Energy Policy 39 (2011) 2467–2474

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Transforming shortcomings into opportunities: Can market incentives solve Lebanon's energy crisis?

Isabella Ruble *, Pamela Nader

American University of Beirut, Department of Economics, P.O.Box 11-0236, Riad El-Solh/Beirut 1107 2020, Lebanon

ARTICLE INFO

Article history:
Received 28 September 2010
Accepted 1 February 2011

Keywords:
Energy policy
Renewable energy
Energy efficiency

ABSTRACT

Over the past decades Lebanon's energy sector has been largely ignored and this has led to high economic and environmental costs. The sector is characterized by electricity poverty, an expanding and mainly unregulated transport sector and a lack of energy savings spanning through all sectors of the economy. Recently, the Government of Lebanon has committed to increase the share of renewable energy to 10% of the total energy supply by 2013 and to 12% by the year 2020; it also aims at reducing energy consumption by 6% by the year 2013. This paper aims at contributing to the formulation of a more comprehensive energy strategy for Lebanon by analyzing the recent changes in policy direction and by recommending legal, regulatory and policy measures in order to transform current shortcomings into opportunities allowing the country to become a regional 'success story' in the deployment of renewable energy and energy efficiency.

1. Introduction

The threat of worldwide oil and gas reserves running out in the next 40–60 years has led countries around the world to diversify their energy portfolios, and renewable energy (RE) has ranked increasingly high on the agenda over the past decade. Energy policy decisions today will influence the environmental, social and economic situations of a country for decades to come. For many developing countries, achieving the provision of reliable and affordable energy in a sustainable manner will allow eradicating energy poverty, foster development and economic growth and thereby lead to higher standards of living.

Lebanon is a small open developing economy located in the MENA region. Despite reconstruction efforts after the long civil war (1975–1990), the prevailing national and regional instability has led to the neglect of its energy sector over the past decades. The latter, in combination with the absence of a national energy strategy, has led to energy poverty in the form of lengthy power cuts, and high energy intensity throughout all sectors of the economy as energy conservation measures are virtually inexistent. These factors have prevented the country from reaching its full economic growth potential.

The MENA region, is however increasingly being identified as a potential future hub for RE, both for its own consumption and as a supplier for the EU. The majority of countries in this region has set clear targets for the deployment of RE and energy efficiency (EE) measures, and has accomplished a number of policy and legal reforms to foster the development of these markets. The MENA region has thus witnessed a substantial surge in investment in the RE and EE sectors. Due to a lack of official interest Lebanon has largely been left out of these regional initiatives in the past.

The recent move of the Government of Lebanon to increase the share of RE to 10% of the total energy supply by 2013 and to 12% by the year 2020, as well as to reduce energy consumption by 6% by the year 2013 (MEW, 2010), might allow Lebanon to catch up with its neighbors in the region. The announced policy targets show the government's new commitment towards RE and EE, and their implementation constitutes an important step in the move towards sustainability.

Different aspects of the Lebanese energy sector have been analyzed to date. Chaaban and Rahman (1998) present options for energy conservation in economic sectors characterized by high energy consumption while Chedid et al. (2000, 2001) identify the benefits of EE measures to the national economy. Karaki and Chedid (2007), Abi Said (2005), Comair (2009) and El-Fadel et al. (2010) present an overview of the Lebanese electricity sector and investigate Lebanon's potential for RE while El-Fadel et al. (2010) also examine the reform of the power sector with a special emphasis on sustainability. The potential for greenhouse gas reductions in the power sector is addressed by El-Fadel et al. (2003), Ghaddar et al. (2005), Chaaban and Chedid (2000) and Dagher and Ruble (2010); Ghaddar et al. (2005) also consider the socio-economic aspects of an increased deployment of RE. El-Fadel and Bou-Zeid (1999) and Chaaban and Chedid (2000) consider greenhouse gas mitigation in Lebanon's transport sector.

* Corresponding author. Tel.: +961 71727535; fax: +961 1744461.
E-mail address: economics.ir@gmail.com (I. Ruble).

0301-4215/$ - see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.enpol.2011.02.011

To the best of our knowledge, Lebanon has not yet developed a comprehensive national energy policy and no thorough study of the recent changes occurring with respect to energy and its use in Lebanon has been published. The present paper is trying to fill a gap in the literature by analyzing these changes in light of regional developments and to make a contribution to the formulation of a comprehensive and sustainable national energy policy by highlighting how the current shortcomings can be turned into opportunities creating a success story.

In Section 2 we provide some country background information and an overview of the current situation in the Lebanese energy sector. Section 3 highlights the developments in the fields of RE and EE in the MENA region. Section 4 presents a discussion, and policy recommendations for a more comprehensive energy policy for Lebanon in light of the regional and global context. Section 5 presents a brief conclusion.

2. Country and energy sector background

2.1. Country background

Lebanon is a small open developing economy. In 2009, its population was estimated to be 4.2 million, its GDP and per capita GDP amounted to roughly 33.59 billion USD and 13,200 USD, respectively (EIU, 2010; CIA, 2009). The external debt reached 21.11 billion USD or 156% of GDP (CIA, 2009). Lebanon primarily relies on services, with exports in services accounting for almost half of its GDP. Banking and tourism followed by construction are the three most important sectors of the economy (EIU, 2010). Inflation in 2009 was estimated around 3.4% while unemployment reached 9.2% (CIA, 2009). GDP growth is expected to reach 6.2% in 2010 (EIU, 2010).

The Lebanese economy has shown considerable resilience in face of the worldwide crisis, according to the IMF resilience prevailed, thanks to a sound banking system, a no-default reputation despite high indebtedness and the implicit guarantees provided by international donors (IMF, 2007).

2.2. The energy sector

Lebanon's economy is slightly atypical for a developing country; its structure with nearly 70% of GDP coming from the services sector resembles more that of a developed economy. Its energy intensity of 0.20 toe per $1000 of GDP (in 2005 PPP) lies slightly above the region's (0.18) and largely above both the World's (0.13) or the OECD's (0.11) averages (The World Bank, 2009b).

The Lebanese energy sector is heavily reliant on fossil fuel imports (97% of total primary energy) and therefore also very exposed to international oil price fluctuations. In 2007, in terms of total primary energy consumption, the transport sector is leading followed by the residential and tertiary sectors and industry (see Fig.1). Considering that Lebanon is not a fossil fuel producer and that its economy is mainly service oriented, the so-called 'sector effect' cannot justify its relatively high energy intensity.

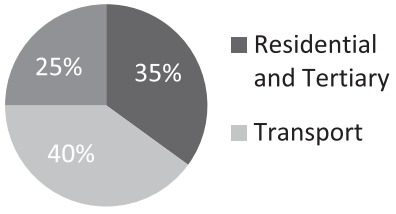

Fig. 1. Energy consumption by sector.
Source: Mourtada (2008).

Furthermore, its major energy consuming sectors often lack the most basic EE measures; hence there is no positive 'energy efficiency effect'. This allows us to conclude that there is a large potential for reducing Lebanon's energy intensity.

2.2.1. The electricity sector

Electricity production relies mainly on imported oil (93.5%); other sources include coal (2.2%), geothermal/solar/wind (0.2%), combined RE and waste (2.1%) and hydro (2%) (ALMEE, 2007).

The public utility Electricite du Liban (EDL) is the sole official provider of electricity in Lebanon. In 2009 its total installed capacity was 2312 MW while its total combined generating capacity of hydro and thermal power plants reached 1848 MW. In terms of total electricity provided, 88% came from thermal power plants, 4.5% from hydro and 7.5% were imports from Syria and Egypt. The overall demand for electricity in 2009 was estimated to be around 15,000 GWh; consumption amounted to 11,522 GWh, thus EDL was not able to satisfy the remaining 3478 GWh in demand (MEW, 2010).

In contrast to many other developing countries, electrification in Lebanon is nearly 100%. Yet, with no more additions to installed capacity for the past 14 years and an electricity demand growth estimated in the range of 2.5–8% per year (Dagher and Ruble, 2010), the shortage in installed capacity is estimated to be around 700 MW in 2010 (MEW, 2010). Furthermore, to meet estimated demand increases, an additional 800 MW of installed capacity will be required by 2014; while another 1000 MW will be required after 2015 in order to reach a total installed capacity of 5000 MW in the medium term (MEW, 2010).

The World Bank (2008) estimates that in 2006 EDL provided around 61% of total electricity demanded while 33.6% was satisfied by the back-up sector and 5.6% was considered to represent suppressed demand. Around 58% of private households and nearly 100% of commercial and industrial enterprises are using back-up generation as an alternative power supply (The World Bank, 2009a). Two groups of back-up generation providers can be identified: the first group generates electricity for its own consumption in the industrial, commercial and residential sectors, while the second group consists of neighborhood generators that sell electricity when power cuts occur (Abi Said, 2005). The subscription to a neighborhood generator costs about $60 a month for a capacity of 10 A (Dagher and Ruble, 2010). In contrast, EDL's tariffs are based on 1996 oil prices of $25 per barrel, effectively subsidizing all households despite its inverted block tariff. The overall average tariff is around 9.4 US cents per kWh; this number is high compared to some other countries in the region (The World Bank, 2008), but much too low to cover EDL's average total costs that amounted to 17.14 US cents per kWh in 2009 (MEW, 2010).

Lebanese households typically pay two electricity bills, one to EDL and one to the back-up providers, yet despite the high costs incurred they are still exposed to lengthy power cuts as the latter, which being paid a flat fee, can increase their profits by not covering the full blackout period. Furthermore, illegally operated, back-up providers are not subject to any type of regulation concerning safety, environmental or fiscal issues, and hence consumer protection is totally inexistent.

While households only rely on back-up generation during periods of blackouts, industrial enterprises also rely on back-up generation during peak-load periods when the price charged by EDL is roughly three times as high as during regular hours (The World Bank, 2008). In addition to the higher tariff charged during peak hours, enterprises also incur the risk of power interruptions if they rely on EDL. In fact, The World Bank (2008) finds that the impact of power failures on industries in Lebanon is among the

highest in the region. Estimated economic losses due to the inability to provide sufficient and uninterrupted power have been estimated to average to 2.5 billion dollars in 2009 (MEW, 2010).

2.2.2. The transport sector

Lebanon, with its 10,452 km^2 and its population of 4.2 million, is relatively densely populated, with 450 people for each square kilometer, and distances traveled are typically short. The transport sector is the largest sector in terms of energy consumption and, as is typical for most developing countries, this sector has experienced substantial growth in recent decades. Furthermore, even though as much as 87% of the population lives in urban areas, the public transport system is largely underdeveloped so that people are relying mainly on private means of transportation.

In 2009 the number of vehicles registered reached over 1.6 million and around 80% of these vehicles were older than 10 years (Blominvest, 2010). Import tariffs for vehicles average 29% of purchase price (Byblos Bank, 2010) and do not take into consideration any environmental aspects, such as, for example fuel efficiency or the inclusion of a catalyst; the import of cars older than 8 years is however not allowed. In 2010 the Government has started to allow the import of diesel-powered cars provided that they are less than 2 years old; the latter restriction does however not apply to vehicles used in public transportation or to mini-vans. The Government is planning to exempt hybrid cars from import duties, budgetary approval pending. The Government is also considering replacing around 20,000 taxi cabs with environmental friendly cars (Byblos Bank, 2010); similar projects have been realized in other MENA countries such as, for example Egypt.

Gasoline prices in Lebanon were frozen between 2004 and 2008, but since January 2009 gasoline is taxed again, and prices are fluctuating in line with changes in world markets (Byblos Bank, 2009). In 2008, Lebanon ranked 14th regionally and 33rd globally for the lowest gasoline prices. Only 8 out of the 19 MENA countries, those heavily dependent on fossil fuel imports (Jordan, Sudan, Lebanon, Syria, Tunisia, Morocco, West Bank & Gaza, Israel), are taxing gasoline while the remaining 11 countries are subsidizing this fuel (Byblos Bank, 2009). Gasoline prices, still low by global standards, have gradually increased in recent months.

