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Stratification and policy implication

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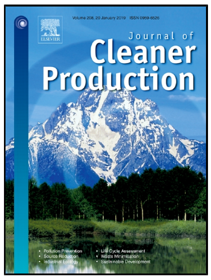

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A SOCIOCULTURAL STUDY ON SOLAR PHOTOVOLTAIC ENERGY SYSTEM IN INDIA: STRATIFICATION AND POLICY IMPLICATION

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Abstract

Cleaner production is a simple defensive mechanism to protect the environment from pollution and depletion of resources. It is also envisioned to minimise the waste and capitalise on natural resources with effective utilization. Solar energy is a natural resource which can be converted into electricity using photovoltaic (PV) system. This article sheds insights on the implementation of solar PV system with interdisciplinary views and analyse motives and barriers for PV adoption by different citizen groups in India. A survey was conducted to understand the people's perception on solar PV energy system and to determine the level of acceptability among the citizens. The survey information was synthesised and consolidated from various perspectives and the result consigns the research findings into technical, human and socio-economic components. The findings were synthesised through cross-cultural, comparative and mixed-method research outcomes by means of Structural Equation Modelling (SEM), Dendrogram diagram and biplot interpretation. Statistical tools such as 'IBM-SPSS Amos' and 'R' language programming were also used to interpret the results. This article concludes by specifying the barriers that limit the retrofitting interventions, suggests possible measures and policies to overcome such barriers and promote solar energy in India.

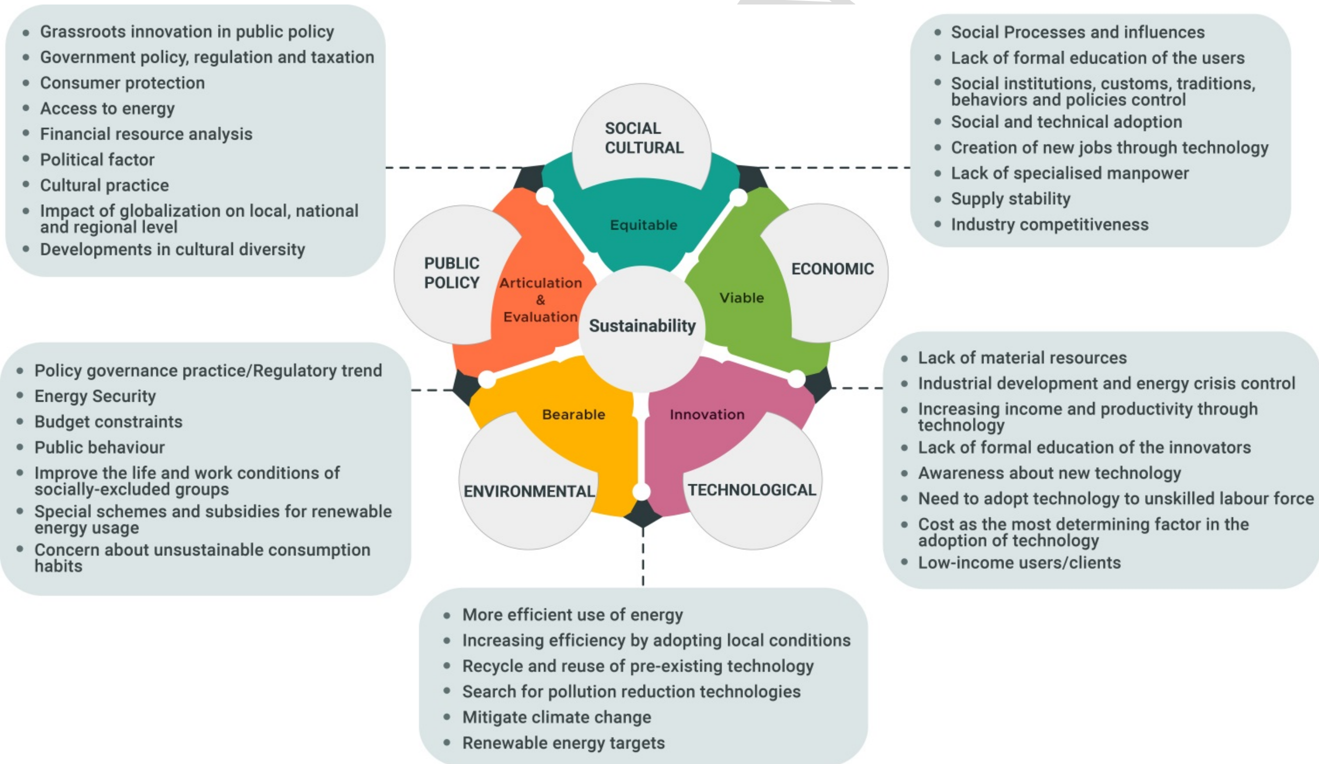
Keywords: Solar Photovoltaic (PV); Energy Policy; Structural Equation Modelling; Dendrogram graph; Biplot interpretation; Socio-Technical regime.

1. Introduction

Solar energy is one of the key energy resources in India. The predicted solar power potential in India is approximately 748 GW, as estimated by the Ministry of New and Renewable Energy (MNRE). A number of initiatives are being taken across the globe to reap solar photovoltaic (PV) energy and India itself has targeted to generate 100 GW by 2022. For this mission to be successful, interdisciplinary studies considering sciences, engineering, social, cultural, economic and environmental aspects are essential.

According to various researchers, consumer behaviour is an unpredictable and complex issue which is decided by a number of correlated, cognitive, affective and conative components that idolises the human attitude (P.A. Ertmer,1993; Chu, 2011; Shareef et al., 2017). The current study focuses on ways such as perception, behavioural intentions, and attitude, perform empirical studies about consumer beliefs and develop conceptual paradigms for investigating solar PV energy technology adoption by the Indian society.

Figure 1 describes a complex range of ideas and meanings of sustainability that has been simplified by self with partial adoption from Adams, W.M. (2006), Pansera, M et.al (2016) and Marteel-Parrish et al. (2017). Figure 1 provides an integrated method considering major influencing elements on social, economical, technical, environmental and public policy.



Source: Padmanathan K *et.al (2018)*

Fig. 1. Cohesive elements for sustainability

The conversion of electricity from solar PV system is a matured technology, both technically and commercially. Although the installation of solar PV systems at present is relatively small compared to total global electricity generation, a review of the existing solar electricity markets has stated that the rate of installation of solar PV systems all over the world is increasing at an average annual rate of 40 percent (Gaëtan Masson et al., 2017). However, India has not attained a satisfying growth due to numerous complexities. Sonal Punia Sindhu et.al (2016) had discussed the existing challenges in the growth of solar energy and identified political and regulatory barriers as the predominant factors using Analytical Hierarchy Process (AHP). A total of thirty-six barriers were identified as obstacles in the development of solar energy. Therefore, it is deemed that the analysis of solar PV requires the examination of technology and economics to cover human and social elements. Jincy Joy et.al (2015), with the team of World Wildlife Fund for Nature (WWF), performed a survey to examine the awareness of people regarding all types of renewable energy in India. The research concluded that 'solar water heater' has the highest applicability (21.98 percent) followed by 'solar lantern' with 17.98 percent applicability. Also, it was revealed that 9.9 percent of the people use solar-based lighting system in their home, while 9.32 percent use other solar stand-alone systems for purposes such as periphery lighting, garden lighting and solar street lighting. Further, 8.99 percent utilise solar cookers and 6.10 percent utilise solar photovoltaic for the production of electricity.

Subhojit Dawnn et.al (2016) conducted an analysis of solar energy development in India and the recent trends in the Indian market based on strategies, perspectives and future goals. The research concluded that India is forecasted to have a total power demand of 400 GW by the end of the year 2020. Furthermore, India will require enormous addition in electrical generation capacity to meet the requirements and maintain the progress in the market economy. Manish Kumar Hairat et.al (2017) critically reviewed solar energy developmental conduit to attain 100 GW of energy from solar in India by 2022. However, no specific target was proposed for various Indian states to accomplish the target. There is a variance raised between the reality and government's approach such as the availability of infrastructure, deficient transmission facilities and solar energy potential in various states.

This paper aims to address the technical fitness of solar energy to participatory planning for India via a comprehensive literature review of energy policy and strategies. The authors have conducted a field survey in the Indian context, considering a sample of 21 questionnaires based on the aforementioned points. In a similar manner, the authors have participated in seminars, exhibition, workshops and conferences that are associated with solar energy conducted by the Federation of India Chamber of Commerce & Industry (FICCI), Confederation of Indian industry (CII), and met global investors from different states of the nation. In addition, the authors organised and conducted three awareness seminars for the development of solar energy in India. The information collected from the survey has been analyzed and synthesised on the social dissimilarity issue from a broad theoretical and methodological perspective using statistical methods.

2. Methodology and conceptual framework

This interdisciplinary study focuses on creating sustainable development for solar PV system. In order to create a conceptual framework and to overcome the practical limitations, a robust approach is followed in the current research. The research agenda and framework, illustrated in figure 2, provides a novel sustainable research model for solar PV energy conversion with specific reference to India. This model links transformation and its associated organizational activities. Through innovating new research models, one can re-conceptualise the purpose of the energy sector, value creating logic and reanalyze the value perceptions.

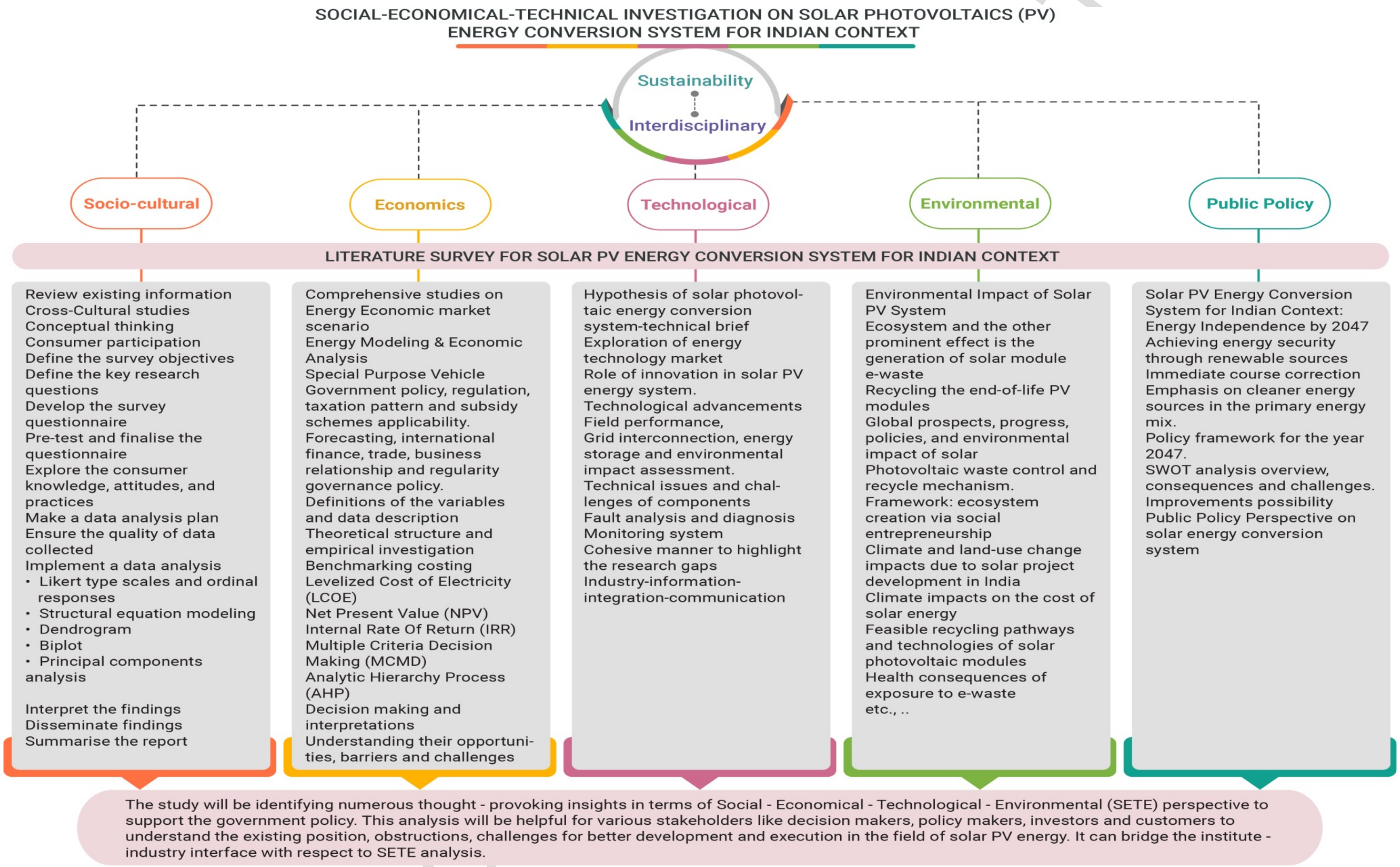
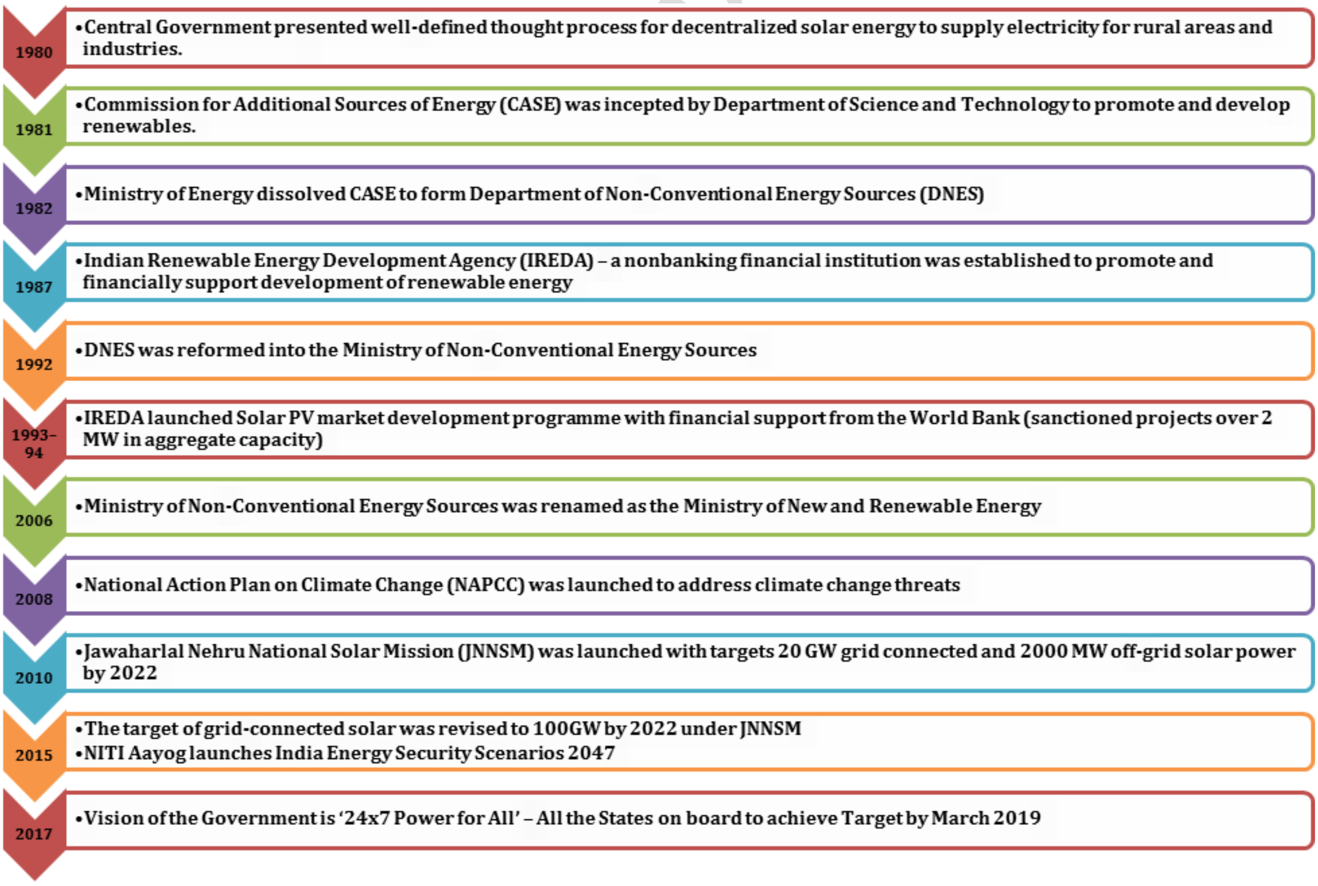


Fig. 2. Methodology and conceptual framework

In the current research paper, the people's insights and socio-cultural divergence upon solar PV energy system is discussed. Padmanathan K et al (2017) performed an economic analysis on solar PV system with respect to performance in Indian market. Subsequently, Padmanathan K (2018) detailed the technical issues and challenges involved in components associated with the generation of energy through solar PV plants. In future, further investigations regarding the environmental impact assessment of solar module waste and other e-wastes generated via solar power plants will be performed. The research aimed to develop a policy framework on the basis of SWOT analysis (Strengths, Weaknesses, Opportunities, Threats) from public policy perspective on solar energy conversion system in Indian Context.

3. Solar Energy in India and planning strategy for policy

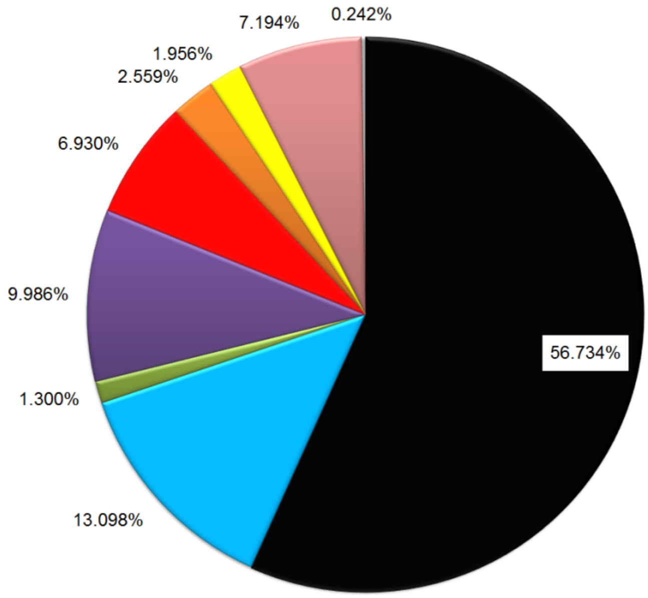
Prabhakar Yadav et al (2018) cited that Jawaharlal Nehru National Solar Mission (JNNSM), India has already set an initial goal of 20 GW for the year 2022. This has been achieved four years before the target year. Through this achievement, it is visible that the government is marching towards 100 GW production i.e., new target within the year 2022. The milestones fixed by India are detailed in figure 3.



Courtesy: Prabhakar Yadav et al., 2018

Fig.3 Key indicators of solar energy milestones in India

With wide exposure to natural sunshine throughout the year, some Indian states such as Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Tamil Nadu, Telangana and Rajasthan can efficiently tap the solar energy to meet its energy requirements. To be precise, Indian landmass harvest 4.8 - 6.5 kWh/m2/day as energy yield efficiency, whereas the Capacity Utilisation Factor (CUF) is 17 - 23% for the conversion of solar PV into electricity (MNRE). For various Indian regions, the Global Horizontal Irradiance (GHI) solar resource, a map published by the National Renewable Energy Laboratory (NREL) and MNRE is used to assess the potential source of solar energy. As of 30th November 2018, the installed capacity of National Grid of Indian utility electricity sector was 346.05 GW in which close to 33.60% was contributed by renewable power plants (Central Electricity Authority (CEA)). According to figure 4, the installed generation capacity by different types in India and the installed solar power capacity was 24 GW. This denotes the fact that more capacity need to be added i.e., approximately 76 GW of solar energy to be generated before 2022 to attain the ambition.



Type of Generation	MW	%
Coal	196652.5	56.73439
Large Hydro	45399.42	13.09777
Small Hydro	4506.95	1.300258
Wind Power	34615.1	9.986481
Solar Power	24021.66	6.930266
Biomass	8869.1	2.558742
Nuclear	6780	1.956035
Gas	24937.22	7.194406
Diesel	837.63	0.241657
Total	**346619.6**	

Source: Central Electricity Authority

Fig.4 Summary of India's installed capacity of generation as on 30th November 2018

Figure 5 deduces the connections of the sustainable policy roadmap in India. The hierarchy of policies and foundation to guide the Indian government for renewable energy and sustainable policy structure is exhibited by MNRE.

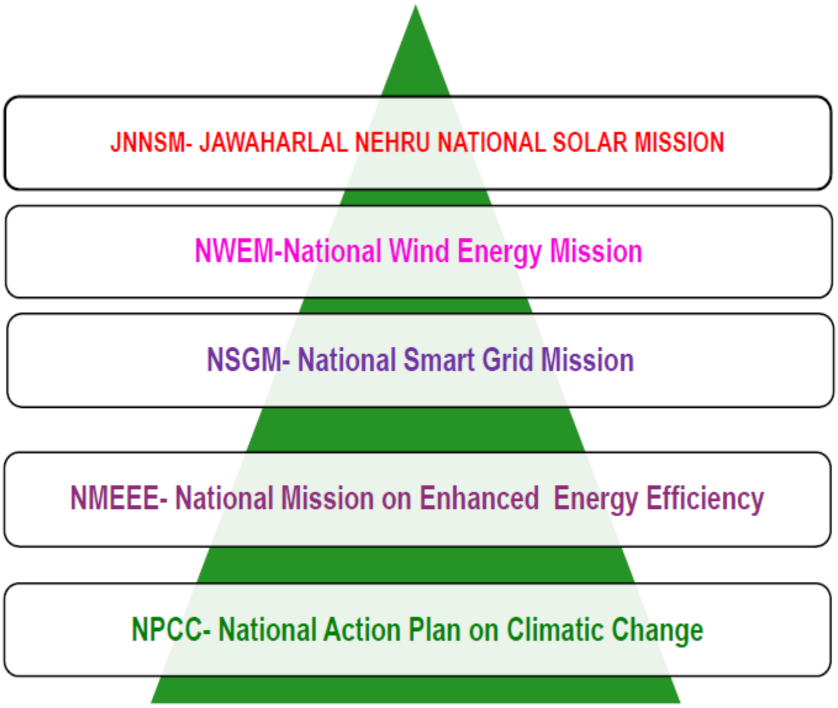
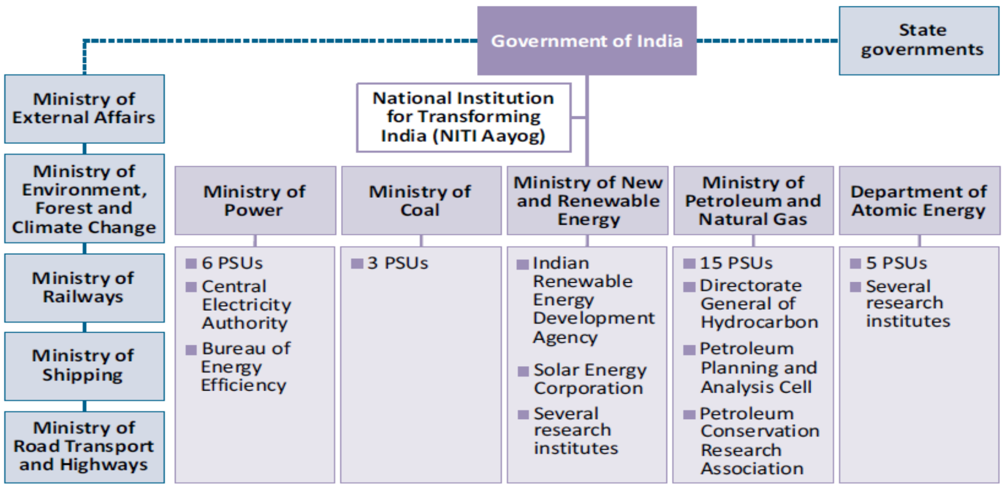


Fig.5. Policy frameworks and road map in India

A large range of state and national level schemes have been announced so as to support the objective of 100 GW by the year 2022. As electricity is a responsibility that should be shared between state and federal authorities, the commitment should be towards prospective growth in the development of solar power projects. Figure 6 illustrates the planning authorities involved in framing solar policies and the hierarchy of authoritative institutions in India, to guide the Indian government on energy policies (IEA 2012).



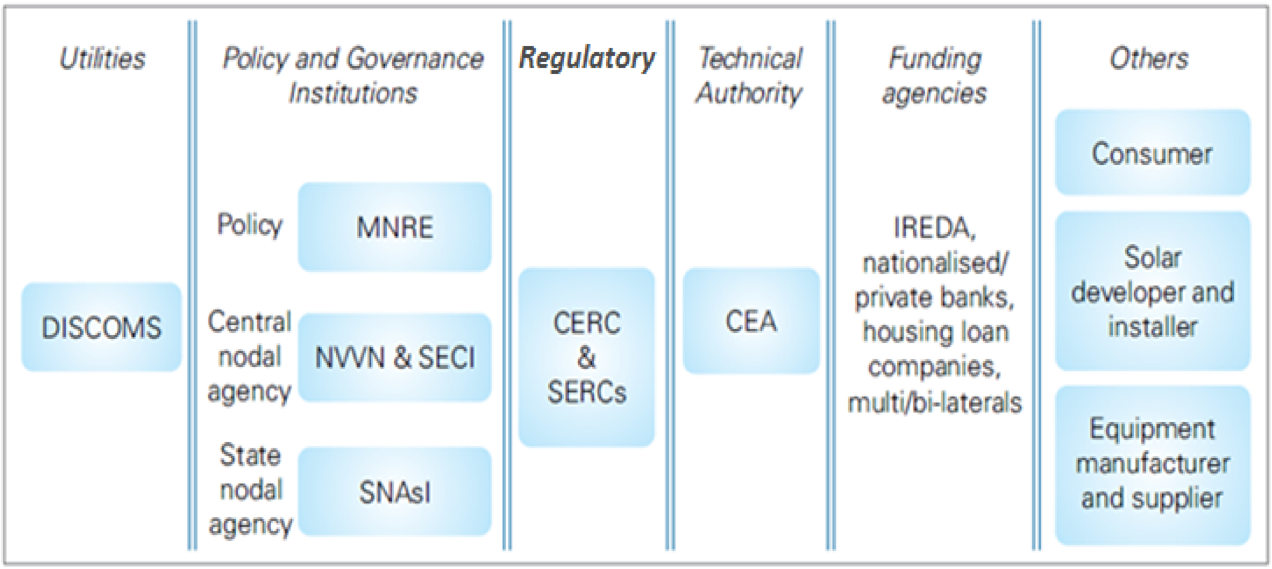
Notes: PSU = Public sector undertaking (state-owned enterprise). Other ministries with responsibilities relevant to the energy sector include the Ministry of Urban Development, Ministry of Water Resources, Ministry of Agriculture, Ministry of Finance and the Department of Science and Technology.

Source: Adapted from (IEA, 2012).

Courtesy: India Energy Outlook, World Energy Outlook Special Report 2015. OECD/IEA, 2015.

Fig. 6. Main institutions in India to influence on energy policy.

A rooftop solar PV financing study was conducted by Nitin Sukh et.al (2016). The information related to solar energy cost, technology and current scenario of the market can be inferred from this study. Figure 7 demonstrates the acquaintances of electricity bodies from authorities, agencies, regulatory bodies, manufacturers, project developers and end users (Nitin Sukh et al., 2016).



DISCOM: Ujwal DISCOM Assurance Yojana (UDAY) is the financial turnaround and revival package for electricity distribution companies of India (DISCOMs) initiated by the Government of India.
MNRE: Ministry of New and Renewable Energy; **NVVN** :NTPC Vidyut Vyapar Nigam Limited (NVVN) under National Solar Mission; **SECI**: Solar Energy Corporation of India; **SNAsI**: State Nodal Agency for renewable energy;
CERC: Central Electricity Regulatory Commission; **SERCs**: State Electricity Regulatory Commission;
CEA: Central Electricity Authority of India; **IREDA** :Indian Renewable Energy Development Agency Limited.

Courtesy: YES BANK.

Fig. 7. Institutional Structure – Stakeholder mapping and governing body of electricity in India.

4. Scientific-integrated approach on Socio-Economic-Technical regime

This study aims to address the challenges related to implementing and practicing solar PV energy utilization from the perspectives of socio-economics, technology, sustainable development and government policies. A detailed literature survey has been made to explore the suitability of solar energy systems by applying scientific knowledge, government policies, resource efficiency, circular economy, life cycle assessment and absolute decoupling method. In 1989, Whetten, D. A. noted down a connection present between the mandatory theory-development contribution which is summarised herewith. Table 1 summarised various pertinent literature of PEST analysis (political, economic, socio-cultural and technological) in the global arena and the specific interest for solar energy development in India.

Table 1: Summary of work related to socio-economic-technical regime

Authors	Coverage area	Objective and outcome
N.M.P. Bocken et al., 2014	Sustainable business model archetypes.	This study introduced sustainable business models so as to build a business model that covers all the mechanisms and provide solutions within the range of sustainability. CSR activites and eco-sustainability practices are getting increased attention nowadays. The model proposed is classified into higher order groupings which portray the prominent business model innovation: Technological, Social, and Organisational oriented innovations.
Kates, R.W et al., 2005; Kuhlman, T et al., 2010; Finkbeiner, M et al., 2010	Sustainability	Sustainable development can be visualised as a social movement "a group of people with a common ideology who try together to achieve certain general goals."
Geraldo Cardoso de Oliveira Neto et al., 2018	Strong sustainability	The study was aimed at enhancing the Strong Sustainability (SS) framework with specific actions and recommendations so that it can be adopted in companies. Such actions identified can be utilised in multi-criteria analysis and in the development of sustainability indicators. The study's positive contributions were, making the organizations increase their efficiency in terms of energy & resource consumption, replacement of non-renewable sources with renewable sources, affordability and sustainable manufacturing.
Pansera, M et al., 2016	Sustainable Development	The article provides novel concepts that works best for entrepreneurs
Benjamin K. Sovacool etal., 2012	Socio-Political	This case study discusses about the different aspects in renewable electricity and compare and suggest the ways how India and US can collaboratively work towards the acceptance of market and create a pathway for solar PV installations as in Germany and Denmark.
Akanksha Chaurey et al., 2012	Energy Business	The study evaluated the role of partnership innovations and business models in order to improve energy access among rural communities
Jenny Palm et al 2010	Engineering and Social Science	Hybrid approach was proposed in this study combining social science and engineering towards efficient industrial energy and for better framing of energy policies
Benjamin K. Sovacool 2013	Pro-poor public private sector for renewable energy	Eight global case studies were evaluated in which the public private partnerships for pro-poor to those who needed were investigated. The Solar Lantern Project in India clearly demonstrated the strength of PPP (Public-Private Partnership)
Benjamin K. Sovacool et al., 2011	Socio-Technical	The study explored the challenges in socio-technical hindrances towards Solar Home Systems (SHS) installation.
NITI Aayog Government of India 2013	Policy	The government entity assessed several attributes which are preventing from achieving the goal of 175 GW through the utilisation of Renewable Energy (RE).
Andreas Goldthau et.al., 2012 and Benjamin K.	Policy	Examined the four dimensions of disputes within all the fields of policy that exhibit energy externalities in global scale. These dimensions examine the differences in the structural

Authors	Coverage area	Objective and outcome
Sovacool 2013		characteristics which imply governance against three major challenges such as energy injustice, energy security and transition of low carbon systemic energy
Benjamin K. Sovacool 2014	Social Science and energy	Examined the social science to develop the renewable energy and energy system.
Komali Yenneti 2016	Policy Economy Political	The temporal evolution of institutions and policies according to solar energy development and politics.
Arunabha Ghosh et al., 2014 and Anjali Jaiswal et al., 2014	India's policy Employment in Solar Sectors	The paper discusses employment opportunities in solar energy sector in which the former experienced a tremendous increase in recent years.
Nishant Rohankar et al., 2016	Schemes Policy	The review summarised different policies, frameworks and schemes putforth for solar energy systems such as Renewable Purchase Obligation (RPO), Renewable Energy Certificates (REC), Feed-in-Tariff (FiT), long term Power Purchase Agreements (PPAs), and Accelerated Depreciation (AD) benefit, Viability gap funding, Tax benefits, Clean Energy Cess, Generation Based Incentives and reverse bidding/auctions and so on.
Maximilian Engelken et al., 2016	Business models	Conducted a review to compare the drivers, opportunities and hindrances of renewable energy business models
Kajsa Ellegård et al., 2015	Policy, household energy	The study evaluated the problems associated with individual and household while policy framingwith an aim to reduce the use of household energy.
Daniel Nugent et.al 2014	Lifecycle Emissions	The paper analyzed 150 lifecycle studies and found 41 relevant assessments so that greenhouse gas (GHG) emissions profile dynamics could be assessed.
Benjamin K. Sovacool et.al 2014	Policy	Examined the challenges of security with specific systems of energy and technologies competing policy packages and energy security complexity
Frank W. Geels 2010	Socio-Technical transitions	Examined the socio-technical transitions to sustainability wherein a multi-level perspective study was conducted to develop reflexivity in transition debates with regard to social theories
Benjamin K.Sovacool 2011	Energy Security and Policy	The energy security in the Asia Pacific to assess how equitably affordable, available, efficient, reliable, and environmentally benign services of energy could be provided is a policy challenge and technology.
Ranajoy Bhattacharyya et.al 2017	Subsidy removal electricity pricing	The study found that food inflation increased due to subsidy removal for electricity pricing in India which indirectly affects incomes of rural households.
Benjamin K.Sovacool 2008	Economic Political social	Revealed that sheer difficulty with the promotion of renewable energy is not economic; but political, social cultural and social conduit.

Authors	Coverage area	Objective and outcome
Rasmus Luthander et.al 2015	Subsidies	The study reviewed the increased PV energy generation in buildings due to the reduction in PV electricity subsidies and increase in self-consumption of PV energy.
Jenny Palm et.al 2010	Energy policy	Public–private break up behaviour in households with relation to energy policy and how such a discourse restricts energy consultants from reaching their full capabilities
Jayanta Deb Mondol et.al 2006 and 2009	Technical economic	Optimal sizing of array and inverter for grid-connected photovoltaic systems. The optimization of the grid-connected PV systems towards economic viability.
Jayanta Deb Mondol et.al (2006)	Technology, & Important components	In this study, solar energy systems are integrated to have different techno-economical strategy frameworks that encompasses all parameters and analyses under single figure.
G. Notton et.al 2010	Performance analysis	Optimised the sizing of a grid-connected PV system using a different PV module technologies and inclinations, inverter efficiency characteristics and locations.
Padmavathi et.al 2013	Performance analysis	The study analyzed the monitored data for a 3 MW grid connected SPV plant for the daily and seasonal variations at five-minute regular intervals
Afshin Samadi 2014	PV modelling	In this study conducted by the large scale solar power integration in distribution grids PV modelling, voltage support and aggregation studies were explored in a detailed and excellent manner.
http://www.cercind.gov.in/ www.ezysolare.com	Regulations Cost Policy	Provides guidance on the Central Electricity Regulatory Commission Amendment Regulations 2017 and the benchmark of capital cost and detailed breakup for solar power plant .
Seth B. Darling et al., 2011 Ferruccio Ferroni et al., 2016	Costing Model	Discussed energy production costing such as Levelised Cost of Energy (LCOE), Energy Return on Energy Invested (ERoEI) concepts and examined for photovoltaic sources and the basis of solar generation in moderate insolation regions
www.bijlibachao.com 2017	Electricity Tariff	Electricity Tariff of different slabs per unit (kWh) cost is presented for residential market of all states in India up to 2017.
Burns et al., 2008	Marketing Research	Essential marketing research methods are detailed.
Christopher D et.al.,1999	Basics of statistical	Fundamentals of statistical are detailed.
Yingfeng Zhang et al., 2017	Big data analytics	The study results can help when there are complex assessments present in cleaner production practices in the data analytics architecture. The solution suggested in this study can be employed for better decision-making, optimization and product lifecycle management.
Yang Liu et al., 2018	Construct	This study primarily concentrates on resource and structural factors for investigating the

Authors	Coverage area	Objective and outcome
	measurement and confirmatory factor analysis results.	relationship that exist between innovation capability and organizational improvisation though the latter factor is less investigated in terms of how organizations benefit from it. The study fills the gap with the help of organizational learning perspective which details the role played by organizational structure and organizational resources in innovation and enhancement.
Boris Mrkajic 2017	Framework of business incubation models	A conceptual framework is proposed in this study containing business incubation models based on qualitative approach i.e., as per the case study analysis of five case studies of business incubators.
Delu Wang et al., 2018	Political ties and managerial cognitive biases	In this study, political ties and managerial cognitive biases especially overconfidence is identified as the threat to R&D processes and outcomes. Further the study also explored how these factors influenced R & D intensity in an emerging market context.
Daniel Jugend et al., 2018	Relationships among open innovation	The study investigated the relationships among innovative performance, govt. support for innovation and open innovation. For a radical innovation to occur, synergy and focus are important. This study is the first of its kind to have tested various models of samples with different levels of radicalism in innovation. Since the study was conducted only upon Brazilian firms, sampling was one of the two limitations whereas the other one is risk of bias since data was collected from every firm's respondents. Theoretically, the choice of constructs is an disadvantage.
Yudi Fernando et al., 2018	Energy management practices on renewable energy supply chains	The study was aimed at understanding the impact of energy management policies upon renewable energy supply chains especially in emerging economies. The study has an absolute energy supply chain flow with five key stakeholder groups for assessment of RE barriers
Charbel Jose´Chiappetta Jabbour et al., 2008	HR aspects on environmental management	The study focuses on HR aspects in a company's environmental management process. The proposed model collaborates and analyses the relationship between HR aspects and environmental management and how the latter is presented before academicians and managers.
Sapan Thapar et al., 2018	Solar auctions in India: key determinants	In this review about Indian solar auctions, different determinants for state-specific constructs and other centre-specific schemes were discussed. Among the determinants, the strongest factors are solar targets, credentials of the utilities and the level of bid subscription. In parallel, the key drivers behind federal bids are cost of funds, module price, solar potential. In this study, possible mechanisms which enhance the bid efficacy were discussed and one of which is tenders to be issued with spatial and temporal considerations in addition to empowering the regulators so as to assure solar RPO compliance. Off-taker risk can be precluded when multiple set of consumers and provision of risk guarantee funds are tied. Green bonds and yield-cost can

Authors	Coverage area	Objective and outcome
		however reduce the cost whereas investors can be provided with list of viable solar proposals as in oil and gas markets.
Clark A. Miller et al., 2013	Social Dimensions of Energy Transitions	Energy debates must be conducted with 360° insights about the current, future requirements of the planet. Energy systems involve both human beings and technology while the latter is designed by the former to develop and consume energy through different ways. It also includes a prism of components that assure its proper functioning.
Aniruddh Mohan et al., 2018	India's energy future: Contested narratives of change	India's energy future lies in the empirical analysis of the dominant narratives. Top-down approach is primarily followed in our country's energy policymaking. This article calls for new arenas that focus on socio-cultural dimensions of future energy requirements. Energy transitions result in drastic social change and social dimensions of such large scale changes require greater exposure especially from researchers in developing countries.
Rakesh Kumar Tarai et al., 2018	Solar PV policy framework of Indian States	This study provided an overview of current Indian solar scenario with its own complications, imprecisions in state solar policies and recommendations to enhance it. The study suggested for indigenous solar policies for every state that leverage the unused lands for solar plant installation. It further highlighted that plotting rasterised maps could help in analyzing the solar potential of the state with more details.
B. Baldassarre et al., 2017	Sustainable business innovation	This research paper suggests the development of sustainable business model with innovation that empowers all the stakeholders such as customers, shareholders, suppliers, partners and the society. User-specific findings lead to meaningful outcomes that benefit customers, users and various other stakeholders in an experimental and iterative design process.
J. Christopher Westland 2015 Wuensch et al., 2009 Carifio, James et al., 2007	Likert Scale	Fundamentals of Likert Scale are detailed. General misunderstanding, misconception, myths and legends about Likert Scales are discussed.
Timothy Teo et al., 2009	SEM	Fundamentals of Structural Equation Modeling (SEM) are detailed.
Hans-Hermann Bock 2004 William H D et al., 1984 S.D. Lang et al., 1999 Denise Earle 2015	Dendrogram Hierarchical Clustering	Fundamentals of Dendrogram and hierarchical clustering are detailed. Efficient algorithms for agglomerative hierarchical clustering methods.

Authors	Coverage area	Objective and outcome
Huan Liu, Motoda et al.,1998 René Vidal et al., 2016 George Henry Dunteman 1989	Principal component analysis	Feature selection, principal component analysis and Kernel principal component analysis are in detailed.
John C. Gower 2010 Michael J et al., 1995	Biplots	Feature selection analysis associated by means of biplots and its interpretation
Isabel Gallego-Álvarez et al., 2013	Analysis of environmental issues worldwide using biplot	The study proposed an innovative statistical technique to analyse the environmental performance of the countries by analyzing its efforts and as per its geographical presence. Biplot is used which is a graphical representation of multivariate data, combining individuals and variables relating to two sets of environmental indicators included in the Environmental Performance Index. The results inferred five separate groups with clear differences between them (Europe, Africa, South America, Asia, North America) of which Africa has significant features that make it different from the remaining areas concerning climate change.
Sourabh Jain et al., 2018	Challenges and opportunity for Solar Energy sectors	The authors developed an energetic flow model that simulates the inputs and outputs of electricity generated from PV system from 2016-2050. The results were positive i.e., large PV systems can be built within 2050 though there needs to be a sacrifice i.e., short term electricity shortage due to substantial electricity investment from existing electricity supply. In this approach, short-term sufferings can lead to bigger picture i.e., surplus electricity in future though this is socially and politically challenging.
Jouni Korhonen et al., 2018	Circular Economy essentially contested concept	Circular Economy (CE), the most popular among policy and business advocacy, is still naïve. Existing investigations on CE were mostly conducted on practical and technical levels of the actual physical flows of materials and energy in production consumption systems. So, the basic assumptions regarding the culture, values, societal structures, underlying world-views and the paradigmatic potential of CE are left untouched still.
Julian Kirchherr et al., 2018	Conceptualizing the circular economy: An analysis of 114 definitions	This paper critically analyzed different CE conceptualizations. Being a practitioner-friendly analysis detailing how barriers were overcome, the future aspects suggested in this study is inclusive of consumer perspective, the most neglected one. For example, more research on the consumer perspective could help in highlighting the pathways to enhance their contribution to CE. Future research on CE must focus on conceptualization of CE to foster cumulative knowledge development on this topic.

Authors	Coverage area	Objective and outcome
Sonal Sindhu et al., 2017	Sustainable future of India: Hybrid SWOC-AHP analysis	The study aimed at conducting the SWOC analysis of solar energy deployment in India. AHP technique was used to understand the priority of SWOC variables in the deployment of solar energy. From the results, it was inferred that 'opportunity factor' was the dominant one denoting multitude of opportunities associated with solar energy. The weakness factor doesn't create any impact in this regard.
Robert A. Holland et al., 2018	Incorporating energy and ecosystem service scenarios. Exemplified as a "*dendrogram tree*"	The authors compared influential energy and ecosystem service scenarios across the domains where the circumstances exercises explore similar futures. However, this comparison met some challenges in terms of limited policy. Integration of ecosystem services lead to optimal routes towards decarbonisation. The recognition towards the importance of ecosystem services for human well-being is increasingly recognised in all scales.
EmrahKarakaya et al., 2015	Hurdles to the acceptance of PV systems	The study opined that adopting PV systems as a replacement is a challenging process. In terms of cost, PV system is still perceived as luxury whereas in socio-economical perspectives, the interaction between the PV systems and people hinder its adoption. Various policy-based barriers still exist in policy dimension and technology management. If the policy measures are ineffective and inappropriate, then the diffusion process becomes cumbersome.
Sonal Sindhu et al., 2017	Importance of social, technical, economic, environmental and political Studies. Feasibility study of solar farms deployment: AHP-TOPSIS analysis	This review paper analyzed the selection of solar farms and identified the research gap in it. The investigation (Socio-Economical-Technology-Environmental-Political) purpose is to develop an highly sophisticated framework that helps policy planners in the evaluation process as well as decision makers in analysis of problem segments. It uses hierarchical structure to present complex decision issue.
Sander van der Linden 2017	Social-Psychological Determinants, Perceptions, Intentions and Behaviours: A National Study	It is complex to understand the ever-changing human social life due to which a dynamic and flexible methodology is needed to model intricate behavioural systems. Cognitive engagement is imperative: If in case, the individuals do not understand the issue in a better way, any mitigation policy risks go ineffective or even rejected.
Milchram, C et al., 2018	Moral Values as	Ethics is a major concern in technology where moral values are utilised to generate statements

Authors	Coverage area	Objective and outcome
	Factors for Social Acceptance	about ethical and social consequences of technologies. Though there is no presence of defined 'moral values', it often refer to abstract principles and *"general convictions and beliefs that people should hold paramount if society is to be good"* .
Scott Victor Valentine et al., 2017	Energy policymaking and ideology & Ontological concept analysis	The article handles the connection between ideology and energy policymaking. In this article, social constructivism was compared to positivism, post-positivism, and relativism in lights of facts and policy implications. Application of this ontological construct in energy-related policy analysis is the primary outcome of the study. The study discusses in depth about the definition, interpretation, communication of energy problems and how energy polices are planned and implemented.
Hengky Latan et al., 2018	Analyzing the data using structural model and hypothesis	The authors analyzed the relationship between CEP (Corporate Environmental Performance) and CFP (Corporate Financial Performance). Reliable results were achieved and validated whereas the study's limitations were discussed in detail with future implications.
Akash Kumar Shukla	Barriers and policy challenges of BIPV development in India	Various policies, missions and targets are set by Indian govt to promote solar PV in large scale though there are major drawbacks such as less public participation and resistance to acceptance of technology.
Martin Geissdoerfer et al., 2017	Relationship between the Circular Economy and sustainability.	This study distinguishes sustainability and Circular Economy where the latter is defined as a regenerative system in which resource input and waste, emission, and energy leakage are mitigated by controlling material and energy loops. Through design, maintenance, repair, reuse, remanufacturing, refurbishing, and recycling, this can be kept under control. Sustainability is defined as the balanced integration of environmental resilience, social inclusiveness, and economic performance for the welfare of the generations ahead.
Proskuryakova. L, 2018	Energy security concepts	The article suggested to revise energy security concepts by integrating future technology considerations. Energy security concepts of old days were examined in this article which reveals the fact that it is of a International Relations-based policymaking. These concepts do not account for the latest technology changes while new developments can be found through forecasting of technology. Classical energy security concepts such as neoliberalism, constructivism, neorealism and international political economy are constructed on the basis of sufficiency. But with the decentralization of energy systems, advancement of renewables and smart grid, new environmental and climate challenges, the question behind the basic elements of energy security should be revamped.
Hengky Latan et al., 2018	Environmental	The authors targeted a combination of top management commitment, environmental uncertainty

Authors	Coverage area	Objective and outcome
	Strategy Top Management's Commitment (EMA)	and corporate environmental strategy with special attention towards the role of Environmental Management Accounting (EMA). The study results were reliable and valid fo all indicators. Based on SEM, the findings provided an in-depth understanding of how companies certified by ISO 14001 in Indonesia. Through the implementation of various activities using EMA tools, their environmental performance gets improved.
Prabhakar Yadav et al., 2018	Capital subsidy scheme to finance energy transition. solar home system	The study discussed the challenges faced by Solar Home System (SHS) deployment in India and other developing countries. The study discusses evolution, SHS business financing, development and its multi-level perspectives in rural areas development. Rural bank support off grid solar technologies for rural Below Poverty Line (BPL) households. The factors responsible for the slow/poor uptake of off-grid rooftop solar photovoltaic in poor rural and remote communities is still under investigation.
Abdul Moktadir et al., 2018	Corporate social responsibility (CSR)	Fuzzy Analytical Hierarchy Process (FAHP) was utilised to find and determine the drivers to CSR-based sourcing in Bangladesh footwear industry. 20 drivers, and some sub-drivers too, were identified for such footwear companies using which strategic planning would be done and decision-maker can enhance the CSR-based practices using these drivers. 'long-term economic benefits' achieved the top position under financial driver category denoting the fact that long-term economic benefits encourage industrial managers to adopt CSR-based sourcing in their business policy.
Vanesa Castán Brotoa et al., 2018	Energy transitions Energy justice Energy sovereignty	In the debate towards energy justice in postcolonial critiques, the underdeveloped countries' energy systems' nature and requirement need to be studied in depth from multiple perspectives and plan for the action which is practical and doable. Such challenge is associated with the pressing need to integrate ideas of justice in current energy policy.
Siddharth Sareen et al., 2018	Energy justice Sociotechnical transitions Multi-scalar solar energy	This study fulfills the gap between sociotechnical dynamics and justice aspects of sustainable energy transitions. The article discusses three brief case studies of multi-scalar solar uptake providing an overview of how justice considerations are intricately involved in the practices and politics of these sustainable energy transitions.
Abhishek Kumar et al., 2017	Multi criteria decision making (MCDM) towards sustainable	The role played by decision analysis is critical and various criteria/objectives are considered to perform such analysis. This is inclusive of disintegrated levels of electrification too. MCDM, operational research branch that finds optimal results in complex scenarios including conflicting objectives, various indicators and criteria. The study summarises the important aspects of MCDM

Authors	Coverage area	Objective and outcome
	renewable energy development	techniques; energy-based MCDM models and outlines various performance indicators that can be utilised to meet the core requirements to achieve the sustainability goal in developing nations especially at rural levels.
Md. Fahim Ansaria et al., 2013	Interpretive Structural Modeling (ISM) & MICMAC analysis	This study identified contextual relationships among the barriers for solar power implementation in India. In this study, ISM and MICMAC analysis were carried out to find the barriers and various ways were proposed to overcome such barriers.
Sunil Luthra et al., 2015	Sustainable valuation and Energy strategy	The paper provided excellent ideas and insights to plan and manage the sustainable energy generation in India
Sunil Luthra et al., 2016	Significant enablers	The research work recognised 16 key enablers for solar power implementation in India using fuzzy DEMATEL technique. Few policy measures and recommendation were suggested for Indian perspective.
Phil Marker et al., 2015	Solar Rooftop Policy	In January 2015, Solar Rooftop Policy Coalition was created so as to find policy-based solutions to support Indian govt's mission to scale up rooftop solar sector.
KPMG Report 2017	Rooftop Solar & Impact Utilities	There is a significant share occupied by Grid-connected rooftop solar photovoltaic (PV) in the global markets such as China, Italy, Germany, US, Japan when it comes to solar PV sector. Rooftop segment cumulatively contributed to 58% of global solar PV installation, which is an increase upto 40% globally.
Bridge To India Report 2017	Policy update	Indian solar capacity has 10-12% share from rooftop solar which is much less compared to US, Germany, China, Spain and Australia.

The consolidation of literature outcomes focuses on India's socio-technical interconnections with regards to the energy sector. Since energy plays a key role in the development of a nation and its social processes, it is highly challenging to understand and walk through the transformation from traditional energy sources to 'solar energy' utilization.

5. Survey strategy for modeling and assessment

The targeted participant in the survey was classified into 41 types which included educational institutions, hospitals, office complexes, industries, government organizations and individual households. However, the remaining target customer segment included the society of residents, commercial users, owners of shops, market places and malls. Twenty one questionnaires were used in these surveys which included incentive and policies, levels of awareness, platforms of knowledge, existing products and technologies, options for finance and cost, business models and technological innovations, and their solutions. These surveys further attempted to examine the important components related to solar energy such as reliability, acceptance, information access, knowledge gap existence, other finance and technology-based hindrances. Furthermore, the survey was also made for project developers, manufacturers, EPC companies and key solar market consultants. Emails and telephonic interaction were also used to target the manufacturers.

The analysis of the data collected requires evaluation from its grassroots. Hence, several approaches of significant modelling are necessary to address the increased complexities, risks, and uncertainties. The statistical analytical tools such as Structural Equation Modelling (SEM), Biplot Interpretation, Dendrogram Diagram and Principle Component Analysis were employed to analyze the data. These analyses were conducted with the aid of the IBM-SPSS Amos Statistics Software Package and R language programming.

6. Likert items and scales of measurement ordinal data

The data was collected from 4,579 individual respondents through personal interviews of which 443 respondents were solar PV energy users. The study also involved organizing three workshops and seminars on solar energy for 246 respondents. A number of telephone-based surveys along with data collection were also conducted.

Of the several methods reported in the literature (J. Christopher Westland 2015, Wuensch et al., 2009 Carifio, James et al., 2007), the Likert method was considered in this paper to understand the primary challenges and research interests of people perceptions. The perception among the consumers regarding the solar energy system forms the rationale of the research using which the Likert items and scales of measurement ordinal data for all the 41 categories with 21 questionnaires were formulated. The respondents (Y1-Y41) and questionnaires (X1-X21) were tabulated (refer Table 2 & Table 3). For example, in the Likert scale of 1-10, the average for questionnaire X1 (Social responsibility), collected from 34 respondents, belongs to Y1 (Architect) is 6.21. The same approach was deployed for the remaining questionnaires as well. Based on the number of respondents in each category, the average values were decided. So the study's overall validity and reliability outcomes were critically evaluated to demonstrate the average response from the respondents of (Y1 -Y41) for the questionnaires (X1 - X21). The graphical representation as shown in figure 7 is made based on the respondents and the questionnaires in Tables, 2 and 3. These outcomes are illustrated in figure 8 by means of colour palette, numerical scale and contour plot graphical technique which were used to characterise the people's perceptions to respective opinion poll. From the scale, the significance can be easily deduced and the scenario can be understood.

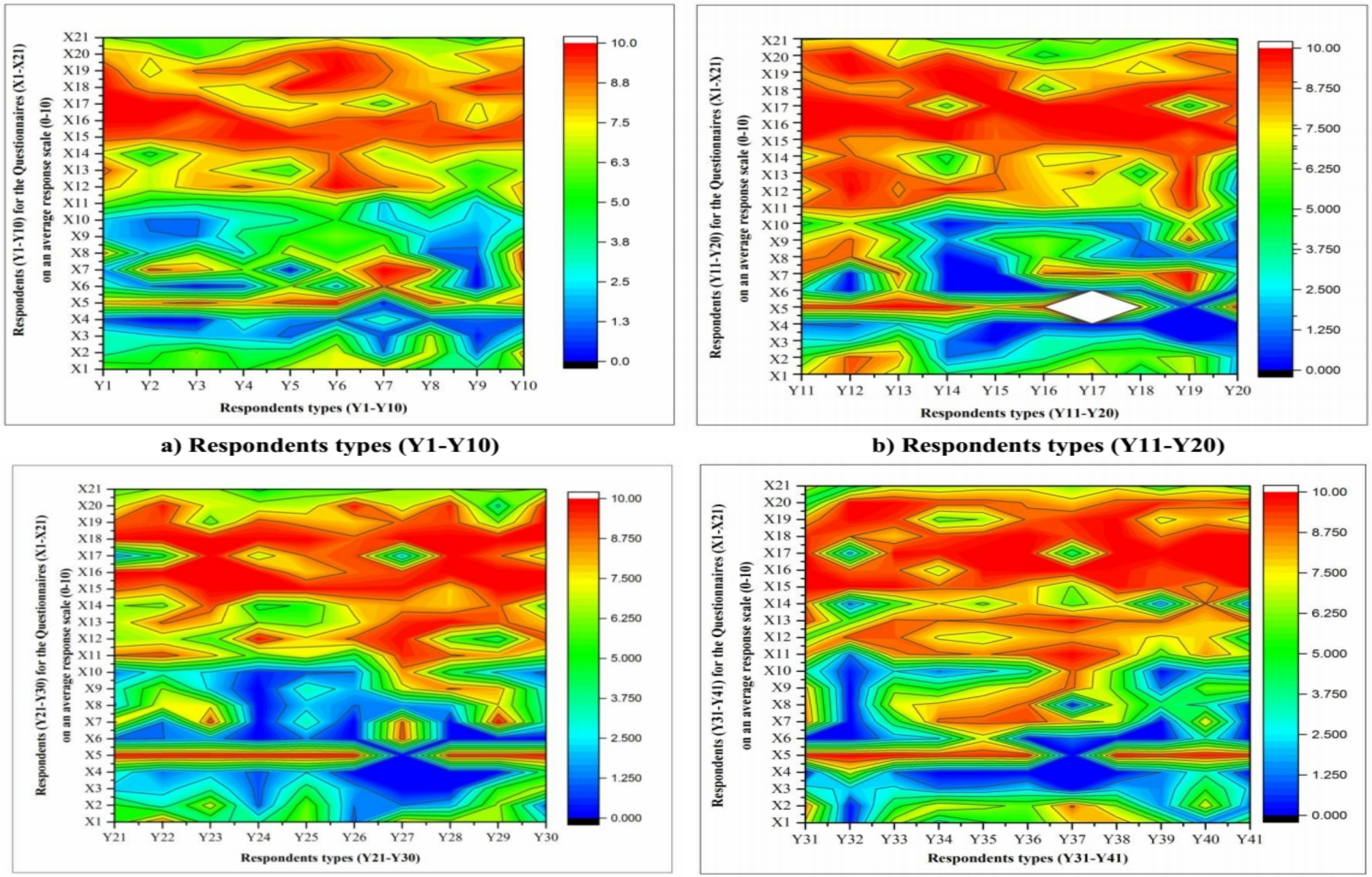
Table 2 : 41 categories of respondents (Y1 - Y41) and Number of respondents in each categories

Symbol Represent	No. of Respondents	Respondent's categories	Symbol Represent	Respondents' categories	No. of Respondents
Y1	34	Architect;	Y22	Non-Governmental Organization (NGOs)	107
Y2	61	Bank (Private/ Government);	Y23	Private Office Buildings ;	202
Y3	74	Bank Employees /Auditors;	Y24	Panchayat President (Community Grid Concept for Village);	64
Y4	82	Building Contractors;	Y25	Petrol/Diesel bunk ;	139
Y5	41	Church;	Y26	Politicians;	58
Y6	267	Colleges (Private/ Government);	Y27	Solar Project Developers (MW);	57
Y7	27	Corporate Social Responsibility(CSR) Support;	Y28	Researchers in solar sectors;	76
Y8	57	Dairy Farms/Cold Storage;	Y29	Residential and Apartments;	307
Y9	32	Dargah and mosque;	Y30	Residential (Individual) in Village ;	112
Y10	106	Doctors;	Y31	Residential (Individual) in Urban;	172
Y11	187	Engineers (Core);	Y32	Rural hut;	31
Y12	443	Existing solar PV Users;	Y33	Schools;	224
Y13	208	Factories/Manufacturing Company;	Y34	Shopping Malls/Complex;	38
Y14	73	Farmers/ Agriculture;	Y35	Software Companies & BPOs;	86
Y15	93	Government Buildings;	Y36	Software Engineers;	91
Y16	159	Government Employees;	Y37	Solar EPC Company;	198
Y17	82	Hospital;	Y38	Teachers/Professors;	183
Y18	49	Private Paying Guest (Hostels);	Y39	Temple;	54
Y19	38	Investors of solar project;	Y40	Warehouses;	39
Y20	65	Lawyers;	Y41	Youngsters	114
Y21	49	New Building Construction;	Total Number of Respondent/ Participant		4579

Table 3:Detailed description of questionnaires (X1 - X21)

Symbol Represent	Detailed description of Questions
X1	Are people installing solar power due to social responsibility?
X2	Are people choosing solar power to reduce the electricity cost and gain profit via net metering (Selling unused power to state electric boards)?
X3	Is solar power opted due to intense power breakdown?
X4	Is solar power chosen as an alternative for non-availability of power?

X5	Are people choosing solar power to avail the subsidy from the Government?
X6	Is solar power plant chosen to avail the Accelerated Depreciation Benefit from the organization / firm's view?
X7	Is solar power plant chosen for implementing individual tax benefits in the future?
X8	Is solar power plant chosen to display the status quo or initiator?
X9	Do the people have sufficient awareness on solar power plant?
X10	Are the people aware of the technical knowledge attributes in solar power plant?
X11	Do the people feel solar power plant as the reliable source of electricity in a longer run?
X12	Is sufficient space available to install Solar Power plant in their premises?
X13	Are people feeling that solar power plant may evolve in the course of time and may become easily available?
X14	Is the public ably guided on the solar power plant in detail and no hidden costs are levied on the customers after purchase?
X15	Is solar power plant an affordable choice for the people despite its high initial cost?
X16	Do people foresee Solar Energy product as the futuristic realm of non-conventional energy?
X17	How would you rate the Transmission availability in your locale / Power evacuation network development for Mega scale Projects?
X18	How would you rate the Government official's (Relevant to Solar sector) support in establishing the solar power plant?
X19	Apart from the space availability for the solar power plant Installation, are other factors viable for solar installation?
X20	Percentage of people who would be willing to purchase the Solar Power plant in near future.
X21	Are there any other solar appliance installed at customer premises?



a) Respondents types (Y1-Y10) **b) Respondents types (Y11-Y20)**

c) Respondents types (Y21-Y30) **d) Respondents types (Y31-Y41)**

Fig. 8. Demonstration of the average response from the respondents of (Y1-Y41) for the questionnaires (X1-X21).

7. Structural Equation Modelling (SEM)

Suhr, D., (2006) described Structural Equation Modeling (SEM) in detail and revealed relevant description for SEM. SEM estimates and tests a network of relationships among variables that consents for specification of relationships between variables, where as (e1, e2…..) represents the error associated with measured variable (X1, X2 …..).

SEM is adopted due to its ability to associate the relationship between unobserved constructs. Using IBM-SPSS-AMOS, the SEM was derived for the following three cases.

7.1 SEM Model I: (Analysis of Readiness to Purchase Solar PV system)

Using the data obtained from the Likert scale, a hypothetical model was constructed as shown in the figure 9, which was used to find the readiness to purchase solar PV energy system. The model is able to describe the interrelationship among the exogenous (independent X5, X11, X8 & X10) and endogenous (dependent X9 & X21) variables. Overall, all the variables were significant and this model was adopted.

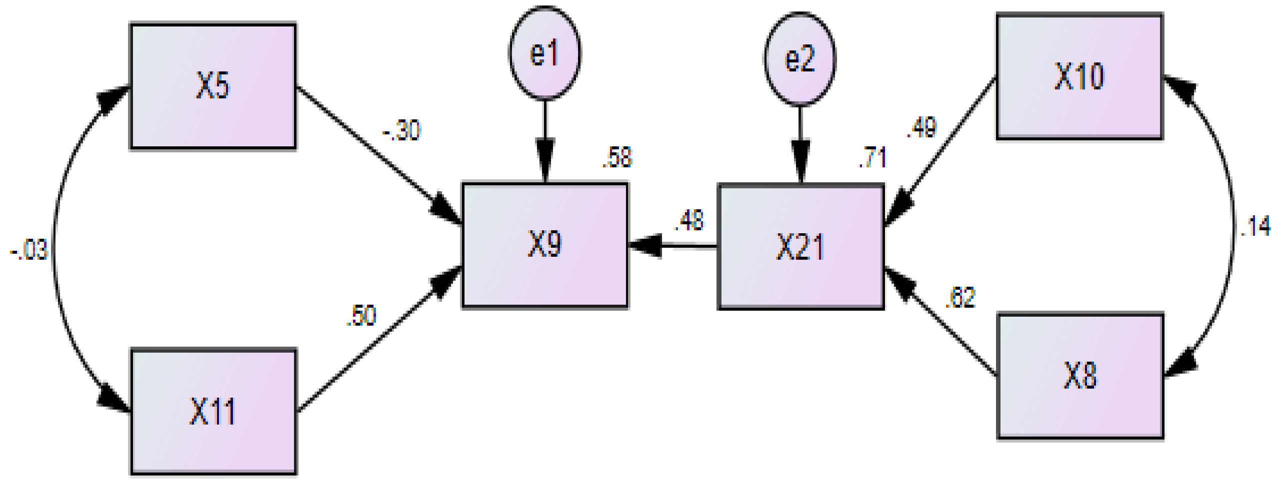


Fig.9. SEM model for analysis of readiness stages to purchase solar PV system

7.1.1 Interpretation of readiness to purchase solar PV system: From Table 4, the Probability (P) value of (X8) social status and (X10) technical knowledge about solar energy influences the (X21) interest to purchase.

Table 4 :Analysis of Readiness to Purchase solar PV system (Explanation for Regression Weights)

			Standardised Regression Estimate	Standard Error.(S.E)	Critical Error.(C.R)	Probability (P)	Result
X21	<---	X10	.488	.035	5.670	***	Significant*
X21	<---	X8	.620	.024	7.209	***	Significant*
X9	<---	X5	-.300	.082	-2.920	.003	Significant*
X9	<---	X11	.505	.155	3.401	***	Significant*
X9	<---	X21	.477	.400	3.213	.001	Significant*
* significant at 1 % level							

The P-values of (X5) ‘expecting subsidy benefit’, (X11) ‘believing the solar’ and (X21) ‘interested in purchasing’ were less than 0.01, and were highly significant at 1% level. This denotes that (X11) ‘believing the solar’ and (X21) ‘interested in purchasing’ are positively influencing (X9) ‘awareness about solar' whereas (X5) 'expecting subsidy benefit/government support' negatively influences the (X9) 'awareness about solar'.

7.1.2 Justification for readiness to purchase solar PV system

While the solar PV system can be readily purchased by higher income society in order to maintain their status *quo*, the awareness about the solar energy among them is less. At the same time, people from middle class and less income groups are least informed and possess little knowledge on solar energy systems, government policies, pricing and subsidy schemes. Mostly, they show interest to purchase without knowing the technology, suitability, and cost. The people in this category requires a number of clarifications prior to purchasing due to the huge investment. Grid parity and payback period will match their requirement. On the whole, SEM analysis revealed that people are misguided by the poor awareness of the government's solar policies and subsidiaries.

7.2 SEM Model II (Negative perception on Solar PV)

Based on the SEM analysis, the hypothesis model shown in figure 10 is used to derive the negative perception on Solar PV energy and concludes that the model can describe the interrelationship among the exogenous (independent X9) and endogenous (Dependent X10, X13, X4 & X15) variables.

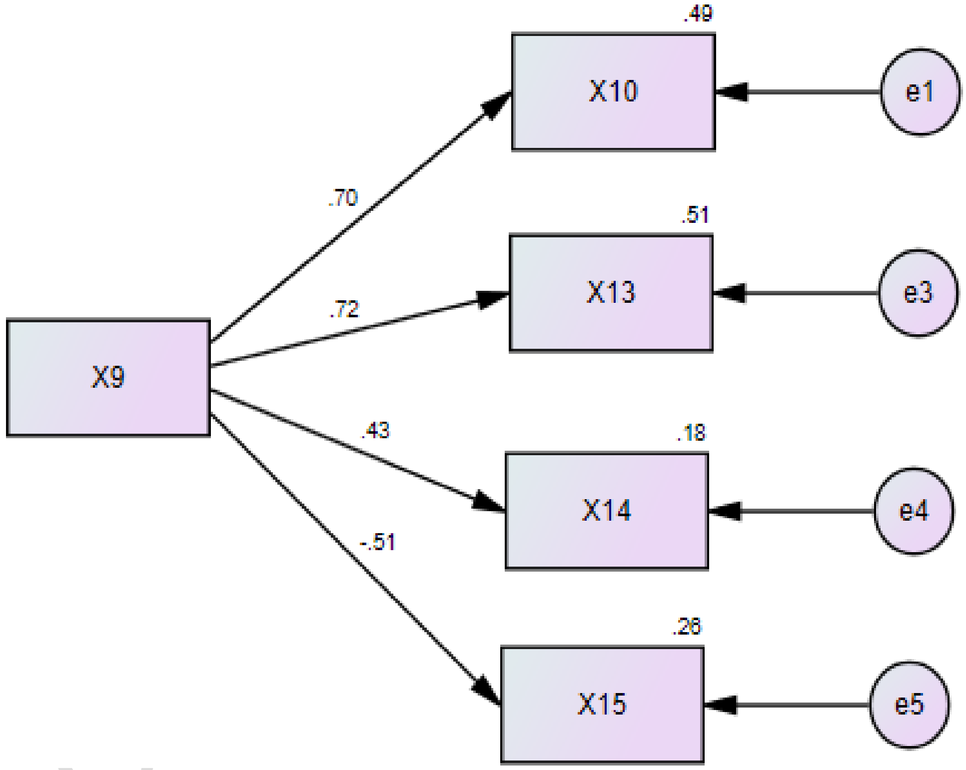


Fig. 10. SEM model for Negative Perception on Solar PV Energy

7.2.1 Interpretation of Negative perception on Solar PV:

From table 5, it is inferred that the Probability (P) values of (X15) 'high initial cost', (X13) 'dynamic transforming technology' and (X10) 'technical knowledge about solar' were less than 0.01 and were highly significant at 1 % level. This denotes that the (X10) 'technical knowledge about solar', (X13) 'dynamic transforming technology', and (X14) 'criticizing the system integrator' are positively influencing the (X9) 'awareness about solar' and whereas (X15) 'high initial cost' does have a negative impact on (X9) 'awareness about solar'.

Table 5:Negative Perception on Solar PV Energy (Explanation for Regression Weights)

			Standardised Regression Estimate	Standard Error.(S.E)	Critical Error.(C.R)	Probability (P)	Label
X15	<---	X9	-.506	.040	-3.710	***	Significant*
X10	<---	X9	.700	.089	6.198	***	Significant*
X13	<---	X9	.715	.071	6.468	***	Significant*
X14	<---	X9	.427	.110	2.983	.003	Significant*
* Significant at 1 % level							

7.2.2 Justification for negative perception of Solar PV:

People do not have much awareness about solar energy since information communicated by the solar EPC company/system integrators are less and misguiding and sometimes it confuses the people in terms of subsidy, cost and quality of the product. In such scenarios, people blame both the government and private sectors. The society unconsciously believes in solar energy technology to be immature. Hence, this has a negative impact. To be practical, the use of solar energy in residential places is a cost-consuming one at the initial stages without subsidy, and is suitable for consumers whose consumption exceeds 600 units (kWh) per month. The government needs to take appropriate measures for effective implementation of solar PV schemes suitable for all grades of people.

7.3 SEM Model III (Perception of Utility Scale Project on Solar PV)

IBM-SPSS-AMOS was used to derive the SEM for utility-scale project perception on solar PV. It is concluded that the model can describe the interrelationship among the exogenous (independent X2) and endogenous (Dependent X1, X6, X7, X11 & X16) variables, as shown in figure 11.

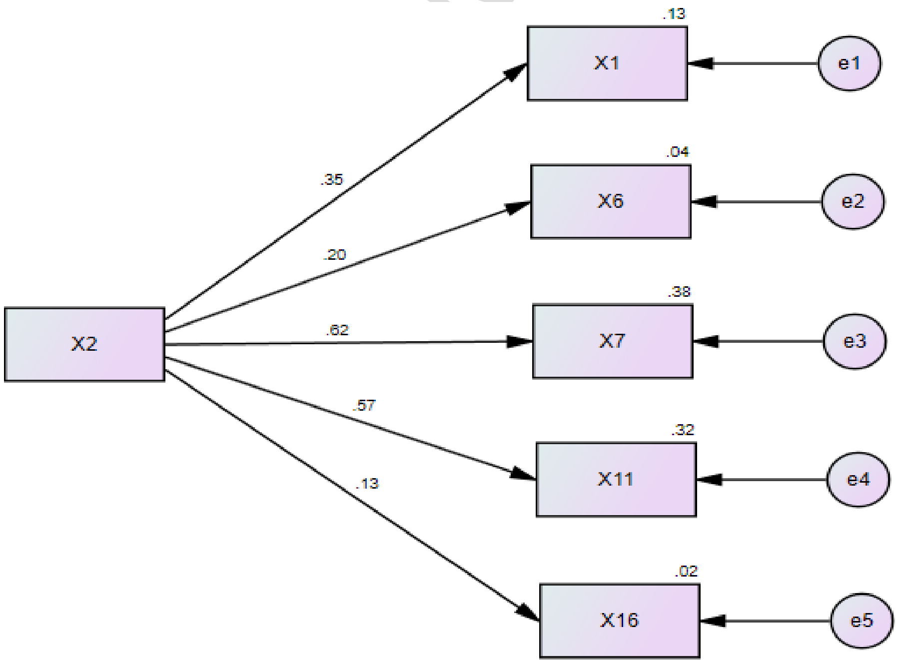


Fig. 11. SEM model for utility scale project perception on solar PV energy

7.3.1 Interpretation of utility-scale project perception on solar PV energy:

From Table 6, the P values of (X1) 'social responsibility', (X7) 'tax benefits' and (X11) 'believing the solar' were less than 0.01, which were highly significant at 1% level. Further, the (X6) 'accelerated depreciation benefit' and (X16) 'solar energy will be future' does not seem to be significant. However, (X1) ‘social responsibility’ is significant at 1 % level and (X7) ‘tax benefits’ and (X11) ‘believing the solar’ is significant at 5 % levels.

Table 6 : Utility scale project perception on solar PV energy (Explanation for Regression Weights)

			Standardized Regression Estimate	Standard Error.(S.E)	Critical Error.(C.R)	Probability (p)	Label
X1	<---	X2	.354	.116	2.396	.017	Significant**
X16	<---	X2	.134	.049	.858	.391	Not Significant*
X6	<---	X2	.203	.169	1.309	.191	Not Significant*
X11	<---	X2	.566	.109	4.344	***	Significant***
X7	<---	X2	.620	.184	4.997	***	Significant***
* Not Significant, ** Significant at 5% level *** Significant at 1 % level							

7.3.2 Justification for utility-scale project perception on solar PV energy:

Large-scale solar project developers/ Solar project investors/ Build-Own-Operate-Transfer (BOOT) / Factory/ Large scale corporate believe that the solar technology is more concerned about social responsibility. These people believe that the solar technology is viable to reduce the electricity cost and at the same time, reduce the recurring cost of diesel generation. However, the large scale industries are only availing the benefits of Accelerated Depreciation (AD). So, invariably the utility-scale solar project developers are looking for tax exemption for the solar project. At the same time, the Small-Medium Enterprises do not possess sufficient awareness on the benefits of Accelerated Depreciation (AD). For example, those who work with government organizations and professionals such as Charted Accountants are not aware of Accelerated Depreciation (AD). Hence, the Accelerated Depreciation (AD) policy has not penetrated in depth into all levels of people. Similarly, most of the participants do not accept the fact that solar energy is for the future. So, these two factors are not significant from the results obtained. Hence, the government needs to take appropriate measures to create awareness among the consumers.

8. Dendrogram Graph and Hierarchical Clustering

A dendrogram is a form of tree diagram which is used frequently by researchers for illustrating a cluster arrangement generated by hierarchical clustering. There are several ways for interpreting a dendrogram such as large-scale group interpretation or similarities within individual chunks. Dendrogram Graph and Hierarchical Clustering are arrived at using IBM-SPSS statistics software package.

8.1 Hierarchical Clustering for 41 types of Customers

The horizontal axis of the Dendrogram represents the distance or dissimilarity between clusters, whereas the vertical axis represents the objects and clusters. The dendrogram is fairly simple to interpret. The focus of the study is to find the similarity and clustering. Each joint (fusion) of two clusters is represented graphically through splitting a horizontal line into two horizontal lines. The horizontal position of the split, shown by the short vertical bar gives the distance (dissimilarity) between the two clusters. Dendrogram results are placed here using the data obtained through a group average clustering algorithm. R language programming software environment was used for the statistical study. The study produced a set of nested clusters, organised as a hierarchical tree, which can be visualised as a Dendrogram. A tree-like diagram illustrating Dendrogram results of hierarchical clustering considering 41 types of customers is shown in the figure 12.

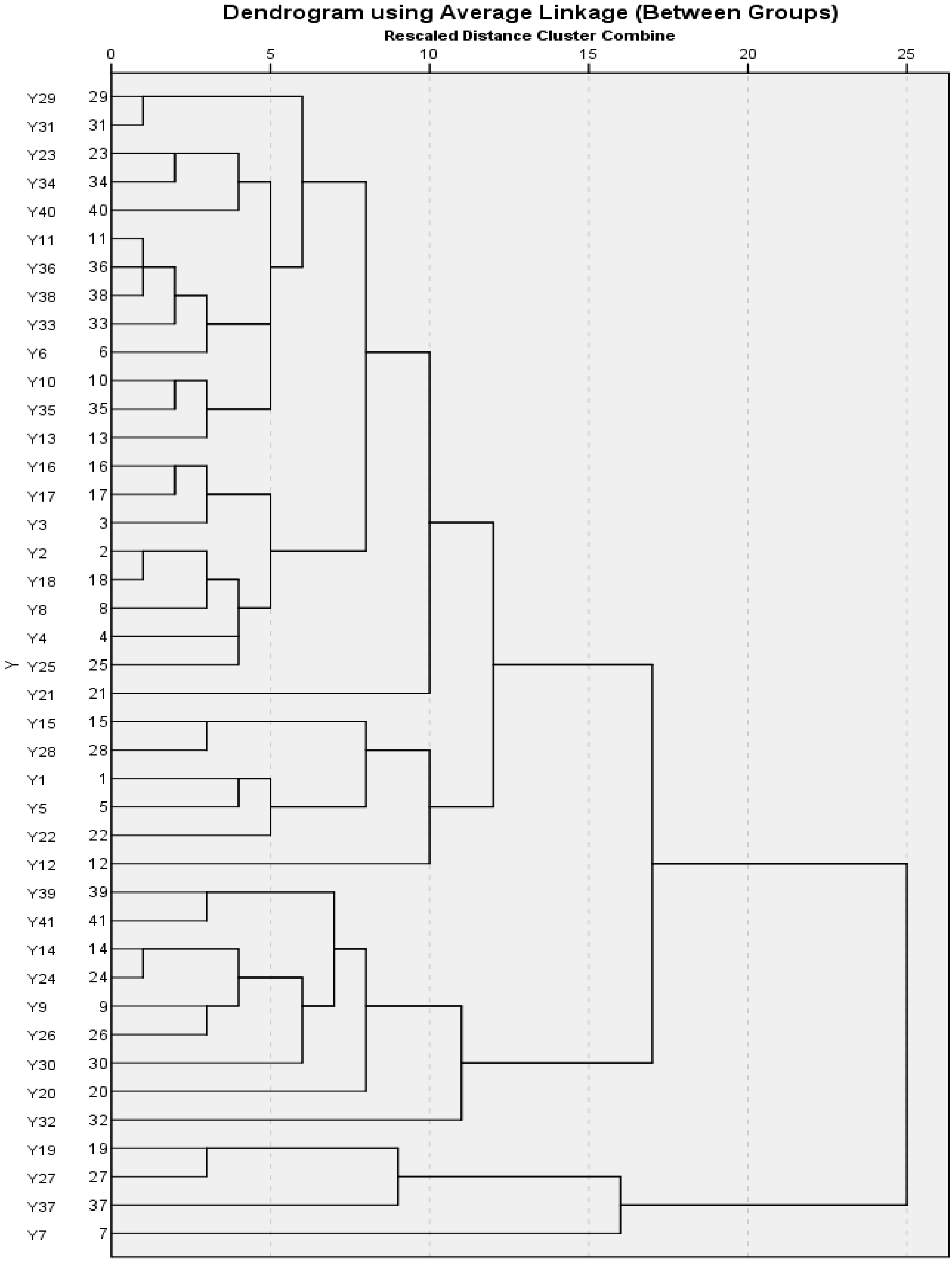


Fig. 12. Dendrogram results for Hierarchical Clustering Group of 41 types of Customers

A number of clusters will be formed using a particular cluster cutoff value which may be determined by drawing a vertical line and at that value, the number of lines that the vertical line intersects gives the stratification. For example, one can see that if a vertical line is drawn at the distance linkage value 15, three clusters will be the outcome. The first cluster (Group α: Y29, Y31,

Y23, Y34, Y40, Y11, Y36, Y38, Y33, Y6, Y10, Y35, Y13, Y16, Y17, Y3, Y2, Y18, Y8, Y4, Y25, Y21, Y15, Y28, Y1, Y5, Y22, Y12) contains 28 types of customers and the second cluster contains (Group β: Y39, Y41, Y14, Y24, Y9, Y26, Y30, Y20, Y32) 9 type of customers whereas the third cluster contains 4 types of customers (Group γ: Y19, Y27, Y37, Y7). Looking at this dendrogram, one can see the three clusters, as three branches occurs at the same horizontal distance. Table 7 shows the frequencies of average linkage of hierarchical Clustering Group of 41 types of Customers and Table 8 presents a hierarchical clustering group of 41 types of Customers into three groups.

Table 7:Frequencies of hierarchical clustering group of 41 types of customers average linkage (between groups)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	28	68.3	68.3	68.3
	2	4	9.8	9.8	78.0
	3	9	22.0	22.0	100.0
	Total	41	100.0	100.0	

Table 8 :Hierarchical clustering group of 41 types of customers

Group α	1	2	3	4	5	6	7	8	9	10
	Y29	Y31	Y23	Y34	Y40	Y11	Y36	Y38	Y33	Y6
	11	12	13	14	15	16	17	18	19	20
	Y10	Y35	Y13	Y16	Y17	Y3	Y2	Y18	Y8	Y4
	21	22	23	24	25	26	27	28		
	Y25	Y21	Y15	Y28	Y1	Y5	Y22	Y12		
Group β	29	30	31	32	33	34	35	36	37	
	Y39	Y41	Y14	Y24	Y9	Y26	Y30	Y20	Y32	
Group γ	38			39		40			41	
	Y37			Y27		Y19			Y7	

8.1.1 Justification of 41 types of customers:

Statistical data visualization provides benefit in the form of systematic ordering of data objects in order to highlight features and structure. It describes several insights and inference coupled with various factors' functions which can be easily adapted to different visualization settings. From the figure 12, looking at the dendrogram illustration, it is possible to arrive at the conclusion from several policies and making insights from the ground level opinions. This will be helpful to categorise the various segments in a society in different developmental perspectives, existing barriers, priority segments, and evaluating whether existing policy benefits reached the society or not. Among the above, 41 categories are eligible to be segregated in different distance linkages arriving at new outcomes for each stakeholder in India. Group α, Group β and Group γ categorised the 41 categories into 3. From these three, it is identified that large utility-scale solar project developers are categorised under Group α, corporate / industries/ financial investors under Group β, followed by financial investors whereas the rooftop and rural-based innovation in product development are under Group γ. It is concluded that the high thrust priority should be given to the combination of rooftop project and self-consumption. Similarly, it is possible to categorise based on various objectives which can be enlightened to make new effective policies to develop solar PV energy in India.

8.2 Hierarchical Clustering for 21 questionnaires

All the 21 questionnaires were set (X1 - X21) with priorities and are described based on 41 categories' of responses from all type of respondents (Y1 - Y41). The same had been arrived at, when using R programming language. The result is illustrated in the figure 13. The Dendrogram algorithms are compared and applications are presented. The number of clusters which are formed at a particular cluster cutoff value may be quickly determined from this plot by drawing a vertical line on that value and counting the number of lines where the vertical line intersects. For example, one can see that if a vertical line is drawn at the value 10, four clusters will be the result.

The first cluster would have 12 objects (Group 1: X15,X18,X16,X19,X20,X12,X14,X21,X11,X13,X5 and X17) followed by the second cluster with 4 objects (Group 2: X3, X4, X6, X10) and third cluster (Group 3: X1, X9, X2, X8) with 4 objects followed by the final one i.e., fourth cluster (Group 4: X7) with only one object.

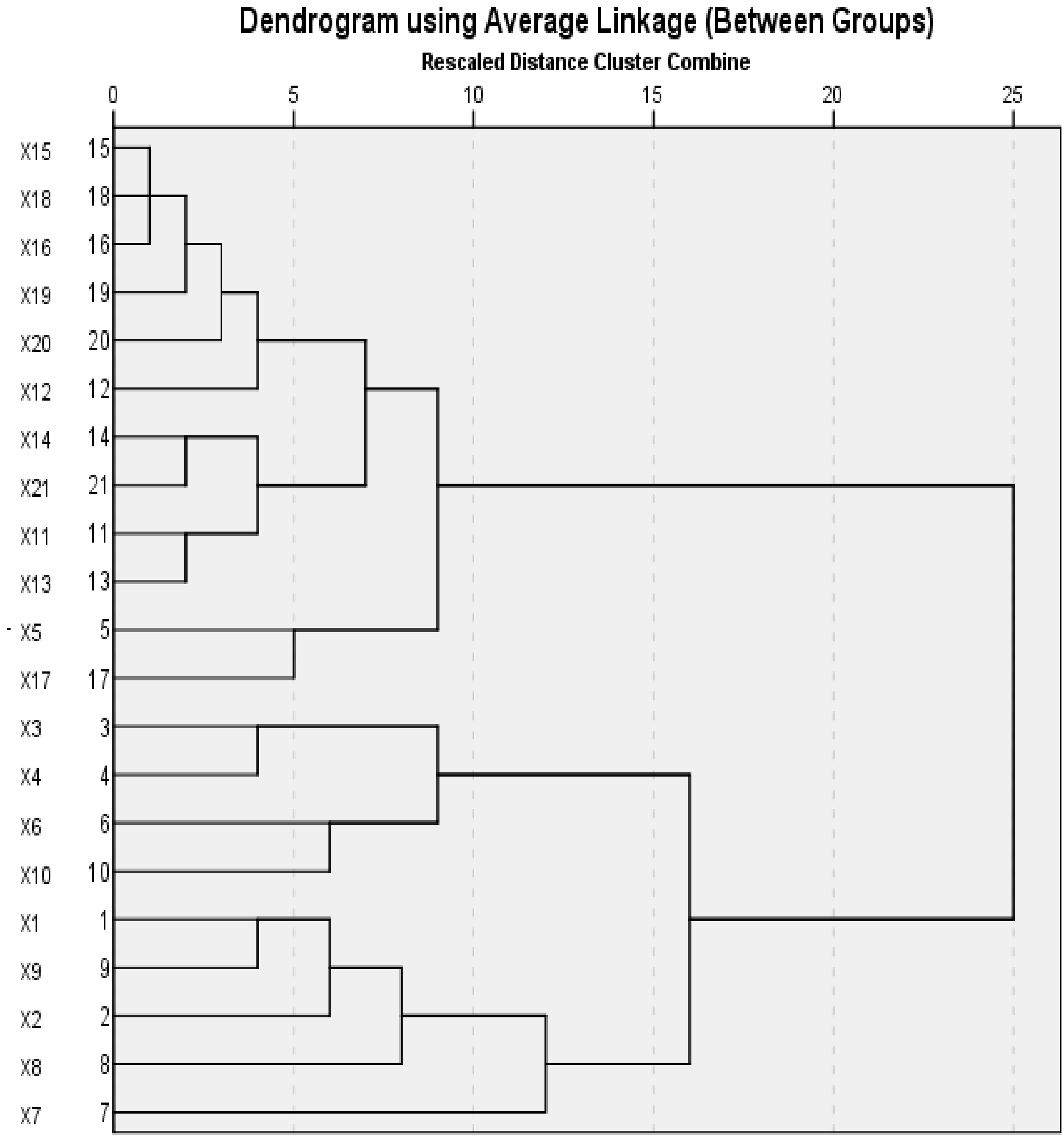


Fig. 13. Dendrogram results for Hierarchical Clustering Group of 21 questionnaires

8.2.1 Justification of 21 questionnaires:

The questionnaires will be helpful to categorise various segments of the society in different developmental perspectives, existing barriers, priority segments, and to measure whether the existing policy benefits reached the society or not. Among the 21 questionnaires set (X1 - X21), the categories that are of more concern are high initial cost and criticism on government officials. Most of the respondents believe that the solar energy will make a change in India. This can be segregated in different distance linkages arriving at new outcomes for each stakeholder in India. For example, one can see that if a vertical line is drawn at the value 10, four clusters will be the result. Group 1, Group 2, Group 3 and Group 4 segregated the 21 questionnaires to 4 categories. Due to the high cost, the solar power plant was not able to reach its full potential. Solar power plant cost is high, hence X15 gains the top priority in the hierarchal list. Similarly, taxation waiver benefits from the government are positively concerned with whoever most likely to purchase the solar system. Therefore, standardised policy should be regularised towards taxation exemption. Table 9 shows a hierarchical clustering group of 21 types of questionnaires categorised into four groups. These four categories were classified into low concerned, concerned, high concerned and very high concerned respectively.

Table 9 Hierarchical Clustering Group for 21 types of questionnaires

Group 1	1	2	3	4	5	6	7	8	9	10	11	12
	X15	X18	X16	X19	X20	X12	X14	X21	X11	X13	X5	X17
Group 2	13			14			15			16		
	X3			X4			X6			X10		
Group 3	17			18			19			20		
	X1			X9			X2			X8		
Group 4	21											
	X7											

From the analysis, very high concern category is to avail the tax benefits exemption that is the expectation of higher class society, factories, business firms, and institutions.

9. Principal Component Analysis

"Principal Component Analysis (PCA) is a statistical procedure that uses an orthogonal transformation to convert a set of observations of possibly correlated variables into a set of values of linearly uncorrelated variables called principal components" .

According to figure 14, based on the relative status of the respective type of contestants, the principle component weights (Distance) hierarchy is ranked. It is highly recommended to compare the Dendrograms with various methods using different datasets and known cluster patterns so that the technique can be best understood. Hence, both the packages, IBM-SPSS statistics software package and 'R' language programming software environment for statistical study were used. Figure 14 illustrates the combinatorial optimization problems and solution for various groups considering different classification based on the weight value (distance) (Group A, Group B, Group C, and Group D).

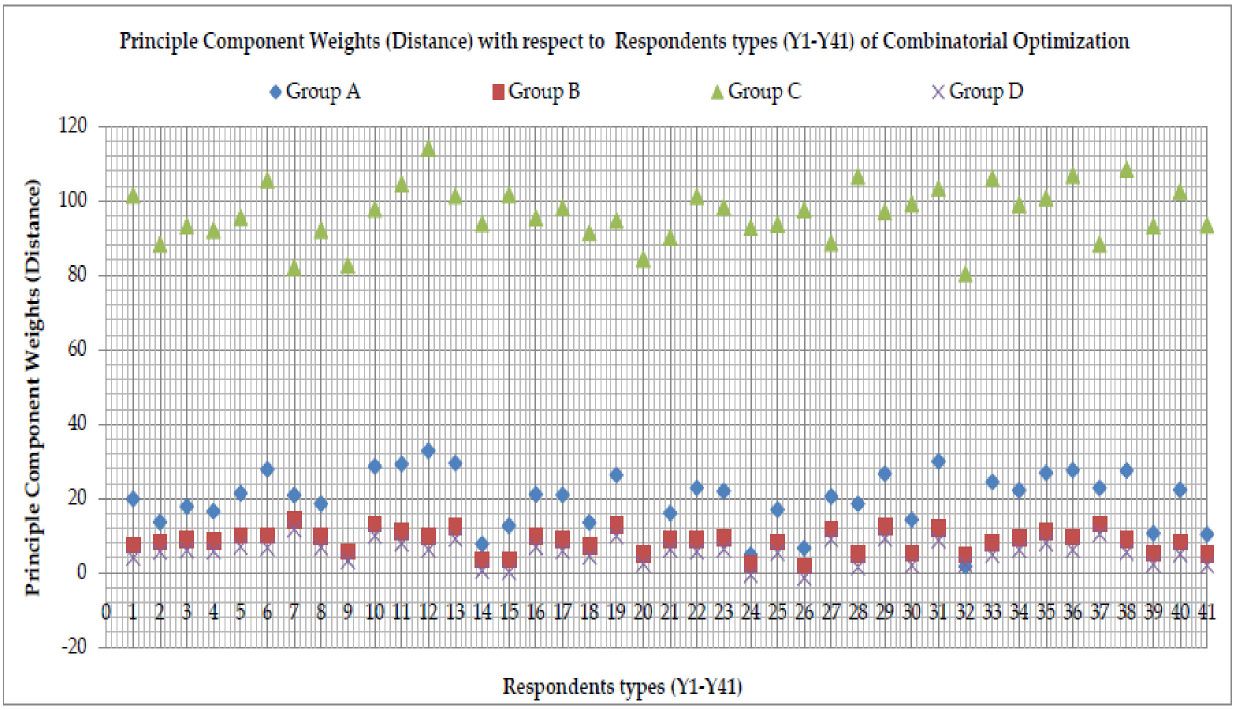


Fig. 14. Combinatorial optimization from Principal Component Analysis

10. Analysis Using Biplots Interpretation

Biplot is a kind of exploratory graph which is used in statistics wherein a generalization could be done through simple scatter plot of two variables. A biplot tends to allow the information on both variables and samples of a data matrix graphically. Samples could be displayed as points, whereas the variables are depicted as linear axes, vectors or trajectories that are non-linear. For categorical variables, category level points are used for the representation of categorical variable levels. A generalised biplot is used to display the information on both categorical and continuous variables.

Various useful features of biplots were identified. Firstly, they summarise wealthy information, concisely in a graph, which includes the relationships among variables and cases; secondly, with respect to Tufte's dictum, biplots have a high data-to-ink ratio; thirdly, since there is no direct modelling of cases, biplots aid in the integration of quantitative and qualitative data and finally, there are no absolute frequent statistics for deceiving the analyst. Biplots summarise a lot of information through single graph. This information includes relationships among both cases and variables. The conditions, under which the correspondence analysis maps or biplots are discussed, as well as the interpretation of such biplots, are illustrated in figure 15. It can be observed that a biplot is an asymmetric map that conjointly displays the profiles and vertices defining the unit vectors in the profile space. Various ways to interpret this joint plot are discussed. One such way is being dependent on the metric choice in the profile space. It is possible to define the biplot axes and can also be calibrated on a scale of zero-to-one profile in the usual way for recovering the approximations to the individual profile elements. At last, the biplot interpretation needs to be discussed in the context of multiple correspondence analysis. Further, it becomes mandatory to point out that joint correspondence analysis paves way for the joint display of several variables that can be calibrated in the same pattern to recover the profile elements.

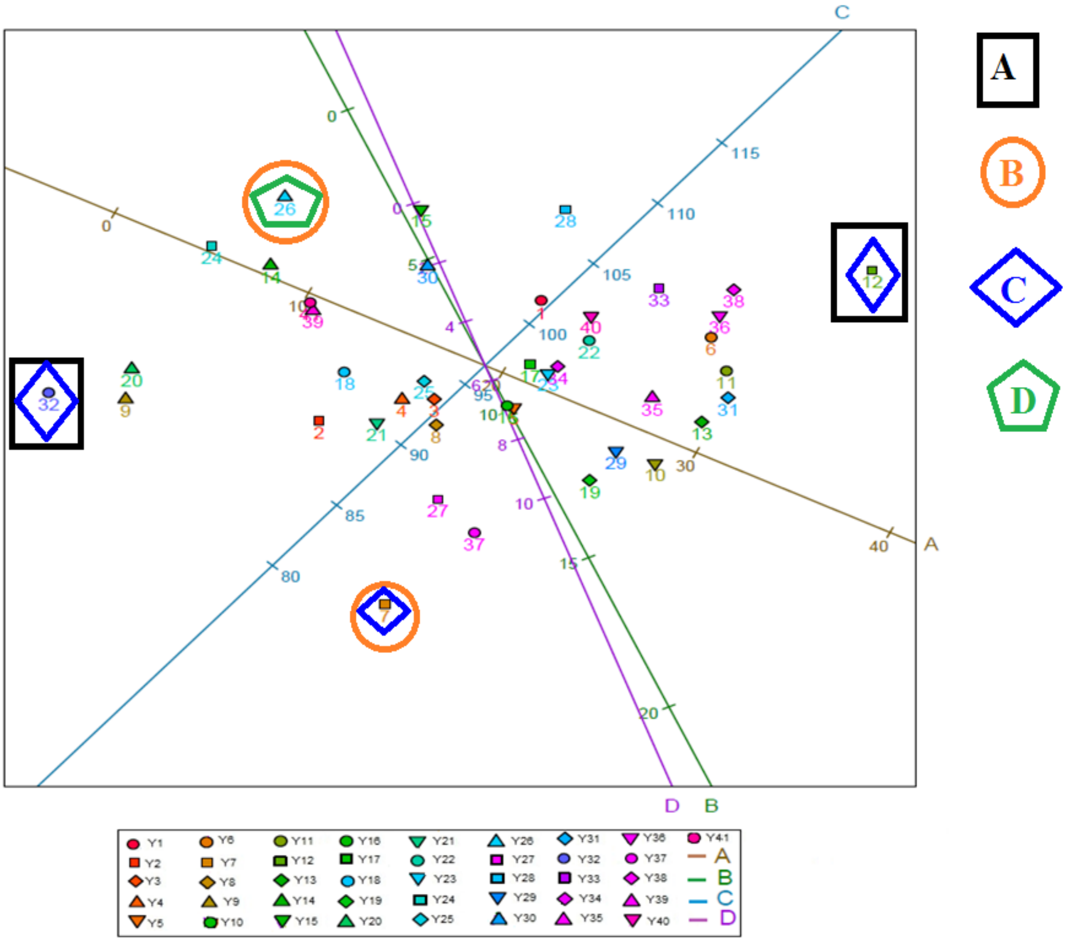


Fig. 15. Several Interpretation using Biplots analysis

10.1 Interpretation from Biplots analysis

From the Biplot illustration shown in the figure 15, it can be concluded that several policy making insights can be retrieved from the ground level opinion. The 41 categories can be segregated in different distance linkages arriving at new outcomes for each stakeholder in India. All the 21 questionnaires were set (X1 - X21) with priorities and described based on 41 categories of respondent (Y1 - Y41) opinions which are grouped as Group A, Group B, Group C and Group D as shown in the figure 14. In Group A: Y12 principle component weights (Distance) 32.772846 had high influence. The same group in minimum at distance weight 1.717914 for Y32. Similar fashion can deduce the significance of another participant around distance for Group A. In Group B, Y7 principle component weights (Distance) 14.193094 had influenced others. The same group is the lowest at distance weight of 1.783485 for Y26 participant. The remaining participants were placed in different lengths with respect to the importance of the respective group objective. In Group C, Y12 principle component weights (Distance) 114.19588 and is highly influential. The same group is lowest at distance weight at 80.41105 for Y32 participant. In Group D, Y7 principle component weights (Distance) 11.7048643 and is highly influential. The same group is minimum at distance weight -1.3723223 for Y26.

10.2 Justification from the Biplots

In Group A and Group C, the (Y12) existing solar PV users are highly significant in all aspects. They have been realised by means of practical benefits of solar energy technology. The same groups

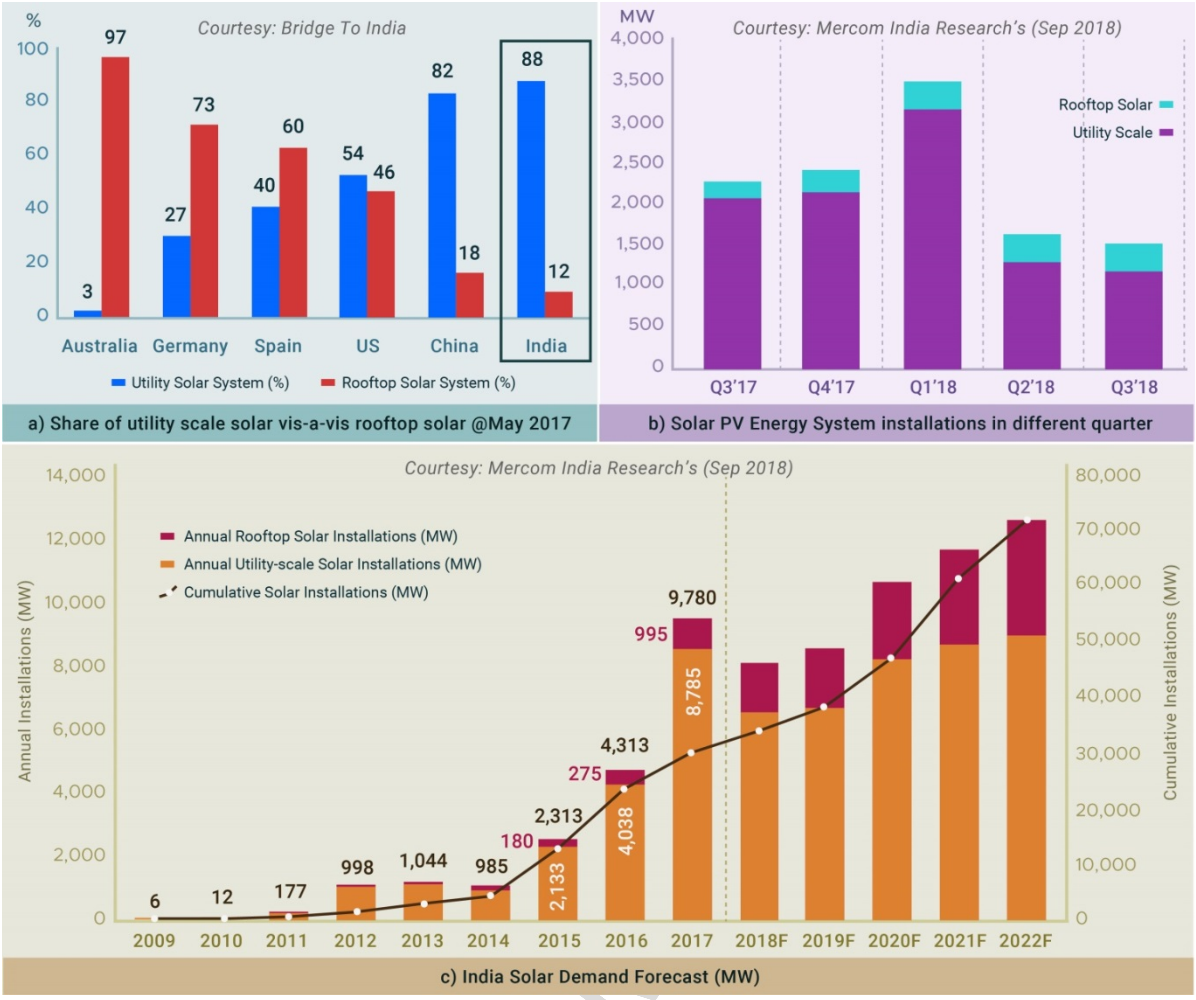
(Y32) of rural hut Community where the grid availability is very less, seems to be rarely developed in India.

In Group B and Group D, (Y7) Corporate Social Responsibility (CSR) support is extremely impacted than others. CSR is making awareness about usage of it, at rural background through solar lanterns. Few CSR projects have been done for the sake of it. Mostly politicians' (Y26) responses are negative. Several politicians have doubts on the benefits that can be derived through solar project.

In Group D, indigenous politicians (Y26) and thugs particularly impacted the large-scale solar project and transmission network developmental process which is considered a big barrier in all states.

11. Policy implication of solar energy in India

The commitment of India towards a vibrant economy has been demonstrated through various policy level changes which have defined a path for quickening the adoption of Renewable Energy (RE) in India. India is expected to run on 40 percent non-fossil fuel power by the year 2030 which includes 175 GW of RE by the year 2022. Renewable energy is predicted to contribute 100 GW electricity whereas 60 GW is expected from wind alone. The thrust of the policy for renewables is said to be significant and specific targets are said to accelerate renewable energy deployment. The National Action Plan on Climate Change (NAPCC, 2008) portrayed a dynamic target for Renewable Purchase Obligation (RPO) and the recent RPO target has increased from 17% to 21% by 2022. The policy for new electricity tariff is identified to be a step in the increasing adoption of RE. Rooftop solar power plant is the only available and best option to achieve this target since it saves landmass, reduces transmission line loss and provides distribution system as well. As mentioned in the report published by Mercom India, by the end of third quarter (Q3) 2018, the total solar installed capacity was approximately 24-25 GW with large-scale ground mounted projects contributing upto 88 percent whereas the balance is contributed by rooftop projects. As on Q3 2018, the total rooftop solar installed capacity in India reached 2.8 GW. This is much less than other key markets such as Australia, China, Germany, Spain and United States of America. 'Bridge To India', 'Mercom India Research', The India Innovation Lab for Green Finance (Shakti Sustainable Energy Foundation) and 'KPMG' reports revealed that India has to face a lot of challenges in the development of rooftop solar projects. Figure 16 exposes the total installed capacity scale and percentile in India with regards to rooftop solar power plant and utility solar power plant. It also compares the available information with other countries. So far, India has not gained any significant place in solar rooftop segment, due to which there are many hurdles to achieve its target of installing 40 gigawatt (GW) of capacity by 2022.



Source: Bridge To India & Mercom India Research

Fig. 16. Comparison of utility scale solar vis-à-vis rooftop solar

Though there is 30% subsidy available for small-sized residential rooftop projects, the end user do not get much benefits out of it, which can be inferred from the survey results. In general, giant organizations gain the benefit of subsidies for rooftop schemes under Operating Expenditure-BOOT (Build, Own, Operate, Transfer) model. There can be gradual growth experienced in rooftop installations since the project economies are getting viable for educational institutions, commercial establishments and industrial customers. However, the states clamp down the policy support rendered for open access projects since the governments predict them to be a threat for the government DISCOM revenues. Another barrier is that some of the State Electricity Boards (SEBs) started demanding for dedicated evacuation line by IPPs (Independent Power Producers) or solar PV system users. Similarly, the Net metering/Gross metering is a complete chaos during implementation. Indian government mandated the installation of rooftop solar units in buildings that exceed specified size and/or power consumption threholds under the model 'Building Bye Laws'.

In figure 17, a complex range of outcomes is depicted whereas from the figure, more insights can be inferred with partial adoption from different studies (Phil Marker et.al 2015, Sonal Punia Sindhu et.al 2016 ,Prabhakar Yadav et al., 2018). Figure 17 provides a complete overview of primary hindrances, retrofitting interventions for policy implication along with the suggestions received during surveys and interviews.

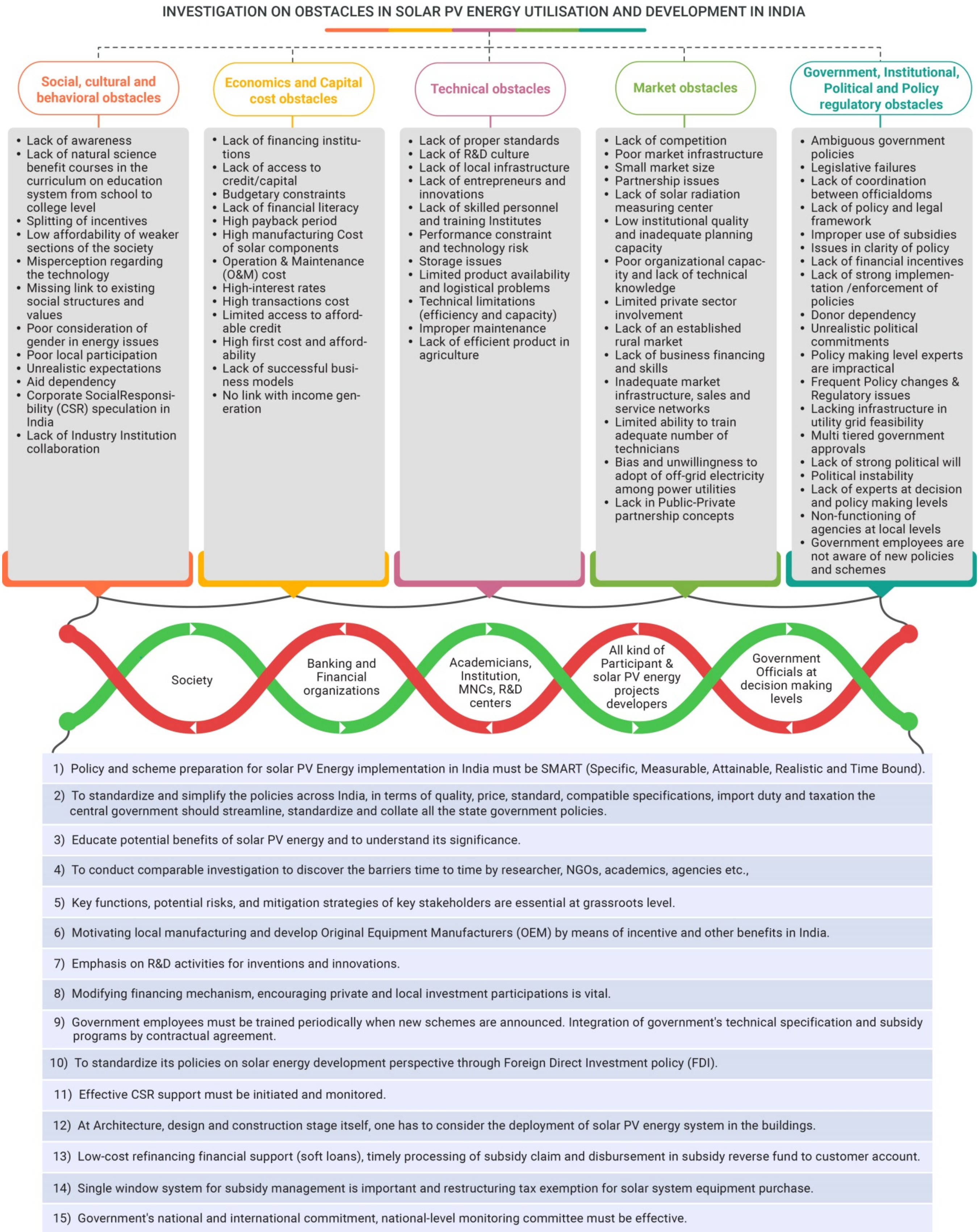


Fig. 17. Obstacles and retrofitting interventions for solar PV energy development in India

11. Conclusion

Studies related to solar energy development will help in providing an advanced inter-disciplinary approach on environmental, technical, cultural, economic and social sustainability of human beings. The information can also be helpful in improving the energy policy and practice. The authors have compared the barriers as discussed by previous studies towards the acceptance of solar energy in India. Mutually the reviews were synchronised in nature with slight variation. The reviews analyzed in this paper also conclude that solar energy had not yet reached the anticipated level at all types of segment particularly the rooftop segment due to high capital cost. The government policy support is still chaos which is also a barrier to the development. The survey also concludes the need for new business models for solar development which can deal with the challenges presented in multiple rural contexts. There is a formidable challenge in changing the behavioural, institutional, and organisational structures which lock unsustainable resource use, existing views, social practices, infrastructures as well as power infrastructures which make the change initiation a difficult process. Hence, policy change mix is needed to target different drivers in a systematic way, based on numerous insights from all the illustrations. Certain new aims of policies that can be concluded from the results include; market coordination, energy markets' transition, challenging policy making, removal of barriers that hinder the restructuring and combination of market signals with command-and-control policy measures.

References

[1]. Abdul Moktadir,Towfique Rahman, Charbel Jose Chiappetta Jabbour, Syed Mithun Ali, Golam Kabir, "Prioritization of drivers of corporate social responsibility in the footwear industry in an emerging economy: A fuzzy AHP approach", 2018., Journal of Cleaner Production, vol.201, pp.369-381

[2]. Abhishek Kumar, Bikash Sah, Arvind R. Singh, Yan Deng, Xiangning He, Praveen Kumar, R.C. Bansal "A review of multi criteria decision making (MCDM) towards sustainable renewable energy development", 2017, Renewable and Sustainable Energy Reviews vol. 69 pp.596–609

[3]. Adams, W.M. (2006). "The Future of Sustainability: Re-thinking Environment and Development in the Twenty-first Century", Report of the IUCN Renowned Thinkers Meeting, 29–31 January 2006. Retrieved on: 20-02-2016.

[4]. Afshin Samadi. "Large Scale Solar Power Integration in Distribution Grids PV Modelling, Voltage Support and Aggregation Studies", Ph.D Thesis. 2014, Stockholm ISBN 978-91-7595-303-8

[5]. Akanksha Chaurey, P.R.Krithika, Debajit Palit, Smita Rakesh, Benjamin K. Sovacool. "New partnerships and business models for facilitating energy access", Energy Policy 47 (2012) 48–55

[6]. Akash Kumar Shukla, K. Sudhakar, Prashant Baredar, Rizalman Mamat, 2018., "Solar PV and BIPV system: Barrier, challenges and policy recommendation in India", Renewable and Sustainable Energy Reviews, vol.82, pp.3314–3322.

[7]. Andreas Goldthau, Benjamin K. Sovacool. "The uniqueness of the energy security, justice, and governance problem", Energy Policy 41, (2012), 232–240

[8]. Aniruddh Mohan, Kilian Topp, 2018 "India's energy future: Contested narratives of change" Energy Research & Social Science, vol.44, pp.75–82

[9]. Arunabha Ghosh, Rajeev Palakshappa, Rishabh Jain, Shalu Aggarwal, Poulami Choudhury (CEEW team) and Anjali Jaiswal, Meredith Connolly, Bhaskar Deol, Nehmat Kaur, Meg Holden (NRDC team), "Solar Power Jobs: Exploring the Employment Potential in India's Grid-Connected Solar Market", Prepared by: Council on Energy, Environment and Water Natural Resources Defense Council, august 2014.

[10]. B. Baldassarre, G. Calabretta, N.M.P. Bocken, T. Jaskiewicz 2017, "Bridging sustainable business model innovation and user-driven innovation: A process for sustainable value proposition design", Journal of Cleaner Production vol.147, pp.175-186

[11]. Benchmark Capital Cost of Solar PV Project 2016-2017 Available online: http://www.ezysolare.com/blog/knowledge-center/benchmark-capital-cost-of-solar-pv-project-2016-2017/ (accessed on 14 January 2017).

[12]. Benjamin K. Sovacool, Anthony L. D'Agostino, Malavika Jain Bambawale. "The socio-technical barriers to Solar Home Systems (SHS) in Papua New Guinea: Choosing pigs, prostitutes, and poker chips over panels", Energy Policy 39 (2011) 1532–1542.

[13]. Benjamin K. Sovacool and Harry Saunders. 2014 "Competing policy packages and the complexity of energy security", Energy, vol.67, pp. 641-651.

[14]. Benjamin K. Sovacool, Pushkala Lakshmi Ratan. "Conceptualizing the acceptance of wind and solar electricity", Renewable and Sustainable Energy Reviews 16 (2012) 5268–5279

[15]. Benjamin K. Sovacool. "Energy & Ethics Justice and the Global Energy Challenge", Published 2013 by Palgrave Macmillan. ISBN: 978–1–137–29865–2.

[16]. Benjamin K. Sovacool. "Expanding renewable energy access with pro-poor public private partnerships in the developing world", Energy Strategy Reviews 1 (2013) 181-192.

[17]. Benjamin K. Sovacool. "Renewable Energy: Economically Sound, Politically Difficult", The Electricity Journal. June 2008, Vol. 21, Issue 5 1040-6190. doi:/10.1016/j.tej.2008.05.009.

[18]. Benjamin K.Sovacool. "Evaluating energy security in the Asia pacific: Towards a more comprehensive approach", Energy Policy 39(2011)7472–7479.

[19]. Birol, F.; Gould, T. World Energy Outlook, Special Report India Energy Outlook 2015; Directorate of Global Energy Economics, International Energy Agency: Paris, France.

[20]. Boris Mrkajic 2017, "Business incubation models and institutionally void environments" Technovation, vol. 68, pp.44-55

[21]. Bridge to India report, 2017 'India solar handbook 2017', Date of publication:08.05.2017

[22]. Burns, Alvin; Burns, Ronald (2008). Basic Marketing Research (Second). New Jersey: Pearson Education. p. 245. ISBN 978-0-13-205958-9.

[23]. Carifio, James and Rocco J. Perla. (2007) " Ten Common Misunderstandings, Misconceptions, Persistent Myths and Urban Legends about Likert Scales and Likert Response Formats and their Antidotes." Journal of Social Sciences 3 (3): 106-116

[24]. Central Electricity Authority (CEA) (accessed on 10 November 2018) (http://www.cea.nic.in/reports/monthly/installedcapacity/2018/installed_capacity-10.pdf)

[25]. Central Electricity Regulatory Commission New Delhi, India. Available online: http://www.cercind.gov.in/2016/orders/SO17.pdf (accessed on 14 January 2017).

[26]. Charbel Jose´Chiappetta Jabbour, Fernando Ce´sar Almada Santos, 2008 "Relationships between human resource dimensions and environmentalmanagement in companies: proposal of a model" Journal of Cleaner Production vol. 16 pp.51-58

[27]. Christopher D. Manning and Hinrich Schütze. 1999. Foundations of Statistical Natural Language Processing. MIT Press.

[28]. Chu, S.-C., (2011). Viral advertising in social media: Participation in Facebook groups and responses among college-aged users. Journal of Interactive Advertising, 12(1), 30–43.

[29]. Clark A. Miller , Alastair Iles & Christopher F. Jones (2013) The Social Dimensions of Energy Transitions, Science as Culture, 22:2, 135-148, DOI: 10.1080/09505431.2013.786989

[30]. Daniel Jugend, Charbel Jose Chiappeta Jabbour, Janaina A. Alves Scaliza, Robson Sø Rocha,José Alcides Gobbo Junior, Hengky Latan, Manoel Henrique Salgado, 2018 "Relationships among open innovation, innovative performance, government support and firm size: Comparing Brazilian firms embracing different levels of radicalism in innovation" Technovation vol. 74–75 pp. 54–65

[31]. Daniel Nugent, Benjamin K. Sovacoo. Assessing the lifecycle greenhouse gas emissions from solar PV and wind energy: A critical meta-survey. Energy Policy 65 (2014) 229–244.

[32]. Delu Wang, Dylan Sutherland, Lutao , Yuandi Wan and, Xin Pan, 2018 "Exploring the influence of political connections and managerial overconfidence on R & D intensity in China's large-scale private sector firms" Technovation, vol. 69, pp. 40-53

[33]. Denise Earle & Catherine B. Hurley. Advances in Dendrogram Seriation for Application to Visualization. Journal of Computational and Graphical Statistics. Pages 1-25, Issue 1 Volume 24, 2015.

[34]. Domestic Electricity LT Tariff Slabs and Rates for all states in India in 2017. Available online: https://www.bijlibachao.com/news/domestic-electricity-lt-tariff-slabs-and-rates-for-all-states-in-india-in-2016.html (accessed on 14 January 2017).

[35]. EmrahKarakaya, Pranpreya Sriwannawit, 2015 "Barriers to the adoption of photovoltaic systems: The state of the art", vol.49, pp.60-66.

[36]. Ferruccio Ferroni, Robert J.Hopkirk. Energy Return on Energy Invested (ERoEI) for photovoltaic solar systems in regions of moderate insolation. Energy Policy 94(2016)336–344.

[37]. Finkbeiner, M.; Schau, E.M.; Lehmann, A.; Traverso, M.Towards Life Cycle Sustainability Assessment. Sustainability 2010, 2, 3309-3322.

[38]. Frank W. Geels. Ontologies, socio-technical transitions (to sustainability), and the multi-level perspective. Research Policy 39 (2010) 495–510.

[39]. G. Notton, V. Lazarov, L. Stoyanov. Optimal sizing of a grid-connected PV system for various PV module technologies and inclinations, inverter efficiency characteristics and locations. Renewable Energy 35 (2010) 541–554.

[40]. Gaëtan Masson, Mary Brunisholz "A Snapshot of Global Photovoltaic Markets (1992-2016)". Report of International Energy Agency, IEA PVPS T1-31:2017, 978-3-906042-58-9

[41]. Gary Chapman, Nola Hewitt-Dundas, 2018, "The effect of public support on senior manager attitudes to innovation" Technovation, vol. 69 , pp.28–39

[42]. George Henry Dunteman "Principal Components Analysis: 69 (Quantitative Applications in the Social Sciences)" May 1989.

[43]. Geraldo Cardoso de Oliveira Neto, Luiz Fernando Rodrigues Pinto, Marlene Paula Castro Amorim, Biagio Fernando Giannetti, Cecília Maria Villas Boas de Almeida, 2018 "A framework of actions for strong sustainability" Journal of Cleaner Production vol.196 pp.1629-1643

[44]. Hans-Hermann Bock, Marcello Chiodi, Antonio Mineo "Advances in Multivariate Data Analysis: Proceedings of the Meeting of the Classification and Data Analysis Group

(CLADAG) of the Italian Statistical ... Data Analysis, and Knowledge Organization)" April 2004

[45]. Hengky Latan, Charbel Jose Chiappetta Jabbour, Ana Beatriz Lopes de Sousa Jabbour, Douglas William Scott Renwick, Samuel Fosso Wamba, Muhammad Shahbaz, 2018 "'Too-much-of-a-good-thing'? The role of advanced eco-learning and contingency factors on the relationship between corporate environmental and financial performance" Journal of Environmental Management, vol.220, pp.163–172

[46]. Hengky Latan, Charbel Jose Chiappetta Jabbour, