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Towards Sustainable Energy: A Systematic Review of Renewable Energy Sources, Technologies, and Public Opinions

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ABSTRACT The use of renewable energy resources, such as solar, wind, and biomass will not diminish their availability. Sunlight being a constant source of energy is used to meet the ever-increasing energy need. This review discusses the world's energy needs, renewable energy technologies for domestic use, and highlights public opinions on renewable energy. A systematic review of the literature was conducted from 2009 to 2018. During this process, more than 300 articles were classified and 42 papers were filtered for critical review. The literature analysis showed that despite serious efforts at all levels to reduce reliance on fossil fuels by promoting renewable energy as its alternative, fossil fuels continue to contribute 73.5% to the worldwide electricity production in 2017. Conversely, renewable sources contributed only 26.5%. Furthermore, this study highlights that the lack of public awareness is a major barrier to the acceptance of renewable energy technologies. The results of this study show that worldwide energy crises can be managed by integrating renewable energy sources in the power generation. Moreover, in order to facilitate the development of renewable energy technologies, this systematic review has highlighted the importance of public opinion and performed a real-time analysis of public tweets. This example of tweet analysis is a relatively novel initiative in a review study that will seek to direct the attention of future researchers and policymakers toward public opinion and recommend the implications to both academia and industries.

INDEX TERMS Energy policies, public opinion, renewable energy sources (RES), renewable energy technology (RET), solar energy, wind energy.

I. INTRODUCTION

The subject of renewable energy (RE) concerns experts as well as the general public increasingly. Studies on renewable energy sources (RES) has increased in the last years in absolute and relative terms [1]. RES can perform an important role by addressing the issues of fossil fuel depletion and global warming [2]. Fossil fuels, nuclear resources, and renewable resources are the three main sources of energy. RES such as solar, wind, biomass, geothermal, and hydro-power are utilized to reproduce energy and are therefore extensively useful to combat energy crises [3]–[5]. A recent study [6] of communities in Western Greece focused on the public attitude and the willingness to pay for electricity from renewable electricity sources.

Renewable energy resources are considered clean energy resources [7] and are critically important due to their environmental-friendly nature [8], [9]. With the increase in awareness of a clean environment, it is believed that traditional dependence on fossil fuels has led to carbon

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dioxide (CO_2) emissions, greenhouse gas (GHG) problems and environmental pollution [10], [11]. RES can cover domestic energy requirements with the potential to provide energy services with zero or almost zero emission of air pollutants and GHGs [12], [13]. Pivotal tasks such as sustainable development of remote regions in the desert and mountain zones in addition to implementation of the obligations to fulfil international agreements relating to environmental protection are expected to be resolved with the development of RE [14]–[16]. To fulfil the excessive energy demand there is currently a global tendency to replace conventional fuels with RES [17]. There are many challenges, such as GHG emissions, CO_2 emissions, climate change and energy security, that have resulted in RE seeking to fulfill a growing need in today's environment [18]–[20]. Unlike fossil fuels, RES provides environmental protection, a pollution-free environment, energy security and economic benefits [21], [86]. Hence, in order to meet the energy need, it is indeed vital for present and future generations to rely on RES. To achieve this, policy-making and exploring public opinion is required to promote the use of RE. Analyzing public opinion toward RE is crucial due to the influence it can have on policy creation. The research has suggested an important link between public opinion and public policy [22].

Public opinions that have become a hot field of research are growing intensively through computer-mediated environments such as Web 2.0. These enable an increasing number of people to communicate and interact with each other using social media such as Twitter, Amazon, blogosphere, etc. [23], [24]. This survey aims at drawing useful insights on the use of RE, the challenges faced therein, the awareness on using RES and the acceptance of renewable energy technology (RET) for domestic use by mining public opinion on social media. The interaction through social media provides a variety of useful opinions that can be a guideline for making better plans for the future [25]. The opinions capture certain sentiment words which are useful in diverse areas, such as marketing, education, business, and health care. Further, they can attract more fields to utilize their significance [26], [27]. Opinions can be recorded and analyzed using survey studies and/or sentiment analysis techniques in order to determine the present and future intentions of users related to RE and explore new insights [28], [23]. Hence it is believed that opinions influence public decision to use any services and technologies such as RES [24], [29]. While most of the research has focused on technical, policy, and financial challenges to RE deployment [30], less attention has been paid on its social dimensions, yet public opinion is highly relevant. In this age of technology, opinions created by social networks provide an exceptional opportunity to mine valuable insights from them that can be used for the development of RES [31].

The aim of this survey paper is to study the worldwide need of RE, types of RES used at domestic scale and draw useful conclusions on use and acceptance of the public opinion on the use and acceptance of RET and RES. Section II explains the research method; Section III presents the results; Section IV analyze the opinions regarding renewable energy; section V provides the discussion; Section VI discuss the implications of the study and section VII concludes the study.

II. RESEARCH METHOD

To advance our understanding of utilizing RES effectively the present study consists of a systematic literature review (SLR) with a specific focus on RES and RET. Recently a SLR has been carried out in the combination of computer science and RE field [32], [33] and a detailed SLR was performed about public opinions [23]. A SLR is a means of identifying, evaluating and interpreting available research relevant to a particular research question or topic area [34]. The design of the SLR reported in this paper started in December 2017. After several refinements and improvements, publication search was started in March 2018. The following subsections present the research questions of the review, search strategy, searched database, search terms, inclusion/exclusion criteria and the quality criteria of the SLR.

A. PLANNING THE REVIEW

The review is planned by proposing the research questions relevant to our research objective. Further, we defined the search strategy, search strings and inclusion/exclusion criteria.

1) RESEARCH QUESTIONS

The main objective of this work is to develop an understanding of the necessity for RE, RES, and RET. We have formulated the following research questions (RQs) to achieve the research objectives.

RQ1: WHY THERE IS WORLDWIDE NEED FOR RENEWABLE ENERGY?

The aim of this research question is to recognize the reasons for the use of RE. The results obtained will be useful to highlight the challenges with the use of energy sources other than RE and bring awareness for the use of environmentally friendly energy sources such as RES.

RQ2: WHAT ARE THE TYPES OF REWNEWABLE ENERGY SOURCES USED FOR DOMESTIC USAGES?

