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Creating An Enabling Environment for Renewable Energy Application in the Sultanate of Oman

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The Sultanate of Oman holds a greatest potential of renewable energy. Despite this important potential, the electricity sector in Oman is primarily fueled by natural gas and oil. As of 2012, 97.5% of the installed electricity capacity was fueled by natural gas and the remaining 2.5% was fueled by diesel. The sustained growth of the population and the expansion of heavy industry have put a strain on Oman's power infrastructure. The aim of the study is to raise the question of renewable energy to the attention of the policymakers and to the interested public from the angle of policies and to stimulate the discussion about the future energy supply in the country. This article discusses, from policies perspective, how to create an enabling environment for renewable energy in the Sultanate of Oman. The article suggests, a summary of the main actions to ensure transition to renewable energy supply. The recommended actions were issued from consultative process with public and private stakeholders. To develop Oman's renewable energy base, it is essential to develop a facilitating environment which includes appropriate policies, regulations, focused institutions, tailored education and skill development initiatives, focused research, and development projects, financing schemes and favorable market scenarios.

Keywords: Renewable energy, Transition, Policy

Introduction

The Sultanate of Oman hold a greatest potential of renewable energy, but at present renewables does not contribute to the primary energy mix. The potential of renewable energy in Oman, particularly solar energy, is very favorable. However, solar energy applications are limited to street lighting, traffic lights, telephone in remote area, and cathodic protection of pipelines. During the last 5 years, several research papers have clearly stated that high solar energy density is available in all regions of Oman. The ratio of sky clearness is about 342 days per year, and the geographical location of Oman result in a huge potential for solar electricity generation. Gastli and Charabi (2010) evaluated the potential of solar electricity using GIS-based solar radiation maps. It was found that in Oman, the highest solar radiation per day was 8217 $\mathrm{Wh/m^2/day}$ during the month of June (summer solstice) and the lowest one was 4059 $\mathrm{Wh/m^2/day}$ in December (winter solstice). The GIS-based maps evaluate available land for harnessing solar power based on geographical location, biophysical attributes, and socio-economic infrastructure of the country. According to the multi-criteria analysis, the most isolated locations were evaluated to be most suitable for solar power generation (Charabi and Gastli 2011). However, solar radiation is also vulnerable to some environmental damage mainly related to mineral dust deposition that can greatly reduce the profitability of any solar energy system. The dust affects the optical properties of any solar energy system and therefore, requires frequent cleaning using fresh water, which can be difficult because of the general scarcity of fresh water in the desert and semi-desert zones (Charabi and Gastli 2012).

Recently, the NASA satellite data from the Multi-angle Imaging Spectro was used to provide information about dust emission transport, concentration, and property evolution in Oman (Charabi and Gastli 2012). The study indicated that large areas of Oman are highly affected by mineral dust. The high concentration of dust and occurrence of dust storm events throughout the year limits the implementation of solar energy systems in some areas. This analysis used the Aerosol Optical Depth (AOD) for analyzing dust. Given that dust can be an important issue in effective utilization of solar power, it is vital to include the annual average AOD as a key constraint during the sitting of solar energy systems. In a case study on Oman, the consideration for dust resulted in reduction of 64% in solar potential in most suitable areas (Charabi and Gastli 2012). In addition to solar power, combined electric power and seawater desalination plants using concentrated solar power technologies have also been evaluated for Wilayat Duqum in Oman (Charabi and Gastli 2010). It was concluded that concentrated solar power (CSP) can be used for electricity generation and desalinated water without any major environmental impact (Gastli, Charabi, Zekri 2010).

Various studies have been pursed to evaluate the wind energy potential in Oman. A multi-criteria research depending on theoretical wind power output, vertical profiles, turbulence, and peak demand fitness was carried out using 5 years of hourly wind

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data from 29 weather stations (Al-Yahyai et. al. 2010). As assessment of the wind power cost per kWh of energy produced using four types of wind machines at 27 locations on an hourly basis from 2000–2009 was also performed. According to the study, the energy cost is low in the southern and middle region of Oman and high in the northern region. The study also developed wind duration curves for 27 locations, which is beneficial in finding the duration and availability of the wind in different areas in terms of the useful range of wind speed (Al-Badi 2011). A detailed wind study was carried out on Masirah Island, the only large inhabited island of Oman (Al-Yahyai et al. 2013).

