Adoption of solar energy in India: a study through interpretive structural modelling

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Abstract

Purpose – Adoption of solar energy plays an important role in the growth of a country. There are many factors which influence the adoption of solar energy in India. The study is designed to identify factors that determine the acceptance or rejection of solar energy systems in India.

Design/methodology/approach – Relationship among identified variables is established through interpretive structural modelling (ISM) and thus a conceptually validated model is evolved. Further, MICMAC analysis is conducted to understand the driving power and dependence of these variables.

Findings – It is revealed that experience and habit, awareness and social influence are the intermediary variables. MICMAC Analysis shows that no variable is disconnected from the system and all the variables influence the adoption of solar energy in India.

Practical implications – The present study is expected to be useful to decision makers, end users and research organisations related to solar energy adoption.

Originality/value – Various intentional factors influencing solar energy systems adoption have been acknowledged in the present study, thus making it useful for formulation of action plans and enhance the usage of solar energy systems to improve environment quality.

Keywords Solar energy, ISM, MICMAC, India

Paper type Research paper

1. Introduction

The economic and social growth of a country depends on the availability of electricity to end users at all times. Energy consumption tends to identify an economy's growth capacity; greater energy efficiency means further growth and increased overall economic development. Fossil fuel reserves have begun to shrink with industry growth, technology development and population growth due to the massive use of scarce resources. Rapidly rising energy demand and mounting environmental issues are moving the world towards renewable energy sources. It is important to encourage consumers to choose renewable energy technologies in order to preserve the planet's ecological balance. So, the time has come to adopt the alternate source of energy.

Many ancient civilisations worshipped the sun as a mighty God. The sun is an abundant, cost-free, reliable and non-polluting renewable energy source (Azadian and Radzi, 2013; Veeraboina and Ratnam, 2012). Even though governments all over the world have made extensive financing options, additional benefits and attractive subsidies available, private household involvement in solar roofing remains largely inaccessible, amidst the multi-purpose benefits of solar energy and its widespread adoption (Masini and Menichetti, 2013). In view of this, it becomes interesting to know which variable that leads to adoption of solar energy in India.

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2. Literature review

The electrical power industry is in charge of making sure that customers have enough power. The power sector's ability to meet this demand is determined by the amount of energy produced and the power transmission network's characteristics. India has vast coal reserves, the fifth largest in the world after the United States, Russia, Australia and China. India holds 12% of the total coal consumption in world and more than 70% of electricity generated here is through coal (IEA, 2020).

2.1 Effect of fossil fuels

CO, CO_2, NO_x, SO_x and other harmful gases are emitted by fossil fuels. These contaminants damage the atmosphere, soil, water, animals and humans, as well as cause a slew of other issues. Global warming and acid rain was largely caused by CO_2 gas. The waste materials generated through coal, petroleum and nuclear power plants are extremely hazardous to people and wildlife and their disposal is a critical piece of work. Traditional resources are non-renewable and restricted. As a result, developing non-traditional energy sources has become crucial in order to minimise dependency on conventional resources (Raghuwanshi and Arya, 2019; Khan, 2016).

Over the years, renewable energy has gained increasing attention mainly because of its role in reducing carbon emissions and increasing energy savings. In most rural areas, renewable energy sources such as biomass or solar are the most appropriate and long-term solutions. This is particularly true in areas with plenty of sunlight and favourable agricultural conditions.

2.2 Use of solar energy

Solar energy technologies are a vital source of energy potential to endure energy demand globally, in order to reduce pollution and save the environment (Tove, 2017). It is known that solar energy is one of the most apt and dependable sources of renewable energy (Pável and Rajagopal, 2017). The proportion of energy touching down the Earth's facade through Sun, every day is much higher to meet the demand for electricity for the entire year (Kumar and Hundal, 2019; Cosimo, 2018; Jiangwei, 2018; Gevorg, 2011). Sun-powered energy is a natural, free source of energy that is both sustainable and abundant as compared to restricted and non-renewable energy sources. It's also a non-polluting energy source that does not produce any ozone-depleting compounds as it produces electricity (Masini and Menichetti, 2013). Since India has 300–330 days of sunshine per year, it has the ability to generate a large amount of solar energy (Kumar and Hundal, 2019). The lack of state-sponsored incentives as well as social acceptance and use of solar energy, are key to the solar mission's long-term success. Addressing a variety of technological, financial and institutional constraints can propel the transition to cleaner energy sources.

Solar energy is directly associated with the sun, such as light or heat. It is the world's oldest and most powerful energy source. It comes from the sun and is emitted in the form of solar radiation (Board, 2020). Solar energy has the ability to meet the world's energy needs if harvesting and distribution technologies are readily available (Kabir *et al.*, 2018; Kamalapur and Udaykumar, 2011). With 250–325 sunny days per year, India gets an average solar radiation magnitude of 200 MW/km^2 (MNRE, 2017). India receives more than 5000 trillion kWh of solar energy each year.

Energy availability and use are crucial for alleviating poverty, rural societal upliftment, e-governance and digital agriculture development in the digital era in India. Energy access would undoubtedly contribute to growth, and "no nation has managed to alleviate poverty without the energy access".

2.3 Global perspective

While a large amount of energy consumption is covered by fossil fuels, satisfying energy needs at low rates using renewable energy sources has raised future concerns within the framework of sustainable energy. According to scientific researches, the positive benefits of renewable energy use on the economy and the environment are becoming more apparent every day (Can and Korkmaz, 2019).

Al-mulali *et al.* (2013), in his study of examining the relationship between renewable energy consumption and growth using the data for 108 countries from 1980 to 2009, have stated that there was a bi-directional relationship between renewable energy consumption and growth for 85 countries. There was no link between renewable energy and growth in 21 nations. There was a one-way association between growth and renewable energy usage in two countries. In all, 79% of nations exhibited a long-term positive bi-directional link between renewable energy consumption and GDP growth. Fotourehchi (2017) examined the association between renewable energy consumption and economic growth in 42 developing countries using data from 1990 to 2012. There was one-way causality between renewable energy consumption and economic growth, according to the findings.

After studying the data from 2001 to 2002 for 45 economies, Chien and Hu (2007) suggested that increasing the use of renewable energy improves an economy's technical efficiency. Bhattacharya *et al.* (2016), after investigating the data from 1991 to 2012 for 38 countries to understand the relationship between renewable energy consumption and economic growth stated that renewable energy has a substantial impact on economic growth and that governments, other related institutions and organisations should work together to develop renewable energy legislation. Bekareva *et al.* (2017) looked at the association between renewable energy and economic growth using data from 2000 to 2014. Renewable energy, according to the findings, is an essential aspect of economic growth in the United States and a few other states.

2.4 Indian perspective

The Government of India announced in April 2018 that it had attained its objective of providing electricity to each one village in the country, an ambitious target that had been reached ahead of schedule. When 10% of households and all public dwellings are linked to the power system, a village is declared electrified. According to the most recent government data from April 2019, the final 600000 villages (and a total of 26 million households) were connected to the power grid (IEA, 2020). Tiwari (2011) analysed the association between renewable energy and GDP in India using data from 1960 to 2009. According to the data, a positive shock in renewable energy sources boosts GDP.

India's investment in solar systems was much higher than its overall combined investment in all fossil fuel sources for generating electricity, according to the IEA, 2020. By December 2019, India had installed a total of 84 GW of grid-connected renewable energy while, on the other hand, it had a total generating capacity of 366 GW in 2019. India is on track in achieving its 175 GW renewable energy goal by 2022. India's Prime Minister, Shri Narendra Modi, announced in September 2019 that the country's electricity mix would finally include 450 GW of renewable energy capacity. The energy demand in India is expected to double by 2040, since electricity demand is certainly reaching almost three times of today as a result of increased appliance ownership and cooling requirements, based on current policies and a population of 1.4 billion people (IEA, 2020).

If we look at the electricity generation mix data of India as reported by IEA, 2020, coal accounted for 74% while solar accounted for 1.7%, as shown in Table 1. After analysing the literature, it is obvious that solar energy is one of the important sources of renewable energy and identifying the gap of low usage of solar energy in rural India specifically, despite the fact of numerous policies and schemes launched by the Government of India, it is essential to conduct this study.

3. Study design

This study aims at bridging the study gap by evolving a detailed model that describes the determinants and their interactive contextual relationships with the help of interpretive structural modelling (ISM) – Matrice d' Impacts Croises – Multipication Applique a Classement (MICMAC) method. ISM is a methodology to develop the interrelationships among the identified variables. It is an effective method to develop and validate a research model. Following steps are used in ISM:

(1) *Identification of variables*: In the first step of ISM variables are identified which are affecting the system under consideration.

(2) *Structural self-interaction matrix*: The structural self-interaction matrix (SSIM) is developed as per the method of ISM.

(3) *Reachability matrix*: From the SSIM a reachability matrix is developed.

(4) *Partition of variables*: The reachability matrix which is obtained in step 3 is partitioned at different level.

(5) *Hierarchy of variables*: Finally, the levels obtained in step 4 are used to develop the hierarchy of variables.

Further, the result obtained through ISM model, MICMAC analysis is done to evaluate these identified variables in accordance with driving power and dependence power.

The study is designed to identify factors that determine the acceptance or rejection of solar energy in India. After analysing the available literature, specific variables are identified that affect the adoption of solar energy in India. These variables are as follows and summarised in Table 2.

(1) *Awareness (AW):* Customers undergo a procedure of knowledge, persuasion, decision-making and assurance until they are able to accept a product or service, according to Rogers and Shoemaker's theory. In other words, they argue that consumer knowledge of the product's benefits and drawbacks is the first step in determining whether or not it will be accepted (Hanafizadeh and Khedmatgozar, 2012). Awareness is a major factor that affects a person's buying decision, as it is the ability to think about each move before making a decision (Kumar *et al.*, 2020a). A process involving the compilation, management and review of information on any commodity is referred to as knowledge (Jaiswal and Singh, 2018). Low level of awareness and less familiarity are the main reasons for the failure to adopt solar energy (Kumar *et al.*, 2020b). Customer awareness of the product, its features,

Sources of electricity generation	Contribution (in %)
Coal	74
Hydro	9.3
Natural gas	4.6
Wind	3.3
Bio fuels and waste	3.2
Nuclear	2.5
Solar	1.7
Oil	1.6

Source(s): (IEA, 2020)

Table 1. Electricity generation in India by different sources

S.No	Variables	Definitions	Supporting studies
1	*Awareness*	Awareness is the initial step to begin with the adoption process. It generally means to have an understanding and information of SESs. Awareness about SESs means knowing about its advantages and disadvantages	Sahu and Singh (2018), Mango *et al.* (2017), Ohunakin *et al.* (2014), Hanafizadeh and Khedmatgozar (2012), Rebane and Barham (2011)
2	*Behavioural intention to adopt*	Behavioural intention to adopt is the measure of whether the person will start to use the application or not. It is the will of the person to adopt the technology depending on the attitude, society and other impacting individuals	Singh *et al.* (2018), Sindhu *et al.* (2016), Lewis *et al.* (2013), Rebane and Barham (2011), Suki and Suki (2011), McEachern and Hanson (2008)
3	*Perceived functional benefits*	Perceived functional benefits refers to the usefulness of the technology or application. It means to acquire the knowledge required to fully understand the technology. This benefit is essential to manage consumer's needs	Zhuang and Xiao (2018), Kuo and Feng (2013), McEachern and Hanson (2008)
4	*Risk-taking ability*	The degree of uncertainty associated with the use of any new technology is determined by risk-taking ability. Customers lack trust which in turn affects the purchase behaviour	Schnall *et al.* (2015), Hanafizadeh and Khedmatgozar (2012), Burgucu *et al.* (2010)
5	*Government policies*	Policies instituted by the government to overcome with the problem of lack of legal support. Any subsidy or financial assistance provided by the government would include government policies	Kumar *et al.* (2020a, b), Kumar *et al.* (2019), Sahu and Singh (2018), Sindhu *et al.* (2016), Karakaya and Sriwannawit (2015), Ohunakin *et al.* (2014), Javadi *et al.* (2013)
6	*Social influence*	Social influence is defined as the influence of families, friends, coworkers, opinion leaders and societal experiences on consumer purchasing behaviour. Influence of others, especially the society, in the decision-making process	Kumar *et al.* (2019), Chang *et al.* (2019), Rai and Beck (2017), Sindhu *et al.* (2016), Lewis *et al.* (2013), Venkatesh *et al.* (2012), McEachern and Hanson (2008)
7	*Price value*	Price value includes the costs such as installation, investment and maintenance, which are very high but incur majorly at the introductory phase. It is the willingness to invest now, so as to avail the benefits in the future	Kumar *et al.* (2020a, b), Chang *et al.* (2019), Sindhu *et al.* (2016), Karakaya and Sriwannawit (2015), Ohunakin *et al.* (2014), Venkatesh *et al.* (2012), Wong (2012)
8	*Performance expectancy*	Performance expectancy "the degree to which using a technology will provide benefits to the consumers in performing certain activities"	Aggarwal *et al.* (2020), Chang *et al.* (2019), Oechslein *et al.* (2014), Lewis *et al.* (2013), Venkatesh *et al.* (2012), Ghalandari (2012)
9	*Availability of resources*	It is the availability of proper resources (infrastructure, technical assistance, etc) at the time of the installation and during the usage of the technology	Chang *et al.* (2019), Sindhu *et al.* (2016), Schnelle *et al.* (2010)

(*continued*)

Table 2.
Summary of variables

Table 2.

S.No	Variables	Definitions	Supporting studies
10	*Perceived ease of use*	Perceived ease of use is "the degree to which a person believes that using a particular system would be free of effort"	Hansen *et al.* (2018), Abdullah *et al.* (2016), Hamid *et al.* (2016), Davis (1989)
11	*Experience and habit*	Experience represents a chance to use target technology Habit is the degree to which people automatically conduct themselves due to education	Chang *et al.* (2019), Lewis *et al.* (2013), Venkatesh *et al.* (2012)

benefits and drawbacks is therefore one of the first and most crucial stages in deciding an individual's innovation (Hanafizadeh and Khedmatgozar, 2012).

(2) *Behavioural intention to adopt (BI):* The decision to perform or not perform an action is referred to as Behavioural Intention. It is the function of an individual's attitude to behaviour and subjective norms. An individual is more likely to perform a behaviour for which he/she has a Behavioural Intent. Customers do not always function rationally when it comes to their customs, autistic thinking and other emotional factors (Wongkitrungrueng, 2018; Jamie *et al.*, 2017). In addition to the price of the product; quality and environmental considerations are also taken into account when purchasing the product (Yadav and Pathak, 2016). It is self-evident that the consumer's purpose is critical to the product's acceptance. As a consequence, this variable is taken into account in the current analysis.

(3) *Perceived functional benefits (PB):* The advantages, efficiency and quality derived from a product's use may be analysed to determine its perceived benefits (Jamie *et al.*, 2017; Akehurst *et al.*, 2012). The advantages of solar energy products are considered to be cost-effective, dependable and environmentally sustainable, and the benefits derived from solar energy based products eventually increase product adoption (Tehreem *et al.*, 2018; Jing *et al.*, 2018). The more benefits a customer receives from using the product, the more likely they are to embrace it (Pathania *et al.*, 2017; Yadav and Pathak, 2016). Furthermore, customers prefer solar energy products over traditional products because they have additional advantages and solar products often provide self-sufficiency (Kumar and Hundal, 2019; Kumar *et al.*, 2019; Chen, 2001). Thus, it is quite evident that perceived functional benefits have an effect on adoption decisions. As a result, the same has been taken into account in the study.

(4) *Risk-taking ability (RT):* Customers' perceptions of lack of confidence and the possible negative consequences in buying a product or service are described as perceived risk by consumer behaviour researchers (Hanafizadeh and Khedmatgozar, 2012). Risk-taking skill has been described as "the willingness to venture into the unknown," "an eagerness to try something new and different without putting the primary focus on success or failure". It can be further referred as an eagerness to make mistakes and defend situations that do not conform to norms and are not common, an eagerness to try something new and different without putting the primary focus on success or failure, an eagerness to try something new and different without putting the primary focus on success or failure, an eagerness to defend situations that do not comply with traditions.

(5) *Government policy (GP):* Any country's government policies are specified in terms of funding, subsidies and financial assistance offered by the government (Pathania *et al.*, 2017). Kevin (2013) stated that government subsidies have a positive impact on the selling of solar energy products. As a result, efforts should be made to provide subsidies to encourage solar products and increase environmental awareness (Zongwei *et al.*, 2018). Holding this in mind, it is important to explore this factor when determining whether or not to implement solar energy. There are a variety of policies that have been assigned by governments to resolve the question of lack of electricity in rural areas (Javadi *et al.*, 2013). High subsidies are offered to promote energy production from traditional energy sources, causing their prices to fall and thereby creating an unfair competitive climate for solar energy exploitation; as a result, demand for solar energy devices has slowed (Ohunakin *et al.*, 2014).

(6) *Social influence (SI):* It refers to how strongly customers believe important others (such as family and friends) believe they can use a certain technology (Chang *et al.*, 2019; Venkatesh *et al.*, 2012). It is a major determinant of consumer purchasing behaviour. Chen (2001) argues that peer conformity is an essential factor in determining whether or not to purchase a specific product. Consumer purchasing behaviour is affected by relatives, friends, colleagues, opinion leaders and societal experiences that the consumer perceives when making a purchase decision (Kumar *et al.*, 2019).

(7) *Price value (PV):* It is the consumers' subjective trade-off between the applications' perceived advantages and the cost of using those (Chang *et al.*, 2019). Any commodity is valued at the amount of all costs that could be incurred by any person in order to buy it (Jiangwei, 2018). Further research has shown that the ever-increasing cost of energy is acting as a persuasion factor for people to turn to solar devices (Pathania *et al.*, 2017). Not only that, but other research has found that consumers who are persuaded to buy solar products have a positive effect on their purchasing decision (Kumar and Hundal, 2019).

(8) *Performance expectancy (PE)*: The extent to which an educator assumes that current and new technologies can assist in enhancing job performance is referred to as performance expectancy. The most important factor used to describe behavioural purpose was found to be success expectation, which was found to be more significant for younger men (Lewis *et al.*, 2013). It assesses how effective a scheme is helping households achieve their goals of lowering their energy bills and contributing to the conservation of scarce natural resources.

(9) *Availability of resources (AR)*: Land and resource acquisition problems, such as restricted access to necessary components, limited rural infrastructure such as highways, a distributed population and long-distance transmission, are all involved in this variable (Sindhu *et al.*, 2016). Power supply is applied to the dimension of resource availability (technological infrastructure and Internet facilities). It takes into account the extent of technical sophistication.

(10) *Perceived ease of use (PEoU)*: It is indeed depicted as "the degree to which a person believes that using a particular system would be free of effort" (Hansen *et al.*, 2018; Abdullah *et al.*, 2016; Hamid *et al.*, 2016; Davis, 1989). It illustrates how simple and easy it is to use solar energy. The simpler a technology is to use, the more likely it is to be used by end users.

(11) *Experience and habit (EH)*: The term "experience" refers to a person's ability to use a specific technology and is usually defined as the amount of time that has passed

since that person first used the technology (Venkatesh *et al.*, 2012). "Habit" refers to the extent to which people continue to execute behaviours unconsciously as a result of learning (Chang *et al.*, 2019; Lewis *et al.*, 2013; Venkatesh *et al.*, 2012). In this analysis, experience and habit were merged into a single variable.

ISM is used to establish the relationship among all the identified variables. It is a widely used rural system methodology (Bhadani *et al.*, 2016), intervening studies (Chandramowli *et al.*, 2011) and other complex structures as it turns complex issues into well-defined structural models, provides better understanding of relationships between variables (Luthra *et al.*, 2014), develops acumen (Shen *et al.*, 2016), identifies focus areas (Kumar *et al.*, 2018) and analyses policies (Attri *et al.*, 2013). ISM hence is an effective and suitable method of building a structural model (Gan *et al.*, 2018) that better understands the system's behaviour (Kumar *et al.*, 2019; Bhadani *et al.*, 2016; Attri *et al.*, 2013).

Those classified variables are, finally, prioritised by MICMAC analysis based on dependency power and driving power. The analysis helps to classify variables by inspecting distributed effects with the multiplication property of matrices in terms of effect and dependence and thus, dividing the variables into four clusters.

4. Data analysis

The variables identified for the adoption of solar energy in India, is tested through ISM and MICMAC analysis. In this process Experts' opinions is taken to develop SSIM. The SSIM answers are then transformed into binary form, forming a reachability matrix. The reachability matrix identifies the levels of the variables, and then the conceptually validated model for the adoption of solar energy in India evolves.

4.1 Structural self-interaction matrix

As per the guidelines of the ISM methodology, experts' view is taken based on brain storming technique. For this purpose, two experts, from the academia are consulted. These experts are well conversant with solar energy in India and they are having more than 15 years of experience. They were asked to establish the relationship among the various variables influencing the adoption of solar energy in India. The four symbols below indicate the presence of a relationship between the two variables (*i* and *j*) and the corresponding order of the relationship.

(1) A, If *i* is dependent on *j*

(2) B, If *j* is dependent on *i*

(3) C, If *i* and *j* are dependent on each other

(4) D, If *i* and *j* are not dependent on each other

On the basis of their response, the SSIM is prepared as shown in Table 3.

4.2 Reachability matrix

The information compiled as SSIM given in Table 3, is transformed into reachability matrix. This is done by replacing A, B, C and D by 1 or 0 as the case may be. The following rules are used to convert the SSIM into the reachability matrix:

(1) If the (*i*, *j*) entry in the SSIM is A, then the (*i*, *j*) entry in the reachability matrix becomes 1 and the (*j*, *i*) entry becomes 0.

i/j Sl. No	Variables	BI 11	EH 10	PEoU 9	AR 8	PE 7	PV 6	SI 5	GP 4	RT 3	PB 2	AW 1
1	Awareness (AW)	C	C	C	C	C	C	C	C	B	B	–
2	Perceived functional benefits (PB)	A	C	C	C	C	B	D	C	C	–	–
3	Risk-taking ability (RT)	A	D	A	A	C	A	D	C	–	–	–
4	Government policies (GP)	C	D	B	B	D	C	A	–	–	–	–
5	Social influence (SI)	A	D	C	C	D	C	–	–	–	–	–
6	Price value (PV)	A	B	B	C	C	–	–	–	–	–	–
7	Performance expectancy (PE)	B	C	B	D	–	–	–	–	–	–	–
8	Availability of resources (AR)	A	B	C	–	–	–	–	–	–	–	–
9	Perceived ease of use (PEoU)	B	D	–	–	–	–	–	–	–	–	–
10	Experience and habit (EH)	A	–	–	–	–	–	–	–	–	–	–
11	Behavioural intention to adopt (BI)	–	–	–	–	–	–	–	–	–	–	–

Table 3.
Structural self-interaction matrix

(2) If the (i, j) entry in the SSIM is B, then the (i, j) entry in the reachability matrix becomes 0 and the (j, i) entry becomes 1.

(3) If the (i, j) entry in the SSIM is C, then the (i, j) entry in the reachability matrix becomes 1 and the (j, i) entry also becomes 1.

(4) If the (i, j) entry in the SSIM is D, then the (i, j) entry in the reachability matrix becomes 0 and the (j, i) entry also becomes 0.

The reachability matrix, the driving power and dependence of each variable is shown in Table 4. The driving power or dependence of a particular variable is the total number of variables (including itself) which may help to achieve it.

4.3 Formation of level of variables

For each variable the reachability set is determined. Then, on the ground of the reachability set, the levels of the variables are determined. This level of variables is shown in Table 5.

i/j Sl. No	Variables	BI 11	EH 10	PEoU 9	AR 8	PE 7	PV 6	SI 5	GP 4	RT 3	PB 2	AW 1	Driving power
1	AW	1	1	1	1	1	1	1	1	0	0	1	9
2	PB	1	1	1	1	1	0	0	1	1	1	1	9
3	RT	1	0	1	1	1	1	0	1	1	1	1	9
4	GP	1	0	0	0	0	1	1	1	1	1	1	7
5	SI	1	0	1	1	0	1	1	0	0	0	1	6
6	PV	1	0	0	1	1	1	1	1	0	1	1	8
7	PE	0	1	0	0	1	1	0	0	1	1	1	6
8	AR	1	0	1	1	0	1	1	1	0	1	1	8
9	PEoU	0	0	1	1	1	1	1	1	0	1	1	8
10	EH	1	1	0	1	1	1	0	0	0	1	1	7
11	BI	1	0	1	0	1	0	0	1	0	0	1	5
	Dependence	9	4	7	8	8	9	6	8	4	8	11	

Table 4.
Reachability matrix

Variables	Reachability set	Level
AW	1, 4, 5, 6, 7, 8, 9, 10, 11	III
PB	1, 2, 3, 4, 7, 8, 9, 10, 11	V
RT	1, 2, 3, 4, 6, 7, 8, 9, 11	V
GP	1, 2, 3, 4, 5, 6, 11	V
SI	1, 5, 6, 8, 9, 11	II
PV	1, 2, 4, 5, 6, 7, 8, 11	V
PE	1, 2, 3, 6, 7, 10	V
AR	1, 2, 4, 5, 6, 8, 9, 10	V
PEoU	1, 2, 4, 5, 6, 7, 8, 9	V
EH	1, 2, 6, 7, 8, 10, 11	IV
BI	1, 4, 7, 9, 11	I

Table 5.
Level of variables

Based on the level of variables and the reachability set a conceptually validated model is evolved which shows the relationship among all the variables. This model is shown in Figure 1.

4.4 MICMAC analysis

It analyzes the driving power and the dependence of the variables. Table 4 indicates the dependence and driving power respectively by an entry of 1 along the columns and rows. The variables are divided into four clusters forming the driving power-dependence diagram as depicted in Figure 2.

The first cluster represents autonomous variables with low driving power and low dependence. These variables are separated from the system. This cluster does not have any variable. The second cluster comprises of dependent variables that are weak in driving power but have strong dependence. Presence of BI in this cluster shows that this variable has high dependence. The third cluster contains linkage variables with strong driving power and

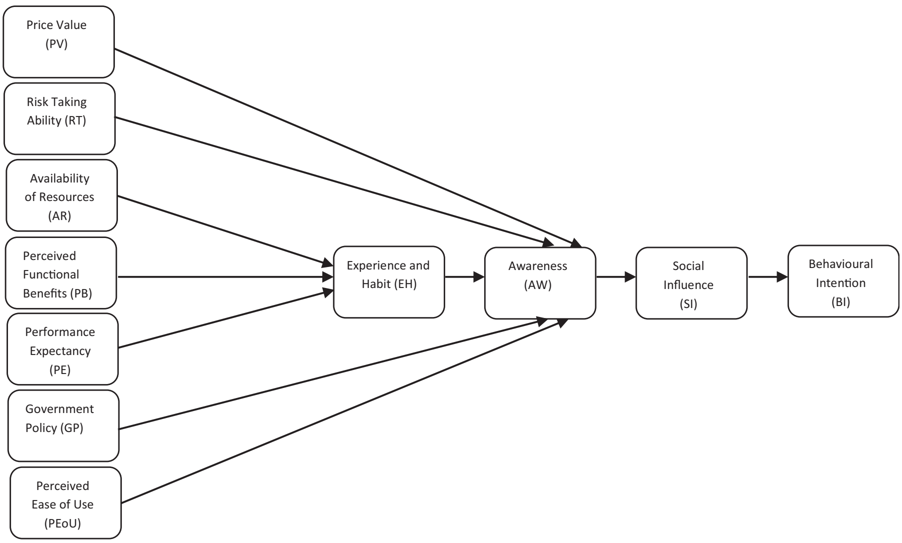
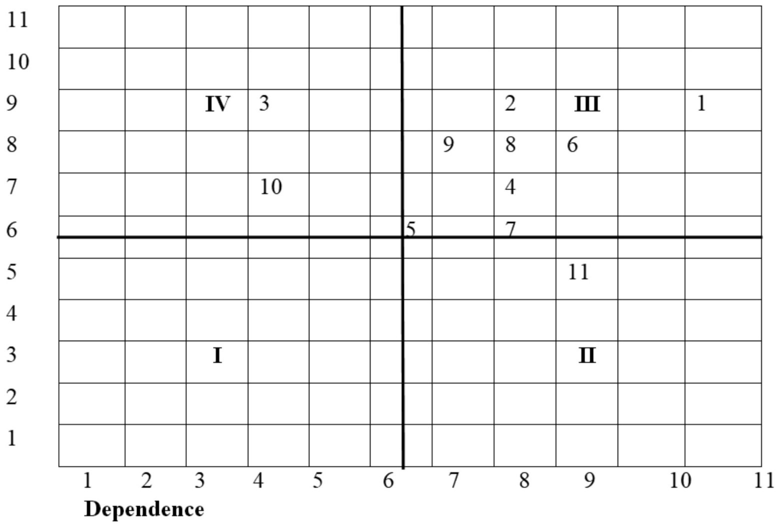


Figure 1.
Model for the adoption solar energy in India



(Cluster classification—I: autonomous; II: dependent; III: linkage; IV: independent)

Figure 2. Driving power-dependence diagram

strong dependence. The fact that any action on these variables will impact others is unstable to these variables. The variables AW, PB, GP, SI, PV, PE, AR and PEoU can be found in this cluster. Fourth cluster comprises of the independent variables which have strong driving power but weak dependence. RT and EH are found in this cluster.

The absence of any variable in first cluster shows that no variable can be regarded as separated from the system as a whole and thus, all the variables considered influence the adoption of solar energy in India.

5. Discussion and recommendation

Adoption of solar energy in India is a significant area of research. This study identifies variables such as AW, PB, RT, GP, SI, PV, PE, AR, PEoU, EH and BI through literary examination that influence the use of solar energy in India. Relationship among these variables is established using the ISM. In this, it is found that BI is a dependent variable for all other variables. PB, RT, GP, PV, PE, AR and PEoU are the independent variables. EH, AW and SI are the intermediary variables. Based on this, a conceptually validated model is evolved, which is shown in Figure 1.

This model shows the relationship among all the variables which influence the adoption of solar energy in India. This model shows that AR, PB and PE are the predictor of EH, which indicates that if resources are made available for the users and they understand the functional benefits of solar energy then their habits will also change. PV, RT, GP and PEoU are the predictor of AW. This shows that if price of the solar energy system is as per the paying capacity of users, and government policy is modified to develop the risk-taking ability of users, then awareness among the users will also change. EH is the predictor of AW, which shows that when users share their experience about the use of solar energy with others, awareness among others also increases. AW is the predictor of SI, which indicates that if users are getting awareness of the solar energy then it will give them social status. SI is the predictor of BI, which states that, to fulfil their social status, users change their behaviour to adopt solar energy.

Further, MICMAC Analysis is conducted to know the driving power and dependence of all the variables. Figure 2 shows that no autonomous variable is seen in driving power dependence diagram. This means that no variable is disconnected from the system and all the variables influence the adoption of solar energy in India. Based on the above findings, following are the recommendations:

5.1 Recommendation for the organisations/research institutions

(1) *Awareness:* It is recommended to make end users aware about the adoption of solar energy. Advertising, public relation, direct marketing and other promotional methods should be used in this process.

(2) *Perceived functional benefits:* Many users perceive that use of solar energy is expansive as compared to the traditional source of energy. Therefore, end users should be educated about the financial benefits in the use of solar energy.

(3) *Price value:* Organisations involved in developing the solar energy equipment should consider the price value. High price of the equipment will discourage the consumers in adoption of the solar energy equipment.

(4) *Performance expectancy:* Solar energy equipment should be designed with the objective to give the high performance as compared with the existing source of energy.

(5) *Availability of resources:* Solar energy equipment should be easily available for the consumers. Further the organizations should provide the aftersales service to the consumers.

(6) *Perceived ease of use:* Solar energy should be designed in such a way that it provides the ease in using the system and it should be user friendly.

5.2 Recommendations for the government

(1) *Risk-taking ability:* Users feel that a lot of risk is involved in the adoption of a new technology. They have the fear of failure of the equipment used in the process of solar energy. Government should take initiative to safeguard the interest of the end users.

(2) *Government policies:* Government should develop a policy that allows greater support for the use of solar energy. The government should provide end users with financial and legal support for effective solar energy adoption.

5.3 Recommendations for the end users

(1) *Social influence:* Consumer purchasing habits are determined by the family, colleagues, employees, opinion leaders and the social interactions. Consumers should be conscious in taking the decision regarding the adoption of solar energy.

(2) *Experience and habit:* New experience of using solar energy should be given to the End users. End users should develop the habit for use of solar energy.

6. Conclusion

Adoption of solar energy plays a vital role in the development of India. In this research variables are identified which influence the adoption of solar energy in India. ISM is used to determine relationship among these variables influencing the adoption of solar energy in India. In this way a conceptually validated model is evolved which shows the relationship among the variables (Figure 1). In MICMAC analysis it is seen that no autonomous variable is there in driving power dependence diagram (Figure 2). This shows that all the variables influence the adoption of solar energy in India. The model evolved in this study can be further validated empirically.

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