The aim of this research question is to identify the various types of RES such as wind, solar and biomass, used to provide energy for domestic scale. The results will assist to develop the awareness for the use of these RES.

RQ3: WHAT ARE THE PUBLIC OPINIONS ON RENEWABLE ENERGY TECHNOLOGIES?

The aim of this research question is to identify the public opinions addressed in the literature regarding the use of RET. The results obtained will be useful to identify emerging trends and provide a possible solution to tackle the barriers for accepting RE.

2) SEARCH STRATEGY

The study has used the guidelines of Kitchenham [35] for carrying out this SLR. We began with the formal search strategy to explore the articles relevant to our research objective and the research questions. To collect the

TABLE 1. Number of filtered publications according to the inclusion/exclusion criteria.

Database	Retrieved	Round 1		Round 2	
		Included	Excluded	Included	Excluded
ACM Digital Library	25	10	15	1	9
IEEE Xplore	22	5	17	3	2
ScienceDirect	260	110	150	35	75
SpringerLink	55	10	45	3	7
Total	**362**	**135**	227	**42**	93

appropriate articles, the search space is defined to cover the prominent databases listed in Table 1. At first, the studies were retrieved and afterwards examined further for other significant studies (i.e. snowballing) [35]. Then the inclusion and exclusion criteria in two distinct rounds (Round 1 & Round 2) were applied as explained in Section 4.

3) SEARCH STRING

The search terms were derived from the key terms used in the topic area and the objective of the review. A number of pilot searches were performed to refine the keywords in the search string using trial and error. The terms whose inclusion did not yield additional papers in the automatic search were removed. The following search string was used: (“renewable energy“ OR “public opinions” OR “use of renewable energy” OR “solar systems for domestic use” OR “solar heaters” OR “solar cooker” OR “solar cooler” OR “biomass” OR “hydropower”, OR ”wind”) AND (“energy sources” OR “energy demand” OR “public opinions” OR “domestic products” OR “home systems” OR “acceptance” OR “attitude” OR “effects“ OR “motivation”) AND (“energy crises” OR “ energy demand” OR “clean energy” OR “electricity need” OR “greenhouse gas emission”).

4) INCLUSION AND EXCLUSION CRITERIA

To select the appropriate studies for inclusion in the review, the meta data and the abstracts of the papers were reviewed, and the following inclusion criteria were applied. Selected papers were I1: peer-reviewed; I2: in the English language; I3: empirical research papers; I4: published between the year 2009 to 2018; where I1-I4 denote the inclusion criteria. Papers that did not meet the inclusion criteria were excluded from the study. We applied the exclusion criteria E1-E4 to filter out irrelevant papers. E1: papers not focusing explicitly on RE; E2: papers that do not discuss the public opinions about renewable energy technologies; E3: studies that do not discuss RES; E4: Grey literature [35], e.g., working papers, project deliverables, and PhD theses were the exclusion criterias applied. Therefore, the final selection consisted of 42 articles.

B. CONDUCTING THE REVIEW

In this section, we present the findings of our search and extraction of information from relevant sources and databases.

1) ARTICLE SEARCH AND SELECTION

By following the search strategy explained in Section 2, the selected electronic databases were searched to retrieve the studies. The initial search returned 362 papers as shown in Table 1. We followed the inclusion and exclusion criteria (Round 1) explained above, and detailed examination of the titles and abstracts of the articles was performed by a researcher and ended up with 135 studies. Afterwards, in the second stage (Round 2) using the exclusion criteria (E1, E2, E3 and E4), the preselected studies were assessed by a second researcher (one of the co-authors) and a third one (experienced and independent researcher). In case of any agreements and disagreements among the researchers in their assessments, a face-to-face meeting was arranged to review and reach consensus. For papers on which consensus was not met, the three researchers read the paper and then excluded the studies based on the defined exclusion criteria. Finally, 42 papers were selected for critical review as shown in Table 1.

2) DATA EXTRACTION AND ANALYSIS

By following the guidelines in [35], we conducted a data extraction process to identify the relevant information from the selected 42 studies after round 2. This data extraction process included the following steps: First, using Mendeley reference manager, we arranged a database of publications and recorded the relevant information about ideas, contributions, and findings of each of the 42 studies in a spreadsheet. From each publication the following data were extracted: review date, title, authors, references; database, relevance to the theme, i.e. need of RE, RES at domestic scale, public opinion on RE, and year of publication.

After the extraction process, we used content analysis to characterize the focus of each study [36]. Content analysis has been recently used in a systematic review [23], [32]. The result of data extraction was assessed by using inter-rater agreement between two researchers using the κ coefficient [37]. The κ coefficient is a measure of the agreement between any two raters who classify the studies into various categories. The value of κ for this study is 0.5 which is considered to be a good agreement [38]. Subsequently, an independent quality assessment was recorded for 42 selected studies.

3) QUALITY OF STUDY

The quality criteria for this systematic review is similarly adopted in other SLRs [39]. The first criterion was (C1): if the aims and objectives of the conducted research were clearly defined. This question was positively answered for 92% of the studies. The second criterion was (C2): if the research context was adequately addressed. This question was positively answered by 86% of the studies. The last criterion was (C3): if the outcome of the research was sufficient for our research purpose. For the quality measures (C3) the heuristic scores were established by a group of two experienced researchers and validated by an independent reviewer.

TABLE 2. Quality criteria for study selection.

Criteria	Response Grading	Grade Obtained
(C1) Is the research aim/objective clearly defined?	{1, 0.5,0} (Yes, nominally, No)	27 studies 93%
(C2) Is the context of research well addressed?	{1, 0.5,0} (Yes, nominally, No)	26 studies 86%
(C3) Based on the findings, for a paper, what is the acceptance quality rate?	> 80% = 1/under 20% = 0/between = 0.5	1

The data was normalized for the 42 papers, combining the percentage obtained in all quality criteria. The results of quality assessment including normalized scores are described in Table 2.

III. RESULTS

In this section, results from the SLR are described in the light of the proposed research questions.

A. OVERVIEW OF STUDIES

To provide more focused results related to our research objective, the current review has focused on 42 papers that were quality-rated as high. Figure 1 shows the stages of the study selection process for the systematic review presented in this work. These studies focused on, specifically: the necessity of RE (9 out of 42); RES at domestic scale (14 out of 42); and public opinion on RE (19 of 42). The results are further discussed in light of the proposed research questions (RQ1, RQ2 & RQ3).

1) RQ 1: WHY THERE IS WORLDWIDE NEED FOR RENEWABLE ENERGY?

The demand for energy is increasing rapidly and, hence, it is crucial to introduce processes to meet the requirements of the growing world population and to avoid energy crises. At the current rate of energy consumption, the demand is expected to increase by 65% by the year 2030, using 2004 as the base year [40]. Currently, most of the energy used globally is produced from non-renewable sources such as coal-fired power plants. These are known to cause serious problems including GHG (CO_2, NO_x, and SO_x) emissions as well as contributing to global warming [41], [42].

With the levels of GHGs in the atmosphere rising at a hazardous rate, it is important to develop sources of non-fossil fuel based energy in addition to determining ways to reduce CO_2 [43]. In contrast to fossil fuels, RE offers alternative sources of clean energy. Moreover, it is also expected to reduce energy crises by playing a key role in meeting future electricity demands. Solar and wind energy are the most promising forms of the RE sources that encourage interest in increasing their use worldwide [44], [45]. There are a variety of reasons identified and policies defined in the literature promoting the use of RE instead of fossil fuels to produce power.

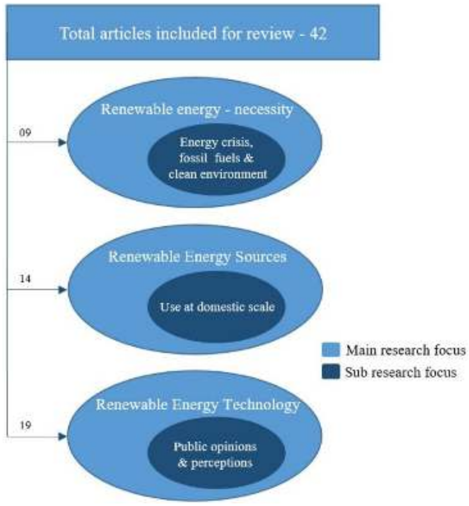

FIGURE 1. Study selection phase.

Shafiullah [46] developed a hybrid RE integration system which aimed to reduce the energy crisis while minimizing global warming issues in order to facilitate RE integration in the Capricornia region of Central Queensland, Australia. The proposed system comprised a techno-economic model that analyzed the techno-economic and environmental prospects of RE, as well as a load management system by which utilities could efficiently manage customer load demand. Irandoust [47] applied a vector autoregression (VAR) model to examine the relationship between RE consumption, technological innovation, economic growth, and CO_2 emissions in the four Nordic countries. In a study [48] to decarbonize electricity renewables, nuclear energy and fossil fuels were compared regarding cost, emissions reductions, and energy security for power systems of Great Britain (England, Wales and Scotland). To promote a clean environment by reducing GHG emissions and dependence on fossil fuels, Park and Kim [49] have identified different measures, for example: (1) consideration of subjecting ocean renewable energy development to strategic environmental assessment; (2) new standards; (3) integration of the environmental impact assessment with the procedures for consultation on utilization of sea areas; and (4) reinforcement of post-development environmental monitoring processes.

Compared to developed countries, energy crises (particularly electricity crises), are profound in underdeveloped countries. A study presented by Shakeel *et al.* [50] defined a roadmap by which to overcome energy crises in Pakistan by integrating RES in the power generation. To meet the need for energy, a review study by [51] recognized the heavy dependency on fossil fuels in rural areas of Iran. This study suggested that, due to dependency on fossil fuels, there is considerable pollution in the environment. According to the report [52], a large amount of global electricity production in 2017 was obtained from fossil fuels. RE production

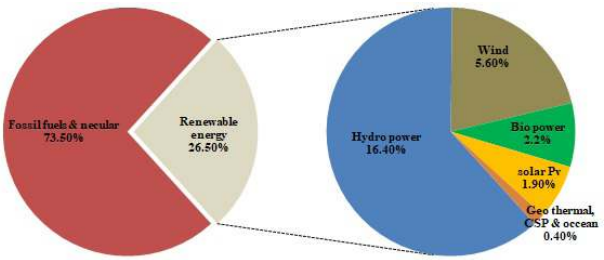

FIGURE 2. Estimated share of global electricity production [53].

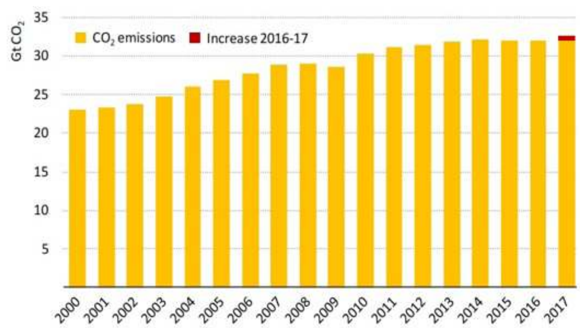

FIGURE 3. Total CO_2 emissions from the consumption of energy [53].

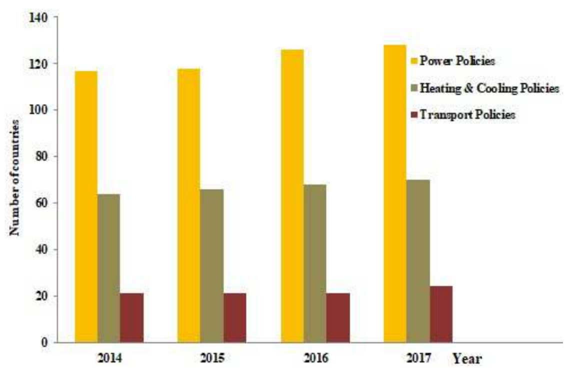

FIGURE 4. Number of Countries with Renewable Energy Policies [53].

comprises a total of 26 percent (26%) of electricity from sources such as hydropower, biopower, solar PV and Geothermal. This is depicted in Figure 2 following. Figure 2 presents the contribution of electricity for the year 2017 at a global level. Due to the large-scale use of fossil fuels, CO_2 emissions are rising exponentially. Figure 3 presents the CO_2 emissions for the period 2000-2017 [53]. In order to control CO_2 emissions, a number of policies have been introduced globally promoting the use of clean energy sources, such as RE. Figure 4 presents the number of countries which have contributed in carrying out these policies for the use of RES during the period 2014 to 2017. These policies include power policies, heating and cooling policies, and transport policies.

As reported [54], at the end of 2017, global renewable generation capacity amounted to 2,179 GW. Accordingly, hydro energy is noted as having the largest share of the global total, with an installed capacity of 1,152 GW. Wind and solar energy accounted for most of the remainder, with capacities of 514 GW and 397 GW respectively. Other renewable sources included 109 GW of bioenergy, 13 GW of geothermal energy and 500 MW of marine energy (tide, wave and ocean energy).

Renewable capacity growth continues to be driven mostly by new installations of solar and wind energy, which together accounted for 85% of all new capacity installed in 2017. The rapid improvement in RE capacity is favorable for, namely: economic growth and job creation; limiting carbon emissions; reduction of air pollution; expansion of energy access; and improvement of energy security.

2) RQ 2: WHAT ARE THE TYPES OF REWNEWABLE ENERGY SOURCES USED FOR DOMESTIC USAGES?

Reliable energy sources such as RES can play a vital role in improving standard of life [44]. Solar thermal energy is the most abundant type of RE and is available in both directions as well as in indirect forms. Solar energy has a vast scope for thermal applications such as: solar water heaters [55], [56]; cooling systems [57], solar home systems [58], [59]; cookers; and refrigeration. These can meet the needs of a family and achieve a sustainable future [60].

Solar thermal-based technologies are extensively used to produce hot water in several countries [61], [62]. They are designed as both a closed loop and open loop. The closed loop solar system is suitable for extremely cold areas [63]. The literature presented different studies related to RET for specifically: domestic use; the performance of portable heating systems [64]; experimental investigation of graphene nanoplatelets nanofluid-based volumetric solar collector for domestic hot water systems [65]; local market flow of solar water heaters in Taiwan [66]; as well as hybrid renewable energy system for household applications. These applications include: boxed hybrid solar cooker designed by photovoltaic and thermal technologies [67]; parabolic-type portable solar cooker [68]; boxed-type solar cooker using internal reflector [69]; design and installation of cooling and heating water systems [70]; in addition to a novel opaque roof solar chimney configuration at home [71].

In order to minimize the electricity consumption of a household and fulfil the energy demand for a single-family detached house, RES applications (solar and biomass) are used [72], [73]. A vast amount of literature is available on the subject of usage of the artificial neural network [74]–[76] for solar radiation prediction to produce effective solar products. All of these gadgets, including solar cookers, water heaters, air conditioners, and dryers are potential means of energy conservation in developing nations. A report [52] shows that in the year 2015, Bangladesh stood in top position for the use of solar home systems. An analysis of the energy consumption of households [56], found that total household energy consumption could be reduced by around 13% with the presence of a solar water heater. In order to improve the use of solar energy on a domestic scale, the study [77] explored the potential of the hybrid solar Photovoltaic/Thermal (PV/T) collector integrated with a thermochemical sorption thermal

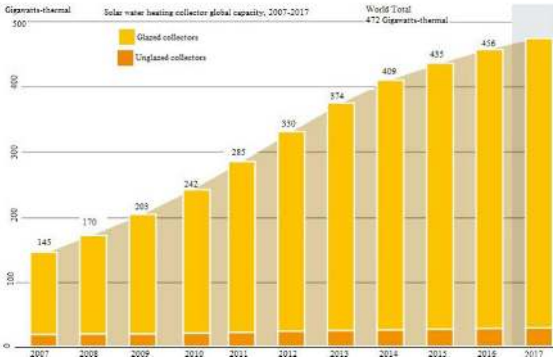

FIGURE 5. Global capacity of solar heating collectors for 2007-2017 [54].

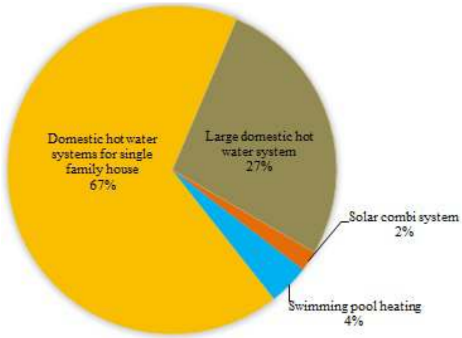

FIGURE 6. The share of the hot water system at a domestic and large scale [80].

storage system for a hot water heater. Solar home systems (SHS), e.g. LED lamps and energy efficient multi-cooker innovations, are used to provide a solution for domestic energy poverty in developing countries [78]. Another study [79] described that the solar photovoltaic system can be used as a supplementary source by which to recharge batteries for home energy management systems (HEMS).

These renewable resources are considered as being safe for health and also inexpensive, which is another motivation for the public to utilize them at home. These RES are used in a variety of forms for domestic usage. For example, RES (i.e. sun) is utilized for solar home systems, solar dryers, solar cookers, solar refrigeration, solar heaters, cooling systems and power generation. Similarly, wind power is utilized for windmills, water pumps and wind generators; while biomass is utilized for heat and power generation. Figure 5 presents the global capacity of solar heating collectors during the period 2007 -2017. Solar thermal heating and cooling systems served millions of residential as well as commercial clients in 2017. Solar thermal technology was used for a wide range of applications such as: hot water; space heating and cooling; product drying; water desalination; and cooking services. The systems with glazed and unglazed collectors provided 388 TWh (1,397 PJ) of heat annually by the end of 2017. The most significant application for solar thermal systems is that of domestic hot water heating. This type of application is considered as being environmentally-friendly thereby helping to avoid CO_2. Figure 6 presents the results for worldwide use of thermal energy in 2017 for heating of domestic hot water. Mainly, the hot water is used by small-scale systems in a single-family house (67%) and large applications such as multi-family houses, hotels, schools, etc. (27%). The heating share of swimming pools was noted as 4% while 2 % was used for solar combi-systems.

In the following section, we will explain the opinions of the public regarding the acceptance of RES and RET at the domestic level.

3) RQ 3: WHAT ARE THE PUBLIC OPINIONS ON RENEWABLE ENERGY TECHNOLOGIES?

Our literature review found that the use of RE is essential in order to meet future energy-related challenges. To achieve this, awareness of RET and RES is crucial to increase public acceptance on these clean energy resources [16], [81]. To boost the acceptance of RES and to avoid the critical problem of global warming (due to the energy provided by fossil fuels), analysis of public opinions towards RES is vital [82]. In this situation, RE is a good replacement for keeping the environment clean [83]. A survey was conducted in Turkey among secondary school students to determine their interest in RE-based systems. The vast majority of the students were familiar with solar and wind plants as RES to produce electricity. These students were aware of the issue of global warming and, in their opinion, the use of RE would reduce this [84]. The opinion of the public on the use of RET was obtained through a survey study in Portugal [85]. It was observed that Portuguese are generally supportive of the development of more RE projects in their country, but they are not familiar with all RES such as biomass. Among the developing countries, Malaysia is significantly contributing to achieving a sustainable environment and reducing climate change. However, based on quantitative analysis, it was perceived that the people in Peninsular Malaysia have a negative attitude towards the use of RET [86]. There are cases where local residents are reluctant to allow the introduction of RE projects such as wind farms. A case study in Japan revealed that silent local respondents are not willing to allow wind farms in their backyards [87]. China is the world's largest emitter of GHG, and Chinese are aware that global efforts to stop climate change depends largely on China's policies. A survey was conducted among 2086 Chinese internet users, and great support was received [88]. Public opinion on installing a project for offshore wind power in Massachusetts was supportive [89]. An upcoming trend in Canada is the establishment of a community energy plan, whereby decisions are considered at the community level. An analysis of 10 of the first community energy plans in Canadian communities found that communities are selecting policies and programs centered on increasing energy efficiency, while RE receives much less attention [90]. A survey based on a random sample of residents in the state of Maine, USA found that they preferred specific types of RES [91].

In some cases, it was noted that demographic parameters influence the acceptability or the decline of RES. Female respondents generally sounded more appreciative towards the acceptability of wind energy as compared to male respondents [92]. A choice experiment was conducted in two Greek Aegean islands (Naxos and Skyros) to attempt to determine the resistance factors to installing RES. It was deduced that the majority of respondents perceived institutional factors as more important for acceptance than the physical attributes of wind farms [93]. The results showed that social acceptance changed rather than diminished when entrepreneurs extend a project's focus from biopower to smart biomass use [94]. A survey study on people of different age groups was conducted in Finland to obtain an opinion on renewable sources and technologies [95]. The study found that less than 50% of people were willing to install wind turbines in their backyards or solar panels on their roofs. Analysis of [96] study shows that users do not understand the energy consumption of their water heaters and they do not know how to control their efficiency. The study [97] reveals considerable differences in perception depending on familiarity and involvement with energy sources, environmental friendliness, and specific environmental impacts respectively.

Analyses of public opinion by [98] regarding climate change and RE in Peninsular Malaysia have proved that the majority of Malaysians are adequately learned about RE and are genuinely concerned about climate change. However, the cost of RE is a significant barrier to the acceptance of RET technologies. The study [99] results revealed that the Korean public's level of acceptability is high regarding RES source expansion policy. However, the education level of respondents had a significant effect on the preference for an increase of RES. In the analysis of public perceptions of RET acceptance, the study [100] deduced that education is particularly relevant for justifying economic, environmental and social perceptions and these are also significant variables for the acceptance of the technology. In particular, the respondent's attitude towards risk can play a major role for each respondent's willingness to accept new RET. Another study [60] has analyzed public opinion by using both qualitative and quantitative methods and found that there is a relationship between RE usage and environmental education. The respondents, however, generally did not agree with the complete transfer towards RE. The findings of a study [101] showed that public acceptance is highly dependent on the technology in question, the dimension of social acceptance (community versus socio-political dimension) and previous experiences with RE.

Figure 7 explains the sources for public opinion and the sources of RE on which public opinion in this review study is based. Table 3 summarizes the results obtained from reviewed studies, which discussed the opinions of the public on the acceptance of RES and RET. Table 4 highlights frequently found barriers to the acceptance of RE, for example: resources of interest; policies of interest; noise; lack of knowledge and awareness; economic conditions; demographics; and climatic conditions.

In this review, public's opinions on the acceptance of RES in the last 9 years, from 2009 to 2018, are discussed. It is noted that the lack of knowledge is the most influential factor in preventing the public from accepting RE.

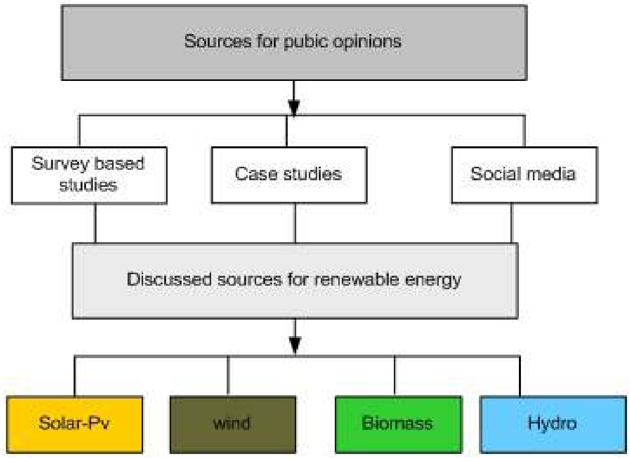

FIGURE 7. Opinions & renewable energy sources.

IV. ANALYSIS OF OPINIONS REGARDING RENEWABLE ENERGY SHARED ON SOCIAL MEDIA

We have performed an analysis of opinions related to RE received through Twitter to provide an overview of social media towards current practices of RE.

A. EXAMPLE FROM TWITTER

Twitter provides useful real-time information on a variety of topics ranging from social issues to serious topics and also entertaining ones. Tweet feeds are handled by different approaches so as to obtain useful information e.g. handle future outbreaks in real time [103]. These tweets are encapsulated with multiple types of opinions inside. Opinion-mining studies have focused on and explored three types of opinions including: 1. Regular; 2. Comparative; and 3 Suggestive opinions [29]. Based on the opinion data results available on social media (Twitter) related to RE, it was observed that users' perceptions about RE are conveyed with significant opinion types. We have found that there are large numbers of tweets available related to sustainable and RE sources. This provides an overview that social media is productive towards generating awareness on various events [104] that may help in promoting RE. As discussed in the above sections, awareness of public opinion is a crucial attribute for a successful outcome of RE acceptance. Results of social media data analysis shows that it is a very useful tool when it comes to public relations issues. In addition to the advantages discussed above, social media is significantly cheaper than traditional advertising. In addition, it is a mode of communication which allows getting in touch with people worldwide anytime and sharing their opinions about RE.

1) ETHICS

No ethical matters were perceived as being essential for this study, as there was no involvement with any human data beyond measuring internet activity among Twitter users.

TABLE 3. Public opinions for attitudes & promotion clues of res & RET's.

Study	Location	Data selection mode	Type of energy	Opinions response	Comparative analysis & drawn facts in light of public opinions
[84]	Turkey	General survey	RES & power stations	Supportive	More awareness & benefits of RET improves its acceptance
[85]	Portugal	General survey	hydro, wind, biomass,& solar power	Supportive	Hydro, wind, & solar is most encouraged as compared to biomass
[86]	Malaysia	General survey	RES & RET	Not supportive	Perceived usefulness & ease of use both are important towards the use of renewable energy technology
[87]	Japan	General survey	Wind farm	Partially supportive	Consensus building is required to encourage local residents that oppose the wind farm installment
[102]	China	Online survey	RES	Supportive	Renewable energy is demanded: reduce air pollution, reduce greenhouse gas emissions, improve the country's energy security
[89]	Canada	Case study	bio-fuels Wind, solar thermal & solar PV	Partially supportive	Smaller & remote communities are more likely to promote multiple renewable energy technologies
[90]	Massachusetts	Telephone interviews & online survey	Offshore /Cape wind	Supportive	Knowledge to offshore wind technology & benefits to air quality, fossil fuel, and the climate concerns effects on public acceptance of RES
[91]	USA	General survey	RE & energy efficiency	Partially supportive	Energy policy is accepted, depending upon the energy type , socio-demographic and personal characteristics
[92]	Germany	Online survey	Wind farm	Supportive	Wind farm acceptance depending upon the respondents' gender, income, educational level, the frequency of visits to the beach & experience with on-land turbines
[93]	Greece	Choice experiment	Wind farm	Partially supportive	Public welfare policies along with wind farm are a more effective approach in RET acceptance
[94]	Netherland	Case study	Smart biomass	Non-supportive	Use of smart biomass is more dependent upon inter-firm trust and more open to recursive patterns
[95]	Finland	Choice experiment	Wind turbines & solar panels	Partially supportive	Increase in knowledge about RET's may improve the acceptance of RET's at home
[96]	South Africa	Survey	RET solar water heater	Partially supportive	Educational and rebate programs are required
[97]	Portugal	Survey	RET	Partially supportive	Familiarity & involvement, environmental friendliness, & specific environmental impacts
[98]	Malaysia	Survey	RES &RET and Climate change	Supportive	High price of renewable energy products, lack of knowledge about government policies, & ineffective programs are barriers in acceptance of RES & RET
[99]	South Korea	Survey	RES	Partially supportive	The government needs to pursue incremental electricity bill hikes while considering the public acceptance simultaneously
[100]	Portugal	Survey	Hydro, wind, biomass & solar	Supportive	Education & attitude towards risk is important for renewable technology acceptance
[60]	Qatar	Survey & Interviews	RES	Partially supportive	Necessary to educate the public on the efficiency of renewable energy
[101]	French, German & Swiss Upper Rhine region	Survey	RET	Supportive	Policy makers need to be aware of potential consequences for public acceptance

1) DATA ACQUISITION TOOLS AND ANALYSIS OF TWEETS

Tweet extractions took place using the NodeXL the Twitter Importer module [105]. The extracted opinions or tweets were parsed to remove the HTML formatting from the text and then transformed into an XML file that separated the data into records (the opinion) and fields (the data in each tweet). We have labeled the tweets into multiple classes (A, B and C) based on a linguistic construct using a similar method to card sorting [106]. The regular reviews are labeled A, comparative as B, and suggestive reviews as C [26]. The aim of this example is to explain the qualitative measures associated with tweets related to RE and monitor the current impressions of public perceptions during the time of this review study.

TABLE 4. Identified barriers and challenges for acceptance of renewable energy sources.

Studies	Resources of interest	Policies of interest	Noise	Lack of Knowledge & awareness	Economic condition	Demographics	Climate conditions
[84]	×	✓	×	✓	×	×	×
[85]	×	×	×	×	✓	✓	×
[86]	×	✓	×	✓	×	×	×
[87]	✓	×	✓	✓	×	×	×
[102]	✓	×	×	✓	×	×	✓
[89]	×	×	×	✓	×	✓	×
[90]	×	×	✓	✓	✓	×	×
[91]	×	✓	×	✓	×	×	×
[92]	✓	×	✓	×	×	×	×
[93]	✓	×	✓	×	✓	✓	✓
[94]	✓	×	×	✓	×	×	✓
[95]	×	×	✓	×	✓	×	×
[96]	×	✓	×	✓	×	✓	×
[97]	✓	×	×	✓	×	✓	✓
[98]	×	✓	×	✓	✓	×	×
[99]	×	×	×	✓	✓	×	×
[100]	×	×	×	×	×	×	×
[60]	×	×	×	✓	×	×	×
[101]	×	✓	×	✓	×	×	×

There was a time restriction which meant that the observational study of Twitter [107] was performed during the last month of the study, e.g. from 1st December 2018 to 31st December 2018. It was carried out in different time slots using one of the authors' Twitter accounts. There were three popular RE information sources, namely, (1) The International renewable energy agency (IRENA); (2) Renewable energy policy network for the 21st century (REN21); and (3) International energy agency (IEA). The selection of three different information sources e.g. IRENA, REN21 and IEA also satisfied the requirement of triangulation that is commonly used in qualitative research [108].

We picked up on the top few tweets that were used e.g., #Renewable energy hashtag and performed manual annotation until we received a variety of review types related to RE. Further, for detailed analysis total, nine tweets were selected; three tweets which were against each source and that were large in size and had gained more "likes". As likes and helpfulness indication show the importance of an opinion [25], we therefore excluded the tweets that had an insufficient number or no likes on it. The detailed analysis of these tweets provides useful information that divides them into different classes (see Table 5).

