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Personal and psychological factors affecting the successful development of solar energy use in Yemen power sector: A case study

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ABSTRACT

The development of the use of renewable energy (RE) to alleviate the electricity, fuel crises and poverty in Yemen and most developing countries is a crucial issue, which is significantly influenced by the psychological, contextual, and personal factors affecting public acceptance. This study aims to determine the personal and psychological determinants that influence the public's knowledge of and attitudes and behavioral intentions toward solar energy use in the power sector in urban and rural areas in Yemen. In this study, the people's behavioral intentions are evaluated by measuring their willingness to pay, willingness to change the currently used electricity source during power outages, and willingness to invest in the feed-in tariff (FiT) scheme. In this context, face-to-face interviews using a self-structured questionnaire were conducted with 348 households in Aden governorate (urban area) and 258 households in Lahj governorate (rural area). The results showed that, although the people in both areas are not well informed about RE resources, the benefits and drawbacks of solar energy use in the power sector, and the solar power technologies, they have highly positive attitudes toward the use of RE. Furthermore, 66%, 55.7%, and 78.4% of the urban population and 70%, 55.4%, and 75.6% of the rural population are willing to pay, to change electricity source, and to invest in FiT scheme, respectively. The findings also showed that existing small-scale solar projects have played a significant role in gaining public acceptance, particularly in rural areas that have higher installation and usage levels than urban area. Consequently, implementing pilot projects, disseminating information through formal and informal education, setting appropriate RE policies, and improving people's livelihood in different country's regions will lead to achieve a sustainable development of RE use.

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1. Introduction

Although underground fossil fuel reserves are expected to run out in the near future [1,2], and burning fossil fuel for electricity leads to change the natural equilibrium of the environment, fossil fuel remains to be the main source of electricity around the world [3]. Developing the use of renewable energy (RE), according to Observer [4] can help in ensuring energy security, reducing carbon emissions and improving the economy.

Yemen is an Arab country in Southwest Asia at the latitude and longitude of 15.0°N, 48.0°E occupying the southwestern to southern end of the Arabian Peninsula and it has different types of renewable energy resources (RERs) that could be used for electricity production [5–9] (refer to Table 1). Currently, most of the electricity in Yemen is generated by burning of fossil fuels (oil and gas), as in most countries in the world. In general, the total electricity generated in the country is limited, which is only sufficient to meet the energy needs of 40% of the total population (24 million in 2004). This limited electricity supply is used to meet the energy needs of 85% of the urban population and 23% of the rural population that constitutes 75% of the total population, with rolling blackouts reaching to several hours per day in both areas. For the non-electrified population, they get the electricity for 6 h/day from small off-grid networks belonging to the Ministry of Electricity or several small investors. This situation has forced most of the population in electrified and non-electrified areas to use alternative sources, such as diesel/petrol-fueled generators and kerosene/petrol lamps to meet their daily household energy needs. However, these alternative sources have negative impacts on the environment and have not significantly alleviated the suffering of the people from power shortages, particularly during hot summers, because the required fuels to operate these alternative sources are not sufficiently available in the local markets. This insufficient supply of fuels in the local markets forces most of the people to either stand in long lines just to buy a little of it or buy it from the black market at high prices.

Table 1
RE potentials in Yemen and the planned RE targets by 2025 [9,10,12].

RE resource	Theoretical potential (MW)	Gross technical potential (MW)	Practical technical potential (MW)	Targets by 2025 (MW)
Wind	308,722	123,429	34,286	400
Solar electric (PV technology)	2,446,000	1,426,000	18,600	4
Solar thermal(CSP technologies)	3014	278	278	100
Geothermal	304,000	29,000	2900	200
Biomass-landfills	10	8	6	6
Hydropower-Major Wadies	12–31	11–30	–	–

Note: Theoretical potential refers to the physical, meteorological or biochemical energy available in a certain region and at a certain time. Gross technical potential means the achievable potential by using known technologies taking into account technical factors and land-use. Practical technical potential takes into account electricity grid accessibility.

Since 2011, the electricity and fuel crises have drastically increased, significantly affecting the performance and sustainability of (i) small and medium enterprises (SMEs), including small-scale industries, that laid out a number of their employees in 2011 and (ii) the agricultural sector, which is considered the main source of income in Yemen and a key factor in rural development [9]. These crises increased the rate of poverty in the country from 42% in 2009 to 55% in 2012 [15], as a result of agricultural production drop and the downscale or suspension of the operations of many SMEs in 2011 [9,15]. Therefore, using RE that have a proven potential in the country's power sector is a crucial and urgent need to mitigate the electricity and fuel crises and alleviate poverty. Whereby, RERs can play a significant role in Yemen's future sustainable development [10,14,15]. It can contribute in poverty reduction, income generation, improved education, better health services and other development areas through providing cost-effective electricity to the rural and remote areas and supplying of sufficient and reliable energy sources. The use of RERs can also contribute in sustaining the fossil fuel reserves that are expected to run out in 2040 (cited in Baharoon et al. [13]).

In fact, the use of RE in Yemen started in 2003 when the Yemeni government allocated a fund to support the use of small-scale technologies, particularly photovoltaic (PV) technologies, in the isolated remote areas from the national grid. This fund still continues to support these types of projects until now [8,10]. In 2008, the government approved the Rural Electrification Policy Statement (REPS), and in 2009, they approved the National Strategy for Renewable Energy and Energy Efficiency that targets to increase the share of renewable energy in the national generation mix [11,12]. In 2012, the Yemeni government set ambitious renewable energy targets and some policies, which aimed to generate 15% of the total energy supply from RERs by 2025 [10]. They aimed to generate 4 MW from solar PV technology, 100 MW from concentrated solar power (CSP) technologies, 400 MW from wind power, 6 MW from solid biomass, and 200 MW from geothermal power (refer to Table 1) [10,12]. Currently, the solar renewable energy (solar electric) is the only renewable energy that is used in the country for producing green electricity. The total electricity production from the PV technology until 2012 was 1.5 MW, which constituted 0.09% of the national generation mix. Although no new PV projects have been implemented in the country since 2012 [9,10,12], the PV technology has significant potential markets in the country for the following reasons: (i) the Yemeni population has suffered from the electricity and fuel crises; (ii) there is a perfect match between the load demands and the potential of solar energy use, particularly in the rural areas; and (iii) the sky is clear in most parts of the country throughout the year, with the annual average hours of daily sunshine between 7.3 h/day and 9.1 h/day and average solar radiations between 450 cal/cm^2/day and 550 cal/cm^2/day [8,9].

To achieve successful implementation and sustainable development of renewable energy projects, the government should