World Academy of Science, Engineering and Technology
International Journal of Architectural and Environmental Engineering
Vol:17, No:8, 2023

Crowdfunding for Saudi Arabia Green Projects

Saleh Komies, Mona Alharbi, Razan Alhayyani, Mozah Almulhim, Roseanne Khawaja, Ahmed Alradhi

Open Science Index, Architectural and Environmental Engineering Vol:17, No:8, 2023 publications.waset.org/10013221.pdf

***Abstract*—**One of the proposed solutions that face some challenges is encouraging sustainable energy consumption across Saudi Arabia through crowdfunding platforms. To address these challenges, we need to determine the level of awareness of crowdfunding and green projects, as well as the preferences and willingness of Saudis to utilize crowdfunding as an alternative funding source for green projects in Saudi Arabia. In this study, we aim to determine the influence of environmental awareness and concern on the propensity to crowdfund green projects. The survey is being conducted as part of environmental initiatives to assess public perceptions and opinions on crowdfunding green projects in Saudi Arabia. A total of 450 responses to an online questionnaire distributed via convenience and snowball sampling were utilized for data analysis. The survey reveals that Saudis have a low understanding of crowdfunding concepts and a relatively high understanding of implementing green projects. The public is interested in crowdfunding green projects if there is a return on investment.

***Keywords*—**Crowdfunding, green projects, renewable energy, Saudi Arabia, solar farms, wind resources.

I. Introduction

HOUSEHOLDS in Saudi Arabia are completely reliant on electricity generated from fossil fuels. They are also one of the biggest consumers of electricity in KSA. The Saudi Arabian building sector accounts for almost 29% of overall energy use, which accounted for around 75% of the electricity output [1], [2]. One of the most critical Sustainable Development Goals (SDGs) set up by the United Nations is to "ensure that all people have access to affordable, reliable, and sustainable energy" [3]. In a country like Saudi Arabia, one of the largest oil producers in the world that provides affordable electricity tariffs due to government funds and low fuel costs, it is essential to diversify the energy mix and promote sustainable energy. Because the reliance on petroleum products is not prolonged and has adverse environmental effects, the Saudi Arabian government is working towards promoting sustainable and clean energy consumption. Saudi Arabia has committed to the Paris Agreement with the ambitious goal of achieving carbon neutrality by 2060 [4], [5]. Saudi Arabia throughout its Vision 2030 has been eager to develop a plan for a less oil-dependent economy. This is done by diversification of energy sources, including renewable and alternative energy, by generating 5.3 and 5.9 gigawatts of renewable energy by 2020 and 2030, respectively [6], [7]. However, the feasibility of achieving this goal is measured upon two indicators: CO_2 emissions from fuel combustion per total electricity output (MtCO/TWh) and the share of renewable energy in total primary energy supply (%). Currently, Saudi has a performance score for the joint indicators that is insufficient to attain this goal [8], [9].

Fig. 1 displays Saudi's CO_2 emissions from fuel combustion per total energy output between the years 2000 and 2019. Although Saudi's performance is on track for maintaining SDG achievement, there are significant challenges that remain. According to the International Energy Agency (IEA) data explorer, power generation (electricity and heat) accounts for the largest fraction of total CO_2 emissions from fuel combustion. Electricity output, generation efficiency, fraction of total generation derived from fossil fuels, and carbon intensity of fossil generation are several drivers which are responsible for CO_2 emissions generated from electricity generation (Fig. 3) [10]. Fig. 2 shows Saudi's share of renewable energy in the total primary energy supply between 2000 and 2019. According to the Sustainable Development Report, Saudi's score has remained stagnant since 2019, making the overall SDG score insufficient to attain the goal [3].

Fig. 1 CO_2 emissions from fuel combustion per total electricity output ($MtCO_2$/TWh)

S. Komies is with the Electrical Engineering Department, Imperial College London (corresponding author, e-mail: smk19@ic.ac.uk).
M. Alharbi is with the Economics and Policy of Energy and the Environment, University of College London, UK (e-mail: Mona.alharbi.21@ucl.ac.uk).
R. Alhayyani is with the Business Management/Arts, The University of Queensland, Queensland, Australia (e-mail: alhayanirazana@gmail.com).
M. Almulhim is with the Materials Science and Engineering Illinois, US (e-mail: mozahma2@illinois.edu).
A. Alradhi is with the Electrical Engineering, King Fahd University of Petroleum and Minerals Dhahran, Saudi Arabia (e-mail: s201859380@kfupm.edu.sa).
R. Khawaja is with the Biomedical Sciences, University of Edinburgh, Edinburgh, United Kingdom (e-mail: Roseannekhawaja@gmail.com).