The above research activities seem has had minimal impact on the deployment of renewable energy even at small scale, because the electricity sector in Oman is still primarily fueled by natural gas and oil. As of 2012, 97.5% of the installed electricity capacity was fueled by natural gas and the remaining 2.5% was fueled by diesel (Authority for Electricity Regulation [AER] 2012). During the last decade, the sustained growth of the population and the expansion of heavy industry have put a strain on Oman's power infrastructure. The Sultanate of Oman has developed significant levels of gas-based petrochemical and refining sector, which contributed to 6.3% of the GDP in 2011 (Central Bank of Oman 2012). These sectors are natural gas intensive industries and require a consistent supply of gas. To satisfy the capacity needs, the country import gas through the 200 million cubic feet per day (Mcf/d) Dolphin pipeline from Qatar via UAE. In addition to the power sector, depleting oil fields and enhanced oil recovery has developed as another major source of gas consumption.

Most likely, Natural Gas will continue to dominate the energy scene for foreseeable future, since there are no tangible actions enabling transition to renewable energy. Like other countries, the Sultanate of Oman must respond to the massive increase in the energy demand and reducing their Greenhouse Gas (GHG) emission for climate change mitigation. According to Oman Power and Water Procurement Company (OPWP) 2012, the single buyer of electricity and water in Oman, peak power demand has reached 3856 MW in 2010, which represent 46.4% increase since 2005. While in the Sultanate of Oman, the annual peak power demand growth rate is 9.5%, which would result in a forecasted capacity requirement of 8106 MW in 2019. In review of such capacity needs, the government has to add roughly 4000–4500 MW of capacity till 2018–2019. This would almost double the existing power generation capacity. In the sultanate of Oman, the CO_2 emission per capita from fuel combustion has increased by over 150% for the past 12 years, from a low of 8.90 t CO_2/capita in 2000 to 22.30 t CO_2/capita in 2011 (International Energy Agency [IEA] 2012). This excessively increase in CO_2 emission per capita from the fossil fuels is alarming and contributing to the warming of the climate system. Despite the fact that the country is facing a sustained growth in the electricity power demand and growing constraints on their natural gas resources, no policies or strategies have been specifically tailored to develop the renewable energy sector. Different studies have stated that progressive policy making has the greatest impact on the deployment of renewable energy. There are enough renewable resources in each continent to encounter the world's total power generation. During the last decade, the cost of different technologies have decreased dramatically yet the key driver for utilizing renewable energy resources is policy making at different levels (Harr and Theyel 2006; Roosa 2007; Toke and Oshima 2007; Lin, Yeh, Chien 2013).

This article discusses, from policies perspective, how to enable the transition to sustainable energy in the Sultanate of Oman. Although references to primary energy are made, the article's focus is on the analysis of the electricity sector. Taking into consideration the exclusively dominance of fossil fuels in the Total Primary Energy Supply for the Sultanate of Oman, the article seeks to present the rational and advantages of renewable energy. The article also suggests a summary of the main actions for the transition to renewable energy supply. The recommended actions were issued from consultative process with public and private stakeholders. It is worth mentioning, that the goal of this article is not to suggest a detailed strategy for renewable energy in the country, but to raise the question of renewable energy to the attention of the policymakers and to the interested public from the angle of policies and to stimulate the discussion about the future energy supply in the country.

The article is organized as follows. The second section, detailed the approach and data used in the study. The third section assesses the status quo of the energy, as well as the electricity sector. The fourth section discusses the potential and benefits from the transition to renewable energy. The fifth section proposes how the transition toward a renewable energy supply can be managed.

Methodology

The aim of the study is to identify barriers and challenges and develop a targeted program of actions; a comprehensive participatory approach was developed. The followed approach was articulated around three axes:

1. Synthetics of the information related to energy and renewable energy: This synthesis is based on a literature review. The literature review covered a broad range of publication types and sources, including national-level reports from Public Authority for Electricity and Water (PAEW), the Authority for Electricity Regulation (AER), Oman Power and Water Procurement Company (OPWP), and The Research Council (TRC), as well as academic papers, International Renewable Energy Agency (IRENA) analyses of particular reports on sustainability and comparative cost of Renewable Energy technologies. All the documents were synthetized to provide a comprehensive look on the primary energy status quo, current situation of electricity sector;
2. Organization of a series of interviews with stakeholders from public and private sectors to gather ideas about promoting renewable energy in the Sultanate of Oman. The interviews were based on questionnaire and covered all the main electrical power companies in the country, Ministries, Educational Institutions and some potential investors in renewable energy;
3. A number of targeted consultation meetings were conducted with key actors (Ministry of Commerce and Industry; Royal Estates; Ministry of Oil and Gas; Ministry of Agriculture; The Supreme Council for Planning; Ministry of Environment & Climate Affairs; Ministry of Manpower and The research Council), to obtain their feedbacks about the possibility of using renewable energy in Oman as one key contributor to the

energy mix and what are the expected actions from the government in order to promote this alternative energy source. The consultation meetings were very useful and prolific in the elaboration of the action plan to promote the deployment of renewable energy.

