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Renewable Energy in India: Assessment of public understanding, social acceptance and attitude

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This research paper investigates the level of public understanding, attitude and social acceptance towards renewable energy (RE) in India. A concise analysis of the present status and future potential of renewable energy sources (RESs) is discussed. Furthermore, the role of renewables in achieving India's sustainable development goals (SDGs) and Intended Nationally Determined Contributions (INDCs) are also discussed. Various social aspects of the RESs are examined. A methodology based on surveying is used in this study. The results clearly reveal a massive understanding level of the participants regarding the RESs and their awareness about various problematic aspects related with fossil energy sources (FESs). The responses also demonstrate that mostly participants are in favor of the RESs projects in their locality and possess very positive attitude towards the RESs. Furthermore, the responses establish that majority of the participants are in favor of increasing the use of the RESs and energy self-sufficiency. Additionally, they want government should increase their interventions in addressing climatic problems.

Keywords: Renewable energy, Renewable energy sources, Fossil energy sources, Sustainable development goals, Intended Nationally Determined Contributions (INDCs)

1 Introduction

Use of RESs for electricity generation has been crucially decisive in the past few years[1]. Role of the RESs has gained dominance mainly due to two reasons: a) increase in energy demand, and b) poor environmental aspects of FESs like oil, natural gas and coal. India is the second most populous country after China, home to around 1.30 billion people, and also it is one of the largest developing economy across the world. Expanding population and growing economy require huge increase in energy demand and energy generation[2-3]. Currently a major portion of this demand/generation is met-up by FESs and nuclear energy. Figure 1 shows the total installed power generation capacity including RESs in India which is equal to 384115.95 MW. Out of the total installed capacity 54.31% is supplied from coal, 6.48% from natural gas, 0.13% from oil, 1.79% from nuclear fuels, 12.05% from hydro power, and RESs contributed approximately one-fourth (25.24%) share. Figure 1 reveals that FESs presently dominate the energy sector. Nearly 63% of the power generation capacity comes from the FESs and nuclear energy sources. Source-wise contribution in total installed capacity is also shown in this figure.

Figure 1 also shows individual RESs installed capacity in MW, and this clearly indicates that solar energy is the leading renewable with 44% share in the total installed capacity followed by wind energy with 41% share. Also bio-power and small hydro power contribute 10% and 5% share in the RESs installed capacity, respectively[4-5].

While FESs have been used to generate electricity, they also produce about 33% of the total greenhouse gases (GHGs) emission across the world[6]. Excessive use of the FESs increases the carbon emissions, particulates, and other harmful pollutants. The rising accumulation of the GHGs and other pollutant particulates in the air trap the heat transmitted from ground surface and increase the earth's surface temperature[7-10]. These factors are responsible for global warming, that finally leads to worse climatic changes[11-13]. The availability of the FESs is limited and they will get drained in coming two and half centuries if they are harnessed at the same rate as today[14]. The estimated reserves of the various energy

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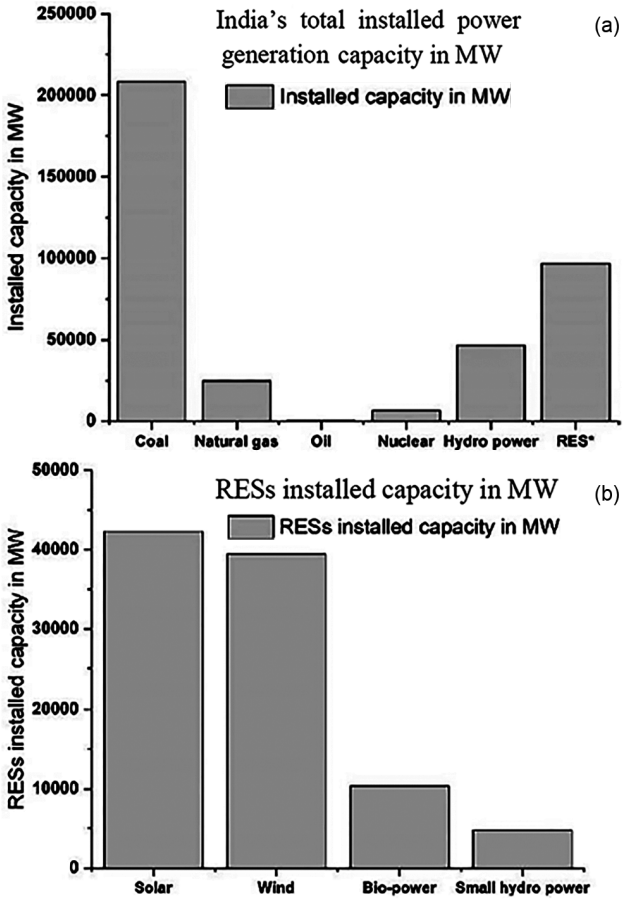

Fig. 1 — India's total and RESs installed power generation capacity in MW[4-5].

RES	Estimated potential in MW	Percentage share
Solar energy	748990	68.25%
Wind energy	302251	27.54%
Bio-energy	25090	1.93%
Small hydro power	21134	2.28%
Total RESs	1097465	100%

sources are as follows: coal - 390.04 billion tons, oil – 603.37 million tons, natural gas – 1371.79 billion cubic meters. Table 1 shows a very high potential for renewable power generation which is estimated at about 1096475 MW[15-17].

Table 2 presents growth of installed power generation capacity in India during last decade. From last one year the growth rate of the FESs (cumulatively includes coal, oil and natural gas) and the RESs is 1.49 % and 11.40 %, respectively. Here it can be observed that, in the last one year, the growth rate of the RESs is nearly ten times more than the FESs. The growth of hydro and nuclear energy is stagnant and power generation through the FESs has decreased except coal over the past few years. Table 2 evidently displays that generation capacity of the RESs has increased many more times than the FESs, hydro and nuclear energy[18-23].

The power requirement in India is rising with a remarkable pace and it will be doubled by the end of 2030[24]. Table 1 and Table 2 demonstrate a very high potential and remarkable growth of the RESs. Currently the fulfillment of power requirement greatly depends on the FESs (~61%) that directly escalates the GHGs emission. While nuclear energy and hydro power projects supply (~13%) share, generally creates displacement and rehabilitation problem among a large population[25-26]. It is very difficult to fulfill the growing power requirement of the country in an environmental friendly manner through the use of the FESs. In general, it is accepted all over the world that dependency on the FESs possess a threat of energy security and calamitous climate change[27-29]. To counter this problem, the United Nations (UN) is pleading to all countries across the globe to adhere with SDGs.

The SDG 7 is specifically devised for providing clean, sustainable, reliable and affordable energy to all and is thus a vital tool in combating the worse effects of global warming. Many countries including India adhere themselves with the SDG 7 by constructing a framework of approbation of the RESs, a blueprint to accomplish its target and individual strategies regarding power generation through the RESs[30-31]. India is a signatory of the Paris agreement (World accord on climate change) and has its own INDCs. India has set a target for the years 2021 to 2030 as follows: a) to cut down the carbon dioxide gas discharge of its gross domestic product by around 35 % by 2030, b) to raise the RESs capacity to nearly 40 % of total power generation installed capacity by 2030[32-36]. So in order to achieve these targets, the usage of the RESs is crucial and indispensable. Also, the RESs have been identified as the most probable replacement of the FESs[37-39]. The graphical/block-diagram view of potential benefits of the RESs is presented in Fig. 2 covering various aspects like climatic, financial, technical and societal benefits[40-46]. Along with these benefits there are also a lot of advantages of RESs like their infinite supply, abundant availability and no fuel cost[47-49].

The state-wise predicted potential of the RESs in India is presented in Fig. 3. Every state has promising

Table 2 — Growth of installed power generation capacity (MW) in India during 2011-21[18-23]

Year	Coal	Oil	Natural gas	FES(Total)	Hydro power	Nuclear energy	RES	Total
2011	93918	1199	17706	112823	37567	4780	18455	173625
2012	112022	1200	18381	131603	38990	4780	24504	199877
2013	130221	1199.75	20109.85	151530.6	39491.40	4780	27541.71	223343.60
2014	145273	1199.75	21782	168254.75	40531	4780	34988	248554
2015	164636	1200	23062.15	188898.15	41267.43	5780	35776.96	271722.54
2016	185173	994	24509	210676	42783	5780	42849	302088
2017	192163	837.63	25185.38	218186.01	44594.42	6780	57260.23	326820.66
2018	197172	837.63	24897	222906.63	45293	6780	69022	344001.63
2019	200705	638	24937	226280	45399	6780	77642	356101
2020	205135	509.71	24955	230599.71	45699	6780	87028	370106.71
2021	208624.5	509.71	24924.01	234058.22	46322.22	6780	96955.51	384115.95
% growth rate in last one year	1.70	0	-0.12	1.49	1.36	0	11.40	3.78

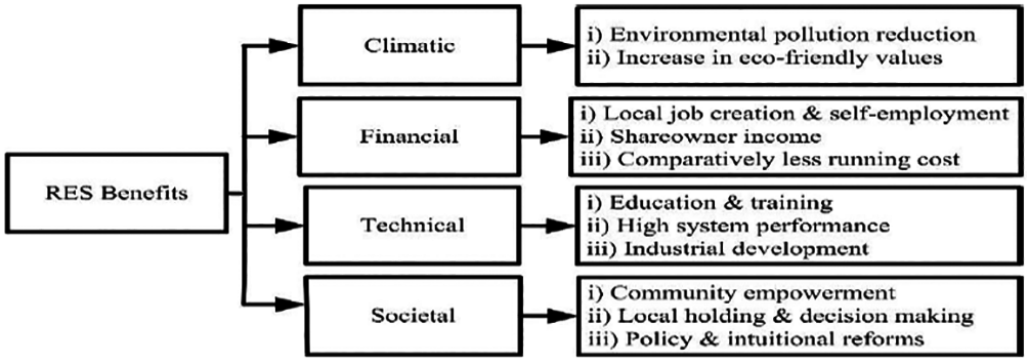

Fig. 2 — The graphical view of potential benefits of the RESs[40-46].

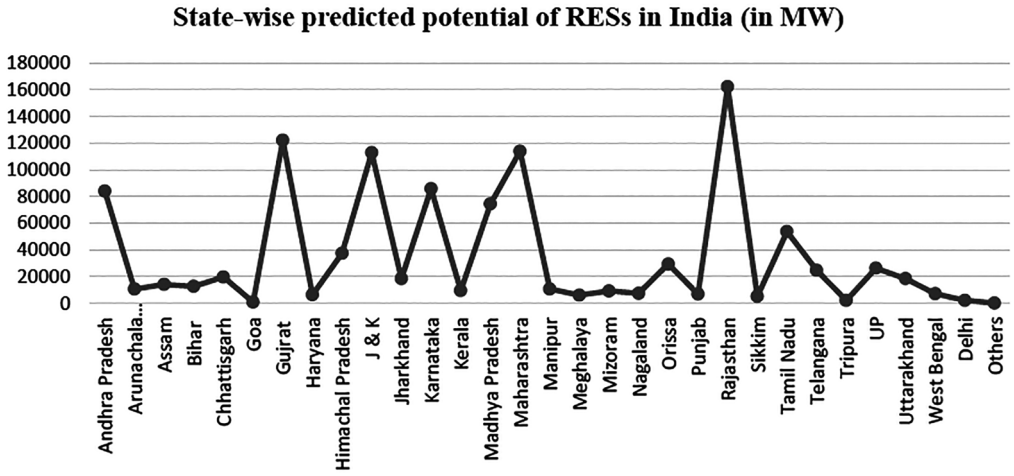

Fig. 3 — State-wise predicted potential of the RESs in India[50-51].

renewable energy potential andthe states like Rajasthan, Maharashtra, Gujarat, J&K, Karnataka, and Andhra Pradesh have highest renewable energy potential[50-51].

By acknowledging the problematic aspects of the FESs, researchers have started shifting their focus on the renewable energy technologies (RETs). But there are several obstacles in the adoption of the RETs. Social acceptance of the RESs/RETs is one of the crucial problem[52-53]. It is necessary to measure the social impacts locally because the deployment of renewable energy projects needs societal acceptance at this level[54-55]. Figure 4 shows the RESs social impacts and their various aspects.

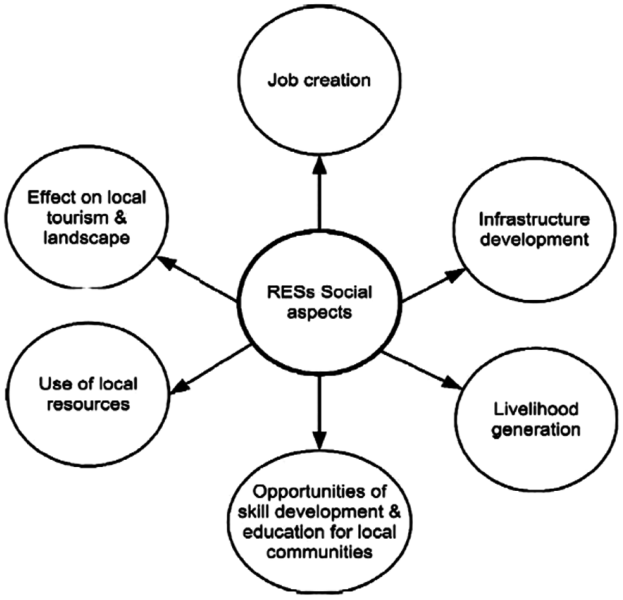

Fig. 4 — Various social aspects of the RESs[56-62].

The social impacts have various beneficial aspects like local job creation, infrastructure development, livelihood generation, opportunities of skill development and education for local communities, use of local resources and effect on local tourism and landscape. So, an adequate assessment of these social impacts help in their societal acceptance and consequently the process of deployment of the RESs projects becomes easier and smooth[56-62]. This require citizens'participation as they play an important role in constructing the renewable energy policies. As they are main stakeholders, their point of view on distinct energy sources is crucial for devising the future energy needs. Public opinion can affect decisions at policy makers' level. Their opinion can help in countering the problems arising from the odd distribution of profits and losses generally linked with renewable energy projects. Therefore, it is crucial to boost and harness citizens' awareness on renewable energy related issues[63-65].

Global studies have been conducted to find the level of social acceptance, attitude and public understanding towards diverse form of energy sources[66-70]. Renewable energy projects are mostly financed by public resources, so the consent of public becomes crucial for successful installation of these projects. Some studies suggest that public understanding of the RESs can enhance social acceptability and improves the customer's energy behavior[71-72]. There is a strong liaison between renewable energy deployment, public understanding and policy making. As this understanding and awareness about renewable energies generally help policy makers in drafting good strategies to meet citizens' concerns, but still very few studies have been conducted related to public understanding and social acceptance especially in developing and poor countries[73-78]. To meet the SDG and INDCs goals of increasing the RESs share in total power generation capacity and clean energy, it is crucial to plan a survey for collecting information about public understanding, social acceptance and attitudes towards the RESs.

The existing studies regarding the RESs have put a lot of attention on the climatic and economic benefits, while their social impacts were largely neglected. There are few challenges and barriers in shifting towards the RESs. One of the main challenge is RESs societal acceptance. It has following dimensions: (a) Socio-political acceptance, (b) Community acceptance, & (c) Market acceptance. The main barriers are restrained technical knowledge about innovative technologies, negative attitude towards RESs, and inadequate information. These barriers and challenges are still a dominant force and negatively affects the expansion of RESs [79-80].

2 Methodology

2.1 The survey and questionnaire design

To measure the attitudes and public awareness level of acceptance of the RESs in India, we have conducted a survey type methodology for this research. Basic aim of this methodology is to incorporate people from diverse social backgrounds to make the study results more significant, consequential and reliable. For conducting this research, we prepared a questionnaire consisting of three segments. The first segment contains a concise introduction to the study. The second part includes respondents' background information like age, gender, address, education qualification and professional details. The last part has questions related to the general understanding and social acceptance of the RESs. There are total 10 questions in the last part which is further segregated in two subsections. The first subsection contains six questions related to general awareness and public understanding and second subsection consists of four questions related to social acceptance and attitude.

2.2 Data collection

The nationwide survey was carried out from July to August 2021 and respondents from 24 States and Union Territories of India took part in it. A total of 1026 people participated in this survey. This survey was conducted through both online and offline modes. Due to pandemic situation mostly responses were collected through the online mode (more than 90 %) and the rest from the offline mode. The online questionnaire was made in google form format and was shared with the respondents through e-mail, WhatsApp and other social media networks like Facebook and Twitter. The responses were recorded automatically in a Microsoft Excel Sheet. The quantitative analysis was done after data collection. For this, we calculated the percentage of the options for every question.

3 General findings and their analysis

3.1 Respondents background information

The participants from all age groups took part in this study who belonged to diverse regions (cities, towns and villages) from all over the country as shown in Fig. 5. A total number of 333 (32.46%) females and 693 (67.54%) males participated, which shows a reasonable gender-balanced sample. The data in Fig. 5 indicates that participants are highly educated. Only 5.98% respondents are below high school whereas 51.21%, 24.67% and 4.11% respondents are graduates, post-graduates, and doctorates respectively.

3.2 Public understanding and awareness related responses

Figure 6 presents six questions related to public understanding and general awareness. The first question is asked to know the basic understanding and familiarity of the participants about certain popular energy related terms and a convincing result is obtained. As can be seen, global warming is the most familiar term followed by climate change, renewable energy, greenhouse effect and carbon emission. Results of the second question certify that, newspapers and books are the most popular medium from where 794 participants learned or heard about the renewable energy followed by TV (378), internet (363), word of mouth (174) and radio (83), respectively. The third question checks the participants' awareness regarding carbon emission rate from different energy sources. Majority of participants (87.13%) think that the RESs produce minimum carbon emission. 6.63% participants think that natural gas produces minimum

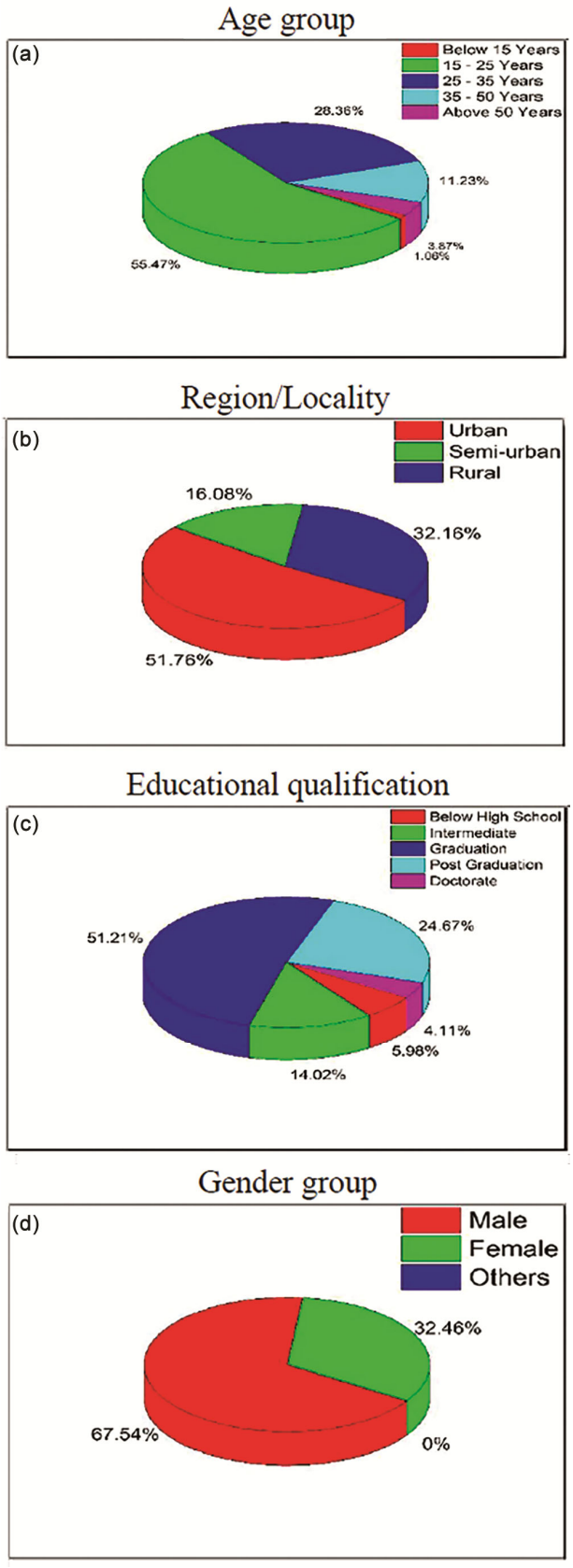

Fig. 5 — Background information of participants.

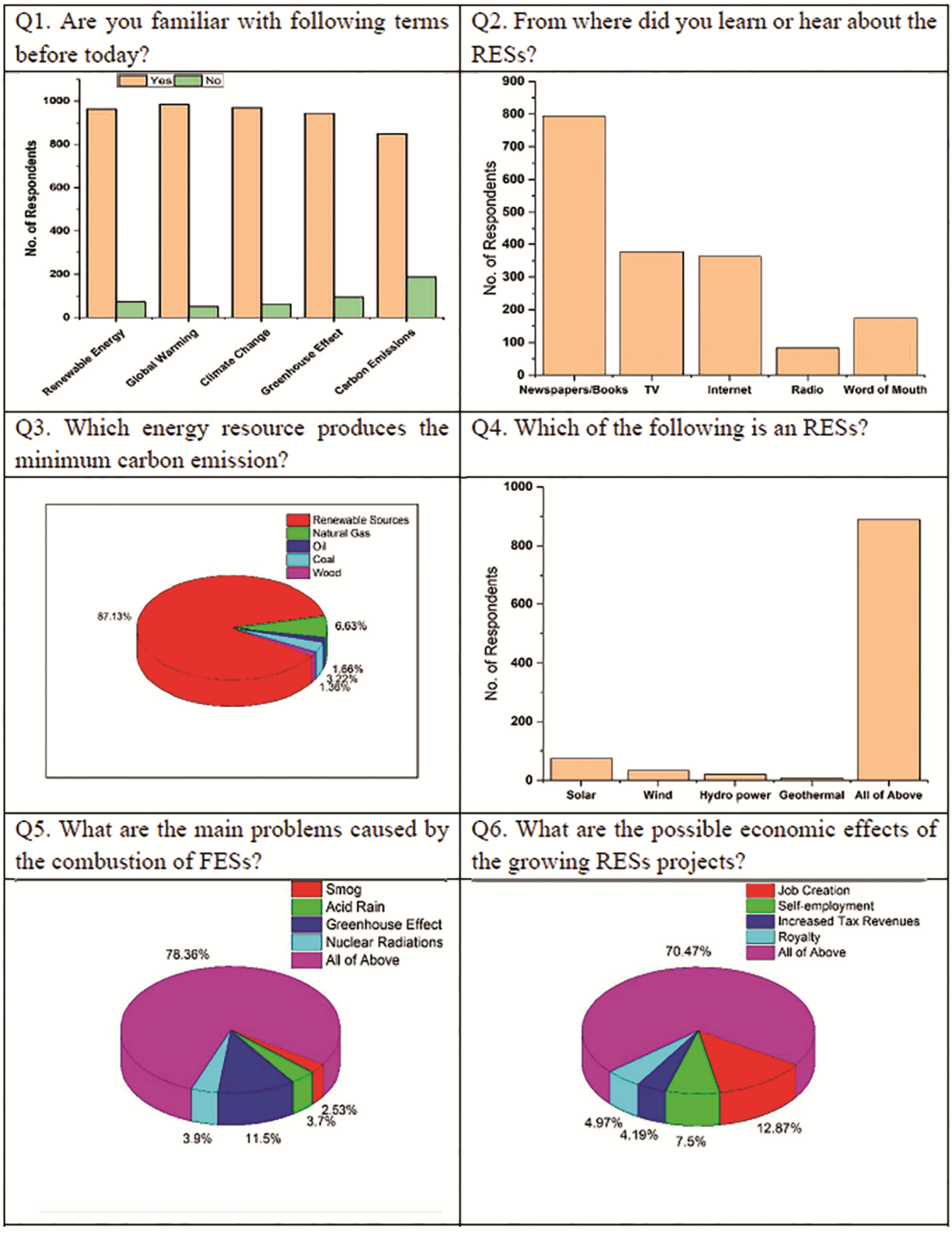

Fig. 6 — Questionnaire part 1 (The responses of questions 1 to 6).

carbon and few participants (3.22%, 1.66%, and 1.36%) assume that coal, oil and wood produce least carbon emission, respectively.

The fourth query corresponds to testing the participants' understanding about different types of renewable energies. The received responses affirm that a majority of participants (888) think that solar, wind, hydro power and geothermal, all these are renewable energy sources. The fifth question is related with the FESs environmental problems. The FESs and nuclear energy sources have various problematic aspects like smog, acid rain, greenhouse effect and nuclear radiations. 78.36% participants agreed that all above mentioned problems are severe,

whereas 11.5% of the participants consider greenhouse effect is the main problem. Simultaneously 2.53%, 3.7% and 3.9% of participants think smog, acid rain, and nuclear radiations are the main concern. The last question of this part is related to possible economic effects of the growing renewable energies. In this case 4.97% respondents believe that royalty obtained from renewable projects is the main benefit, while 4.19% think that increased tax revenue is the leading one.

Also, 7.5% and 12.87% of respondents assume that self-employment and job creation, respectively are the central economic impacts. But majority of respondents (70.47%) consider all of above in the category of possible economic impacts.

3.3 Social acceptance and attitude related responses

Figure 7 contains four questions related to social acceptance and attitude regarding the RESs. The seventh question formulated to know the approval level of participants regarding the RESs installation in their own locality. 64.33% of the total participants strongly approve and 25.63% slightly approve the renewable projects in their locality. Only 6.34% of the participants do not want to see them in their proximity and around 3.70% are resistant towards these projects. This particular response affirms a massive awareness and social acceptability level of participants towards the renewable projects. The eighth question investigates the respondents' behavioral attitude towards the FESs and the RESs. The responses clearly reveal a very positive attitude of the respondents towards the RESs. Solar energy is the most positively perceived RES by participants followed by the wind energy, hydro energy and geothermal energy, respectively. On the other hand, majority of the respondents have a negative consent towards the FESs. The ninth question is put up to enquire the main

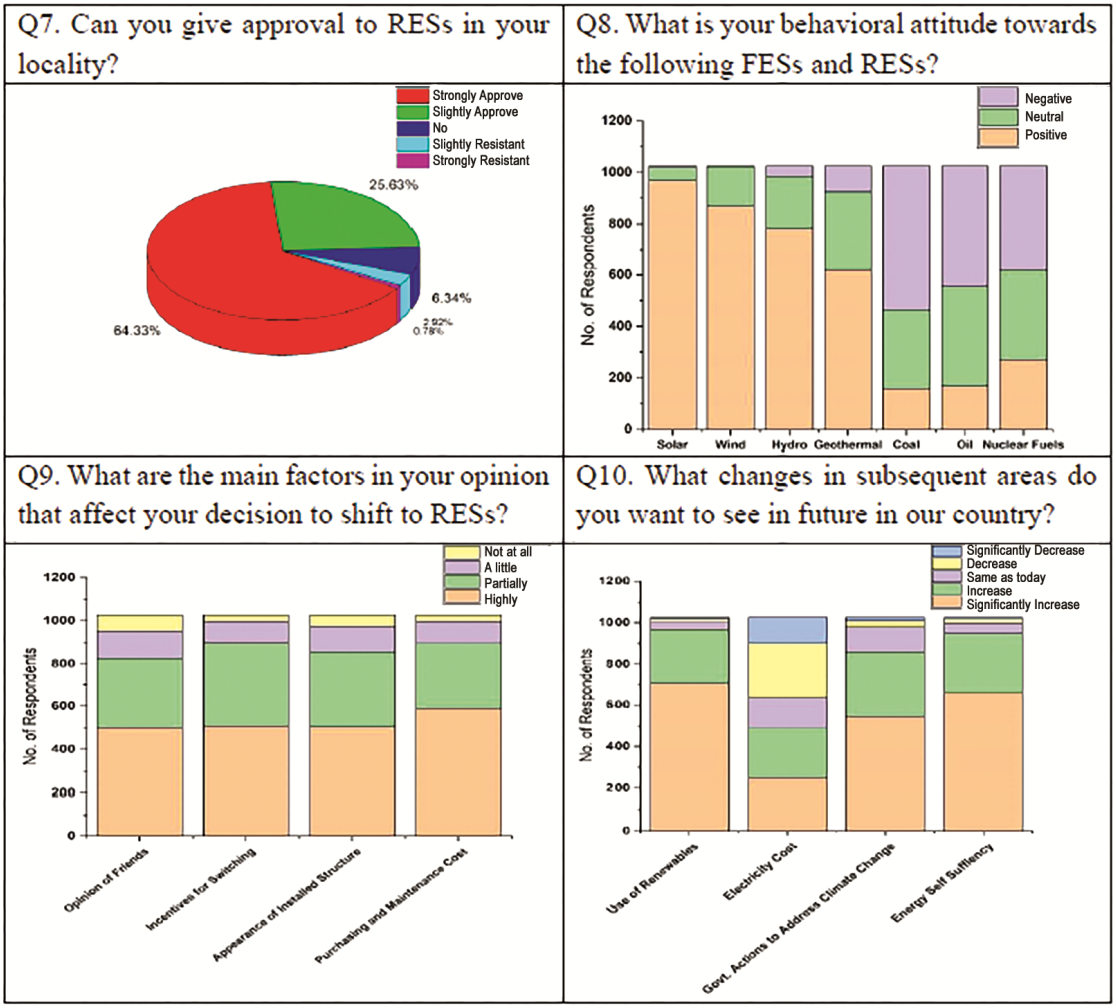

Fig. 7 — Questionnaire part 2 (The responses of questions 7 to 10).

factors that affect the decision making in transiting towards the RESs. It is assumed that responses of the participants for each of the option is approximately the same. Purchasing and maintenance cost is the prime factor for 589 respondents followed by incentives for switching with 508 respondents and appearance of installed structure is prime for 505 respondents. Around 500 respondents consider opinion of friends is a deciding factor that influence their decision in switching towards the RESs. The last question of this segment sums up the survey study querying the participants' viewpoint on the changes in subsequent areas they want to see in future. About 707and 663 participants want significant increase in use of the renewables and energy self-sufficiency, respectively.

A total of 546 participants want government should increase their interventions in addressing the adverse climatic change. One contrary result is obtained regarding electricity cost, where 489 participants want an increase in electricity cost and 392 participants want decrease in the cost. Also, there are about 145 participants who don't want to see any change in this regard. The responses of this question reveal that participants have a very positive attitude towards the renewables, as they want to see increase in use of the renewables and energy self-sufficiency despite increased electricity cost.

4 Conclusion

In this paper, the public understanding, social acceptance and attitude regarding the RESs in India has been investigated in order to prepare a corresponding standard knowledge base. A survey was conducted for this purpose to check the understanding of participants and their attitude regarding the RESs. More than 90% participants are already familiar with energy related terms and newspapers/books are the most popular medium from where the participants have learned or heard about the RESs. Majority of participants (87.13%) think that the RESs produce minimum carbon emission. A bulk of participants (888) consider solar energy, wind energy, hydro energy and geothermal energy as the RESs. 78.36% of the participants assume that smog, acid rain, greenhouse effect and nuclear radiations are the major environmental problems caused by the FESs. Job creation, self-employment, royalty and increased tax revenue as the possible benefits of increasing RESs projects are considered by 70.47% participants. All these results reveal a massive understanding level of the participants towards the RESs and simultaneously problematic aspects of the FESs.

The received responses demonstrate that most of the participants are in favor of installation of the RESs projects in their locality. All participants want transition from the FESs to the RESs but their opinion on main factors that facilitate this transition is divided. Cost and incentives are prime for some participants whereas some consider appearance of installed structure and opinion of friends is important. The responses also demonstrate that most of the participants have a good opinion to increase use of the renewables and energy self-sufficiency, and increased interventions of the government in addressing the climatic problems. It is found that there are some issues which affects the transition process (FESs to RESs) and need to be addressed. To achieve the SDGs and INDCs effectively it is the need of the hour to draft a policy or amend the existing policies regarding deployment of the RESs. Finally, the overall information from the citizens will help in scheming rational strategies that will protect the climatic and socio-economic concerns of India.

References

1 Bielska R M, Bielski S, Pik K, & Kurowska K, *Energies*, 13(18) (2020) 4624.

2 Singh A K & Idrisi A H, *JInst Eng (India): C*, 101 (2020) 415.

3 Kumar S, Thiagarajan T, & Jayasingh S, *Int J Adv Res Eng Technol*, 12(1) (2021) 119.

4 Central Electricity Authority (CEA), *All India Installed Capacity (in MW) of Power Stations*, (2021) 1.

5 Ministry of New and Renewable Energy (MNRE), *Annual Report 2020-21*, (2021) 1.

6 Zabeltitz C V, *Renew Energ*, 5(1) (1994)479.

7 Panwar N L, Kaushik S C, & Kothari S, *Renew Sust Energ Rev,* 15 (2011) 1513.

8 Hall D O, Mynick H E, & Williams R H, *Nature* 353(6339) (1991) 11.

9 Dincer I, *Energ Source Part A,*20(4) (1998) 427.

10 Georgakallos D A, *Energy Econ,* 32 (2010) 202.

11 Nazir M S, Ali Z M, Bilal M, Sohail H M, & Iqbal H M N, *Environ Sci Pollut Res,* 27 (2020) 33516.

12 Khafaie M A, Sayyah M, & Rahim F, *Environ Sci Pollut Res,* 26 (2019) 22103.

13 Fuss S, Johansson D J A, Sazolgayova J, & Obersteiner M, *Energy Policy,*37 (2009) 733.

14 Kumar A, Kumar K, Kaushik N, Sharma S, & Mishra S, *Renew Sust Energ Rev,*14 (2010) 2434.

15 National Statistical Office (NSO), *Energy Statistics India 2021*, (2021) 1.

16 Ministry of Power (MoP), *Annual Report 2020-21 (Energizing India Enriching Lives),*(2021) 1.

17 Ministry of Power (MoP), *Annual Report 2019-20 (Illuminating the Vision of New India)*, (2020) 12.

18 Ministry of Statistics and Program Implementation (MoSPI), *Annual Report 2021 (Installed Capacity and Capacity Utilization, Chapter 2)*,(2021) 1.

19 Central Electricity Authority (CEA), *Executive Summary Power Sector*,(2016) 1.

20 20Central Electricity Authority (CEA), *Executive Summary Power Sector*, (2017) 1.

21 Central Electricity Authority (CEA), *Executive Summary Power Sector*,(2020) 1.

22 Central Electricity Authority (CEA), *Executive Summary Power Sector*, (2021) 1.

23 Raghuwanshi S S, & Arya R, *Int J Sustain Eng*,12(5) (2019) 291

24 IRENA, *Renewable energy prospects for India, A working Paper Based on REMAP*, (2017) 1.

25 Dudely B, *BP statistical review of world energy*, (2017) 1-52.

26 Sharma N K, Tiwari P K, & Sood Y R, *Renew Sust Energ Rev,* 16 (2012) 933.

27 Cocker P, Barlow J, Cockerill T, & Shipworth D, *Renew Energ*, 53 (2013) 111.

28 O' Mahony T, & Dufour J, *Environ Sci Policy*, 50 (2015) 62.

29 Sobri S, Koohi-Kamali S, & Rahim NA, *Energy Convers Manag*, 156 (2018) 459.

30 Santika W G, Anisuzzaman M, Bahri P A, Shafiullah G M, Rupf G V,& Urmee T, *Energy Res Soc Sci*, 50(2019) 201.

31 Liu Q, Lei Q, Xu H, &Yuan J, *Resour Conserv Recycl*, 128 (2018) 78.

32 Ministry of New and Renewable Energy (MNRE), *Annual Report 2019*-20, (2021) 1.

33 James CRK, & Majid MA, *Energy Sustain Soc*, 10(2) (2020) 1.

34 Sawhney A, *Clean Technol Environ Policy*, 23 (2021) 491.

35 Elavarasan RM, Shafiullah GM, Padmnaban SK, Kumar NM, Annam A, Vetrichelvan AM, Mihet-Popa L, & Holm-Nielsen JB,*IEEE Access*, 8 (2020) 74432.

36 Sahoo M, & Sahoo J,*J Public Aff*, (2020) 1.

37 Yuan XC, Lv YJ, Wang B, Liu QH, & Wu Q, *J Clean Prod*, 205 (2018) 980.

38 Schmidt J, Gruber K, Klingler M, Klockl C, Camargo LR, Regner P, Turkovska O, Wehrle S, &Wetterlund E, *Energy Environ Sci*, 12 (2019) 2022.

39 Chabhadiya K, Srivastava RR, & Pathak P, *Environ Eng Res*, 26(2) (2021) 200083.

40 Ciulla G, D'Amico A, Dio VD, & Brano VL, *Renew Energ*, 140 (2019) 477.

41 Park E, *J Clean Prod*,215 (2019) 796.

42 Nazir MS, Bilal M, Sohail H M, Liu B, Chen W, Iqbal H M N, *Int J Hydrog Energy,* 45(41)(2020) 22113.

43 Stigka E K, Paravantis JA, & Mihalakakou GK, *Renew Sust Energ Rev*,32 (2014) 100.

44 Nazir M S, Ali N, Bilal M, & Iqbal H M N, *Curr Opin Environ Sci Health*, 13 (2020) 85.

45 Fridahl M, & Lehtveer M, *Energy Res Soc Sci*, 42 (2018) 155.

46 Overland I, *Energy Res Soc Sci*, 49 (2019) 36.

47 Shahbaz M, Raghutla C, Chittedi K R, Jiao Z, & Vo X V, *Energy*, 207 (2020) 118.

48 Ganiyu S O & Martinez-Huitle CA, *Curr Opin Electrochem*, 22 (2020) 211.

49 Saidi K & Omri A, *Environ Res*, 186 (2020) 109567.

50 National Statistical Office (NSO), *Energy statistics India 2020*, 27 (2020) 1.

51 Elavarasan RM, Shafiullah G M, Kumar N M, & Padmanaban S K, *Energies*,13 (2020) 1.

52 Wustenhagen R, Wolsink M, & Burer M J, *Energy Policy*, 35 (2007) 2683.

53 Walker G & Devine-Wright P, *Energy Policy*,36 (2008) 497.

54 Karytsas S, Mendrinos D, & Karytsas C, *IOP Conf Ser: Earth Environ Sci*, 410 (2020) 1.

55 Rio P D, & Burguillo M, *Renew Sust Energ Rev*, 12 (2008) 1325.

56 Sheikh NJ, Kocaoglu DF, & Lutzenhiser L, *Technol Forecast Soc Change,*108 (2016) 102.

57 Domac J, Richards K, & Risovic S, *Biomass Bioenergy*, 28 (2) (2005)97.

58 Akella A K, Saini R P, & Sharma M P, *Renew Energ*, 34 (2009) 390.

59 Vezmar S, Spajic A, Topic D, Sljivac D, & Jozsa L, *Int J Electr Comput Eng Syst*, 5(2) (2014) 47.

60 Jaramillio-Nieves L & Rio P D, *Sustainability*, 2 (2010) 783.

61 Simas M, & Pacca S, *J Sustain Dev Energy Water Environ Syst*, 1(1) (2013) 27.

62 Rio PD & Burguillo M, *Renew Sust Energ Rev*, 13 (2009) 1314.

63 Visschers V H M, & Siegrist M, *J Environ Psychol*, 40 (2014) 117.

64 Keramitsoglou K M, *Renew Sust Energ Rev*, 59 (2016) 1159.

65 Bergmann A, Hanley N, & Wright R, *Energy Policy*, 34 (2006) 1004.

66 Karatepe Y, Nese S V, Kecebas A, & Yumurtaci M, *Renew Energ*, 44 (2012) 174.

67 Zyadin A, Puhakka A, Ahponen P, Cronberg T, & Pelkonen P, *Renew Energ*, 45 (2012) 78.

68 Celikler D, *Renew Energ*, 60 (2013) 343.

69 Zoellner J, Schweizer Ries P, & Wemheuer C, *Energy Policy*, 36 (2008) 4136.

70 Moula M M E, Maula J, Hamdy M, Fang T, Jung N, & Lahdelma R, *Int J Sustain Built Environ*, 2 (2013) 89.

71 Rijnsoever F J V, & Farla J C M, *Renew Sust Energ Rev*, 31 (2014) 71.

72 Karytsas S, & Theodoropoulou H, *Renew Energ*, 71 (2014) 480.

73 Chen D, Cheng CY, & Urpelainen J, *J Clean Prod*, 112(5) (2016) 3750.

74 Ediger VS, Kirkil G, Celebi E, Ucal M, & Kentmen Cin C, *Energy Policy*, 120 (2018) 492.

75 Assali A, Khatib T, & Najjar A, *Renew Energ*, 136 (2019) 254.

76 Stoutenborough J W, Shi L, & Vedlitz A, *Energy*, 81 (2015) 406.

77 Karasmanaki E, & Tsantopoulos G, *Energy Policy*, 131 (2019) 111.

78 Oluoch S, Lal P, Susaeta A, & Vedwan N, *Sci Afr*, 9 (2020) 1.

79 Owen A D, *Energy Policy*, 34 (2006) 632.

80 Kumar A, & Choudhary S, *Indian J Pure Appl Phys*, 59 (2021) 779.