Open Science Index, Architectural and Environmental Engineering Vol:17, No:8, 2023 publications.waset.org/10013221.pdf

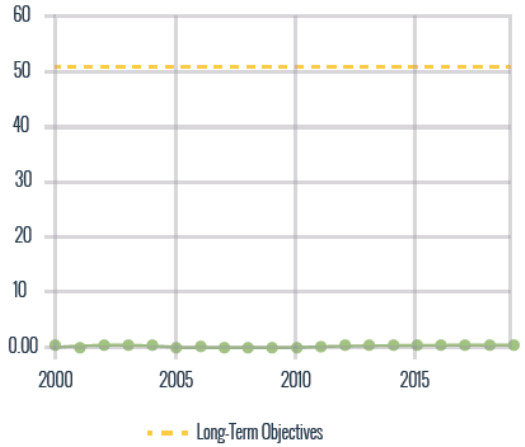

Fig. 2 Renewable energy share in the total primary energy supply (%)

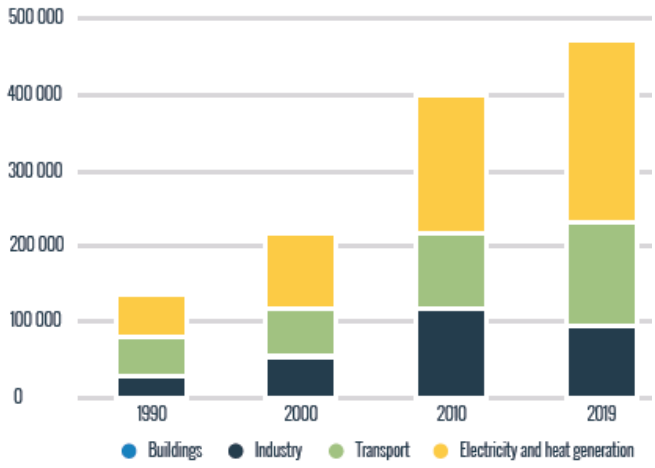

Fig. 3 Global CO_2 emissions from fuel combustion by sector with electricity and heat separated, Saudi Arabia

Saudi Arabia has made commitments to increase renewable energy resources, promoting a more sustainable form of energy consumption. Due to the cost and capital requirements of green energy generation, these investments are typically borne by governments. In order to accelerate our adoption to it, we need to promote a more reachable form of energy in the commercial market, like making green energy cheaper though crowdfunding. This will offer consumers investment opportunities in renewable energy such as building wind or solar farms that are 100% consumer owned. The power generated from these projects are put back into each of the investors' electricity bills, prompting a decrease in their monthly electricity bills–and consuming sustainable forms of energy. By enabling customers to own their own source of low-cost green energy, crowdfunding will make renewable energy more affordable by giving consumers control over how much they are willing to invest.

In this paper, we will investigate Saudi consumers' willingness to invest in green energy through crowdfunding projects. The upcoming sections include the research methodology along with the analysis of the questionnaire's responses given to the Saudi public.

II. Research Methodology

This study employs a quantitative methodology in which data were collected through an online questionnaire using Google Forms. The questionnaire consists of three main sections. Section one includes the participant's background and demographic characteristics. These include gender, age, nationality, region of residence within Saudi Arabia, education level, occupation, and monthly income level. In this study, these are the control variables. The questionnaire was designed so that it would take approximately 5 minutes to answer all questions.

Section two surveys the participant's awareness of green energy and their willingness to use and invest in green energy. This section focuses on the importance of green energy for Saudi individuals, specifically (wind and solar) sources, which is measured via the "Important" or "Not important" response; the level of cost awareness of implementing renewable energy technologies, which is measured via "More expensive" or "Less expensive", "I don't know"; the willingness of participants to pay extra cost to obtain green energy, which is measured via "Willing to pay up to 10% more", "Willing to pay up to 50% more", "Cheapest solution" and "Not willing to pay the extra cost"; the willingness of participants to use green energy if a renewable energy solution was provided to reduce energy costs in the future, which is measured via the "Yes", "No", "I don't know"; the utilization of household roof space for participants, which is measured via the "Yes", "No"; the willingness of installing solar panels on roof tops, which is measured via the "Yes", "No", "Maybe" and "Dpends on the return of investment"; the participant's opinion on whom should be involved in renewable energy production in Saudi Arabia, which is studied via the "Government sector", "Energy producers", "Energy distributors/other " and "Consumers" options.

Section three showcases the participant's awareness of crowdfunding in general. The participants are asked if they are familiar with the concept of crowdfunding, which is studied via "No knowledge", "I have heard about it", "I know what crowdfunding is, but I never used it in financing", and "I know what crowdfunding is, and have used it in financing before"; their willingness to invest in future crowdfunded green projects in Saudi Arabia which is measured through the "Yes" and "No" response options; their crowdfunding model preference after defining two models (equity crowdfunding and debt-based crowdfunding), which is measured via "equity-based" and "lending-based"; their usage of crowdfunding platforms such as Scooper, Manafa, etc.; the number of crowdfunding investment opportunities they invested in, which is measured on a 1-4 scale; their investment average on each crowdfunding opportunity or how much are they willing to invest in each option, which is measured on a "0-1000 SR scale", "1000-5000 SR scale", "5000-10000 SR scale", "10000-20000 SR scale", "more than 20000 SR scale" and "I never invested in crowdfunding before"; what they see as the most attractive factors to invest in a project, which is measured based on "Platform transparency", "Sustainability and environmental impact", "Financial return", "Reputation of the platform",

Open Science Index, Architectural and Environmental Engineering Vol:17, No:8, 2023 publications.waset.org/10013221.pdf

"Technology type", "Duration of the project", "Perceived risk "and "Social values"; Finally, participants were asked would contribute to green projects that raise funds through crowdfunding, which is measured by "Yes" and "No".

TABLE I
ANALYSIS OF FREQUENCY AND DEMOGRAPHIC CHARACTERISTICS

	Freq.	%		Freq.	%
Gender			Age		
Male	258	57.3	18 or younger	4	0.9
Female	192	42.7	18-24	112	24.9
			25-34	153	34
Nationality			35-44	86	19.1
Saudi	433	96.2	45-54	57	12.7
Non-Saudi	17	3.8	Older than 55	38	8.4
Education level			Monthly salary		
Below High School	2	0.4	No income	68	15.1
High School	53	11.8	Less than 5,000 SAR	55	12.2
Diploma	19	4.2	From (5,000 to less than 10,000) SAR	77	17.1
College	265	58.9	From (10,000 to less than 15,000) SAR	81	18
Higher Studies	111	24.7	From (15,000 to less than 20,000) SAR	65	14.4
			From (20,000 to less than 25,000) SAR	47	10.4
			From (25,000 to less than 30,000) SAR	28	6.2
			More than 30,000	29	6.4
Region of Residence			Occupation		
Riyadh	114	25.4	Employed in the government	133	29.6
Eastern	178	39.7	Employed in the private sector	122	27.1
Mecca	96	21.4	Freelancer	16	3.6
Madinah	10	2.2	Student	97	21.6
Asir	25	5.6	Retired	39	8.7
Jazan	3	0.7	Unemployed	43	9.6
Hail	2	0.4			
Najran	6	1.3			
Al-Baha					
Al-Jawf	6	1.3			
Northern					
Al-Qassim	6	1.3			
Tabuk	1	0.2			

III. ANALYSIS AND DISCUSSION

The first part of the analysis gives a general overview of the background and demographic data. Saudi Arabia's population in 2022 [11] is 35.84 million. The median age is approximately 32.4 years. The male population is 20.70 million, and the female population is 15.14 million.

Table I provides a breakdown of the demographic characteristics and background of the survey participants. It reveals that most respondents are male, with 258 (57.6%), and females make up 190 (42.4 %). It is indicated that many of the respondents are from Saudi Arabia, with a percentage of 96.2%, and non-Saudis are represented at 3.8%. The majority age of participants in the survey is between 25-34 years with 153 (34%) and 18-24 years with 112 (24.9%). The education level of participants is mainly a bachelor's degree with a total of 265 (58.9%) and higher studies with a total of 111 (24.7%). It is apparent from Table I that an approximately equal distribution of participants lies within all the salary ranges. What stands out in the monthly salary section in the table is that most participants earn between 10,000 and less than 15,000 SR. In this study, the survey questions and data analysis were conducted following established academic practices and were adapted from [12]-[18] to ensure rigor and accuracy in the research process.

The respondents' knowledge and familiarity with climate change, renewable energy technology, the cost of renewable energy to consumers, the use of roof space, and potential solar panel installations are then assessed using frequency analysis. Over half of those surveyed reported that they care about saving the environment, with 396 (88%). The majority of participants responded "It is important" to the question of how important green energy is, with 402 (89.3%). Also, the majority care about solar and wind sources, with 415 (92.2%). Technology awareness questions revealed that 193 (42.9%) think it is more expensive, whereas 159 (35.3%) does not have any knowledge. Interestingly, 129 (28.7%) of participants are willing to pay up to 10% more to obtain more sustainable green energy. On the other hand, 228 (50.7%) of respondents would like the cheapest possible solution, and 394 (87.6%) would like to use a proposed solution if an energy reduction is introduced. The most striking result to emerge from the data is that 339 (75.7%) of people do not utilize their rooftop spaces, while 109 (24.2%) are thinking of installing solar panels, 171 (38%) are skeptical, and 115 (25.6%) of participants are willing to install solar panels

depending on the return on their investment. Table II displays the summary statistics for green energy. More details of mentioned crowdfunding survey can be found in the Appendix.

TABLE II
GREEN ENERGY

	Freq	%
What is your opinion on climate change?		
I care about saving the environment	396	88
I don't care	32	7.1
It does not affect me	22	4.9
How important is green energy for you		
Important	402	89.3
Not important	48	10.7
How important is the local production of green energy for you? (wind, solar)		
Important	415	92.2
Not important	35	7.8
Do you think using existing renewable energy technologies is more or less expensive?		
More expensive	193	42.9
Less expensive	98	21.8
I don't know	159	35.3
Are you willing to pay some extra cost to obtain green energy?		
I'm willing to pay up to 10% more	129	28.7
I'm willing to pay up to 50% more	10	2.2
I want the cheapest solution	228	50.7
I'm not willing to pay	83	18.4
If we presented a renewable energy solution that would reduce energy costs in the future, would you use it?		
Yes	394	87.6
No	55	12.2
Do you utilize your rooftop space?		
Yes	339	75.7
No	109	24.3
Do you think of installing solar panels on your roof?		
Yes	109	24.2
No	55	12.2
Maybe	171	38
Depends on the return of investment	115	25.6

IV. CONCLUSION

This study aims to determine the level of knowledge regarding green projects and crowdfunding in Saudi Arabia, since the subject of this study is crowdfunding for green projects. Additionally, the characteristics that individuals consider while investing in green projects are evaluated. This study determines how environmental awareness and concern influence individuals' willingness to crowdfund green projects in Saudi Arabia. To achieve the objectives, data from 450 online questionnaire replies are employed. Numerous analyses, which include frequency analysis and descriptive statistics, are carried out.

According to the findings, the respondents' awareness of green projects and crowdfunding is quite poor, the topic remains unexplored in prior research endeavors; thus, the outcomes of this study can contribute to a greater knowledge of climate awareness and concern in Saudi Arabia. This study provides a starting point and reference for future research on climate challenges in Saudi Arabia, particularly the financing of green projects. The majority of respondents are eager to support green initiatives and projects. Saudi Arabia plans to have 50% of its energy mix by 2030 from renewable sources.

This research has a few limitations. Most importantly, this is quantitative research survey research that provides information on both crowdfunding and environmental aspects. To gain a better insight, however, focus interviews and other qualitative approaches can be used to allow for a more in-depth study of the issues and comprehension of the tested correlations.

TABLE III
DEFINITION OF CROWDFUNDING

	Freq	%
Are you familiar with the concept of crowdfunding		
No knowledge	261	58
I have heard about it	85	18.9
I know what crowdfunding is, but I never used it in financing	72	16
I know what crowdfunding is, and I have used it in financing before	32	7.1
Would you consider investing in crowdfunding as an investment opportunity?		
Yes	340	75.6
No	110	24.4
If you used crowdfunding before, what platforms did you use?		
I have not used any	387	86
Manafa	31	6.9
Scopeer	19	4.2
Emkan	18	4
Lendo	15	3.3
How many crowdfunding investment opportunities have you invested in?		
Zero	385	85.6
One	21	4.1
Two	20	4.4
Three	18	4
On average, how much did you invest on each crowdfunding opportunity or how much are you willing to invest in each opportunity?		
0 – 1000 SR	40	8.9
1000 – 5000 SR	46	10.2
5000 – 10000 SR	20	4.4
10,000 – 20,000 SR	14	3.1
More than 20,000 SR	13	2.9
I never invested om crowdfunding before	317	70.4
If given the chance, would you contribute to green projects that raise funds through crowdfunding?		
Yes	374	83.1
No	76	16.9

APPENDIX

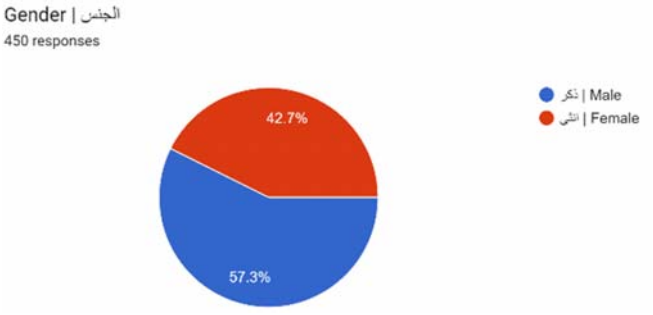

Fig. 4 Gender percentage

Open Science Index, Architectural and Environmental Engineering Vol:17, No:8, 2023 publications.waset.org/10013221.pdf

Open Science Index, Architectural and Environmental Engineering Vol:17, No:8, 2023 publications.waset.org/10013221.pdf

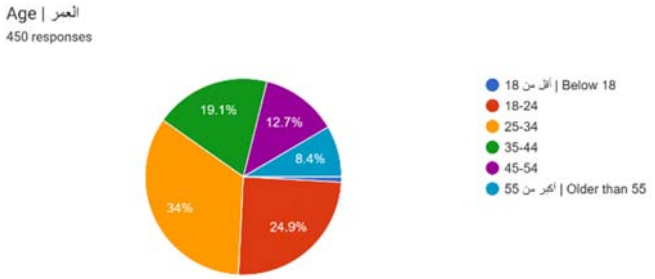

Fig. 5 Age percentage

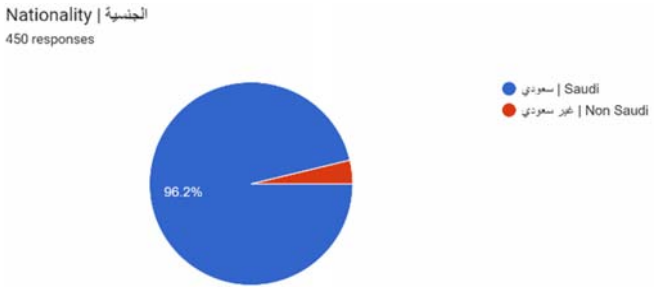

Fig. 6 Nationality percentage

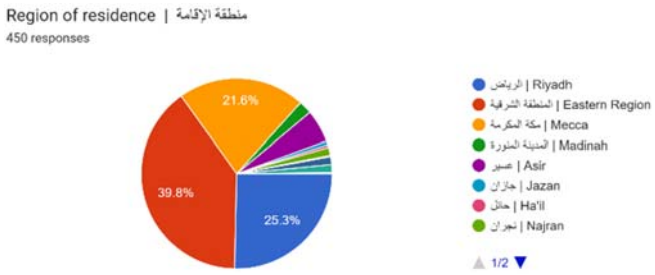

Fig. 7 Region of residence percentage

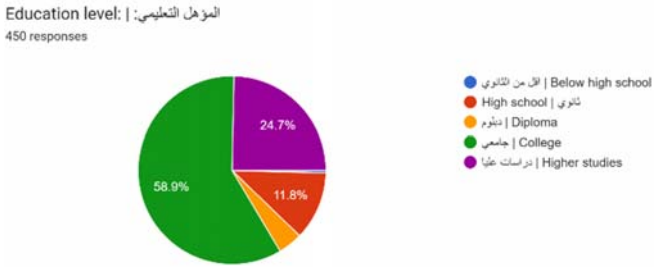

Fig. 8 Education level percentage

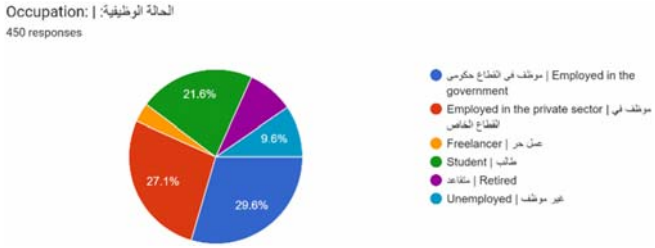

Fig. 9 Occupation percentage

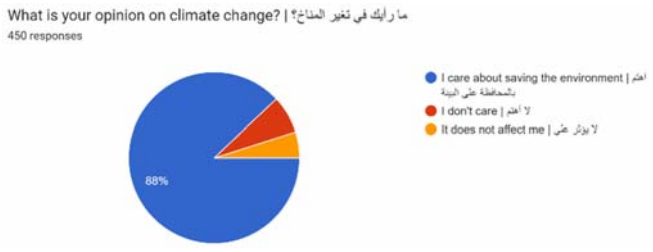

Fig. 10 Perception of climate change

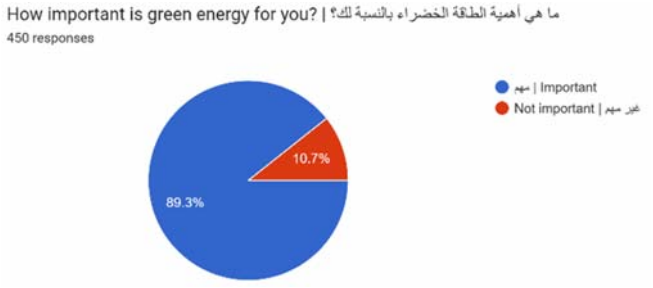

Fig. 11 Green energy importance

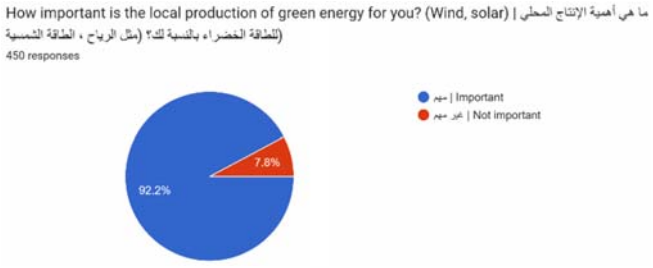

Fig. 12 Sources of green energy importance

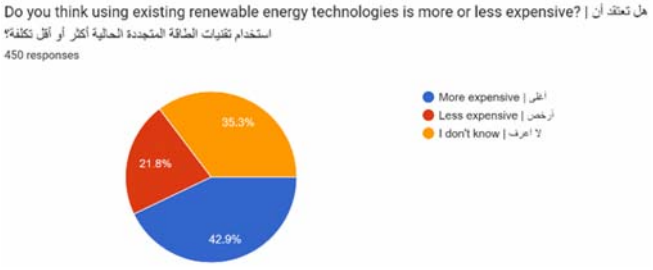

Fig. 13 Technology of renewable energy

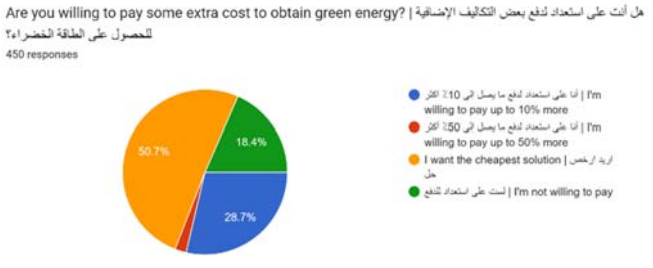

Fig. 14 Cost of energy

Open Science Index, Architectural and Environmental Engineering Vol:17, No:8, 2023 publications.waset.org/10013221.pdf

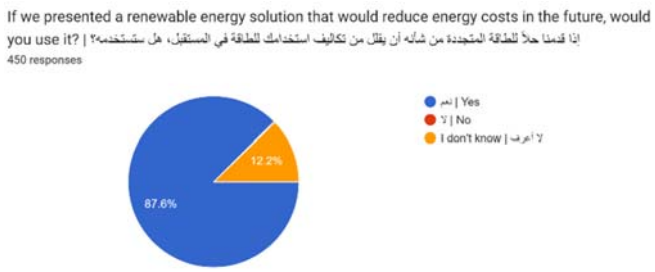

Fig. 15 Energy solution

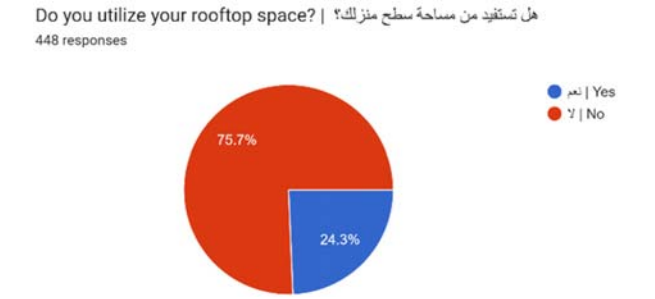

Fig. 16 Roof space

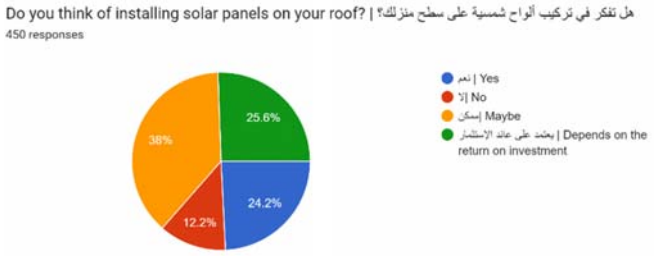

Fig. 17 Installing solar panels on roof

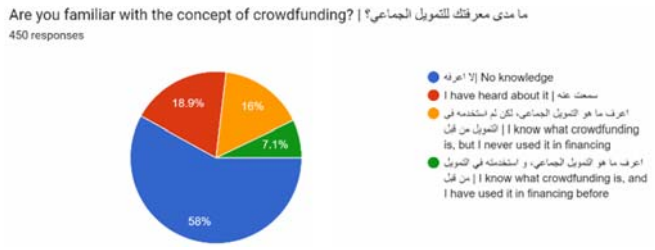

Fig. 18 Concept of crowdfunding

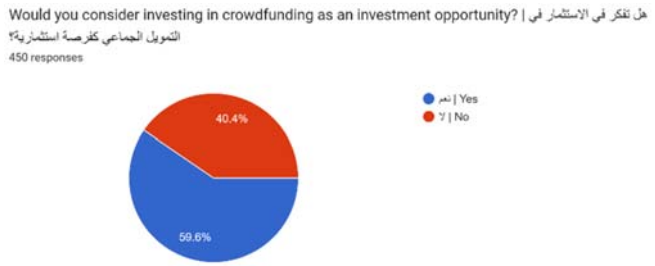

Fig. 19 Participants consideration of investments

Fig. 20 Preferred crowdfunding model

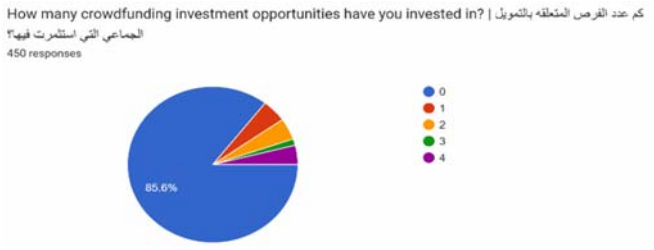

Fig. 21 The number of crowdfunding invested in

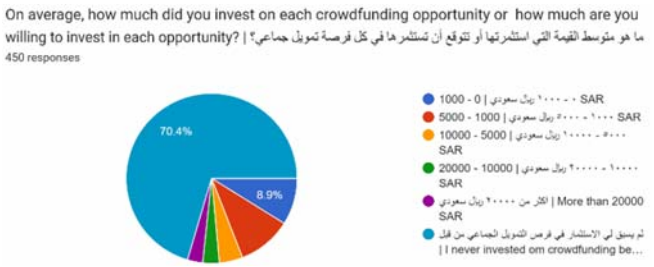

Fig. 22 How much money invested

Fig. 23 Possible investment opportunity in green project

ACKNOWLEDGMENT

The authors would like to thank Mohammed bin Salman Foundation (MISK) for their support and funding during the MISK fellowship program 2022.