Analysis of The Status Quo of Energy in The Sultanate of Oman

Primary Energy

The energy sector has been a major contributor to the overall economic development in Oman. In 2010, the oil and gas sector contribution to the GDP was 44.9%. The Total Primary Energy Supply (TPES) of Oman has always been entirely dependent on natural gas and oil (IEA 2012). For 2011, natural gas accounts for about 82% of the country's energy supply with oil products accounting for about 18%. The Sultanate of Oman has total proven reserves of 5.5 billion barrels of oil. The Sultanate of Oman produced 863,000 barrels per day (bbl/d) of total petroleum liquids in 2010 rising up to 920,000 bbl/d in 2012. Average oil production in Oman has increased by over 20% for the past 3 years, from a low of 714,000 bbl/d in 2007 (U.S. Energy Information Administration 2012).

Over the past decade, Oman has been intensively utilizing enhanced oil recovery (EOR) to improve oil production becoming a regional leader in the usage of this technology. With such measures, soon Oman will be able to produce nearly 1 million barrels per day compared to 918,500 barrels per day by the end of 2013.In 2010, the Sultanate of Oman consumed approximately 13% of its overall petroleum production. The increase in internal consumption has been largely due to Oman's industrialization and expanding petrochemical sector, along with better roadways and an expanding vehicle fleet.

The Sultanate of Oman has significant reserves of natural gas and it is a leading regional exporter of liquefied natural gas. Oman's proven reserves of natural gas amount to 30 trillion cubic feet (Tcf) as of January 1, 2011. The Sultanate of Oman produced a total of 875 billion cubic feet (Bcf), about 2.4 billion cubic feet per day (Bcf/d) in 2010 (U.S. Energy Information Administration 2012). Within Oman, natural gas is primarily used for electricity generation, water desalination, and enhanced oil recovery. Local consumption rose rapidly over the past decade, seeing a 180% increase from 2000 to a total of 1228 Bcf in 2011 as shown in Figure 1.

This increase is largely attributable to economic expansion and population growth, while re-injection of natural gas to increase oil production takes up just over 20% and continues to rise (AER 2012). In recent years, the demand for natural gas, both for local consumption and exports, has outpaced the supply. The Sultanate of Oman imports small volumes of natural gas from Qatar via UAE through the Dolphin Pipeline. The Dolphin Pipeline is Oman's only means for importing natural gas, providing approximately 200 million cubic feet per day (Mcf/d). In 2010, Oman exported a total of 406 Bcf, a decline of 2 Bcf from the previous year. Despite facing a gas shortage and increasing domestic demand, Oman exports 55% of its gas because of term contracts, the first of which expires in 2020 (The Ministry of Oil and Gas 2012). The government has realized the future constraints in meeting the gas demand and has announced plans to reassess natural gas reserves, planning to increase reserves by a trillion cubic feet per year for the next 20 years (The Ministry of Oil and Gas 2012).

Sustained Growth in the Electricity Power Generation and Demand

The Sultanate of Oman does not have an interconnected national grid; rather the electricity grid is segregated into the Main Interconnected System (MIS) in the north and the Salalah power system in the south. The remaining scattered rural areas of Oman are provided with electrical power by diesel generators. The electricity sector in Oman is primarily fueled by natural gas (AER 2012). As of 2012, 97.5% of the installed electricity capacity was fueled by natural gas and the remaining 2.5% was fueled by diesel. During the last decade, the sustained growth of the population and the expansion of heavy industry in cities such as Sohar, Salalah, and Duqm have put a strain on Oman's power infrastructure. Oman's electricity sector and GDP are strongly correlated as shown in Figure 2. This exemplifies the contribution of the oil and natural gas sector for electricity generation and the direct correlation between GDP and the electricity sector (Statistics for Oman, World Data Bank 2012).

The natural gas is used to produce 7.2 TWh of electricity and 52 million m^3 of desalinated water in 2000 and accounted for 19.1% of total Oman gas use (104.4 bn Scf of 547.2 bn Scf). By 2011, following the increase demand in electricity and desalinated water production by 180% and 190%, respectively, total gas use had increased by 124% but the electricity

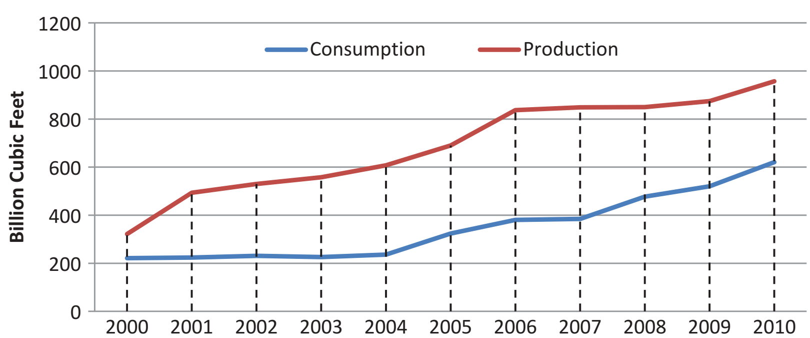


Fig. 1. Natural Gas production and consumption in the Sultanate of Oman, 2000–2010.