The tweets were collected with time and date stamp e.g. from IRENA (*2:10 PM -24 Dec 2018, 4:44 AM-28 Dec 2018,10:10 AM-31 Dec 2018*), REN21 (*10:59 PM -18 Nov 2018, 10:15 22 PM-7 Dec2018, 2:20 AM-10 Dec 2018*) and IEA (*2:04 AM -26 Dec 2018 3:10 AM 30-Dec 2018, 10:01 PM- 24 Dec-2018*). This analysis showed that people posted tweets frequently in different time spans and, overall, there is a supportive trend towards RE and future adoption of RES. This information will open ways to bring up innovative ideas of research in the field.

V. DISCUSSION

Driven by the requirement for world energy demand and clean energy, research on RE has uncovered a high potential to create a sustainable environment and meet today's need of

TABLE 5. The analysis of three #renewable energy tweets.

Source	Sample tweet phrase	Sentiments & opinions
IRENA	Generate rural economic activity improved health, less pollution & more job	Positive & A/C
	Renewables can help achieve socioeconomic objectives from meeting energy demand to powering growth & job creation	Positive & A/C
	Energy use is changing fast but the shift to #renewables needs to happen faster in power generation, heating, buildings & transport to keep #climatechange in check.	Positive & B/C
REN21	Need policies to support renewables & stop subsidizing the destruction of our future	Positive & C
	To decarbonise #transport sector we need #renewables. Both TCC-GSR and @REN21's Renewables GSR track the advancement in the transport and renewable energy sectors to inform policy processes and support integrated approaches	Positive & C
	Using sunlight to feed the hungry; improve health; help decrease poverty and conflict. @REN21 is happy to support @solarcookersint and this #renewable solution	Positive & A/C
IEA	To meet long-term climate & sustainability goals, renewable energy development must accelerate	Positive & C
	Having reliable data and indicators on how energy is used is key to informing and monitoring the effectiveness of energy efficiency policies	Positive-& A/C
	While individual clean energy technologies are the building blocks to clean energy transitions, a variety of "energy integration" technologies will also need to play an increasingly important role	Positive & A

energy [109]. In this review study, 42 papers were critically examined in an attempt to explain the importance of RE and RET practices at a domestic level in addition to public opinion on the adaptation of RE. With reference to a hybrid renewable energy integration system [46], results revealed that the large-scale renewable energy integration system (wind/PV/grid-connected) is more economically viable in contrast to a grid-connected-only system because of high upfront costs. The study [47] using the Granger non-causality test for four Nordic countries reveals unidirectional causality running from RE to CO_2 emissions for Denmark and Finland and bidirectional causality between these variables for Sweden and Norway. Interestingly, the results could not confirm any causality from RE to growth. In terms of costs, emissions and energy security, the study [48] revealed that the cost for renewables, nuclear energy and fossil fuels are essentially the same; whereas energy security of up to 60% of variable renewable capacity is possible with little cost increase. Large amounts of emissions are prominent with the use of fossil fuels. In relation to a clean environment, a study by [49] has identified several issues which it addressed in the current environmental assessment systems. In the case of developing countries being able to meet the challenges of energy crises (particularly electricity shortages), a study [50] indicated several issues such as lack of foresight, flawed policies, poor decision-making and lack of seriousness at a higher level. It is stated that currently, a mix of energy is skewed towards the thermal, where hydrocarbons constitute 87% of total primary energy supply that ultimately increases GHG emissions. To confront such issues, Pakistan needs to switch towards RES as it has rich land reserves of 800,000km2 with plenty of opportunities for solar, wind, bio and hydro energy. Another study [51] explains the need for RES to combat the energy crises in rural areas of Iran. Estimated solar radiation in Iran is between 1800–2200kWh/m2 per year, which is higher than the global average. Despite having productive land, some infrastructural, managerial, socio-cultural and economic challenges are seen for the instalment of RES. One of the proposed solutions to meet these challenges in developing countries is the development of aggressive and innovative policymaking.

With reference to RET for domestic use, hot water production was one of the considering factors for public need at the domestic level [64]. For domestic hot water production, direct solar with thermal store integration (DSTSI) configuration showed high efficiency with a demand of 277 kWh thermal energy in order to supply domestic hot water at the rate of 80 L/min [65]. The main diffusion barriers to solar water heaters (SWH) for households are economy, household composition, and the structure of the house for available installation location of SWH [66]. For household items powered by RES, the solar cooker is perceived as a most important and useful appliance. There are three different types of solar cookers, specifically: solar panel cookers; solar box cookers; and parabolic solar cookers. A box-type hybrid solar cooker has been specifically designed for a small family, by keeping it small in size and light in weight, weighing 4.8 kg [67]. It was deduced that the combination of thermal and photovoltaic energy reveals 38% higher efficiency as compared to the baseline model. It comprises attractive features including being: user-friendly; convenient (unattended cooking is allowed at any time); fast-cooking; affordable; able to cook 4-5 times meals/day. A portable parabolic-type solar cooker has been designed with reused metallic cardboard [68]. The parabolic design gives the best result compared to other tested designs with an average efficiency of about 14-18% as compared to rough fire. Such portable solar cookers could be easily usable in the case of emergencies in humanitarian camps. In a study [69], a box-type solar cooker was designed and experimented upon by using internal reflectors; higher performance was observed compared to the same cooker without a reflector. A tri-generation system has been developed at the University of Technology, Sydney (UTS), which delivers: (1) hot water; (2) cold water; and (electricity) to the Faculty of Engineering [70]. This unique tri-generation system uses photovoltaic panels, flat plate collectors, and wind power as generators with thermal and chemical energy storage. For ventilation and cooling of a building, a roof solar chimney

(RSC) was installed and tested against four different climatic conditions [71]. Results found that a ventilated roof with RSC provides free cooling and natural ventilation in all four climates and seasons. A numerical investigation was conducted on a single family detached house in order to reduce the cost of household electricity in the Philippines [72]. As a result, it was observed that installing solar photovoltaic panels on the rooftop is helpful for electricity consumption. In the study [73], it was revealed that by using RES, such as solar energy and biomass energy, a household could minimize its dependency on both fossil fuels and grid line electricity.

Moreover, progress has been made to investigate public opinion on the adoption of RES and RET. In relation to the use of RES and power stations, a supportive survey response was received from secondary school students in Turkey [84]. The success behind the supportive response was due to the awareness of RES and the benefits of RET. Similarly, Portuguese opinions towards the use of RET showed as being positive towards the acceptance of RES because of awareness of it [85]. According to this survey, the public's attitude towards accepting hydropower was most welcome as compared to biomass. It is evident that people do not know much about the concept of biomass. We argue that public awareness about RES is a significant factor in the acceptance of RES and unawareness is observed as a major barrier in acceptance of RES. Although there are RE policies, RES has not yet been established in Malaysia [86]. The main reason can be attributed to unawareness and the high subsidy for fossil fuels which made Malaysia uncompetitive economically in term of RET technologies. There was a case in Japan on the acceptance of a presently installed wind farm; however, the acceptance of a new wind farm was at first very low among silent residents [87]. Possible solutions for the acceptance of sustainable wind farms are: (1) providing opportunities for the locals to express their opinions; and (2) the developers providing a response to the locals on their requests during the project planning phase. These may enhance the possibility of acceptance in future wind farm projects. In terms of current global warming, China is the world's largest emitter of GHS. A significant response in the acceptance of RET was reported from a survey conducted in China [88]. Interestingly, people were willing to accept RET because of the cost and security of these technologies, as opposed to reasons of pollution and climate change. It shows that energy security is one of the prominent aspects in the acceptance of RET. In another case [90], regarding the usage of RES among Canadian communities, biofuels received greater acceptance compared to wind, passive solar design, solar photovoltaics and solar thermal. In the latest survey study in Massachusetts, an offshore wind project received maximum support [89]. The observed minimal rejection can be overcome by providing education about offshore wind technology. This shows that with growing knowledge and awareness of RET, people become more inclined to accept it. Preference and selection of RES make a significant difference in the acceptance of RE policies for the development of RET. There is case reporting that, without giving preferences to any RES, investments may face rejection by the public who may have a preference on energy type [91]. The public demographic and their attitude towards using the beach is a contributing factor to accepting offshore wind farms [92].

People who visit the beach less frequently sounded more willing to use offshore wind farms. Despite other factors discussed above, welfare is considered as another promising aspect in promoting RES. A study [93] among Greek residents showed that the governance characteristic of the planning procedure is a significant aspect in local community welfare. The welfare aspect as opposed to the physical aspect plays a vital role in the acceptance of wind farms. A case study revealed that the improvement of bioenergy towards smart biomass is not enough for its acceptance [94]. People may accept it for the purpose of enhancing energy and economic efficiency levels. Finland received support for RES from people with more knowledge on RES as well as age and experience on home energy issues.

More precisely, based on literature analysis, several insights concerning the acceptance of RES are provided. Firstly, RES is the ultimate solution to combat energy crises and environmental pollution. Secondly, the public need for home systems can be resolved by using RE-based technologies instead of fossil fuels. Thirdly, the perceived public opinions on RES and RET disclose various important factors that significantly influence the acceptance of RES. These influencing factors are well-versed with, specifically: RE knowledge on RET and RES; demographics; usage of certain environments where RETs are installed; climatic conditions; economy; global warming; energy security; and policies embedded with public welfare and involvement in issues involving energy. The geographical area also impacts the acceptance of diverse RET; for example, people who live near an island receive a higher amount of wind and solar power than hydropower, and therefore, they are acknowledged more than other types of RES.

VI. IMPLICATIONS OF THE STUDY

Through the comprehensive analysis of previous and related literature, this study offers several implications for both researchers and policymakers regarding RE development. Researchers need to focus more on factors influencing the intention of people in using RE. Moreover, there is a definite need to conduct more research that incorporates RES using public opinion, which can assist to reduce reservations among the public and promote future use of RES and RET. The government can make plans to expand RE concepts and introduce study of this topic in secondary schools and higher levels of education. A variety of RET should be available through government policies and incentives. It is evident that for the development of RET, government and research and development (R&D) programs play a vital role [110]. In the case of industry, the policymakers can develop attractive policies embedded with the preferred choice of RES by utilizing public opinion. Various public awareness policies can be proposed for the identified challenges e.g. awareness of RES and RET use. Another important practical implication for policymakers and government sector is the introduction of welfare programs related to RE projects so as to gain a positive response from the public. The implications for academia are considerable. They can include, for example, the university sector, where R&D could be working on RE projects. In this case, it would indeed be important to conduct workshops for students from diverse disciplines to deliver knowledge on RES and RET. Furthermore, the study highlights the need to obtain useful information through public opinion that can be used by future researchers for successful acceptance of RE.

VII. CONCLUSIONS

The objective of this article was to highlight the importance of RES and the RET. RES such as solar, wind and biomass are mostly used in the manufacturing of domestic products; namely, windmills to produce electricity, water pumps and heat and power generation, etc. Among all types of renewable energies, solar energy is available in the majority of the world. This is the reason for solar energy being the most suitable substitute for fossil fuels and most household products leverage solar energy in RET. In order to ensure sustainable development for the future generations, it is indeed important to raise awareness about RES. RE can be utilized in making many products employed in daily use, such as solar cookers, solar coolers and heaters, as well as solar dryers. The application of RES such as solar is worldwide. Biomass assists to absorb dangerous gasses such as CO_2 and can also be used for electricity and as a fuel. Wind is another useful RES resource that can be used to produce electricity and power generation. Our findings endorse the fact that the success of RE may be gained by providing greater awareness of RES and RET to the public. This can be achieved by introducing educational programs related to RE through domestic and international platforms.

This SLR has been carried out in attempt to focus on RES & RET in light of public opinions, that are indeed important to promote the development of RES & RET. Even though the results evidently contribute to the RE literature, the study has certain some limitations. First, included articles discussed the need of RE, RE at domestic level and public opinions about the use of RET through the use of well-established keywords. However, there may be other relevant keywords that have not been considered in the present SLR. Second, to certify the study remained focused and quality conscious articles written in a language other than English have been excluded. Overall, our analysis is a qualitative interpretation of RES & RET practices among public providing aggregated overview of the research and thus allowing us to systematically identifying future research avenues. We hope this systematic review can assist both academia and industry to promote renewable energy and encourage the analysis of public opinions that are present in Twitter or other social network platforms such as LinkedIn.

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