The transport sector is the second largest sector in terms of greenhouse gas emissions (SNC, 2009), and Byblos Bank (2010) estimates that this sector might be responsible for as much as 70–80% of total air pollution in Lebanon. The transport sector places an increasingly large burden on the environment and the economy, and is characterized by a chronic lack of fiscal and environmental regulation.

2.2.3. The residential and tertiary sectors

The residential sector's electricity consumption in Lebanon was estimated to be around 42% (Mourtada, 2008). While less than half the countries in MENA has building codes in place that incorporate EE measures, a large number of countries are at diverse stages between developing and adopting such codes (The World Bank, 2009b). Strong population and economic growth lead to an active construction sector. The potential for energy savings is substantial, both for new buildings and for the existing stock of buildings.

2.3. Recent efforts to introduce renewable energy and energy efficiency

Lebanon has been lagging behind most MENA countries in its efforts to introduce RE and EE measures or energy efficient equipment. The creation of the Lebanese Center for Energy Conservation (LCEC) in 2002 and the Country Energy Efficiency and Renewable Energy Demonstration Project for the Recovery of Lebanon (CEDRO) in 2005 has lead to a great multitude of initiatives. To date, the major already accomplished or ongoing initiatives include the introduction of compact fluorescent lamps (CFL), solar water heaters, EE measures in industry, street lighting programs, the development of standards and labels and the development of a number of energy related laws and financing mechanisms.

The LCEC, as the main link between major national and international stakeholders, has conducted intensive research and a large number of pilot projects in order to evaluate local market conditions. For example, the energy audits that were conducted throughout economic sectors have allowed assessing different energy conservation measures (The World Bank, 2009d). Furthermore, the LCEC has in cooperation with the Lebanese Standards Institution (LIBNOR) developed EE standards for the following five household appliances: solar water heaters, compact fluorescent lamps, refrigerators, AC split units, electrical and gas water heaters (The World Bank, 2009d). In fact, in 2009 the LCEC has launched a project distributing, free of charge, three million compact fluorescent lamps to Lebanese households throughout the country in return for incandescent lamps (LCEC, 2009). In addition, detailed studies concerning potential energy savings, costs and payback periods for various measures in new buildings were conducted and allowed the development of thermal standards (The World Bank, 2009d). In December 2010, the LCEC has also launched the National Energy Efficiency Action Plan (NEEAP) that consists of 14 individual initiatives.

2.3.1. Solar energy

Water heating has a great potential for electricity savings as it accounts for 22% of household electricity consumption (Chedid et al., 2001). Over the past decade the use of solar water heaters has substantially increased, and installed solar collectors reached 2310 m^2 in 2008. The penetration rate in some neighboring countries, such as Greece or Cyprus, is however still much higher than in Lebanon and it even reached 85% in Israel (Namovicz et al., 2007). The LCEC has provided training sessions and technical assistance in order to foster the deployment of solar water heaters and it has recently launched an initiative with the aim to increase the solar collector area by 190,000 m^2 over the 2009–2014 time-period and by 1,050,000 by 2020 (LCEC, 2010). The increased solar collector area will yield savings in electricity produced through conventional fuels of over 1 million MWH (LCEC, 2010). A testing facility for solar water heaters will be operational starting March 2011 at the Industrial Research Institute (IRI), and solar water heaters will have to comply with the newly adopted standard (NL 12976) before being sold on the market.

Distributed RE for power generation also gains increasing interest. Recently, a feasibility study has been commissioned to assess the construction of a CSP plant with a capacity of 50 MW in the Byblos area. The CSP plant is intended to provide electricity to industry and businesses in the area. If deemed successful, similar plants are foreseen for other industrial cluster areas in Lebanon (UNSTDA, 2010). These types of projects potentially qualify to benefit from financing through the Clean Development Mechanism.

2.3.2. Wind energy

As for wind energy, in Lebanon so far two wind turbines have been installed prior to 2006, one of them was however destroyed during the 2006 summer war (Al-Widyan and Al-Muhtaseb, 2009). Recently, the Government of Lebanon has commissioned the assessment of micro-wind turbines for power generation in

10 different locations in Lebanon (UNDP, 2010); while the development of a national wind atlas has revealed that Lebanon's potential for wind energy is estimated around 1500 MW (UNDP, 2011).

2.3.3. Institutional framework

The economic and legal framework that determines the market conditions relating to energy has not yet been properly established and consequently the above mentioned initiatives are only timid first steps in relation to the potential scope of these markets. The MEW has commissioned a European Union (EU) funded project aimed at assisting the LCEC in achieving a comprehensive policy reform program that consists of establishing the appropriate legal framework, developing the necessary financial platform and launching an information and capacity building campaign (EU, 2010). The development of the legal framework foresees the development and the implementation of new laws (EE Law, Thermal Standards Law for the Residential and Commercial Sector, RE law, Law on Mandatory Audits for Large Consumers), as well as the assessment of existing laws in order to identify potentially necessary changes to the latter (EU, 2010). The reform program also aims at establishing an energy conservation fund, identifying measures that increase incentives in the adoption of energy efficiency measures, scrutinizing current energy pricing policies and assessing their effects on market development, as well as supporting lobbying efforts. In the MENA, EE laws have already been introduced in Algeria, Israel, Saudi Arabia and Tunisia (The World Bank, 2009b). The project also aims at establishing the LCEC as an independent government agency; experience in countries around the world has shown that the existence of a 'one-stop' energy agency is crucial in fostering the introduction of EE and RE (The World Bank, 2009b).

The upfront investment for RE sources and energy efficient equipment is usually larger than for their conventional counterparts. Operating costs for RE sources are however lower, due to the lower costs of their main inputs, which in the case of the sun or the wind are even zero. Similarly, for a given output the necessary power input for energy efficient equipment is typically lower than for their conventional counterparts. A proper cost comparison between RE sources or energy efficient equipment and their conventional counterparts therefore requires the use of lifecycle analysis.

The reform of current energy pricing policies (such as the removal of subsidies, for example), and other regulations affecting the energy sector, will allow RE sources and energy efficient equipment to become more competitive while at the same time energy saving will be encouraged. The relative prices of different energy sources determine the interactions between stakeholders in the market (Dukert, 2009), and prices should reflect economic and environmental costs.

Furthermore, the availability of suitable financing instruments and support schemes has revealed its usefulness in overcoming the barrier of higher initial investment costs. Empirically, countries that have successfully developed their local RE and EE markets such as, for example China or India, have done so by providing favorable financing mechanisms and various forms of subsidies.

The Lebanese banking sector is one of the driving forces of the economy and is as such very well developed. In general firms have good access to external finance; small and medium sized enterprises do however suffer from high lending rates and less favorable lending terms. In recent years, the Lebanese Government has therefore implemented a variety of support programs, hence local banks should have no difficulties implementing similar or even new financing mechanisms aimed at developing the markets for RE and EE. The LCEC has initiated the subsidization of solar water heaters through the Lebanese Central Bank (Circular Nr. 25-11-2010) whereby consumers can benefit from interest free loans to purchase solar water heaters. In addition a rebate of 200 USD is given to the first 7500 customers. The 1.5 million USD in subsidy are provided by the Government of Lebanon.

In most developing countries there is a need to create the necessary awareness and knowledge about RE and EE. Understanding the meaning of energy and the need to contain its consumption is, in addition to pricing and other financial incentives, the basis for acceptance and interest. The spreading of knowledge about RE and EE, and its potential benefits, as well as promoting financing mechanisms, will allow individual consumers or firms to overcome existing barriers. The necessary human capital can only be built up gradually, as there is typically a lack of specialized labor at the onset of such markets in developing countries.

2.4. Greenhouse gas emissions

Lebanon is a party to the United Nations Framework on Climate Change and it has issued two national communications on climate change, in 1999 and 2009. It has also ratified the Kyoto Protocol in 2006 that entered into force in 2007. Lebanon emits around 17.5 million tons of CO_2 and per capita emissions amounted to 4.4 tons (WRI, 2009). In 2007, the main CO_2 emitting sectors in Lebanon are energy, accounting for 47.5% of total CO_2 emissions, followed by transport accounting for 31% and industry accounting for 14% (Mourtada, 2008). The remaining 7.5% of total CO_2 emissions is shared nearly equally among the residential, agriculture/forestry/fishing and commercial/institutional sectors (Mourtada, 2008). The CO_2 emissions of both the power sector and the transport sector lie above the regional average of 44% and 22%, respectively (CIF, 2009b).

The CDM, as one of the three flexible mechanisms used to promote greenhouse gas mitigation under the Kyoto Protocol, presents a potential financing source for the deployment of RE and EE measures for countries that have ratified the Kyoto Protocol, and have set up a Designated National Authority (DNA) responsible for the assessment of the submitted Project Idea Notes (Karakosta et al., 2010). Lebanon is thus qualified to benefit from the CDM and has registered its first CDM project in 2009. The MENA region however, accounts only for 2% of total worldwide CDM projects; clear leaders are countries like China and India (Fenhann, 2009; Karakosta et al., 2010). In the MENA region, the use of the CDM faces a number of obstacles as most countries still lack the necessary institutions and/or expertise; in addition, the transaction costs of this mechanism are too high for the more typical small-scale projects in this area of the world. Interestingly however, the 71 CDM projects undertaken so far in the MENA region are spread unequally among countries in the following way: Israel (28), followed by Egypt (13), Morocco (10), UAE (9), Jordan and Iran (3), Tunisia and Syrian (2) and Quatar (1) (Karakosta et al., 2010; Fenhann, 2009).

3. Renewable energy and energy efficiency in the MENA region

3.1. Overview

The Middle East possesses nearly 60% of the worlds proved oil reserves and 41% of proved natural gas reserves (BP, 2009), and hence this region has long been lagging behind other regions in the world, when it comes to the deployment of RE sources and EE measures. Economic development and important population

growth have lead to high growth in energy demand that is expected to double over the coming two decades and will thus require an additional 250 GW to be added to existing installed capacity in order to meet demand (Global Arab Network, 2010). Furthermore, the region's energy intensity of 0.18 toe per $1000 of GDP (in 2005 PPP), is about 40% above the world's average (The World Bank, 2009b). However, over the past 15 years, the MENA has increasingly been identified as a potential hub for RE, possibly even supplying the EU with clean energy in the future (Trieb et al., 2009). Energy saving policies and the deployment of RE now rank high on national policy agendas and most MENA countries have developed individual targets for the deployment of RE and EE measures. The following paragraph aims at giving a general overview as a detailed account of all initiatives is beyond the scope of this paper.

Abu Dhabi aims to generate as much as 7% of its electricity from solar, wind, geothermal and hydrogen power plants by the year 2020. Its program is the largest in the region with investments reaching more than $22 billion (MENA Renewables, 2010). The 'Masdar City' project, for example aims to create a carbon neutral town by investing some of Abu Dhabi's oil wealth into a RE future (for a detailed policy analysis, see Reiche, 2010). Algeria aims to generate 5% of electricity from RE sources by 2017 and 10% by 2025 (CIF, 2009b). Jordan aims to generate as much as 7% of its energy from RE sources by 2015 and 10% by 2020; solar capacity is expected to reach 300–600 MW over the same period (CIF, 2009b). Several small windmills are currently operating in Jordan and six more projects are currently in the pipeline (Al-Widyan and Al-Muhtaseb, 2009). Egypt is planning to increase the share of electricity generated by renewable sources to 20% by 2020. Morocco's target for RE is to reach 42% by the year 2020 (CIF, 2009b). A $9 billion solar energy project will account for 38% of the country's installed power generation capacity by 2020 (MENA Renewables, 2010). It has also doubled its wind power capacity to reach 260 MW in 2009. Tunisia is one of the frontrunners and its energy management program aims at decreasing its energy intensity by 3% per year and to satisfy 4% of electricity demand through the use of RE by 2012 (CIF, 2009b). Tunisia has also developed a 'Solar Plan' with around 40 RE projects (CIF, 2009b).

3.2. International and regional cooperation

The surge in interest in RE sources and EE has led to increased investments in this region by the EU, the US and international organizations such as the World Bank for example, as well as by public and private stakeholders in the region. Even though the policies of the different MENA countries are not harmonized, and there is no commonly formulated policy (Mason, 2009), the aim of these initiatives is to allow achieving a critical mass of investment, triggering sufficient private sector interest to jumpstart these markets in the region within the next few years.

The sun is at the origin of most RE sources and solar radiation values ranging between 4 and 6 kWh/m^2/day throughout the year (CIF, 2009b) combined with little rain make this region's geography particularly suitable for the deployment of both solar and wind energy (Karakosta et al., 2010; Al-Widyan and Al-Muhtaseb, 2009), but the interest in other RE sources such as geothermal or biomass is also increasing.

The deployment of CSP in the MENA is gaining increasing popularity among the scientific community. According to the IEA it is one of the most attractive technologies for greenhouse gas mitigation (The World Bank, 2009c). Consequently, the 'MENA Clean Technology Fund Investment Plan' is participating in the financing of CSP projects in five MENA countries, and this participation is expected to lead to overall investments of over 5 billion USD (The World Bank, 2009c).

The Trans Mediterranean Renewable Energy Cooperation (TREC), on the other hand, has identified the use of Concentrated Solar Power (CSP) as the most suitable technology to solve regional energy and water problems. The TREC has selected CSP based on studies carried out by the German Aerospace Institute commissioned by the German Government (Mason, 2009). In terms of levelized cost of energy, CSP is currently less expensive than photovoltaic (PV) but still more expensive than wind energy (CIF, 2009b). With increased deployment the costs for CSP are however expected to decrease by as much as 8.6% per year; it is therefore reckoned that the cost of CSP will soon be close to that of wind energy (CIF, 2009a, 2009b).

The cooperation between the EU supplying technology and the know-how to MENA countries in return for clean energy could lead to a win–win situation (Trieb et al., 2009). Although the TREC is new in that it considers energy cooperation in RE sources, the idea of North–South cooperation is not new. There already exist two pipeline connections to supply southern European countries with Algerian natural gas. The Trans-Med pipeline is operating since 1983 and runs from Algeria through Tunisia to Italy while the Gas Maghreb–Europe pipeline originates in Algeria and spans through Morocco to supply both Spain and Portugal (Al-Widyan and Al-Muhtaseb, 2009). Furthermore, a regional gas pipeline extending from Egypt through Jordan, possibly Lebanon and Syria to Turkey, should be completed by 2011 (Al-Widyan and Al-Muhtaseb, 2009).

As there already exist connections between the Maghreb and the EU, projects in this region can realistically be considered to lead to clean energy exports to Europe in the medium term; projects funded by the Clean Technology Fund in the Mashreq area however, are at this point, more geared towards further developing regional inter-connections, as these are currently too weak to cope with any additional loads (CIF, 2009b).

4. Discussion and policy recommendations

The various aims of an optimal sustainable energy policy broadly formulated are illustrated in Fig. 2 and the weights assigned to each aim will depend on the specific context and a country's 'energy vision' for the future (Dukert, 2009).

Lebanon's energy policy has to take into consideration the national economic characteristics, the current situation of the energy sector and the developments on the regional and international energy scene. The challenge faced by those in charge of

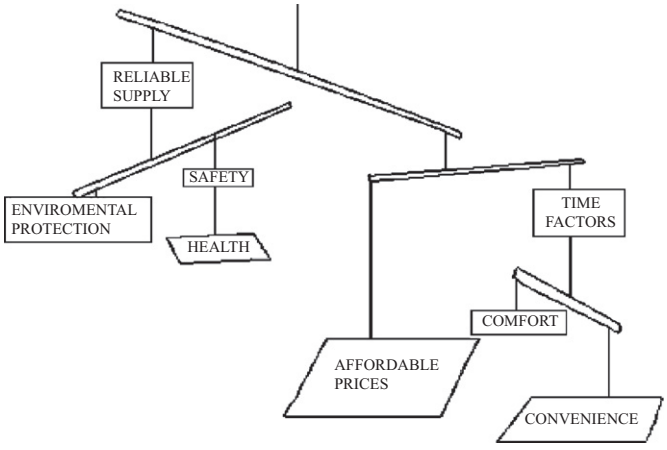

Fig. 2. Our energy goals are always in a delicate, changing balance. *Source:* Dukert (2009).

reforming Lebanon's energy sector is daunting; it provides however, at the same time, for an extraordinary opportunity.

The introduction of institutional frameworks that will allow market forces to operate freely, in combination with incentives encouraging the use of RE and EE measures, could help solving the problems faced by Lebanon's energy sector.

The main objectives of a comprehensive energy policy for Lebanon should aim for the security of supply, reforming the electricity and transport sectors and reducing overall energy consumption in the economy.

4.1. Security of supply

Security of supply for Lebanon implies diversifying both energy sources and suppliers. Lebanon needs to drastically reduce its heavy dependency on oil, because of the resulting negative economic and security impacts.

A high dependence on either imported oil or gas has similar consequences, as it exposes countries to international price fluctuations in these markets, and increases their vulnerability to supply disruptions, as both markets are highly concentrated.

In order to evaluate the oil and gas fields recently discovered off the coast of Lebanon, the government has adopted a petroleum law. But even if these fields reveal themselves as favorable for exploitation, we do not encourage an increase in the share of gas in electricity consumption, to as much as two thirds, such as has been suggested in the latest plan by the Government of Lebanon (MEW, 2010). National gas reserves would increase the relative attractiveness of this energy sources in comparison to all other energy sources available.