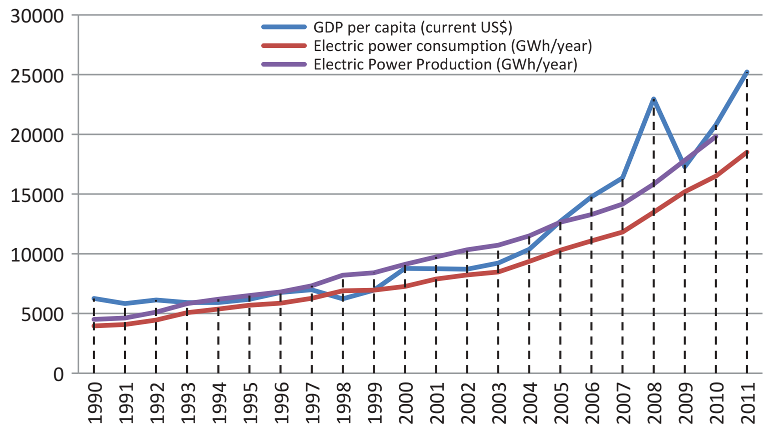


Fig. 2. Relationship between GDP, electricity production and consumption for the Sultanate of Oman.

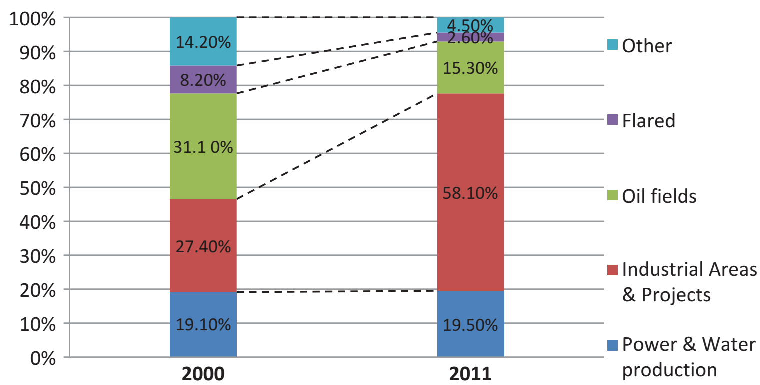


Fig. 3. Comparison of Gas use per activities in 2000 and 2011.

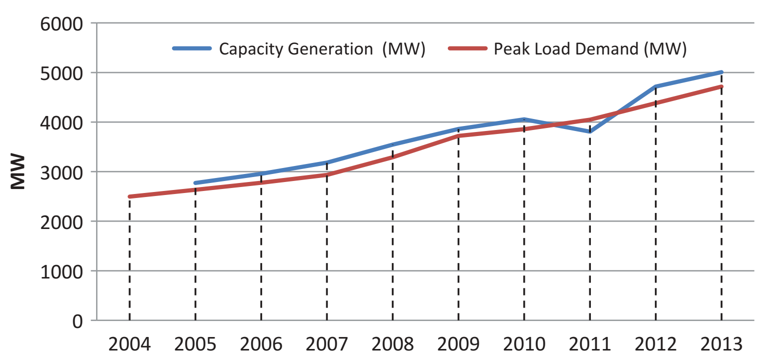


Fig. 4. Electricity capacity and peak load in Oman between 2004 and 2013.

sector's share of gas use was 19.5%, similar to its 2000 share and indicating significant improvement in gas use efficiency (AER 2012). The structure of domestic gas use changed considerably between 2000 and 2011: while the electricity sector's share remained close to 19%, gas use by Industrial areas and projects increased from 27.4% in 2000 to 58.1% in 2011. Gas use at oil fields, flared gas and other uses accounted for 22.4% of total gas use in 2011, significantly less than the 53.5% share in 2000 (Figure 3) (AER 2012).

Figure 4, shows the trend in electricity capacity and peak load in Oman between 2004 and 2013 (AER 2012). According to OPWP, peak power demand has reached 3856 MW in 2010, which represent 46.4% increase since 2005. During the same period, the capacity generation registered 4054 MW in 2010 for the Main Interconnected system (MIS) and Salalah system together, which represent an increase of 46.3%, slightly less than the peak demand growth rate.

The power demand will continue to grow with a steadily rate during the next decade. The peak demand in MIS is projected to grow at 8% per year to reach 6,582 MW in 2018. For Salalah system, the peak demand is expected to grow at 10% per year, reaching 689 MW in 2018. Oman's Rural Areas Electricity Company (RAEC) is responsible for electricity generation for the remote, rural areas of Oman, which have limited or no access to grid based electricity. RAEC manages 49 diesel-based power stations across the Sultanate of Oman with a cumulative installed capacity of roughly 447 MW in 2006. The rural power supply increased to 605,204 MWh in 2011 from 513,038 MWh in 2010 reflecting an increase of 18% in total power generation. This is subsequent to the 12% increase in power generation from 2010 to 2011(RAEC 2012).

Rational for Renewable Energy Resources in the Sultanate of Oman

Growing Constraint and Concerns on Natural Gas

As of January 2011, Oman's proven reserves of natural gas amounted to 30 trillion cubic feet (Tcf) and these reserves have remained stagnant at 30 trillion cubic feet since 2006. Oman's annual natural gas production capacity has remained close to 900 billion cubic feet (Bcf) per year (936 Bcf/year in 2011). Given the same production levels sustain in the long term, the current natural gas reserves would last 32 years, if complete extraction of the current resources is considered to be economically viable. The Sultanate of Oman can also import gas through the 200 million cubic feet per day (Mcf/d) Dolphin pipeline from Qatar via UAE. The natural gas production attends for both local demand and exports in the form of liquefied natural gas (LNG).

The Omani power network suffered significant electricity shortfalls in the summer of 2011 when the crisis could only be averted through the procurement of temporary power capacity. The issue questioned the government's long-term strategy for effective power generation and distribution. According to OPWP, the annual peak power demand growth rate for the country is 9.5%, which would result in a forecasted capacity requirement of 8106 MW in 2019. In review of such capacity needs, the government has developed an active strategy to deploy a series of natural gas fueled combined cycle power plants to add roughly 4000–4500 MW of capacity till 2018–2019. This would almost double the existing power generation capacity. The power generation expansion plan consists of two key additions:

1. 2000 MW power project in the city of Sur (east of Oman), which is currently in construction stage,
2. Series of power capacity additions amounting to 2000–2500 MW.

According to the new strategy, all future power generation expansion projects would be fueled by natural gas. The excessive reliance on natural gas given that production capacity is limited is questionable. This is summarized in Table 1, which describes the supply and demand of natural gas in Oman. The future Natural gas requirements were calculated with a capacity factor of 75% and 7980 cubic feet of natural gas per MWh.

Table 1. Oman's Natural Gas Supply and Demand

	Activities	Bcf/year
Natural Gas Supply	Natural Gas Production	950
	Natural Gas Imports (Dolphin Pipeline from Qatar via UAE)	73
Natural Gas Demand	Natural Gas Exports (LNG)	406
	Local Natural Gas Consumption (2011)	500
	Enhanced Oil Recovery (20% of consumption)	125
	Natural Gas Requirements for 2000 MW power project in governorate of Sur	101
	Natural Gas Requirements for further addition of 2000-2500 MW (2018–2019)	131

As Table 1 shows, even if other nonpower increments in natural gas consumption are not accounted for, the in-house consumption would climb to 886 billion cubic feet per annum just on grounds of the natural gas requirements for the new power plant.

The Omani government has recognized the need to conserve its natural gas resources. Oman has cut exports of liquefied natural gas, only fulfilling long-term contracts that were locked in years ago. The shortage of natural gas is not restricted to Oman rather the whole-GCC region faces extraordinary challenges in maintaining and increasing gas production at a level that would allow it to meet demand. The demand for natural gas in the region has increased rapidly over the period 1998–2008 at a rate of about 7.6% annually. With the GDP growth and economic diversification, the demand for natural gas and electricity grew at 5.5% and 6.1% per year (Gas Shortage in the GCC 2010). According to EIA's forecasts, the power demand in the region would increase by 50% up to 2040 and most of this additional generation capacity would be fueled by natural gas.

In addition to the power sector, depleting oil fields and enhanced oil recovery has developed as another major source of gas consumption in the GCC region. Oman and Qatar spend a considerable portion of their gas production on enhanced oil recovery. It also needs to be highlighted that with cheap electricity and abundant availability of natural gas in the past, the region has developed significant levels of gas based petrochemical sector, which has become a major contributor to the overall GDP. According to the Oman National Center for Statistics and Information, petrochemicals and refining sector contributed to 6.3% of the GDP in 2011. These sectors are natural gas intensive industries, which are strategically important to the country, and it is important to maintain a consistent supply of gas to them. However, with rapidly increasing natural gas requirements for power generation, the supply to such industries could be limited.

