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The effect of islands' interconnection to the mainland system on the development of renewable energy sources in the Greek power sector

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ABSTRACT

The capacity expansion planning is a crucial process taking into account multiple aspects and various parameters of the examined power sector in order to optimally satisfy the future electricity demand. In the case of Greece, the long-term energy planning of the electricity supply sector faces a lot of challenges deriving from the peculiarities and geomorphology of the country mainly referring to the large number of islands. This paper explores the feasibility and the consequences of interconnecting Greek islands to the mainland grid by establishing two alternative scenarios of least cost electricity planning for the period 2009–2020. Namely, the reference scenario assumes isolated electric systems of islands and is compared against the alternative option of their interconnection to the mainland. The main purpose of the present study is to illustrate the great importance of islands' interconnection on the development of renewable energy sources (RES) to generate electricity while pointing out the consequent economic and environmental benefits.

Contents

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1. Introduction

Electricity corresponds to the most widespread form of energy while being the fundamental commodity to everyday's social and economic activities across the entire world. The power sector represents the core element of the electricity's energy chain and comprises all the production units used to transform energy and produce power through either physical or chemical processes.

Historically, the power sector is based on fossil fuels like oil, coal and natural gas while in some countries electricity originates from the utilization of nuclear energy. The increasing and severe environmental problems arisen and caused by the conventional ways of power generation, along with the depletion of fossil fuel reserves gave the opportunity to renewable energy sources (RES) to appear as an alternative, trustworthy and sustainable mean to produce electricity. During the last decade, RES started to play an increasingly important role and to increase their share in many countries' electricity mix. Nowadays their huge potential is widely recognized as a decisive factor to satisfy the continuously growing demand while at the same time mitigating severe environmental problems like climate change, acid rain, ground erosion etc. Wind and hydropower possess actually the most prominent position in the electricity sector followed by other forms of RES like biomass, solar etc.

The multiplicity of technological solutions implies that the electricity supply industry (ESI) has to satisfy the increasing demand by taking difficult investment and operational decisions. Besides its economic profitability and viability, major concerns are the protection of environment and the fulfillment of various commitments and obligations under national and international treaties. Furthermore, electric utilities have to adapt to the sociopolitical situation in each country, as well as to the particular conditions of each electricity system.

Therefore, the power sector performs into a manifold canvas composed by economic, technological, political, environmental and social hues facing a lot of problems and challenges to respond. The application of energy planning is a necessary condition to manage electricity demand and supply and ensure the effective operation of the electricity supply sector. Usually, it is categorized in short-term, medium-term and long-term energy planning. In this paper, we are interested in long-term energy planning for the electricity system which is also referred as capacity expansion planning and or least cost electricity planning.

Capacity expansion planning is occupied with four major queries concerning the investment decisions about power units [1–3]:

- ***what***, corresponding to the choice of technologies to produce power
- ***how***, meaning the number, the size and the capacity of future power plants
- ***when***, the time to build new installations and to retire old ones
- ***where***, the location to install new power plants

Least cost electricity planning tries to answer these questions and to designate the appropriate strategies to manage and expand the power sector. As implied by the term 'least cost', the aim is the satisfaction of consumers' electricity needs through the minimization of total cost of investment and operation of power units. In the past, cost minimization was the unique criterion to decide on energy planning. After 80's the introduction of environmental dimension altered this consideration and a multicriterion perspective was adopted [4]. It was the increasing concern about the greenhouse effect and the consequences of global warming that triggered the international social and political interest to institute new and stricter legislations with specific commitments for the power sector which has a large share on total emissions. Environment has been upgraded to a very significant parameter in designing future capacity expansion strategies consolidating the triptych of energy, economy and environment.

In many energy problems, environment is introduced either as constraint or as additional criterion (or objective) giving the importance of mitigating pollution effects but also is often embedded as an economic parameter through the internalization of penalties and external environmental costs [5]. Such example is the purchase of greenhouse gases (GHG) emissions rights which is mandatory for electric utilities in the European Union (EU) and it is incorporated into the total cost of generating electricity.

The long-term energy planning of a country's power sector is usually implemented by appropriate energy models. Energy models provide the methodological framework to simulate and optimize energy systems and guide to the solution of a sustainable capacity expansion planning.

The present paper considers all above aspects and implements energy planning in the Greek power sector by developing and using an optimization energy model. The main scope of this paper is to investigate the effect of interconnecting Greek islands to the mainland system via electric submarine cables. The islands' interconnection is a crucial issue that has been examined many times in the past but never really advanced. The starting point was the possible interconnection of Cyclades which has been debated and explored at the end of 1980 from Public Power Company (PPC) but soon postponed due to the citizens' opposition. The concern about Cyclades emerged again in 2004 and a relative study was prepared for Regulatory Authority for Energy by National Technical University of Athens [6] confirming their interconnection as a highly beneficial project, from both the economic and social point of view. The Cyclades project was included in the development programme of the Greek transmission system and PPC was assigned to implement the designated interconnection up to 2010 but still nothing has implemented. Similar attempts and plans have been elaborated from private power companies that wanted to undertake the cost of islands' interconnection in order to install large wind farms and exploit the existing huge wind potential specifically in Cyclades and Northern Aegean islands. Recently, in 2006, alternative options to install submarine cables and interconnect the majority of Greek islands by grouping them per geographical proximity have been systematically studied [7].

Nevertheless, all these attempts did not succeed to promote the interconnection of Greek islands to the mainland, despite the prospective economic, social and environmental benefits. The challenge continues to be extremely essential and the islands' interconnection should be subsumed to the long-term energy planning of the whole power sector. The interconnection project is a capital intensive investment and a fundamental intervention in Greek electricity system and has to be considered at a strategic level in order to make a right pre-assessment and reveal its far-sighted and sustainable benefits for the insular regions and the whole country.

Considering the great potential of Greece on RES, this study attempts to show the positive effects and the reinforcing role that the interconnection of Greek islands can play on further RES development. For this reason, we developed two scenarios, a reference case without the option of interconnection and a second scenario giving this possibility in order to compare the power sector's behavior towards RES promotion.

The remainder of the paper has the following structure. After this detailed introductory section, the current status of Greek power sector is presented by giving emphasis to its main problems and obligations and by analyzing the challenging topic of islands' interconnection. In Section 3, the adopted methodological approach and the developed energy model are described. Section 4 presents synoptically data and main assumptions used in the