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Considering a Subscription to Butane Gas: A Beneficial or Detrimental Choice? An In-Depth Examination of the Energy, Economic, And Ecological Implications in a Highly Critical Sector in Morocco

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ABSTRACT: The gas industry in Morocco poses a significant financial burden on the country. Finding a solution to this challenge is progressing slowly, given the absence of concrete alternatives capable of replacing a source present in almost all Moroccan households and agricultural farms. The transition from gas dependence could be gradual or abrupt, depending on the solutions implemented. However, considering Morocco's ecological aspirations and investments in renewable energy, electrifying this energy source emerges as the most plausible option. From an environmental standpoint, this transformation would undoubtedly contribute positively to the overarching objectives. Beyond assessing the ecological impact, this study aims to inform the interested public about the economic and social aspects, as well as the strategies employed to phase out this polluting energy source, ideally as quickly as possible.

KEYWORDS: The energy transition; Butane gas; governmental reforms; renewable energies; Special energy requirements.

1. INTRODUCTION

In Morocco, the issue of butane is a complex matter with more political implications than purely practical considerations. The debate over the subsidy for this gas has persisted for decades. This prolonged discourse stems from the disparities it creates within Moroccan society. The benefits of this subsidy [1] favor some individuals while leaving others without such advantages, and the reasons for this are multifaceted. Furthermore, it raises questions about fairness, as those who utilize alternative methods for cooking or heating their homes [2]don't receive any benefits from this government measure, despite often aligning with more forward-thinking approaches. This study aims to generate widespread interest and foster synergy between the government and citizens to formulate a new roadmap founded on principles of equity, innovation, and commitment to implementing a solution that addresses both economic and ecological aspects [3,4], aligning with national, regional, and global contexts [5]. On the global stage, the environmental situation is increasingly alarming, with optimistic projections foreseeing a temperature increase exceeding 2°C by 2100 [6,7]. While this might seem moderate, the repercussions include a 560% surge in heatwaves and nearly 2.5 times more frequent drought periods than today. Despite these stark figures, some nations are still investing significant resources in discovering new fossil fuel reserves [8–10], and conflicts have arisen over exploiting territories rich in non-renewable energy sources [11–14], exemplified by instances like Venezuela and French Guiana.

2. METHODOLOGY

This study will adhere to a conventional methodology, encompassing two primary phases. The initial phase is dedicated to explicitly delineating the requisite data essential for comprehensively describing all aspects related to this subject, spanning energetic, economic, ecological, and social dimensions [15–17]. The subsequent phase will endeavor to leverage this accumulated data to derive meaningful outcomes pertinent to this study.

1.1. Statistical Overview of Butane:

Figure 1 above presents essential data concerning the butane industry in Morocco [18,19]. The majority of these statistics are sourced from public information provided by reputable institutions such as the Moroccan Ministry of Economy and Finance. Some figures result from straightforward calculations using available data. An example is the derivation of data point #1 in the table, which involves combining the quantity of cylinders in Morocco (5 million 3kg cylinders and nearly 28.5 million 12kg cylinders), their usage duration, and the associated carbon footprint [20,21] linked to the manufacturing of these cylinders.