In review of such circumstances, the GCC countries are looking up to the biggest reserves of natural gas in the region, primarily Qatar and Iran. Oman is trying to jointly develop gas fields in Iran and transfer natural gas through an under-sea pipeline from Iran to Oman. However, it is important to recognize that, although Iran holds the world's second-largest gas reserve, it currently imports almost 5% of its gas needs from Turkmenistan to satisfy local demand. Iran uses almost one-third of the produced natural gas for power generation and roughly one quarter of the produce for enhanced oil recovery. in addition, the country has been seeking natural gas imports from Azerbaijan, Bahrain, Armenia, and other neighboring countries. Although all neighboring countries are eyeing Iran's natural gas deposits, its excessive domestic consumption and political uncertainties limit possibilities for any firm agreements for natural gas trade (Gas Shortage in the GCC 2010).

Given such circumstances, a trend to shift toward renewable energy is clearly visible in Oman. Such resources are indigenous, sustainable and can help to meet the shortfall in electricity supplies by freeing up oil and gas for processing and exports.

Electricity Subsidies and Renewable Energy Opportunities

The electricity sector in the sultanate of Oman is too highly subsidies. The consumer's benefit from indirect subsidy as the cost at which fuel is sold by the government to production facilities is below its economic opportunity cost (the price of fuel in the international market). Over 99% of electricity supplied from the MIS and the Salalah Power System is produced at gas-fired facilities, which purchase gas at a cost of \$1.5 per mmBTu (AER 2012). Nonetheless, energy market information suggests a price of up to \$9 per mmBTu would provide a reasonable estimate of the opportunity cost of gas for the purposes of this analysis. Figures 5 and 6 clearly depict the current and future subsidies expended by Oman for power generation. In the MIS at a cost of \$4.5 mmBTu and \$9 mmBTu, the subsidies increase by 165% and 448%, respectively. For Salalah power system, a cost of \$4.5 mmBTu and \$9 mmBTu the subsidies reach \$ 66.5 million (103.6 cents/KWh) and \$ 166.5 million (163.4 cents/KWh) (AER 2012), respectively.

The government heavily subsidizes the power generation for rural areas and the subsidy allocated to RAEC reached \$102.8 million in 2012. The economic cost for power generation through diesel has been on the rise increasing from 23.3 cents/KWh in 2010 to 27.4 cents/KWh in 2012 (RAEC, 2012).

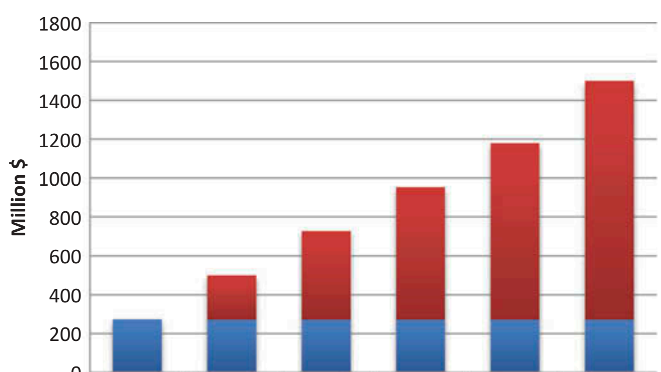
As such high costs, diesel power generation can be replaced with renewable energy technologies such as solar and wind energy in a cost-effective manner. Solar energy includes concentrating solar power (CSP) and solar photovoltaic (PV). The two main CSP systems are parabolic trough and solar tower. The majority of commercial experience has so far come from parabolic trough systems. The two technologies currently have similar Levelized cost (20 cents to 36 cents/kWh for parabolic trough and 17 cents to 29 cents/kWh for solar tower) assuming the cost of capital is 10% (IRENA 2012a). The cumulative installed capacity of solar PV grew by around 70% in 2011. Combined with the high-learning rate for solar PV, this growth has resulted in significant cost declines over recent years. The levelized cost of solar PV came down to 14 to 17 cents per kWh (IRENA 2012a).

Thereby, diesel-based power generation presents an opportunity where renewable energy technologies are technically and economically viable. However, it is important to develop an enabling framework through appropriate strategies, policies, regulations, and other protocols to employ renewables.