A more balanced mix of energy sources including oil, gas and a much larger share of RE than the recently set targets of 10% by 2013 and 12% by 2020 (MEW, 2010) seems more appropriate both for reasons of energy security and sustainability. This can also be confirmed by looking at the current trends in natural gas exporting countries, such as Algeria or even Egypt, where more and more efforts are made to develop the markets for RE and EE.

Furthermore, Lebanon should break its 'energy isolation' by taking advantage both of an expanding regional gas pipeline network as described above and the existing regional grid interconnections (Al-Widyan and Al-Muhtaseb, 2009) depicted in Fig. 3. In fact, the Ministry of Energy and Water's latest plan foresees the construction of LNG terminals and the connection to the regional gas pipeline running through Syria.

To reach the Government's RE targets the Ministry of Energy and Water (MEW) seeks to rehabilitate or replace existing hydro plants and facilitate private investment for increases in capacity in hydro (40 MW by 2012 and 80 MW by 2015), wind energy (60–100 MW by 2011) and waste (15–25 MW by 2015) (MEW, 2010). In parallel, as described above, demand side measures fostering energy conservation are being developed.

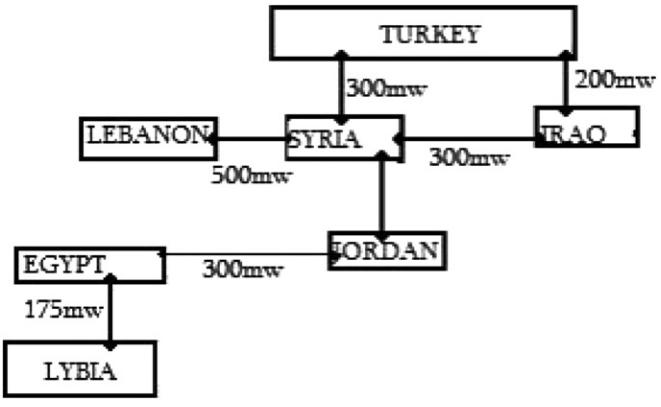

Fig. 3. The interaction of electricity between MENA countries.
Source: Al-Widyan and Al-Muhtaseb (2009).

4.2. Electricity sector

Energy poverty, characterized by power cuts that reach up to 13 h a day in some areas of the country (The World Bank, 2009a) and the consequent heavy economic losses as described in detail above prevent the country from reaching its development potential. Electricity supply, like water, is considered a basic need for economic development and the present situation leads not only to harsher living conditions but also to social tensions. Recurrent protests and roadblocks, in response to power cuts, are a manifestation of frustration of the population in areas hardest hit by the power cuts.

The deteriorating situation in the power sector becomes increasingly difficult to solve. On the one hand, the financing needs involved are huge; it is estimated that the overall cost of investment required to increase installed capacity to 5000 MW in the medium term are close to USD 4.9 billion (Le Commerce du Levant, 2010). The huge stakes involved make centralized decision making more and more challenging. The various stakeholders potentially affected by reforms, such as EDL, a small number of distribution concessions, the illegal back-up generation sector, the various political fractions and consumers, all have interests to defend. The combination of these factors has placed the electricity sector at the center of the political battlefield and solving the sector's problems has hence become more difficult. Providing the proper institutional framework, by gradually introducing the appropriate laws and regulations, and letting market forces operate freely, would allow to side-pass some of these obstacles.

The electricity sector's market structure is still defined by EDL's monopoly position, although there do exist a small number of distribution concessions that benefit from unusually high profit margins. A more decentralized market structure with smaller sized power stations whether they are based on natural gas or on RE sources could solve a number of problems EDL currently faces. Specifically in the case of Lebanon, the decentralization, for example at the municipal level, and/or the privatization of production, transmission and distribution can facilitate the operation, maintenance and management, as well as the collection of bills and the prevention of theft. These measures can therefore lead to a more efficient provision of electricity.

Further arguments in favor of a gradual move towards privatization and/or decentralization are the current subsidies paid to EDL, and the consumers' willingness to pay for electricity. On the one hand, EDL subsidies steadily increased over the past decade to reach around 1.5 billion USD per year for the past 3 years. On the other hand, the total annual amount spent by the Lebanese on electricity consumption in 2009 amounted to roughly 2.37 billion USD out of which only 700 million USD were paid to EDL while the remaining 1.67 billion USD were paid to back-up generators (Le Commerce du Levant, 2010).

Law 462 dated 02/09/2002 and entitled 'Regulation of the Power Sector' has been adopted by the parliament and published by the President of the Republic. The primary aim of this law was the establishment of a regulatory commission in charge of elaborating the important details pertaining to the introduction of RE and energy conservation. The lack of political agreement has however prevented the establishment of the commission, and hence the implementation of law 462. The latter has subsequently been amended by law 775 dated 11/11/2006 that foresees

independent power production for personal use. Law 775 is currently under review; it deals mainly with technical, environmental, safety and other regulatory aspects of private power production, but no provisions allowing private power producers to sell electricity are planned. The development and implementation of the new laws and initiatives relating to the energy sector (see Section 2.3 above) show the Government of Lebanon's commitment to its recently formulated targets for RE and EE.

In order to set the stage for market forces to operate freely the amended law 462 should allow independent power production, not only from RE sources, but it should also foresee the legalization of the back-up electricity providers, that according to Karaki (2010) account for an estimated 1400 MW of installed capacity.

Several levelized cost analysis for distributed electricity generation from wind and solar energy sources in Lebanon has revealed their cost competitiveness with conventional energy sources (El-Fadel et al., 2010; Karaki, 2010).

Furthermore, the cost of RE sources is steadily decreasing and in the EU, electricity produced from the latter is expected to become cheaper than that produced from conventional sources within the 2010–2020 period (Trieb et al., 2009). With the increased investment activity observed in the MENA in recent years, similar price developments can be expected.

