewable energy investments. Competitive tendering is recommended for projects above a certain size, otherwise a standard PPAs or a feed in tariff could be envisaged. A financial mechanism to purchase renewable energy generated electricity is needed. To attract investors it should transparent and based on clearly defined funding principles. The prices offered to renewable energy generated electricity should reflect the economic costs of electricity generated and compensate for the fuel price subsidies to thermal electricity.

Description	The actions includes in particular; • setting medium- to long-term renewable energy targets • comprehensive programmes for renewable energy implementation target and market including technology and financing mechanisms • creating evolving market-based support instruments such as competitive tendering • strengthening private capacity and encouraging private sector to invest in renewable energy • assessing manufacturing potential and developing a medium- to long-term strategy taking into account regional markets opportunities • facilitating access to finance and promoting public and private funds, renewable energy investments and the promotion of public-private partnerships
Actors	AER, PAEW, OPWP, OETC, RAECO
Timing	Preparation during the second half of 2014 with a view to implement before mid-2015
Keys for Success	Nomination of one key Omani actor to drive the process and secure the needed consensus between stakeholders, consultations with potentially interested investors, drawing on lessons to be learnt from experiences in other countries adapted to the Omani situation in particular taking into account the structure of the electricity sector and the country's resource base
ACTION 3 Institutional and Legal Framework	
Resource-Service pair(s)	Wind and solar, all applications
Description	A renewable energy law is recommended to secure efficient implementation of the national renewable energy policy. An important step would be the nomination of an authority having the prime responsibility and the decision powers needed to secure the preparation, contraction and deployment of renewable energy projects in line with the national renewable energy strategy. Institutional and local regulatory obstacles are considered to be major barriers to the deployment of renewables in urban and industrial areas. Permitting requirements are complex and unclear, and there are numerous restrictions regarding land use, zoning and interconnections of renewable energy power projects to the utility grid. A renewable energy law could address the following: • securing efficient implementation of the national renewable energy policy by nomination of an authority having the prime responsibility and the powers of decision to secure the preparation, contraction and deployment of renewable energy projects • the conditions of purchase and remuneration for electricity generated from renewable energy plants and the conditions of their connection to the grid network • framework rules for PPAs for renewable energy produced electricity sold to the grid and for PPAs for renewable energy installations on off-grid sites • tax and customs duties applicable to renewable energy equipment • securing the sources of electricity sector revenues needed to fund the on-grid and off-grid purchase of contracted renewable energy electricity. The funding mechanism should create stable incentives for renewable energy and in doing so attract private financing into the sector • create the basis incorporating renewable energy in urban planning, zoning rules, and building regulations • create the basis for needed changes to the electricity grid code
Actors	Ministry of Finance, AER, PAEW, OPWP
Timing	From mid-2014 to end-2015
Keys for Success	Nomination of one key Omani actor to drive to process and secure the needed consensus between stakeholders.

ACTION 4 Resource Mapping of Renewable Energy Sources and R&D	
Resource-Service pair(s)	Wind and solar, all applications
Description	There have been general studies and assessments of wind and solar resources. Resource assessments have been made by using both satellite mapping and measured data. Earlier assessments should be verified and as needed supplemented by more detailed and targeted studies. The availability of comprehensive and consistent data will facilitate the drafting of a renewable energy strategy and is a prerequisite for future project development. Main actions to address this could include: • identify requirements for resource mapping, based on priority areas for renewable energy development • verification of earlier wind and solar power assessments • identification of gaps in earlier assessments and needed areas of improvement • establish a plan for collection of data • seek multilateral/bilateral expertise to the definition of measurement programmes • establish a funding framework and a protocol for sharing of data
Actors	PAEW, AER, academia
Timing	From mid-2014 to end-2015
Keys for Success	Technical and human resources available for data collection, identifying and securing funds for data collection, protocol for data sharing

ACTION 5 Developing Capacity Building for renewable energy	
Resource-Service pair(s)	Wind and solar, all applications
Description	Oman has very little experience in the deployment of renewable energy technologies. There is therefore a need for capacity building on several levels. This could include the following actions: • develop and fund training programmes to address capacity gaps • identify training and education requirements for the building of the necessary local skills • securing the coordination of overall capacity building activity by creating a Renewable Energy Steering Committee composed of private and public entities • launching offers by technical schools for training courses in design, execution, operation and maintenance of renewable energy installations. It could be taken further by the creation of a National Industrial Training Centre, which could be funded by public and private companies • obliging foreign companies active in renewable energy design and execution in Oman to propose Omani engineers and technicians internships in their renewable energy project developments • consider the option to create a dedicated R&D institution for renewable energy to pursue research activities and contribute to increased public awareness IRENA and other development partners could facilitate training in policy development and project financing for renewable energy projects and establish "Peer to Peer" learning through sharing experiences with other countries
Actors	Ministry of Finance, PAEW, AER, academia, private sector participants
Timing	Renewable Energy Steering Committee to be created in 2014, remainder of actions before end-2015
Keys for Success	Securing coordination and funding of renewable energy related R&D, developing technical training and renewable energy related undergraduate and postgraduate programs

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