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Natural gas in Cyprus: The need for consolidated planning

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ABSTRACT

The electricity supply system of Cyprus is currently dominated by oil-fired generation, with small but increasing contributions from renewable energy technologies. As regulations regarding emissions of greenhouse gases and air pollutants will become stricter with the turn of the decade, change is imminent. Available offshore gas reserves and the possibility of natural gas imports have shown that the substitution of oil with gas can reasonably be expected in the not-so-distant future. However, the framework under which change could occur has not yet been established. Should imports of gas serve as a short-term bridge until domestic gas becomes available? What are the infrastructure implications associated with such a medium-term solution? How does a policy-driven transition to gas affect energy security and how compatible is this with a liberalized electricity market? Can short- and longer term strategies be consistently designed and implemented? A cost-optimization model (OSeMOSYS), representing the electricity system of the island, is used to provide insights to these questions. Results regarding generation mix, capacity and system costs are presented for a set of scenarios. In all cases investigated, compliance with environmental regulations of the European Union after 2020 makes gas the strategic fuel of choice for low cost electricity generation.

1. Introduction

Recent discoveries of offshore natural gas in the exclusive economic zone of Cyprus might, within a decade or so, disengage the island's electricity generation from imported oil products, improve the trade balance and reduce the cost of electricity to the economy. The potentially sizable volumes of gas reserves provide a strong incentive for the government to scrutinize a range of options other than domestic use, especially exports given that the domestic gas market is rather limited. Current expectations are that gas production will commence by 2023 and that the gas will be priced at market value, irrespective whether it will be exported or used in the domestic energy market. However, the range of options and associated implications for domestic energy supply in the interim appear to have hamstrung governmental decision making.

With the objective of lowering domestic electricity supply costs without delay, importing LNG as an interim approach until domestic gas deliveries become available is one of the options considered by the Government of Cyprus. LNG imports would not only pave the way for the development of a domestic gas extraction and delivery infrastructure, but also make use of existing highly efficient combined cycle gas turbines in base-load mode. Currently, these turbines operate on diesel and serve intermediate and peak loads. However, there are notable investments and risks involved - investments in the development of the off-shore gas and delivery infrastructure. There is the risk of a long-term lock-in in the off-shore gas project without achieving lower electricity costs. A prolonged low oil price future may well make such an investment financially inviable. Low oil prices usually also cap the prices of traded natural gas and LNG might be purchased in the global spot market cheaper than domestic gas.

Starting around 2005, renewable energy technologies (RET) began supplementing electricity generation in Cyprus rising to some 10% of total supply from practically zero in one decade – in large part motivated by the 20% renewables the 20/20/20 targets of the European Union (EU).[1] Several studies explored the future of RET deployment that would ensure compliance with the EU renewable target by 2020. Poullikkas et al. (2011) explored renewable energy pathways to inform the country's 2010 National Renewable Energy Action Plan; RET capacities of 300 MW wind, 192 MW solar PV, 75 MW solar thermal and 17 MW biomass were foreseen by 2020 to

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[1] Set in 2007 and enacted in legislation in 2009, the 20/20/20 package comprise three targets of (at least).

- 20% cut in greenhouse gas emissions (from 1990 levels).
- 20% of EU energy from renewables.
- 20% improvement in energy efficiency.

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achieve 16% renewable share in electricity. Other studies focused on the future role of individual renewable technologies such as solar photovoltaics (Fokaides and Kylili, 2014; Kylili and Fokaides, 2015) or biomass (Kythreotou et al., 2012). Demand side management options and energy efficiency improvement potentials affecting final energy demand were carried out by Fokaides et al. (2014) and Zachariadis and Taibi (2015). Most recently, the European Commission published a comprehensive study for each of its Member states with detailed projections of long term energy and electricity mixes until 2050 (European Commission, 2016). For Cyprus, the study reports a renewable electricity share of 21.5% by 2020 and almost 30% by 2030.

The objective of this paper is to assess the viability of a range of electricity generating options – continued reliance on oil products, utilizing domestic off-shore gas, interim solutions until domestic gas becomes available, LNG imports (interim or long-term) to an accelerated development of renewable generation. The study used a scenario approach to explore least-cost generating strategies as well as to carry out assessments regarding their flexibility, economic robustness and energy security impacts. More specifically, the study scrutinized:

a. At what gas price would the Interim Gas scenario (LNG imports until domestic gas has been developed) be cost-competitive taking into consideration the gas infrastructure development costs in a low oil and gas price future and the prospects for rapid RE cost reductions?
b. How much gas can the Cypriot market absorb in the medium- to long-term and what is the volume/price flexibility to cope with future "unexpected developments", such as a sharp decline in demand as experienced in the recent financial crisis?
c. What would the impact be on the island's greenhouse gas emissions of a decision to postpone the introduction of natural gas until domestic reserves are available?

2. Methods

An existing electricity supply model used in a previous IRENA study (IRENA, 2015) has been transferred and coded in an OSeMOSYS (Howells et al., 2011) framework.[2] Code extensions introduced during this transfer allow the integration of short-terms constraints (Welsch et al., 2014), thus capturing local specificities in greater detail. Features such as ramp up and ramp down rates, minimum generation levels of thermal plants which were absent in the previous study (IRENA, 2015) are now included. Initial simulations of the model without these parameters greatly overestimated the rate of renewable energy integration, so their inclusion in the final model structure is necessary. Each year is divided in 63 time steps[3] to simulate seasonal and daily variability in electricity demand as well as the intermittent availability of renewable energy sources such as wind and solar energy.

In this study, the model has been designed to reflect the current Cypriot electricity system and future generating options characterized by a set of technical and economic performance parameters, e.g., conversion efficiencies, ramp rates, capital and operational costs. It is applied to compute the least-cost technology mix in terms of installed capacity and electricity generation to meet an exogenously determined electricity demand. The study horizon extends from 2013 to 2040, but model results are for the most part reported only until 2030.

Four scenarios are developed reflecting the principal electricity supply options before the Cypriot policy makers. The economic, security and environmental impacts of each scenario are assessed and compared. The scenarios are:

- No Gas (P0): This scenario assumes no change in government policy regarding domestic off-shore gas development or LNG imports. Imported oil products remain the mainstay of electricity generation. Investment in renewable generating capacity is the only available option for supply diversification and emission abatement.
- Delayed Gas (P1): Domestic offshore gas will be developed and first pipeline deliveries are scheduled to land on the island by 2023. Negotiations on LNG imports as an interim solution to replace oil products in electricity generation before or by 2020 proved unsuccessful. Investing in renewable electricity generation is, as in all scenarios, both a short and long-term option.
- Two-phase Gas Supply (P2): As scenario P1 but the negotiations on an interim gas solution were successfully concluded. LNG imports commence in 2017 and continue through 2025. A floating regasification infrastructure is leased for the nine-year period.
- Long-Term Gas Supply (P3): Instead of the two-step introduction of natural gas to the island (see P2), this scenario foresees the purchase of regasification infrastructure (floating, onshore or mixed) with a service life of 30 years. As in P2, all-imported LNG is regasified during the first six years; after 2022 regasification uses either imported or domestically sourced LNG. Cypriot off-shore gas is transported via pipeline to Egypt, liquefied in existing, but underutilized, liquefaction facilities (Idku and Damietta) and then sold in the international LNG market including Cyprus at international LNG prices.

The consortium that holds the rights to the Aphrodite gas field[4] has the off-shore field developed by 2023 and subsequently lifts and sells the gas on a concessional basis. Sales are not restricted to Cyprus exclusively but can be elsewhere with royalties paid to Cyprus. The gas price is negotiated between the buyer and seller. Table 1 summarizes the key characteristics of the four scenarios.

All scenarios reflect the latest government renewable energy targets - a minimum of 13% renewable energy share in final energy supply by 2020 (Ministry of Commerce, Industry and Tourism, 2010). This corresponds to a 16% share of renewably generated electricity to be achieved in the electricity supply sector; in 2015 this share was at 8.5% (TSO Cyprus, 2016). Also, new conventional generating capacities are integral part of the technology menu in all scenarios.

Unlike the previous analysis of Cyprus' electricity system (IRENA, 2015) which considered an optional interconnection to the mainland, this option is not included here. Clearly, an interconnector delivering competitively priced electricity can affect the level of domestic generation (and vice-versa, of course). By excluding electricity trade the different scenarios can be compared at a constant level of domestically generated electricity.

2.1. Key assumptions

The Cyprus OSeMOSYS model is an image of the existing electricity infrastructure plus the menu of future technology and infrastructure options. The electricity supply system is represented by:

(a) fuel imports and domestic extraction of fossil resources and harvesting of renewable energy flows
(b) fuel preparation and related infrastructure (e.g., regasification)
(c) conversion of fuels and renewable flows to electricity in power plants.
(d) transmission and distribution networks delivering the electricity to customers at the final energy level
(e) decentralized generation by final consumers (bypassing the grid)
(f) storage options - pumped hydro and flow batteries for centralized

[2] OSeMOSYS is a long-term dynamic energy systems model that minimizes overall system cost to meet a set of externally defined demands. The focus of this study, however, is the Cypriot electricity supply system and its future generation mix in the absence or presence of natural gas on the island.

[3] These time steps correspond to 7 seasons, 2day types (weekday and weekend) and 6day parts in the first day type and 2day parts in the second day type.

[4] This is the only proven gas field so far in Cyprus and has an estimated volume of 141 bcm (Taliotis et al., 2015).