In the quest for eradicating energy poverty, a legalized back-up sector can play an important role in a transition period as it provides an indispensible service. It is clear that even if the latest power sector reform plan is carried out as intended, back-up providers will be around for a number of years to come. Allowing independent power production not only for personal consumption but also for sale, whether this power is produced by already existing back-up providers using diesel powered generators, or through the use of small scale distributed RE stations, could accelerate the move towards a greater share of RE.

A number of additional measures, such as adjusting electricity prices to cost reflective levels, importing tax exemptions for all types of RE equipment (currently only wind turbines are import tax exempted) and providing financing facilities or other subsidization policies can make the replacement of currently used diesel generators attractive. High and fluctuating oil prices also affect back-up providers; legalization and the introduction of RE for power production will introduce an element of competition in a sector that is characterized by a monopolistic pricing behavior (The World Bank, 2009a). Furthermore, these measures will allow improving public finances.

It should be noted that as the quality of electricity provision improves with these policy measures and blackout periods are reduced, the individual household's total monthly expenditures might not necessarily increase; we can thus expect household welfare to increase with the introduction of IPP.

The surge in RE will lead to the development of new skills and technologies, increased employment, more even economic development and increased economic growth. Last but not the least, RE sources can contribute to an improvement in local and global air pollution. Dagher and Ruble (2010) show that if EDL satisfies the growth in electricity demand, between 2006 and 2025, conservatively estimated at 2.5% per year, solely by introducing wind energy, avoided CO_2 emissions would be around 6 million tons.

The example of Tunisia that has successfully opened up its electricity sector to private operators since 1996 constitutes an interesting reference case for Lebanon, especially since the two countries share a number of similarities. Tunisia has unbundled its electricity sector and has gradually (2005–2008) increased its prices to cost reflective levels, now charging 16 cents/kWh to households and 10 cents/kWh to industry. (The World Bank, 2009c)

The potential contribution of EE measures and RE sources in reducing the need in additions to installed capacity should not be underestimated. Measures fostering the introduction of CFLs or solar water heaters for example, if they are widespread can spare the Lebanese government the payment for hundreds of MW in installed capacity.

4.3. Reforming the transport sector

As exposed above the scope for energy savings from the transport sector is large and in light of the current lack of regulation one can expect substantial payoffs. Furthermore, this important sector in terms of both fuel consumption and environmental impact allows for reform measures such as taxes depending on engine size, fuel efficiency standards, import regulations and others, which are easy to implement from an administrative perspective and improve public finances. Developing the public transport system and improving the road network are further important measures that are more costly and require careful planning. Some of the latter items could however be financed through earmarked taxation.

5. Concluding remarks

In this paper we have presented the current challenges and the recent move towards RE and EE in the Lebanese energy sector. We have shown that Lebanon has clearly taken the path to a more sustainable energy future, and we have formulated policy recommendations that can contribute to solving the country's energy crisis. A market based approach, in which the government provides the legal, regulatory and policy framework and lets market forces operate freely, would most probably attract sufficient private investments and allow to by-pass lengthy political processes with uncertain outcomes. Both political instability and the confirmation of exploitable national gas reserves will certainly slow down the development of the markets for RE and EE. Given the recent progress in market development, it is however very unlikely that the shift towards sustainability in the energy sector will be reversed. In fact, the increased awareness might even lead to a more careful handling of the newly discovered gas reserves.

Acknowledgements

The authors would like to thank Tyler Cowen, Antoine Nasrallah and two anonymous reviewers for the helpful and constructive comments.

References

Abi Said, C., 2005. Electric energy and energy policy in Lebanon. Report. GNESD Project 18/05/2005.

ALMEE, 2007. State of the Energy in Lebanon. Association Libanaise pour la Maitrise de l'Environment.

Al-Widyan, M., Al-Muhtaseb, M., 2009. Institutional aspects of regional energy systems. In: Mason, M., Mor, A. (Eds.), Renewable Energy in the Middle East, Springer Science and Business Media.

Blominvest Bank SAL, 2010. The Lebanon Brief, Issue 663, Economic Research Department, February 1–6.

Byblos Bank SAL, 2009. Lebanon This Week. Economic Research & Analysis Department December 14–18.

Byblos Bank SAL, 2010. Lebanon This Week. Economic Research & Analysis Department March 29–April 3.

BP Statistical Review of World Energy, 2009. Available at: 〈www.bp.com/statisticalreview〉.

Chaaban, F.B., Chedid, R., 2000. Policy options for GHG emissions reduction in the energy sector, case study of Lebanon. World Renewable Energy Congress VI, 1161–1664.

Chaaban, F.B., Rahman, S., 1998. Baseline energy and electricity consumptions in Lebanon and opportunities for conservation. Energy Policy 26 (6), 487–493.

