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SOLAR ENERGY POTENTIAL IN ALGERIA: EMPOWERING RESIDENTIAL BUILDINGS FOR LOCAL AND REGIONAL ENERGY SUSTAINABILITY.

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Introduction

The global energy crisis, intensified by post-pandemic recovery and the 2022 Russia-Ukraine conflict, has emphasized the need for sustainable energy solutions, particularly in Europe. [1]. Algeria, with its significant natural gas reserves (4.5 trillion cubic meters as of 2021) [2], has emerged as a potential source to alleviate Europe's energy shortage [1]. However, Algeria's export capabilities are limited by insufficient infrastructure and high domestic consumption [3], which uses 45% of its production. A detailed analysis of local energy consumption reveals that the residential sector is the largest energy consumer in Algeria[4]. This indicates that managing the current energy supply should start with focusing on the largest energy consumers: houses. Transitioning to renewable energy, especially solar energy, which Algeria has significant potential for due to its 3000 hours of annual sunlight [5], could address these challenges. However Adopting solar energy in the residential sector faces many obstacles [6] . Overcoming these barriers is essential to reduce reliance on fossil fuels and achieve sustainable energy.

This study aims to demonstrate Algeria's potential and capability to meet significant domestic and EU energy demands in residential buildings through efficient utilization of solar energy, highlighting its contribution to regional sustainability. Additionally, it aims to identify barriers to solar energy adoption in the residential sector and propose solutions.

Methodology:

The method adopted in this study involves two steps: qualitative examination and quantitative evaluation, as illustrated in figure 1.

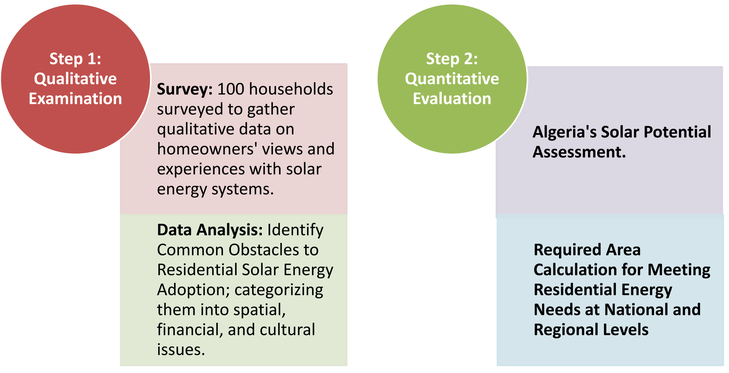

Fig.1. Qualitative and Quantitative Methodology Overview

2.1- Survey-Based Analysis:

We conducted a survey with 100 villas to identify the obstacles preventing the adoption of solar energy systems in homes by residents, revealing key obstacles illustrated in Fig.2.

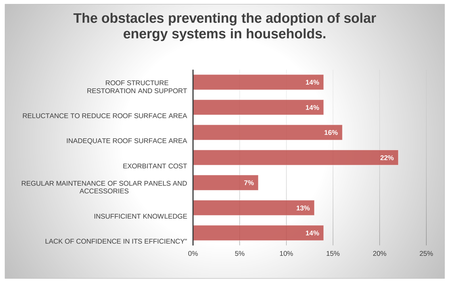

Fig. 2. The obstacles preventing the adoption of solar energy systems in homes.

The analysis revealed that the high upfront cost is a significant barrier for many households. However, , when we categorized the obstacles into three major groups As illustrated in Fig.3. the primary barrier, identified by 44% of respondents, is spatial and structural constraints. These include insufficient roof surface area, the need for roof repairs and reinforcement, and cultural habits that resist reducing roof space due to certain lifestyle norms.

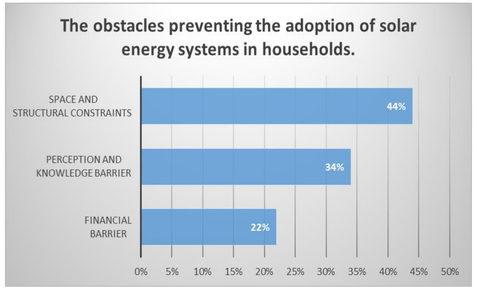

Fig. 3. Categorized Obstacles to Household Solar Adoption.

Therefore, one way to overcome the limitation of spatial and structural constraints in residential buildings is to broaden the perspective to include large-scale solar energy initiatives that rely on solar energy systems requiring significant space, such as large solar farms.