REFERENCES

[1] AlGhamdi, Abeer. 2020. Saudi Arabia Energy Report. Accessed: 20 Aug. 2022. (Online). Available:https://www.kapsarc.org/research/publications/saudi-arabia-energy-report/.
[2] US energy information administration, Saudi Arabia, Accessed: 20 Aug. 2022. (Online). Available: https://www.eia.gov/international/analysis/country/SAU .
[3] Our World in Data. Goal 7: Affordable and Clean Energy - SDG Tracker. Accessed: 15 Aug. 2022. (Online). Available https://sdg-tracker.org/energy.
[4] The Paris Agreement", Accessed: 8 Aug. 2022. (Online). Available

https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement .
[5] The 26th Conference of the Parties (COP26) of the UN Framework Convention on Climate Ministry of energy, Riyadh, KSA", Accessed: 8 Aug. 2022. (Online). Available https://www.moenergy.gov.sa/en/Trends/Pages/cop-26-main-page.aspx .
[6] The Saudi Green Initiative (SGI), Ministry of energy, Riyadh, KSA", Accessed: 22 Aug. 2022. (Online). Available:https://www.moenergy.gov.sa/en/Trends/Pages/The-Saudi-Green-Initiative-(SGI).aspx.
[7] Renewable Energy, Ministry of energy, Riyadh, KSA", Accessed: 22 Aug. 2022. (Online). Available: https://www.moenergy.gov.sa/en/Pages/default.aspx.
[8] Vision 2030. A Sustainable Saudi Vision. Accessed: 19 Aug. 2022. (Online). Available https://www.vision2030.gov.sa/v2030/a-sustainable-saudi-vision/.
[9] IEA. Data explorer – Greenhouse Gas Emissions from Energy: Overview – Analysis - IEA. Accessed: 19 Aug. 2022. (Online). Available https://www.iea.org/reports/greenhouse-gas-emissions-from-energy-overview/data-explorer.
[10] Global Energy Review: CO2 Emissions in 2021. Accessed: 31 Aug. 2022. (Online). Available: https://www.iea.org/reports/global-energy-review-co2-emissions-in-2021-2
[11] Saudi Arabia Population Statistics. Accessed: 24 Aug. 2022. (Online). Available: https://www.globalmediainsight.com/blog/saudi-arabia-population-statistics/.
[12] Soreh, W.C. (2017), "Awareness and attitude towards crowdfunding in Nigeria", International Journal of African and Asian Studies, Vol. 36, pp. 1-8.
[13] Vergara, R. (2015), "Awareness and attitudes towards crowdfunding in the Philippines", 9th Global Business Conference, Manila.
[14] Moon, Y. and Hwang, J. (2018), "Crowdfunding as an alternative means for funding sustainable appropriate technology: acceptance determinants of backers", Sustainability, Vol. 10 No. 5, p. 1456.
[15] Bergmann, A., Betz, S., Burton, B., Kohl, K., Maidonis, T. and Klaes, M. (2016), "Crowdfunding for renewable energy: survey results on public perceptions and the views of crowdfunding platforms and project developers.
[16] Wasiuzzaman, Shaista & Pungut, Nurul & Md Don, Muhmmad Khaliq Syafie. (2021). Crowdfunding green projects in Brunei: awareness and investing preferences. Management of Environmental Quality: An International Journal. ahead-of-print. 10.1108/MEQ-03-2021-0046.
[17] Bergmann, Ariel & Betz, Stephanie & Burton, Bruce & Kohl, Kathrin & Maidonis, Thomas & Klaes, Matthias. (2016). Crowdfunding for Renewable Energy: Survey Results on Public Perceptions and the Views of Crowdfunding Platforms and Project Developers. 10.13140/RG.2.1.2580.8888.
[18] De Broeck, Wouter. (2018). Crowdfunding platforms for renewable energy investments: An overview of best practices in the EU. International Journal of Sustainable Energy Planning and Management. 15. 3-10. 10.5278/ijsepm.2018.15.2.

Saleh Komies is currently pursuing the Ph.D. degree within the Department of Electrical and Electronic Engineering at Imperial College London.

Mona Alharbi holds a master's degree in economics and policy of Energy and the Environment.

Razan Alhayani is in her final year of a Bachelor of Business Management (majoring in Business Information Systems and Political Science).

Mozah Almulhim is a senior majoring in Materials Science and Engineering at the University of Illinois at Urbana-Champaign (UIUC).

Ahmed Alradhi holds a bachelor's degree in electrical engineering from KFUPM.

Roseanne Khawaja is an undergraduate student at the University of Edinburgh pursuing her bachelor's degree in biomedical sciences.

Open Science Index, Architectural and Environmental Engineering Vol:17, No:8, 2023 publications.waset.org/10013221.pdf