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A new method for cost of renewable energy production in Algeria: Integrate all benefits drawn from fossil fuel savings

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ABSTRACT

The high generation cost of renewable energy is one of the main barriers to their development and large-scale deployment. This is the case of Algeria, in which despite its significant renewable energy potential, more than 96% of electricity is generated with gas turbines to cover increasing national demand. This choice is also driven by the important natural gas reservoirs in Algeria in addition to the low cost of electricity that is generated by this fossil fuel. The purpose of this paper is to investigate the cost of electricity production from a renewable source, substituting conventional fossil fuel processes. An economic value can be captured through the trade of greenhouse gas emissions and the reallocation of fuel savings to export. This approach is particularly well supported considering the growing local demand for natural gas, threatening the country's natural gas export capacity in which the economy of Algeria is tightly dependent. The conventional evaluation of the generation cost of electricity, using the Levelized Cost Of Electricity (LCOE) and the cost structure of electricity production is selected for comparing the cost of electricity generation from gas power and photovoltaic plants. The environmental benefits and their financial valuation mechanisms are discussed. To illustrate all these parameters, a case study of a photovoltaic plant with a capacity of one megawatt (1 MW) installed in Algeria is presented and the potential benefits in terms of fuel savings and CO_2 eq emission assessed.

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1. Introduction

We are witnessing since over 10 years to a real inflation of studies on the production cost of electricity, particularly on external costs, with the objective to guide public policies for alternative energies with CO_2 low-emission or for renewable energies [1]. These studies promote better decision making in energy and environment, which increasingly needs a better evaluation of the production cost of electricity looking for a standard for energy efficiency or an internalization of external costs.

If the accuracy of these assessments is fundamental to guide public policies on energy as it allows to make technological choices or set the necessary incentives or penalties, recent studies do not currently allow to define a consensual method for comparing the unit costs of different technologies for electricity generation taking into account regional contingencies or essential facilities. This paper focuses on costs for producers, in fact the costs that can be directly attributed to the investment and operation of power plants, with an energy policies' orientation perspective, more particularly in the specific case of Algeria, one of the important oil and gas exporting countries. Firstly, we examine the conventional method of assessing the electricity production cost, more particularly the concept of the « levelized cost and conventional calculation method », and the structure of the total cost of production costs by different technologies, as defined by OECD in 2010 [2]. Secondly, we study the reduction of GHG emissions through renewable energy and economic valuation, before examining the precise case of evaluation of fuel consumption for electricity generation in Algeria and the evaluation of fuel savings and CO_2 eq emissions for a one-megawatt photovoltaic plant to justify recourse to a composite method taking into account economic specific factors to different regions of the world as we'll see it for the specific case of Algeria characterized by two significant variables: the income generated due to the reduction of domestic consumption of natural gas for power generation and the non-null cost of carbon, contributing to the revenue generated by the emissions saved.

The most used method for comparing the unit costs of different technologies is a common metric for comparing power-generating technologies called "levelized cost of electricity" (LCOE) [2]. However, the generic nature of this method has been criticized in recent works [3]. Critics focus on the inadequacy of this method to take into account economic factors specific to different regions of the world [4], but also for the integration of indirect costs-also called external costs-related to renewable technologies [4]. These are two shortcomings of current studies that our research attempts to rectify in a specific contingent case.

These deficiencies lead to wrong estimates, particularly for renewable generation costs. The integration of the specific economic parameters to the study area appears to be essential to achieving relevant results. So, the assessment of the energy production cost does not only determine the choice of technology, but also the deployment of the energy policy to adopt (program funding, grants, penalties…). This is more particularly by this focus that we study the renewable energies' cost in Algeria. The Algerian market context is specific to the hydrocarbon exporting countries. Indeed, the last decade has seen a considerable increase in national electricity consumption for several reasons: demographic growth, the increase of the Algerian citizen living standards (more than 98% of Algerian citizens have access to electricity), the increase of household comfort, among other reasons. This consumption has almost doubled since 2001, from 7,802 to 15,073 k toe in 2013 [5,6]. In correlation with this demand, the natural gas requirements of thermal power plants-where the bulk of domestic production-will be equally affected. In 2013, the production of electricity had mobilized more than 40% of domestic consumption of natural gas. Along with this consumption, domestic natural gas production will have changed very little from 74,353 k toe in 2001 to 77,058 k toe in 2013, i.e. an increase of 3.63% [5,6]. This has been reflected, in the recent years, in a downward trend in exports of natural gas. Since 2005, the volume of natural gas exports has decreased from 37,838 to 30,463 k toe, falling to 19.5% [6,7].

Furthermore, it is recognized that the use of renewable energies can significantly reduce carbon dioxide or equivalent (CO_2 eq) emissions compared to their fossil equivalents and it is considered therefore as one of mitigation solutions to keep global warming under 2 °C. There are international mechanisms of pricing carbon, including those of the United Nations Framework Convention, which provide an opportunity for developing countries to monetize the quantities of CO_2 eq saved by using renewable energies. These instruments internalize the external costs of climate change and reduce the investment costs of renewable energy.

In this way, we underline two main features for the Algerian case that might influence the evaluation of the actual cost of electricity production from renewable sources. On the one hand, it seems that the production of electricity from renewable energy in Algeria, indirectly generates income, due to the reduction of domestic consumption of natural gas for power generation, which will be therefore allocated to the quantities exported-due to the fact that Algeria is an oil exporting country. So instead of having a variable fuel cost to zero, it will be replaced by a variable that quantifies the fuel saved.

On the other hand, and complementarily, the variable cost of carbon becomes non-null, and so should be adapted to express the revenue generated by the emissions saved.

Thus, in order to better assess the electricity generation costs from renewable sources, the revision of the conventional method LCOE seems necessary in the case of Algeria. Such reassessment may be extended to groups of developing country exporters of fossil fuels.

Our research focuses on the comparison between gas plant technology-dominant technology in our case-and photovoltaic power plants for renewable energy, which is expected to be an emerging technology in Algeria. It will be addressed according to the following plan:

- First, the calculation method usually used to evaluate the cost of electricity generation;
- Second, the structure of production costs of the two technologies concerned;
- Third, the fuel consumption of thermal power plants in Algeria;
- Fourth, a case study of a virtual photovoltaic plant with a simulation on the PV GIS software followed by estimates of fuel savings and CO_2 eq emissions.

2. The conventional method of assessing the cost of electricity production

2.1. The concept of "levelized cost and conventional calculation method" defined by OECD

The concept of levelized cost is the most common tool for comparing the unit costs of different technologies over their useful economic life [2]. This method consists of an inventory and evaluates all expenditures to date for the entire life of the project. This value is divided by the total number of units to be produced throughout the lifetime of the project.

Specifically, the levelized cost of electricity is given by the following equation:

This is transcribed as presented in the OECD report, 2010 [2]:

Electricity t: The amount of electricity produced in year "*t*";
P Electricity: The constant price of electricity;