High Demand for Desalinated Water in the Foreseeable Future

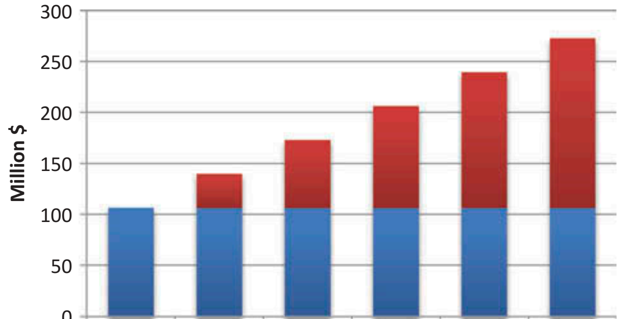
Sultanate of Oman is one of most water-stressed countries in the World, with less than 1000 cubic meters in freshwater availability per person per year (UNEP, 2008). In 2010, there was a water shortage of Sultanate of Oman estimated around 378 million cubic meters. Keeping water supply and demand in equilibrium in one of the most pressing challenges facing Sultanate of Oman in the years ahead (Ministry of Regional Municipalities and Water Resources 2012).

Groundwater accounts for the overwhelming majority of supply, representing about 78%. Desalinated water accounts for the next highest share of water supply, representing about 15%. By the end of 2007, there were a total of 94 desalination plants in Sultanate of Oman. Based on the annual report issued by OPWP in 2008, the projected total demand for the desalinated water in the regions covered by the MIS is expected to increase from 102 million m^3 in 2008 to 234 million m^3 by 2015, an average



	$1.5 mmBTu	$3 mmBTu	$4.5 mmBTu	$6 mmBTu	$7.5 mmBTu	$ 9 mmBTu
Subsidy cents/KWh	16.5	30.5	44.2	58.2	72	85.7
Subsidy increase at higher Gas Cost (Million $)		226.366	452.991	679.357	905.723	1225.588
Subsidy at financial Gas cost (Million $)	272.986	272.986	272.986	272.986	272.986	272.986

Fig. 5. Main Interconnected System (MIS) subsidies analysis.



	\$1.5 mmBTu	\$3 mmBTu	\$4.5 mmBTu	\$6 mmBTu	\$7.5 mmBTu	\$ 9 mmBTu
Subsidy cents/KWh	63.7	83.7	103.6	123.5	143.5	163.4
Subsidy increase at higher Gas Cost (Million \$)		33.411	66.563	99.974	133.126	166.537
Subsidy at financial Gas cost (Million \$)	106.19	106.19	106.19	106.19	106.19	106.19

Fig. 6. Salalah system subsidies analysis.

annual increase of 13% per year. OPWP has forecasted also that the peak demand for water will reach 723,000 m^3/day by 2015, and thus at least 133,000 m^3/day of additional water desalination capacity is needed.

Given Oman is facing water scarcity issues and some desalination capacities are spread across the rural areas, renewable desalination could potentially be a viable option in some areas. The economics of renewable desalination depends on the cost of renewable energy as the cost of desalination is largely determined by the energy costs. Although, the cost of renewable desalination is still higher if compared to the cost of conventional desalination, but the costs of renewable technologies are decreasing rapidly and renewable desalination can already compete with fossil fuel-based desalination in some areas (IRENA 2012b).

Enabling Transition to Renewable Energy

Policies and Targets

In Oman, no policies or strategies have been specifically tailored to develop the renewable energy sector. Also, the country has not announced any official targets for renewable energy deployment. However, a report by Frost and Sullivan stating the targets and plans for GCC countries, mentions a 5% renewable energy market for Oman by 2020 (Frost & Sullivan, 2013). This amounts to 1.25 GW of renewable energy capacity. However, this target would be hard to attain at current progress levels. The consultative process with public and private stakeholders, clearly mention that there is an urgent need to set-up a national strategy and policy for renewable energy in Oman through the direct involvement of relevant stakeholders. The main aspects to consider when developing effective policies to promote RE deployment are:

1. Set target medium and long terms for on-grid and off-grid renewable applications
2. The maturity of a given renewable Energy technology;
3. The maturity of the national and global market for the considered technology.

On the other hand, deployment of RE can be segmented into three main phases:

1. Inception phase, when the first projects of a technology are deployed
2. Take-off phase, when the market grows rapidly, leading to widespread deployment; and
3. Consolidation phase during which the market grows towards the targets that have been setting by Government.

In general terms, across the three main phases mentioned above, challenges evolve as renewable energy market growths and the penetration levels increase correspondingly. Policy priorities should change as deployment levels increase (Inception, Take-off and consolidation phases). So as Oman is now at the Inception phase, it would seem careful to start with a simple and implementable policy such renewable energy auctions. The auctions process will certainly give the opportunity to compare technology costs and decide on the way forward. Furthermore, during this inception phase, the country should take some initiatives/decisions by:

1. Establishing the costs and potential of renewable technologies so as to be able to set reasonable targets;
2. Ensuring that the infrastructure or market access can be achieved;
3. Developing the institutional capacity required to manage and monitor the progress;
4. Establishing a supply chain capability (local content and services)
5. Identifying and tackling other institutional, legal, and administrative barriers which can impede penetration of renewable energy;
6. Deploying pilot projects with reasonable size to establish the feasibility and credibility of the technologies (particularly wind and solar) and to give the opportunity to the main actors to learn and practice their skills.