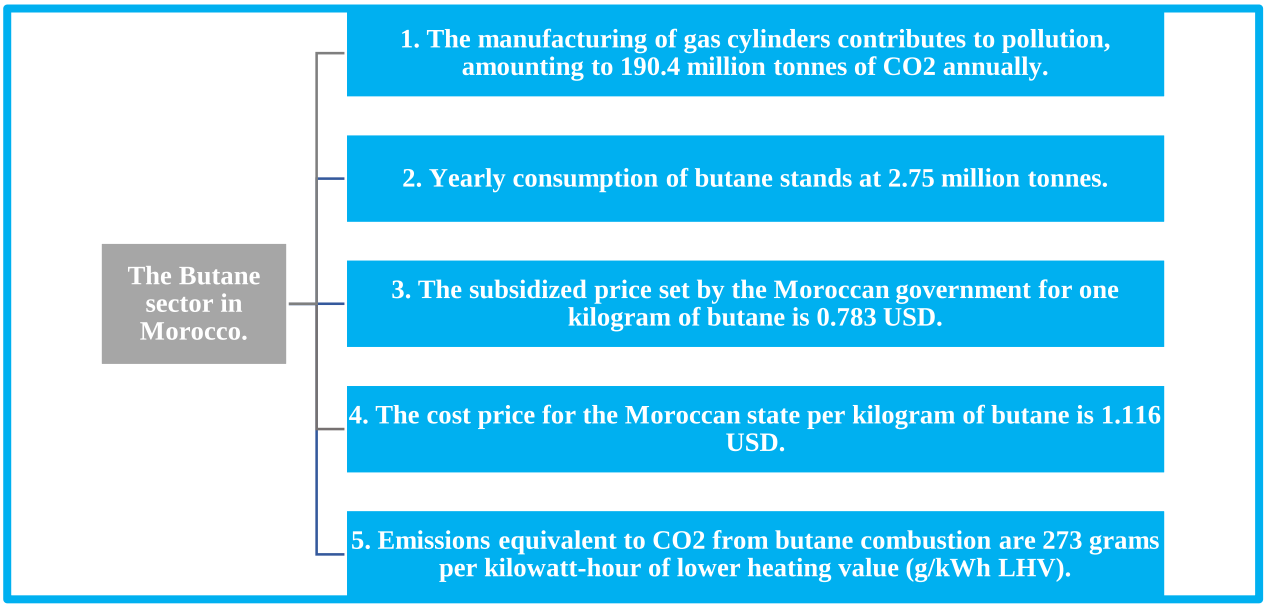

Figure 1. Key data on the butane industry in Morocco.

1.2. Possible replacements for butane, considering the overall national context:

In the current era, and given the prevailing circumstances, the logical replacement for butane use would typically be electricity. However, two critical considerations must be taken into account when considering this transition [22,23]. Firstly, the continual advancements in electrical and electronic technologies, facilitating the performance of tasks traditionally handled by gas-powered counterparts. The second crucial point in this context pertains to the country's energy landscape, particularly in electricity generation.

Presently, 90% of Morocco's energy is derived from fossil fuels, with the remaining portion sourced from renewable energies for electricity production. The latter, in turn, is harnessed from various sources in varying proportions. Figure 2 below illustrates the contribution of each energy type to electricity generation.

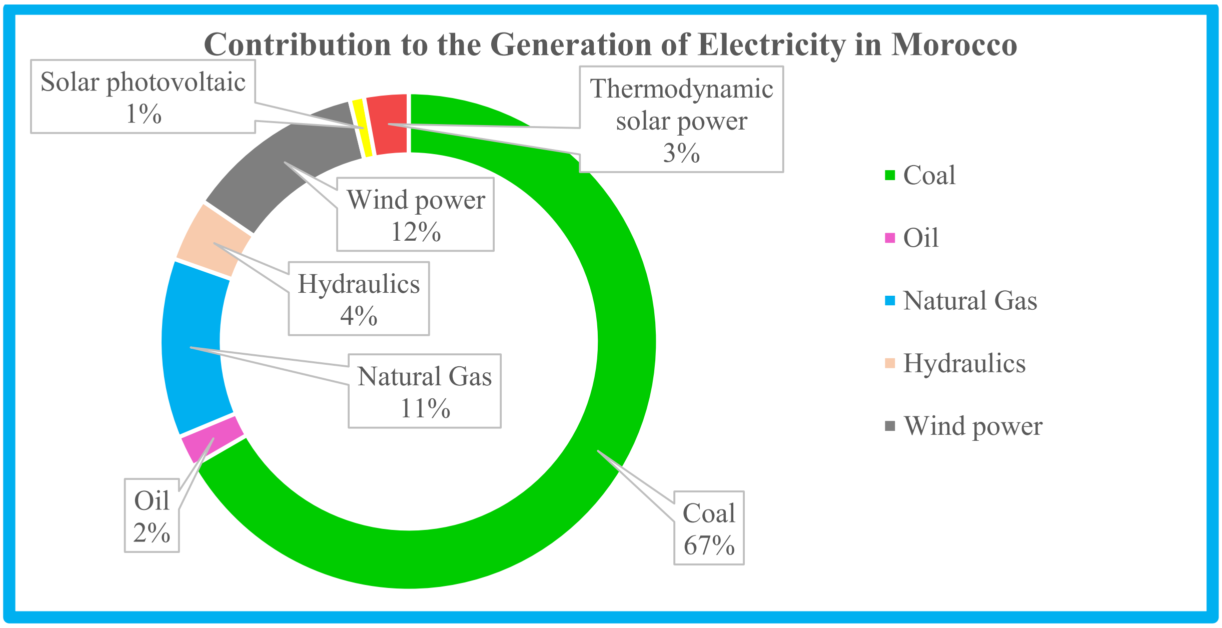

Figure 2. Distribution of Energy Sources in Moroccan Electricity Generation.