2.2- Algeria's Potential for Solar Electricity:

. Geographic location.(Fig.4)**:**

. Centrally located in North Africa, between Morocco and Tunisia.
. Only 240 km from Europe (Spain and Italy) across the Mediterranean Sea.
. Largest country in the Mediterranean region and Africa (2381741 km²).

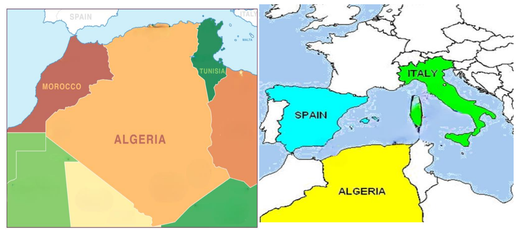

Fig. 4. Map of Algeria and its neighbors.

. Solar Potential Assessment:

. Algeria's climatic conditions are highly favorable for developing solar energy, as affirmed by the World Energy Council [7], and shown in Table 1.

Table1: Algeria's Solar Potential [7].

Areas	Desert Region	Elevated Plains	Coastal Zone	Total
Surface area (m²)	2,048,297	238,174	95,270	2,381,741
Mean daily sunshine duration (h)	9,59	8,22	7,26	-
Average duration of sunshine (h/year)	3500	3000	2650	
Received average energy (kwh/m²/year)	2650	1900	1700	
Solar daily energy density (kwh/m²)	7.26	5.21	4.66	
Potential daily energy (Twh)	14,870.63	1240.89	443.96	16,555.48

Given these favorable conditions, its central location, proximity to Europe, and abundant sunlight make it ideal for exporting renewable energy.

2.3- Required Area Calculation for Meeting Residential Energy Needs at National and European Levels:

First, the steps to calculate the surface area necessary to generate 1 Mwh/day are undertaken, as mentioned in Table 2.

Table 2: Calculation Method for Required PV System Area to produce 1 Mwh/day.

Parameter	Calculation	Value
Energy Consumed (EC)	-	1 MWh/day
Energy Produced (EP)	EC + 20% EC	1200 kWh/day
Peak Power of Panels (Pc)	EP / 9 hours	133 kW = 133000 W
Surface Area of PV Modules (Sm)	Pc / (1000 W/m² * 0.2)	665 m²
Total Area for PV System (S)	Sm * 3	1995 m² = 0.002 km²

Table 3: Energy Consumption and PV System Area for Algeria and Europe.

Parameter	Calculation	Algeria's Residential Sector	European Residential Sector
Annual Energy Consumption 2022 (AEC) (GWh)	-	68090.1	3729398.5
Daily Energy Consumption (DEC) (GWh/day)	-	186.5	10217.53
PV Area Required (S) per (1 GWh/day) (km²)	-	2	2
Total Area for PV System (SS) (km²)	DEC *S	373	20435.06
Total Area of Algeria (AS)	-	2381741	2381741
Percentage of Algeria's Total Area	SS/ AS	0.015%	0,8%

When: . 9 hours represents Mean daily sunshine duration (h) in the desert region; 1000 W/m² denotes the standard value of solar radiation; 20 % signifies the efficiency of the solar panel; '3' is a factor used to account for spacing between solar panel rows and other operational considerations."

Results:

This study reveals Algeria's substantial potential to address energy challenges for both its own needs and the European union through solar energy systems.

Land Requirement: (see Table 3)

-Only 0.015% (373 km²) of Algeria's land is needed to meet its residential daily energy demand.

-0,8% of Algeria's land can fulfill the EU's residential daily energy needs.

Feasibility:

The calculated required area for installing solar energy systems demonstrates the feasibility of such an initiative.

-Expansive land availability and high solar irradiation support the viability of this initiative.

-Proximity to Europe enhances potential for energy exportation, helping to address regional energy shortages.

Conclusion:

Algeria possesses remarkable solar energy potential that, if properly harnessed, could address both local and regional energy challenges. The transition to solar energy in Algeria's residential sector, while impeded by structural, financial, and cultural barriers, can be facilitated through strategic measures such as large-scale solar farms. The quantitative analysis reveals that a relatively small portion of Algeria's landmass is sufficient to meet significant residential energy demands both domestically and across the EU. Consequently, Algeria has the opportunity to become a key player in the sustainable energy landscape, contributing to energy security and sustainability in the region. Overcoming the identified obstacles and capitalizing on Algeria's solar potential will require concerted efforts from policymakers, industry stakeholders, and the international community.

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