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The Lebanese electricity system in the context of sustainable development

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ABSTRACT

The Lebanese electricity system has been evaluated in terms of its sustainability. An integrated approach was adopted to assess the life-cycle technical, environmental, energy and economic attributes of the system. The findings show that the Lebanese electricity system is characterized by a weak performance in all analysed aspects related to the sustainability of energy systems. Specifically, the system lacks adequacy and security leading to a supply–demand deficit and poor diversity. It gives rise to significant environmental emissions (including green-house gases), and produces large economic inefficiencies. The costs and benefits of optimising the performance of the centralised electricity system are presented, indicating substantial net benefits (together with considerable benefits in reduced environmental impacts across the life-cycle assessment categories, including carbon emissions) from improving the transmission and distribution networks, upgrading existing conventional plants to their design standards, and shifting towards the use of natural gas. The expected levelised cost of various energy sources in Lebanon also indicates that renewable energy sources are competitive alternatives at the present time.

1. Introduction

The challenge of any electricity system is to deliver reliable and continuous power to meet the economy's total needs at all times and at a reasonable total cost. However, with the growing concerns about climate change, coupled with local pollution implications on human health and ecosystems, the overall environmental performance of an energy system should receive attention on a par with reliability considerations. 'Sustainable development' may be seen therefore as an overarching goal of development or 'sustainability' (Hammond, 2000). As 'sustainable development' requires that "present generations meet their needs without compromising future generations' ability to meet theirs" (World Commission on Environment and Development (WCED), 1987), it becomes a necessity for current generations to use non-renewable energy resources most efficiently (i.e., produce a unit of output with least input), decouple energy consumption from environmental pollution (including greenhouse gas (GHG) emissions), and invest in renewable energy resources. Investing in the latter will enable the current generation to bequeath non-renewable fuels to future generations (Vob, 2006).

The current Lebanese electricity system (LES) has been assessed in the context of sustainable development, and more specifically against the characteristics of a 'sustainable electricity system'. It attempts to examine the subject from an integrated approach as recommended in Hammond and Winnett (2006), Allen et al. (2008a) and Hammond et al. (2009), specifically relying on environmental life-cycle assessment (LCA), energy analysis and economic appraisal, in addition to a reliability assessment. Section 2 attempts to define what the characteristics of a sustainable electricity system actually are. Section 3 describes the current Lebanon electricity system, while Section 4 evaluates this system through an integrated appraisal toolkit. Discussion and conclusions are presented in Section 5 and 6, respectively.

2. The characteristics of a 'sustainable electricity system'

There is on-going debate as to what constitutes a sustainable electricity system. In its most general terms a sustainable electricity system could be thought of in terms of its energy and economic performance, its environmental impacts and its reliability. The basic requirement of an energy system is to generate power for everyone at an affordable price while ensuring that that power is clean, safe and reliable (Alanne and Saari, 2006).

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Acres (2007) defines a sustainable electricity system by combining the energy hierarchy with a set of economic, social and environmental principles. The energy hierarchy advocates starting with the reduction in the use of energy, followed by energy efficiency measures (improvements), adoption of renewable energy sources, and finally using the most efficient non-renewable conventional energy sources coupled with the best available end-of-pipe technologies (Acres, 2007). Within this hierarchy however, Acres (2007) proposes several principles, namely that the energy system (1) should have zero net emissions of GHGs (i.e. it would not contribute to climate change), (2) should not have any other significant environmental impacts, (3) should enhance security of supply, particularly as power interruptions have considerable social implications, (4) should reduce costs of energy supply and improve access to energy (paying attention to industrial competitiveness and lower income groups' affordability), and (5) should harness renewable energy as much as possible.

Mitchell (2008), on the other hand, indicates some important differences between 'conventional' and 'sustainable' electricity systems, which could clarify the characteristics of each. A conventional system is commonly characterised as a centralised top-down system which focuses on supply-side solutions and delivery, with large conventional plants (most of which need time to ramp up) connected to the 'passive' transmission (and distribution) network to customers who see energy simply as being present at a 'flick of a switch'. Concerns about energy security are met by additional conventional generation, whereas environmental externalities are regarded minimally. The overall market under a conventional system is likely to be a government-owned monopoly, offering little consumer choice, that is unworried about risks or losses due to continuous government support (Mitchell, 2008). In contrast, a sustainable electricity system is characterised by publicly aware citizens that see the connections between energy and the environment, and who use energy efficiently. Within this system, the environment plays a greater role and is an important driver of policy, while energy security concerns are answered through the diversification of generation technologies. It brings together large-scale and distributed renewables sources (including micro-generation), a reduced dependence on imported oil, and the targeting of demand reductions through behaviour change or energy efficiency measures. The sustainable electricity system will contain different technologies and unit sizes, connected to both the transmission and the distribution networks, which become in themselves 'active'. The market structure for such a sustainable electricity system is liberalised and privatized, where choice is given to customers (competition) and risks are faced by the private companies themselves (Mitchell, 2008).

A sustainable electricity system would therefore have to balance several criteria; particularly reliability, economic efficiency, energy efficiency, and environmental impacts, including GHG emissions, in order to move towards 'sustainability'. This paper aims at establishing a baseline or benchmark of several selected sustainability indicators for the LES, against which any future action can be monitored.

3. The Lebanese electricity sector

The Lebanese electricity system (LES) is a publicly owned sector which suffers from substantial inefficiencies, poor management, and under-investment (inadequate maintenance–emergency maintenance instead of preventive with a chronic lack of spare parts). It absorbs approximately 2–6% of national gross domestic product (GDP), as shown in Fig. 1, through annual

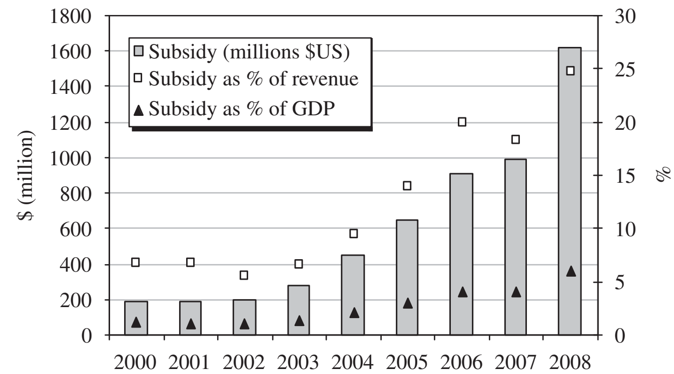

Fig. 1. Total annual subsidies to Electricité du Liban (EDL) and % of total revenues (MOF, 2008; World Bank, 2008).

government subsidies, depending mainly on the price of fuel as Lebanon imports 99% of its primary energy requirements (Houri, 2006a). Additionally it falls far short in terms of satisfying the growing energy demand in the country. Urgent and radical changes in the supply–demand balance are therefore long overdue.

Electricity supply in Lebanon is managed by Electricité du Liban (EDL), a public institution that has a nominal installed power supply capacity of approximately 2100 MW. 1900 MW of this consists of thermal power capacity and 200 MW of hydro (end of 2006). Available net thermal capacity however has varied from as low as 1600 MW (and sometimes lower) to a maximum of 2000 MW. This is due to several shortcomings such as restoration requirements, plant failures, fuel supply problems, and external hostilities (i.e. damage to fuel storage capacity or electricity generators due to war time hostilities) among other occurrences (World Bank, 2008). Hydro power availability depends on rainfall and has been as low as 80 MW (Abi Said, 2005). A further 200 MW capacity of electricity has been purchased from Syria (International Institute for Energy Conservation (IIEC), 2008). Additionally an electricity supply of 100–150 MW is being currently considered from Egypt. Table 1 shows the most recently published generation supply mix in Lebanon.

In the transmission and distribution (T&D) networks, technical losses are on average 15% in Lebanon, while non-technical losses amount to a further 17.8% of electricity produced (World Bank, 2008). Non-technical losses are high, but have improved from a decade earlier when they were estimated to be approximately 48% (Badelt and Yehia, 2000). These are attributed to either electricity consumed through illegal connections, meter manipulations, or are consumed yet unbilled due to the shortcomings in the billing system. Overall, at least 50% of the electricity went to residential and business customers (i.e., low-voltage demand), while the rest was divided (from higher demand to lower) between industrial, administrative buildings, and concessions, respectively (World Bank, 2008). Other sources place residential demand higher at 65–73% of total electricity consumed (Houri and Ibrahim-Korfali, 2005), or 80% if combined with the commercial sector (Houri, 2006a).

Peak demand for electricity was at least 2600 MW in 2006 (including electricity demand used for generation itself), and is expected to grow between 4% and 6% annually over the period 2008–2015. Based on the nominal design of all power plants as indicated in Table 1 and inclusive of maximum imports from Syria and Egypt this peak demand is just about met subject to the time schedule of the electricity imports. Yet based on the actual reported availability of power plants and including imports from Syria and Egypt, an annual and growing electricity deficit