Institutional and Regulatory Structures

Three governmental institutions manage the electricity sector in Oman:

1. The Public Authority for Electricity and Water (PAEW): Its key role is to secure production of potable water in the unrelated water sector in accordance with Oman's standards and proportionate to the expansion of development and population growth. It is responsible for enforcing the government's policy in relation to securing electricity supply for the greatest portion of society.
2. Authority for Electricity Regulation (AER): The Authority is competent to regulate the electricity and related water sector
3. Oman Power & Water Procurement Company (OPWP): Is the single buyer of power and water for all Independent Power Producer (IPP) and Independent Water and Power Plants (IWPP) projects within the Sultanate of Oman. The OPWP undertakes long term generation planning and publishes a 7-year statement.

There are no dedicated agencies for the promotion of sustainable energy. Although most government agencies appear to have an interest in the subject, sustainable energy is not an objective for any of these organizations. At the ministerial level, Oman lacks a ministry, commission or directorate, which is specifically focused towards the energy sector in general or renewable energy and energy conservation in particular. There is no Ministry of Energy as such rather energy related issues are split between Ministry of Oil and Gas, Ministry of Environment and Climate Affairs or Ministry of Finance in a complicated manner. The current governance structure lacks a dedicated institution focused on developing political mandate around renewable energy sector policies whether as economic, legislative, and/or administrative measures. The Sultanate of Oman has an ambitious plan for attracting investments and modernizing its power and water infrastructure with some level of commitment for developing its renewable energy resources and enhancing use of energy conservation practices. However, the development of renewable energy resources requires focused institutions.

Resource Mapping of Renewable Energy Sources, Research Development and Capacity Building

In Oman, all the knowledge related to renewable energy in Oman, is mainly based on academic studies, using models and satellite data. To attract investors, there is a need for comprehensive mapping of all renewable energy resources to produce bankable information and to conduct studies on grid capacity to uptake variable renewables sources. Thereby, the government should urgently initiate a comprehensive resource mapping exercises based on ground measurements. The information attained should be made available freely through a public domain.

Also, Oman suffered from a shortage of trained professionals and technical personnel to formulate renewable energy policies and regulations; develop legal and financial frameworks; and design, operate, and maintain renewable energy systems. Renewable energy technologies are a broad subject comprising various technologies and their applications. Therefore it is essential to facilitate development of appropriate skills and local capacities. This can be performed through graduate and postgraduate courses that need to be started to develop a cadre of renewable energy professionals and thus enhance the development of the renewable energy industry. This will also boost research and development activities in the technological, economic, and social aspects of renewable energy.

Conclusions

This article clearly shows that there is a need to shift to renewable energy based on the national circumstances, which characterized by gas shortage. Also, the article indicates the existence of real opportunities to invest in renewable energy mainly in remote areas. But to develop Oman's renewable energy base, it is essential to develop a facilitating environment which includes appropriate policies, regulations, focused institutions, tailored education and skill development initiatives, focused research and development projects, financing schemes, and favorable market scenarios. During the last 5 years, little funding was provided for research and development for the growth of the Omani renewable sector. However, the previous 'fear and distrust' of renewable energy sources in Oman as an oil- and gas-producing country has changed into realization of renewable energy resources as essential components of the national energy supplies as well as a global strategic option for both extending the life of oil and gas reserves while reducing carbon dioxide emissions and combating climate change.

The participatory approach reach a consensus, that there is an urgent need to develop and implement appropriate national policies and measures to create an enabling environment for the development, utilization, and distribution of renewable energy sources, through the establishment of a national agency responsible for all renewable energy activities. The priorities of this national agency are:

1. Mapping of resources according to the concept of the bankable date
2. Setting medium and long term targets for on-grid and off-grid renewable applications
3. Development of a sectorial business model and financial mechanism

The national agency is also mandated to improve the functioning of national energy markets in such a way that they support Renewable Energy, overcome market barriers and improve accessibility. Lack of local capacity was also identified as a major obstacle to the expansion of Renewable Energy in the country. It is important that academic institutions, infrastructures and human resources should be strengthened. Information and knowledge sharing on technologies and policies was considered as a good vector to facilitate efforts to promote the deployment of Renewable Energy. Relevant information could direct decision makers to suitable policy and energy supply options. Very often, the lack of such information and knowledge prevents stakeholders from adopting renewable energy applications.

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