
Solar Thermal Technologies Dynamics and Strategies for Market Creation in Sindh

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ABSTRACT

In order to sketch Sindh's RE (Renewable Energy) based scenario, it is vital to trace the dynamics of simplest RETs (Renewable Energy Technologies) such as STTs (Solar Thermal Technologies). STTs are simple to operate, easy to maintain and requires low cost of fabrication. Due to these advantages, STTs possess scope for mass market creation in Sindh as can provide alternate energy solutions to meet daily fuel requirements of heating and cooking etc. The paper identifies that the low awareness creates a negative perception about the price and efficiency of these technologies in masses, which can be removed once the awareness increases. This paper consists of survey findings, which traces the trends for STTs utilization in Sindh by testing various hypotheses to identify the suitable tactics required for their market creation. Finally the key policy recommendations are provided at the end.

Key Words: Solar Thermal Technologies, Renewable Energy Technologies, Awareness Policies, Sindh.

1. INTRODUCTION

Very few organizations in Sindh are working in the field of renewable energy, despite of persistent energy crises. In Sindh, the share of renewable energy e.g. solar, wind, biomass etc in the electricity generation mix remains very low (Hassan, et. al. [1]). Solar energy based technologies are primarily divided into two groups i.e. Photovoltaic and Solar Thermal. The principal applications for large, central, ST (Solar Thermal) systems are: hot water production (domestic use, large public and commercial buildings, industrial applications and greenhouses), space heating and cooling and desalination (Theocharis, [2]). STTs are considered to be simplest in bulk of other RETs (Shah, et. al. [3]). STTs utilize solar energy directly by exploiting its heat characteristics (Bhutto, et. al. [4]). Pillaie, et. al. [5] highlighted various STTs and their applications as shown in Fig. 1.

Hyat [6] suggested that operation simplicity, low cost of manufacturing and easy adoptability are the key points for STTs, whereas photovoltaic are costly and difficult to manufacture locally due to involvement of complicated electronics circuitry. In order to create STTs market among a large population of Sindh to face energy crises, it is prerequisite to understand the attitudes of the society towards STTs. These features represent the attractiveness of Sindh's society towards various STTs to meet daily household requirements of energy supply such as electricity generation, water heating/ cleaning and cooking. Shah, et. al. [7] identified that the majority of the Sindh's population is not aware with (about) the applications of STTs such as cooking, desalination in general and solar dehydration in particular.

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This paper, at first traces the trends of STTs i.e. the awareness towards STTs utilization/application in Sindh by investigating the needs of stakeholders. These stakeholders are mainly the decision makers, which have tendency to shape techno-economic dynamics for STTs utilization. For this research, the Techno-economics dynamics are investigated through techno-economic network approach rather than techno-economic paradigm approach as indicated by Green and Hull [8]. In network approach the focus is placed upon innovation rather than economics. Today's energy policy decisions will influence the environmental, social and economic situations of the country for decades to come (Ruble, [9]). The investigation of techno-economic dynamics through a network approach of STTs is essential to devise better policy guidelines to create a mass market for these technologies. The paper further investigates the hurdles in creating a market penetration of STTs in Sindh through testing of various hypotheses. Finally, conclusions are drawn for policy recommendations.

2. RESEARCH METHODOLOGY

The contact details of 200 stakeholders were obtained from PCSIR (Pakistan Council of Scientific & Industrial

Research) Laboratories Hyderabad. A survey was conducted from these stakeholders, identified to be active or intend to be active in utilization of STTs in Sindh. In this manner by using random sample approach a total of (100) survey questionnaires were sent to identified stakeholders. A total of (78) respondent replied. The survey questions were framed on the basis of an extensive literature review and findings of research conducted earlier i.e. Shah, et. al. [3,7]. The main survey questions inquired from the respondents are:

- What do you think there is a scope of RET in our society?
- RETs/STTs can improve economic conditions, remove poverty in Sindh.
- The problem of water purification/cleaning can be solved through Solar Desalination plants.
- Food/vegetables drying provide much economic up-gradation opportunities through solar dehydrators.
- After sales service for STT is essential for their commercialization. If it is provided society may greatly adopt STTs.

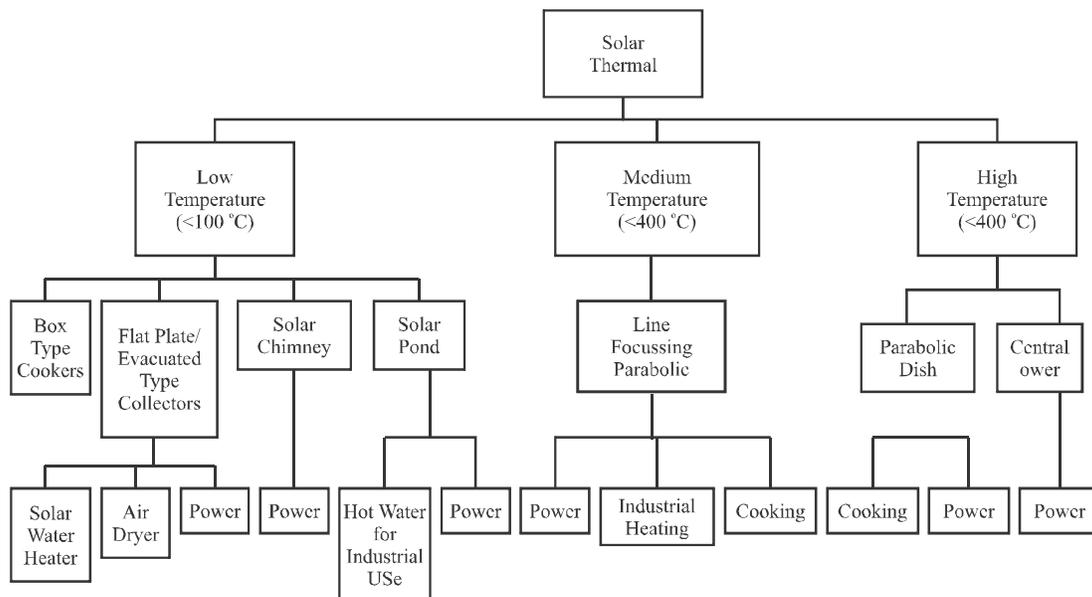


FIG. 1. STTS AND THEIR APPLICATIONS (SOURCE: PILLAI, ET. AL. [5])

- High cost of RETs/STTs is the main hurdle in their diffusion.
- A major cause for almost no diffusion of RETs/STTs is unawareness regarding their utilization.
- Lack of Incentives/Disincentives from Govt. do make hurdles for the diffusion of RETs/STTs.

The response was measured on likert scale on five points ranging from strongly agree to strongly disagree. The reliability test was performed on the collected data. After finding the reliable data, non parametric tests (2 independent and 2 dependent sample approaches) were also conducted through SPSS to test following hypotheses:

- H1: High cost is the main hurdle for market creation of STTs in Sindh.
- H2: Increase in awareness creates optimistic thinking towards STTs.
- H3: The solar dehydrator possesses least economic up-gradation and poverty alleviation capabilities through food/vegetable drying.

Through the survey, it was identified that mainly stakeholders of six sectors i.e. industry, academia, FIs (Financial Institutions), government, NGOs (Non-Governmental Organizations) and landlords are interested in utilizing the STTs. The respondents are further classified into low and medium awareness groups, keeping in view their knowledge toward STTs application/ utilization. Table 1 represents the background and characteristics of some of the stakeholders identified in six sectors.

3. ANALYSIS AND RESULT

3.1 Guidance and Demand Scenario of STTs

Those respondents which have shown the interest to obtain guidance for various STTs are characterized as a

low awareness group. The stakeholders in this group were not previously aware about the utilization of STTs to fulfill their energy related needs. Therefore the guidance obtained mainly concerned with electricity generation, cleaning of water, heating of water and cooking. The generation of electricity through PV (Photovoltaic) system is the most sought out option in this group. Since, 48% of respondents have shown interest in PV System to meet their daily electricity needs. Meanwhile, 26% of respondents persuaded guidance for water cleaning through desalination process. However, the remaining respondents have expressed interest to obtain guidance for cooking through solar cookers and water heating through solar geyser. It is identified that “No Body” in this group have shown interest in the solar dehydrator to solve their food drying requirement.

The respondents, which are identified to precisely possess previous knowledge for the applications of STTs are categorized as moderate awareness group. These respondents are quite clear in their requirements (demand) for drying, water purification and cooking process that can be fulfilled through STTs. In this group, 58% of respondents have shown interest in the solar dehydrator to dry food items. Whereas, 31% of respondents, demand the application of STTs to be used for cleaning of saline water for drinking purposes through solar desalination plant. Rest of the 11% of respondents has shown interest in solar cooking and solar water heating applications to be done through solar cookers and solar geyser respectively.

3.2 Trends for STTs Utilization

It has been identified that the trend for technology selection is quite opposite for stakeholders possessing low awareness as compared to moderate awareness (Fig. 2) e.g. respondents categorized in low awareness group have not shown any interest in solar dehydrator to dry food items, whereas, moderate awareness group have shown high interest in solar dehydration. The generation of such opposite trend for solar dehydrators

is caused by the unawareness respondents possess in this group for the potentials of solar dehydrators. For electricity generation through PV System moderate group stakeholders have not shown any interest, which is again quite opposite to “low awareness group”. Since

the “moderate aware group” is well aware with the high prices of PV system. Meanwhile, interest for cleaning of saline water through solar desalination plants is same in both groups. The trends for STTs application is shown in Fig. 2.

TABLE 1. BACKGROUND OF STAKEHOLDERS

Sectors	Institutes	Characteristics of Stakeholders
Industry	Clairient Pakistan Private Limited, Hyderabad	Industries owners/technical staff looks into the possibilities for installation of RETs/STTs in their industries to overcome electricity needs.
	Total Parco Pakistan Private Limited, Karachi	
	KBI Textile Mills Private Limited, Hyderabad	
	National Food Private Limited, Karachi	
	Aga Khan Planning & Building Services, Karachi	
	Technology Links, Karachi	
Academia	Aga Khan School & Colleges, Hyderabad	Academia (Teaching faculty such as Professors, Assistant Professors, etc.) inserted in joint R&D ventures to improve the efficiency of STTs.
	NISTE (National Institute of Science & Technical Education), Islamabad	
	University of Sindh, Jamshoro	
	Institute of Industrial Electronics, Karachi	
FIs (Financial Institutions)	Al-Zamin Leasing Moaraba, Karachi	FIs are interested in offering financial support such as leasing to commercialize STTs.
	IDBP (Industrial Development Bank of Pakistan), Hyderabad	
	Saudi Pak Commercial Bank, Hyderabad	
	Sindh Board of Investment, Government of Sindh	
	Technology Transfer Division, Zarai Terqiyati Bank Ltd, Islamabad	
Government	Environment Protection Agency, Government of Sindh, Hyderabad	This group consists of government officials having diversified background and are working in various organizations / departments in the public sector at a decision making level such as Directors, Chairmen, etc.
	Women Development Department, Government of Sindh	
	Pakistan Bait-ul-mall, Umerkot, Sindh	
	Public Health Engineering Department, Government of Sindh	
	Agriculture Research Institute, Tandojam	
	Environment and Alternative Energy Department, Government of Sindh	
	Community Development Department, District Government Jamshoro	
	Agriculture & Biological Engineering Institute, National Agriculture Research Council, Islamabad	
	PCRET (Pakistan Council of Renewable Energy Technologies), Karachi	
Pakistan Council of Scientific & Industrial Research, Hyderabad		
NGOs	Badin Rural Development Society, Badin	This group intends to utilize RETs/STTs for community benefits. NGOs belonging to Thatta and Badin interested in the provision of clean drinking water to local communities, whereas other NGOs are looking for electricity generation, cooking, drying solutions.
	ACF International, Thatta	
	DOSTE (Trust), Karachi	
	Sindh Radiant Organization, Thatta	
	Shah Abdul Latif Bhittai Welfare Organization, Hyderabad	
	Red Chillies Growers Association, Kunri	
Landlords	This group primarily consists of progressive landlords, which belongs to different districts of Sindh	These Landlords intend to utilize RETs/STTs for agricultural processes, especially post harvest processing of agricultural products.

The contrast in stakeholder’s choices was observed once they were segregated in terms of low and moderate group of awareness points towards the stagnant mass market for these technologies in Sindh. Policies developed to encourage the wider deployment of renewable electricity generation, transport biofuels and energy efficiency have over-shadowed policies aimed at encouraging the use of RES (Renewable Energy Sources) for heating and cooling purposes (Kristin, [10]). Hence, to study the tactics through which, mass market of STTs can be created in Sindh is tested through hypotheses discussed in the next section. These hypotheses are formed to identify the

Phase i.e. (nursing, bridging, or mature) of STTs market in Sindh as suggested by Bergek, et. al. [11]. These hypotheses were also responsible to extract the policy issues or hurdles in market creation of STTs in Sindh.

3.3 Market Creation of STTs in Sindh

It is assumed that the Sindh’s market for STTs is in very early stage or in “nursing phase” due to very few people have awareness about these technologies (Fig. 3).

Kemp [12] suggested that in “nursing phase” market began to open up to learn about new technologies.

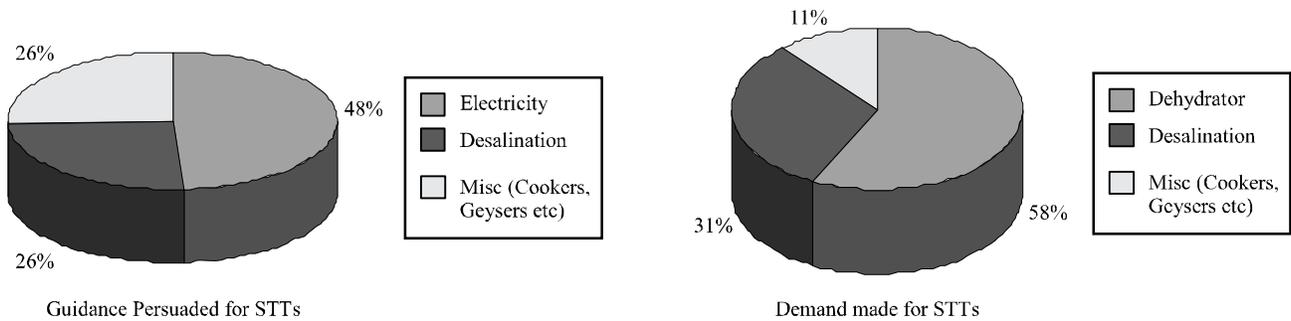


FIG. 2. GUIDANCE AND DEMAND TRENDS FOR STTs

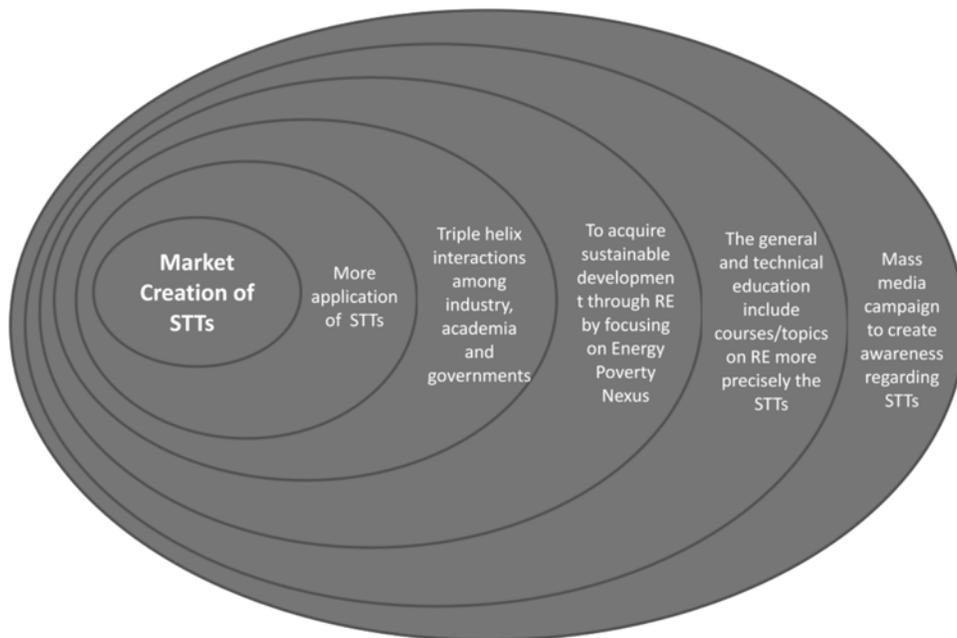


FIG. 3. LAYER BY LAYER IMPLEMENTATION OF STRATEGIES FOR MARKET CREATION OF STTs IN SINDH

Therefore, various questions are framed to investigate the in-depth structure of market formation in Sindh for STTs. These questions mainly structured to identify the demand and purchasing trends of STTs, customers preferences and the actions required to make these devices more successful in Sindh. Thus, in Sindh's context various hypotheses are tested and proved, which are discussed below:

H1: High Cost is the Main Hurdle in Market creation of STTs in Sindh: It is a common perception that RETs including STTs technologies not only involve huge investments but are also costly in nature. The creation of this perception based upon the first visible application of RETs in Sindh was concerned with PV technologies being utilized for electricity generation. In the absence of subsidies and few market players the cost of PV technologies at that time are on much higher side. Implementation of subsidized technology increases the national contribution to early deployment, independent of the level of spillover (Thomas, [13]). Therefore, the common man's first impression for these technologies in Sindh is that they are costlier to purchase and difficult to adopt, however, in reality STTs does not involve any PV system and are much cheaper and easier to operate. They can be fabricated locally. Masoud et al [14] also suggest that RETs in general have got public acceptance but lot of questions always remain in the minds of general public regarding their applications. Creation of such perception hampered the diffusion of these technologies in Sindh, where much of the population is unaware for the application of RETs. In order to prove the above assumption that somehow the higher cost perception for STTs is related with the low level of awareness attempts are made to test the hypothesis "High cost is the main hurdle for market creation of STTs in Sindh".

Therefore, according to Mann-Whitney U Statistics test the relationship between the awareness level and negative perception regarding the cost of STTs is significantly different for each level of awareness (at the significant

level of 0.001). It is evident that the mean rank for each level of awareness, the level of agreement with the statement that cost of STTs is the main hurdles in their diffusion/commercialization is considered highly significant (Significant level=0.001) by the low group (mean rank: 28.08) as compared to moderate group (mean rank: 18.50) as shown in Table 1.

In this context the null hypothesis is rejected. It is concluded that lower the level of awareness, higher the perception that the cost of STTs is the main hurdle for diffusion of these technologies. Increase in awareness, thus changes this perception. Once the awareness increases, then moderate group thinks that there are other problems such as absence of financial incentive, policy mismatches, lack of R&D (Research & Development) and educational focus to increase the efficiency of STTs etc. leads to low diffusion of these technologies. Glemarec [15] states that the public policy levers are required to remove the specific investment barriers for a given technology in each location. Hence, in Sindh perspective, a negative correlation between the cost of STTs with government incentives (-0.23) is also identified. Therefore, the stakeholders are not visualizing any chance that the government can provide the incentives to boost these technologies, which generate economic upgradation opportunities to alleviate poverty. It is then proved the assumption that low awareness towards STTs makes pessimistic perception regarding these technologies. To further determine how this negative perception among masses towards STTs can be removed the following hypothesis is developed and tested.

H2: Increase in Awareness Creates Optimistic Thinking Towards STTs: A question i.e. "What do you think that is there any scope for successful diffusion of RETs in our society?" is framed and data is collected to test the above hypothesis. According to Mann-Whitney U Statistics test the relationship between the awareness level and creation of optimistic perception regarding the successful diffusion of STTs is significantly different for each level of awareness

(at the significant level of 0.002). It is evident that the mean rank of the moderate group (Mean Rank: 29.05) is higher as compared to low group (Mean Rank: 18.42) as shown in Table 1. Therefore the null hypothesis is rejected. It is concluded that the increase in awareness certainly creates positive thinking for the capabilities of STTs to be diffused in Sindh to fulfill the energy requirements to generate economic up-gradation opportunities to common people. Hence, it is clear that the high awareness group is more optimistic for STTs diffusion, whereas, the low aware appeared to be pessimistic. To change the current scenario of STTs utilization in masses to create their market requires an urgent attention. The strategy could be the introduction of more STTs, which satisfy the everyday needs of common people by creating further awareness towards the potential of existing STTs such as solar dehydrators.

H3: The Solar Dehydrator Possesses Least Economic Up-Gradation and Poverty Alleviation Capabilities for Food/Vegetable Drying: One of the most important potential applications of solar energy is the solar drying of agricultural products (Zoffen, [16]). In the first portion of survey, it is identified that stakeholders having low awareness are unaware regarding the potentials of solar

dehydrators. Therefore, further efforts are taken to identify “what are Solar Dehydrator devices that common people has least explored”. A question “Food/vegetables drying provide much economic up-gradation opportunities through solar dehydrators” is being asked from the stakeholder in low and moderate group. The main reason for making this assumption is that solar dehydrators are the least explored STT devices by the stakeholders. Therefore, on the basis of data collected following trends were emerged (Table 2).

According to Mann-Whitney U Statistics test, the relationship between awareness levels and awareness towards the capabilities of solar dehydrators to produce economic up-gradation opportunities is significantly different (at the significant level of 0.000). In terms of awareness level the moderate group is much more aware for the utilization of solar dehydrators that it can create opportunities of economic up-gradation through food and vegetable drying. Whereas, the stakeholders possessing low awareness found to be disagreeing with this statement. Therefore the null hypothesis is rejected. This then proves the assumption that solar dehydrators are the least explored devices among people of low awareness people.

TABLE 2. SOLAR DEHYDRATORS LEAST EXPLORED DEVICES

Statement (Societal Perception)	Awareness Level	N	Mean Rank
High cost of RET STTs is the main hurdle in their diffusion.	Low	40	28.08
	Moderate	38	18.50
	(Significant Level) 0.001 Standard Deviation: 0.625		
Statement (Societal Perception)	Awareness Level	N	Mean Rank
STTs can be successfully diffused in our society?	Low	40	18.42
	Moderate	38	29.05
	(Significant Level) 0.002 Standard Deviation: 0.721		
Statement	Awareness Level	N	Mean Rank
Food/vegetables drying provide much economic up-gradation opportunities through solar dehydrators.	Low	40	16.75
	Moderate	38	30.86
	(Significant level) 0.000 Standard Deviation: 0.813		

4. DISCUSSION

It has been identified that the larger population of Sindh, despite of severe shortage of energy supplies are unaware regarding the application of most simplest form of technologies based on utilization of RE. Through the research it has also been identified that increase in awareness towards STTs, makes the respondents more intelligent in selecting the better technologies to fulfill their energy needs. Whereas, unawareness towards STTs infused a pessimistic perception in common people that these technologies are costlier to purchase and hence, are difficult to adopt. It is the pessimistic perception, which is the main hurdle in market penetration of STTs in Sindh. In the absence of government incentives to promote STTs, the common people are unable to visualize the potential of these technologies to meet their energy requirements. Thus, in order to make STTs more viable in Sindh, household energy needs of heating should be fulfilled through these technologies.

The weaknesses of the electric network, forced many different organization like universities, NGOs and local enterprises, to search alternative solution (Pansera, [17]). In this context more R&D and government interest needed to be diverted in this direction. Moreover, Sindh may adopt Charles [18] idea and work upon “Holistic Innovation Policy” by bringing the entire stakeholder on one platform to diffuse such technologies. But, in current scenario the respondents are not optimistic that market

penetration for STTs could be achieved in Sindh, when absence of incentives and lack of more efficient household energy related applications are not available. According to GCR [19], Pakistan has the highest ranking in terms of market size, but lowest technological readiness, exactly the same trend is also visible in Sindh. Currently as per correlation (**Table 3**), the relationship between the successful diffusion of STTs in the society is negative with its ability to solve two main problems of common people i.e. the electricity generation to cool and warm buildings. It implies that the common man is not witnessing any visible impact of these technologies to solve their daily problems of energy needs. Hence, STTs cannot be successfully diffused in Sindh until and unless it provides remedies for general problems being faced by the common people. Huge efforts are then needed to be undertaken by STTs experts to introduce innovation in available STTs applications to get the attention of masses.

Meanwhile, solar dehydrators are identified to be least explored by the stakeholders. Thus, it points towards the fact that common people are not much aware with their economic potential to be achieved through food and vegetable drying. The same hypothesis is also true for solar dehydrators utilization for (i) Fresh Date Palm Drying (ii) Fresh Chillies Drying (iii) Fresh Rose Petals/Spinach/ tomato drying. It is also tested that once the awareness increases for STTs, it creates optimistic thinking for diffusion and market creation of these technologies in Sindh.

TABLE 3. CORRELATION

		The Shortfall of Electricity can be Removed through STTs	The Cooling Systems of Buildings can be done through STTs	Are Enough Incentives from Government available for Diffusion of STTs in Sindh
STTs can be successfully diffused in our society?	Pearson Correlation	-0.141	-0.003	-0.348
	Significant	(2-tailed)	0.351	0.984

5. CONCLUSIONS

From the above discussion it is concluded that more efforts are needed by government to create awareness about STTs in masses. This is the single most identified factor hindering the pace for market creation of STTs in Sindh. To support NGOs, financial intuitions and industry, which wants to promote these technologies in Sindh, should be encouraged through incentives. The key policy recommendations for market creation of STTs in Sindh are needed to be implemented in step by step or layer by layer.

The market creation of STTs in Sindh can have a profound impact on the promotion of these technologies, once the mass media campaign regarding the effectiveness of these technologies is launched. The focus of this campaign should be to remove the misconception about the operational complexity and higher cost elements associated with STTs. To support this campaign general and technical education must initiate to focus on the introduction of RETs base courses/topics in the syllabuses. Thus, the introduction of innovative ideas by linking sustainable development, RE and poverty alleviation would be the next step for market creation of STTs. This step roots lies in the strengthening of triple helix partnership between academia, government and industry. It will result in more applications of STTs or even increasing the efficiencies of existing one. Ultimately, in the end a stable market is created in Sindh, having much scope for STTs.

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