To determine the electricity required to replace the extensive use of butane gas [24], especially given its widespread popularity among the Moroccan population, making them the largest consumers of this energy type globally, with an average of

74kg per individual per year of bottled butane. Identifying the specific areas where butane is most utilized would be prudent to gauge its consumption accurately [25]. As previously mentioned, two sectors predominantly utilize nearly all available butane:

- The domestic sector represents nearly 59%, encompassing four primary applications illustrated in Figure 3.

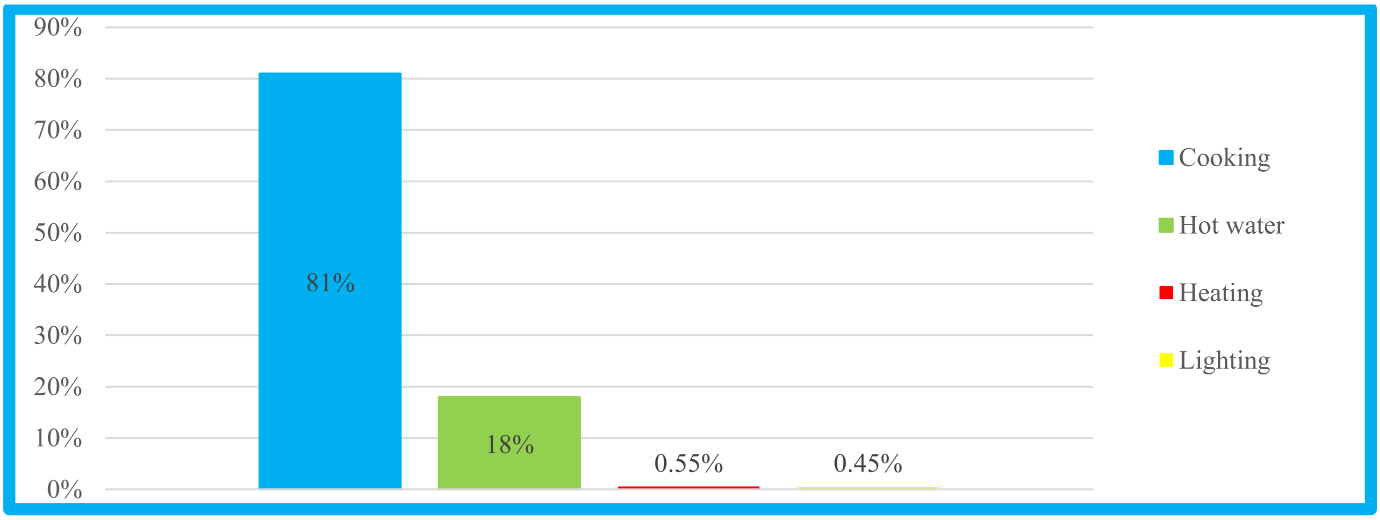

Figure 3. Primary applications of butane in Moroccan households.

- A significant portion of the remaining percentage is primarily utilized in rural areas by the agricultural sector. This energy is predominantly allocated to irrigation on one hand and livestock farming on the other. For a more detailed breakdown, please refer to Figure 4 below.

