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Addressing 2030 EU policy framework for energy and climate: Cost, risk and energy security issues

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ABSTRACT

The different energy sources, their costs and impacts on the environment determine the electricity production process. Energy planning must solve the existence of uncertainty through the diversification of power generation technologies portfolio. The European Union energy and environmental policy has been mainly based on promoting the security of supply, efficiency, energy savings and the promotion of Renewable Energy Sources. The recent European Commission communication "*Towards an European Energy Union: A secure, sustainable, competitive and affordable energy for every European*" establishes the path for the European future. This study deals with the analysis of the latest EU "Energy Union" goals through the application of Markowitz portfolio theory considering technological real assets. The EU targets are assessed under a double perspective: economic and environmental. The model concludes that implementing a high share of Renewable Energy target in the design of European Policies is not relevant: the maximization of Renewable Energy share could be achieved considering a sole Low Emissions of carbon dioxide policy. Additionally it is confirmed the need of Nuclear energy in 2030: a zero nuclear energy share in 2030 European Mix is not possible, unless the technological limits participation for Renewable Energy Sources were increased.

1. Introduction

The energy policies of a territory are aimed at achieving secure, permanent access to resources at an established level of quality and a reasonable cost for consumers, with the lowest possible environmental impact. They are also focused on increasing the level of energy efficiency and savings, which will contribute to reducing energy intensity. This ultimately improves competitiveness and the sustainable development of the State in question, as reflected by less pollution [1].

The design of the portfolio of technologies used to produce electricity takes on special importance in the context of energy and environmental planning. It is a matter of defining "how" electricity should be produced over the medium-long term in a territory. In play are not only acceptable production costs to the consumer, but also the level of dependence on outside resources, the corresponding energy security of the territory, and the social and environmental impact that the use of the available technologies might entail.

However, the application of the energy policies is subject to a high degree of uncertainty. The origin of this lies in the insecurity associated with the anticipated technological development, the evolution of the economic situation, possible changes in the regulatory framework, the evolution of the factors that impact the final price of the policies to be implemented, and the efficacy of compliance with the environmental objectives that have been set. All of these circumstances clearly complicate decision making.

The quest to determine the environmental dimension of the portfolio can be framed within a social trend that seeks not only the efficient use of resources, but also waste reduction, the conservation of local resources and the reduction of pollutant gas emissions [2]. The most developed economies with the highest levels of income are the ones that show the greatest demand for environmental protection [2,3]. As a matter of fact, a European technologies

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portfolio that is both environmentally and socially friendly would also provide greater energy security.

In the European Union, its energy dependence amounted to 53% in 2012 [4]. It meant an impact over its economy of a 3.1% of its GDP (gross domestic product) [5,6]. In this context, the European Union has based its energy policy on the improvement of its competitiveness, security of supply and sustainability [7–9]. In 2009, the European Union approved Directive 2009/28/EC [10] establishing the environmental and energy targets for 2020, referred to as the "20-20-20 strategy". It calls for a 20% reduction in pollutant gas emissions as compared to 1990, 20% of all energy consumption from renewable sources and a 20% improvement in energy efficiency, understood as the ratio between gross energy consumption and the gross domestic product. The strategy was clear, to continue to reduce energy dependence and pollutant gas emissions, while increasing energy efficiency.

Recently, in October 2014, the European Union [11] presented its energy targets for 2030, the "Energy Union": attaining at least a 40% reduction in greenhouse gas emissions as compared to 1990 levels (rising to a 61% reduction for power sector[3]), and increasing the share of energy efficiency and renewable energies to 27% of gross energy consumption (a 43% of renewable power portfolio share[4] [5]).

The energy horizon for the European Union has been clearly defined. There is also a clear commitment to increase the level of energy security by reducing the risk of disruptions and increase the level of respect for the environment by means of emissions reductions up to 2030 and 2050. The main question in relation to this strategy is whether the European Union is on the right track towards an efficient design in terms of the cost and risk of its future technology portfolio.