Chedid, R., Chaaban, F., Salameh, S., 2000. Policy analysis of greenhouse gas emissions: the case of the Lebanese electricity sector. Energy Conversion and Management 42 (3), 373–392.
Chedid, R., Ghaddar, N., Chaaban, F., Chehab, S., Mattar, T., 2001. Assessment of energy efficiency measures: the case of the Lebanese energy sector. International Journal of Energy Research 25 (4), 355–374.
CIA, The World Factbook, 2009. Accessed at 〈http://www.cia.gov/library/publications/the-world-factbook/geos/LE.html〉.
Climate Investment Funds, 2009a. Clean Technology Fund Investment Plan for Concentrated Solar Power in the Middle East and North Africa Region. In: Inter-sessional Meeting of the CTF Trust Fund Committee, Washington, D.C.
Climate Investment Funds, 2009b. Clean Technology Fund: Concept Note for a Concentrated Solar Power Scale-Up Program in the Middle-East and North Africa Region. CTF/TFC.3/7, April.
Comair, F., 2009. Renewable energy profile for Lebanon. In: Mason, M., Mor, A. (Eds.), Renewable Energy in the Middle East, Springer Science and Business Media.
Dagher, L., Ruble, I., 2010. Challenges for CO_2 mitigation in the Lebanese electric-power sector. Energy Policy 38 (2), 912–918.
Dukert, J., 2009. Energy. Greenwood Guides to Business and Economics. Greenwood Press, 88 Post Road West, Westport, CT 06881. An imprint of Greenwood Publishing Group, Inc., USA.
EIU—Economic Intelligence Unit, 2010. Country Report on Lebanon. EIU, United Kingdom.
El-Fadel, M., Bou-Zeid, E., 1999. Transportation GHG emissions in developing countries: the case of Lebanon. Transportation Research Part D: Transport and Environment 4 (4), 251–264.
El-Fadel, M., Chedid, R., Zeinati, M., Hmaidan, W., 2003. Mitigating energy-related GHG emissions through renewable energy. Renewable Energy 28 (8), 1257–1276.
El-Fadel, R.H., Hammond, G.P., Harajli, H.A., Jones, C.I., Kabakian, V.K., Winnett, A.B., 2010. The Lebanese electricity system in the context of sustainable development. Energy Policy 38 (2), 751–761.
European Union, Europe Aid, 2010, Terms of Reference, Ref# Europe Aid/129347/D/SER/LB 'Support to the Lebanese Centre for Energy Conservation'.
Fennhann, J., 2009st. CDM Pipeline Overview. UNEP Risoe Centre, Denmark 1st September.
Ghaddar, N., Mezher, T., Chedid, R., Fadel, M., Moukalled, F., 2005. Final Report on Renewable Energies Technologies Contribution and Barriers to Poverty Alleviation in Jordan, Lebanon, and Syria. "Renewable Energy Technology" Working Group, Global Network on Energy for Sustainable Development.
Global Arab Network, 2010. MENA Powering Up—Energy Demand to Double by 2030, Alan Mackie, June 1st. Available at 〈http://www.english.globalarabnetwork.com/201006106074/Energy/mena-powering-up-energy-demand-to-double-by-2030.html〉.
IMF—International Monetary Fund 2007. Statement by the IMF Representative at the International Donors' Conference for Lebanon. Available at 〈http://www.imf.org/external/np/dm/2007/012507.htm〉 (accessed on August 30, 2010).
Karaki, S., Chedid, R., 2007. Renewable Energy Country Profile for Lebanon. American University of Beirut, Lebanon.
Karaki, S., 2010. A Renewable Energy System Study of Lebanon. American University of Beirut, Lebanon. Internal Communication, August.
Karakosta, C., Doukas, H., Psarras, J., 2010. EU-MENA energy technology transfer under the CDM: Israel as a frontrunner? Energy Policy 38 (5), 2455–2462.
Le Commerce du Levant, 2010. Le plan de Gebran Bassil pour l'electricite. S.R. July.
L.C.E.C.—Lebanese Center for Energy Conservation, 2010. Saving Energy, Issue 6, January.
L.C.E.C.—Lebanese Center for Energy Conservation, 2009. Saving Energy, Issue 5, June.
Mason, M., 2009. Conclusion: Towards a Renewable Energy Transition in the Middle East and North Africa?. Department of Geography and Environment, London Schoolof Economics, Houghton Street, London,WC2A 2AE, UK.
MENA Renewables 2010. African Brains. Available at 〈http://www.africanbrains.org/about.php?event_id=1&EVENT=1〉.
MEW—Ministry of Energy and Water, 2010. Policy Paper for the Electricity Sector. Government of Lebanon (COM#1-21/6/2010) June.
Mourtada A., 2008. Energy efficiency in the building sector: Lebanese experience. National experiences in the field of energy conservation with a focus on building sector. Round Table MED 3, ENERGAIA.
Namovicz, C., Dustewitz, M., Grossman, G., Misra, A., Ruether, R., Sakuta, K., Bell, J., Lew, D., 2007. Energy Policy in Handbook of Energy Efficiency and Renewable Energy. In: Kreith, F., Yogi Goswami, D. (Eds.), C.R.C. Press, Taylor & Francis Group.
Reiche, Danyel, 2010. Renewable Energy Policies in the Gulf countries: a case study of the carbon-neutral 'Masdar City' in Abu Dhabi. Energy Policy 38 (1), 378–382.
SNC—Second National Communication, 2009. Republic of Lebanon's Second National Communication to the UNFCCC (SNC draft).
The World Bank 2008. Electricity Sector Public Expenditure Review. Sustainable Development Department, Middle East and North Africa Region, Report No.41421-LB.
The World Bank 2009a. Lebanon Social Impact Analysis—Electricity and Water Sectors.
The World Bank 2009b. Tapping a hidden resource: energy efficiency in the Middle East and North Africa. Washington D.C.
The World Bank, 2009c. Clean Technology Fund Investment Plan; Approved for concentrated solar power in the MENA region. MENA Knowledge and Learning. Quick notes series. December, Number 15.
The World Bank, 2009d. Energy Efficiency Study in Lebanon. Final Report, December.
Trieb, F., Krewitt, W., May, N., 2009. Hexagon Series on Human and Environmental Security and Peace, 1, vol. 4, Facing Global Environmental Change, Part IV, pp. 411–426.
UNDP —United Nations Development Program, 2010. Request for Proposals for Consultancy Services to Conduct a Wind Resource Assessment for Distributed Electricity Generation with micro Wind Turbines in Ten Sites Located in the Regions of Akkar, Bekaa and South, Lebanon.
UNDP —United Nations Development Program, 2011. The National Wind Atlas of Lebanon. A report prepared by Garrad Hassan for the United Nations Development Program (UNDP)—CEDRO Project.
UNSTDA—United States Trade and Development Agency, 2010. Request for Proposals, Lebanon Concentrated Power Feasibility Study (Solicitation Number: 2010-21035A).
WRI—World Resource Institute, 2009. Climate Analysis Tool. Available at 〈http://cait.wri.org〉.