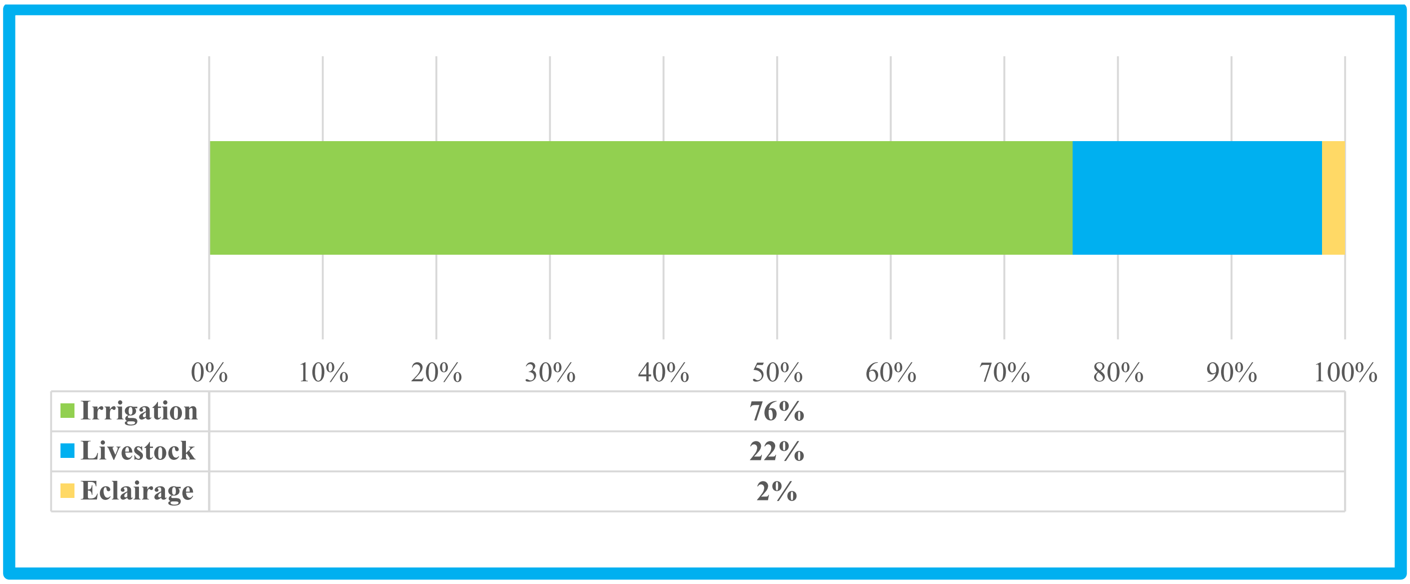

Figure 4. Butane consumption by agricultural sub-sector.

The latter part of this paragraph focuses on researching and presenting electrical equipment that can serve as reliable and practical alternatives to existing gas-powered devices. Numerous off-the-shelf solutions have been available for some time. These encompass electric motors designed to substitute butane-powered heaters, heat pumps for the climate control of sheds and greenhouses used in diverse crops, and in terms of food preservation in an agricultural setting, refrigerators running solely on gas (absorption refrigerators) should ideally be replaced with electric counterparts, unless they integrate a conversion to electric power [26]. Similar to the agricultural sector [27], the residential sector should transition away from gas cylinders, opting for electric hotplates or induction cookers for cooking and electric water heaters for hot water needs [28,29].

To conclude the data collection phase, the next step is to compare the electrical energy needs required to perform the same tasks as those carried out by gas-powered devices [30]. Table 1, presented below, has been compiled for this specific purpose.

Table 1: Calorific value of various raw materials

Fuels	**Calorific values**
Heating oil	*9,96 kWh/L*
Natural gas	*12,66 kWh/L*
Wood logs	*4,6 kWh/kg*
Propane gas	*12,78 kWh/kg*
Butane gas	*12,66 kWh/kg*
Coal	*8,72 kWh/kg*

3. RESULTS

The objective of this section, and consequently, the entire study, is to derive essential conclusions for quantifying the electrical replacement solution for the three primary sectors of interest. Subsequently, it aims to provide an order of magnitude for the required size of renewable energy installations to meet the compensatory energy needs.

Figure 6 below outlines the significant outcomes of electrifying the gas sector in Morocco [31], specifically examining the potential impacts on energy, ecology, and socio-economic aspects under conditions similar to those currently prevailing.

The initial energy outcome is determined through straightforward calculations involving two parameters: the total butane consumption and the Lower Calorific Value (LCV) of the same gas, using the data from the previous section.

For the second outcome, which is ecological in nature, two assessments are suggested: comparing the carbon footprint of the gas-fired solution with the alternative solution, considering the current electricity generation regime. However, arriving at this result necessitates preliminary calculations. Figure 5 illustrates the carbon footprint of each energy source utilized in Morocco to generate one kWh of locally-produced electricity, thereby deducting the carbon footprint of the kWh of electricity.