We seek the answer of this question through the application of Modern Portfolio Theory –hereinafter, MPT- to energy planning, which has been widely accepted as a valid, proven methodology. We decide to design an efficiency assessment model that would permit minimizing the risk of generating electricity while still meeting the three proposed EU 2030 goals: minimum portfolio share of renewable energies, efficiency improvement, CO_2 emissions reduction and the diversity level of each portfolio.

In order to facilitate the analysis we propose four policies scenarios for 2030: the *Base* scenario, the *Low Emissions* scenario which incorporates the European CO_2 emission reduction goal, the *High Renewable Energy Sources* (hereinafter, RES) scenario which considers the minimum share of RES target, and the European *Energy Union* scenario, which includes both restrictions: emission reduction and minimum RES share goals in the 2030 European power mix. Additionally the study about two cases of nuclear energy share reduction is proposed: the impact over policies and efficient portfolios considering 50% or 100% reduction on nuclear energy share in 2030. It is based on the analysis of the effects of a possible generalization of German shutting down nuclear energy decision in 2022 in European Union policy [12].

The contribution made by this paper is to evaluate the efficiency of the proposed framework of European Union energy and environmental policy to 2030 in terms of power technologies portfolio –Markowitzás approach-. The paper presents an enriched quadratic optimization mathematical model perspective and its solutions contain the different issues of the European energy and environmental policy: cost, risk, technological change, efficiency, the environmental impact and security of supply. The analysis allows calculating the costs of this policy comparing to different scenarios of policies and targets. The approach seeks the *social and environmental aim* [13,14] of European electricity generation with a triple perspective: an acceptable level of risk for society, a low social cost and respect for environmental conditions. To this end, in the second section we begin by outlining and reviewing the methodological approach of MPT applied to power real assets and portfolios and we present our model. Right afterwards, in the third section we report the results of EU 2030 energy and environmental policy scenarios. Next, in the fourth section we discuss about the effects in terms of cost, risk and emissions policy impacts of a possible nuclear energy shutting down scenario. Finally, we conclude in the fifth section with a discussion about the policy implications of our analysis.

2. The Markowitz portfolio model: an useful tool for energy planning

Considering that Financial Portfolio Theory can be implemented in a context of real assets, some recent studies have stated that it has become a valid and useful methodological tool to identify efficient power technologies portfolios [15,18–25,27–30,41,44–48]. A less-than-strict assumption of the portfolio theory hypotheses is required with regard to market efficiency.

The Portfolio Theory proposes that the expected performance of the Portfolio can be calculated as the weighted sum of the costs of each technology which participates in the mix, and the expected risk is associated with the variability of the considered cost - measured by each standard deviation and the different correlations between costs and technologies-. The different technologies are defined employing the same approach: expected cost and risk. The aim of this proposal is the achievement of the minimum costs or risks depending on the objective function approach. The model will define the efficient portfolios frontier with different cost-risk combinations through different technologies shares (which compose the portfolio). The portfolio optimization model seeks the minimum risk or the minimum cost, including the Markowitz's model constraints and four specific ones. These constraints would permit considering the three proposed EU 2030 goals and the level of energy supply of each portfolio: minimum portfolio share of renewable energies, efficiency improvement, CO_2 emissions reduction and the diversity level of each portfolio.

Portfolio theory can result in a valid and contrasted methodology for evaluating real assets and electricity production portfolios. The application is based on an approach change: substituting return by asset and portfolio cost. Proposing the analysis from the simultaneous conceptual consideration of the cost and the risk confers the approach a greater capacity and conceptual wealth than that of the simple least-cost individual generating technology perspective [15].

The Markowitz model [16] follows a quadratic optimization mathematic formula. The analysis of the technology portfolio by model is based on the study of both variables defined for each technology. In this manner, the expected cost of the portfolio $[E(C_p)]$ (Eq. (1)) consists of the weighted sum of the share of each technology $[x_t]$ and is defined by its expected cost value:

[3] This 2030 GHG reduction objective for Power Sector is calculated as the average of the EU reduction interval lower and upper bounds [32]. Thus, as these bounds are 54% and 68%, we used 61% as the reduction objective.

[4] According to EC (2014) [5], the 27% overall Renewable Energy Sources share in 2030 of gross energy consumption would translate into a 43% Renewable Energy Sources-Electricity share.

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