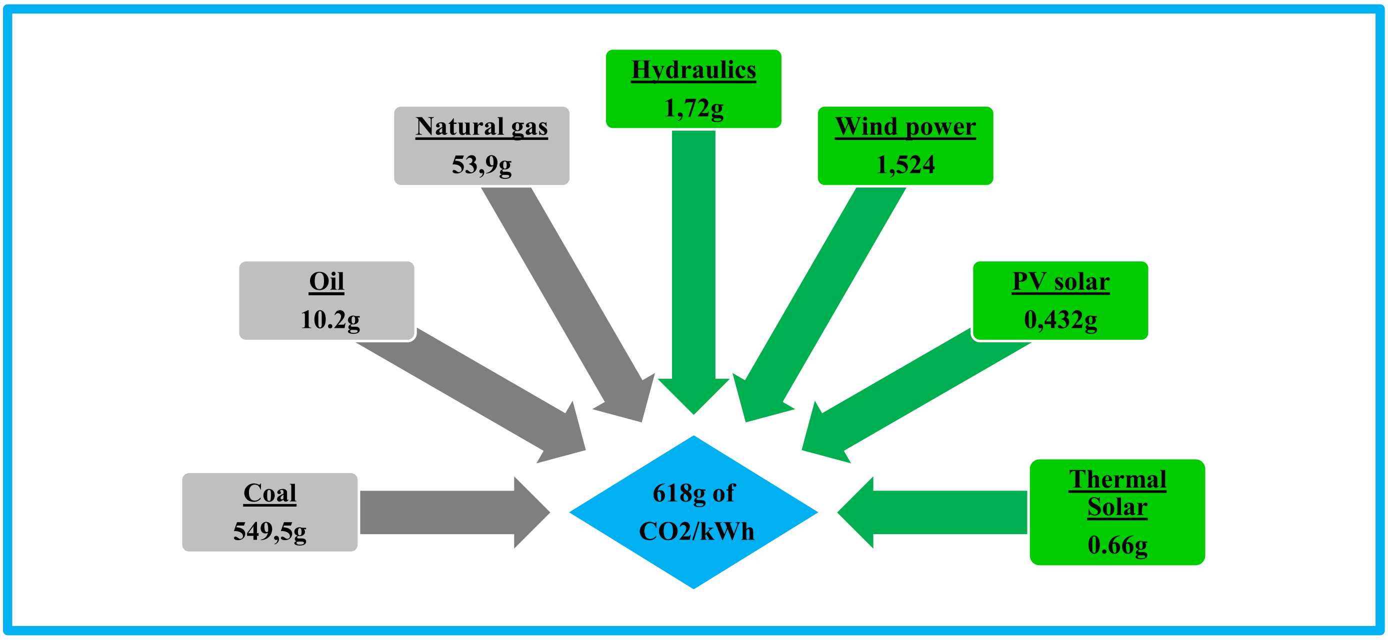

Figure 5: Amount of CO2 emitted to produce one kWh of electricity in Morocco, taking into account the contribution of each energy source.

Table 2 furnishes crucial information for computing the carbon footprint of the gas solution. This data needs to be amalgamated with information related to the manufacturing of gas cylinders to derive the desired result.

Table 2: Carbon footprint of butane gas

Energy sources	Émissions de CO2 par kWh
Butane gas	392g

In conclusion, the third and fourth results facilitate a comparison between the former and new economic constraints to be imposed on the local population. The fourth result offers insights into the financial implications for the Moroccan government concerning this transition, all within the context of the nation's prevailing energy landscape.

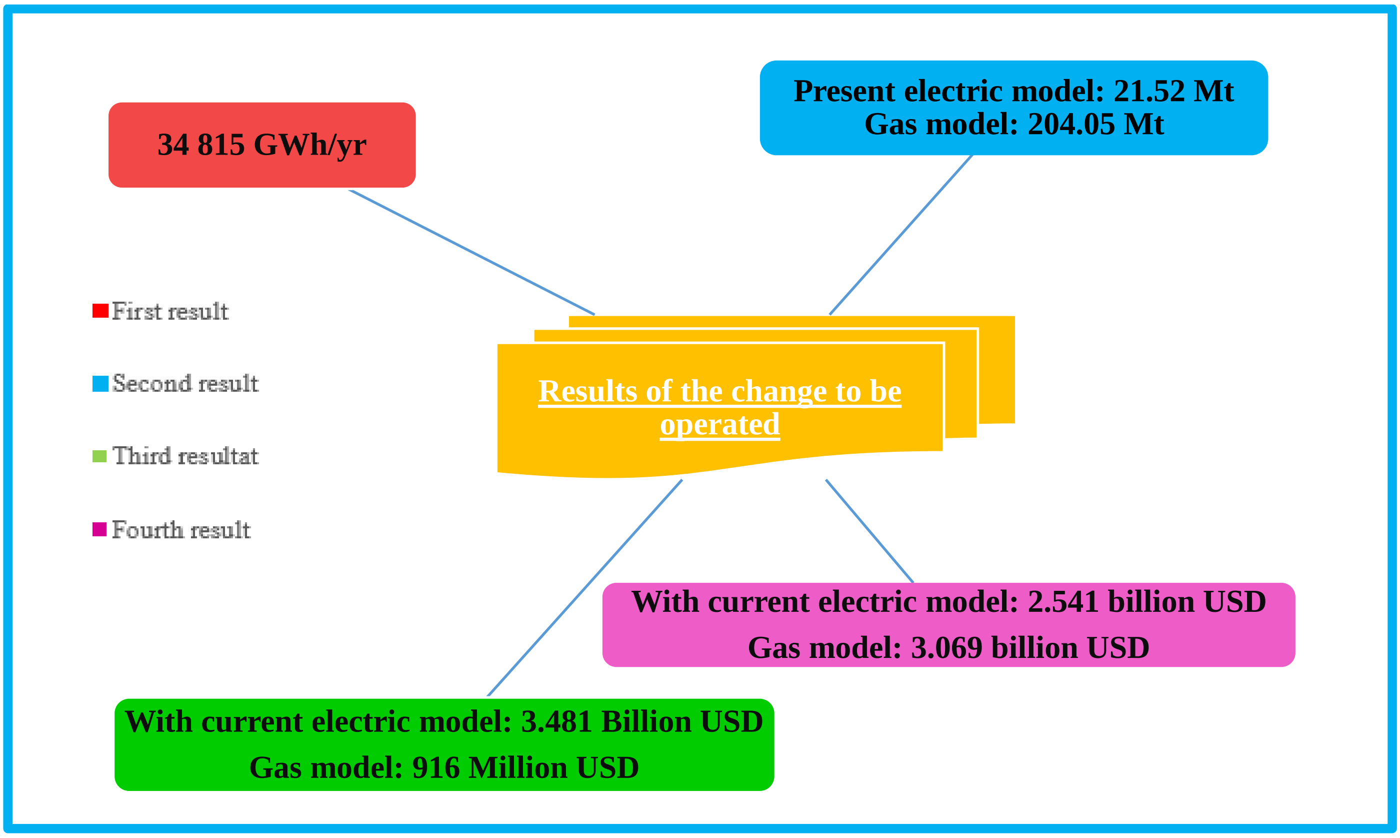

Figure 6. Computed results leading to noteworthy observations across multiple sectors.

The initial revelation stemming from this study is that, from an economic standpoint, the Moroccan state, even in a highly unfavorable scenario, can generate electrical energy at a significantly more favorable cost compared to the gas-based energy model.

The second revelation, from an ecological perspective, indicates that the gas model would result in nearly 20 times more pollution compared to the electric model [32]. This is noteworthy, especially in a local energy context predominantly reliant on the import and utilization of fossil fuels.

The third equally significant point pertains to the purchasing power of the Moroccan citizen. To fulfill their needs using gas, the individual would have to pay almost 3.8 times more. However, the abandonment of gas and its associated subsidy would free up a substantial budget. This budget could be redirected toward electricity, either through initial electricity subsidies or other long-term measures to counteract the increase.

4. CONCLUSION

Given these considerable advantages, it is strongly recommended to incorporate the energy demand currently met by the gas sector into the country's future expansion plans for installed capacity. Ideally, these future installations should predominantly be based on renewable sources. While the investment required would be significant, the returns from such a move would ensure energy independence for the Moroccan state, a highly competitive electricity price, and a carbon footprint nearly 10 times smaller than the current electricity production. This initiative could generate additional funds through carbon offsets and project an exemplary international image of a country at the forefront of sustainable practices.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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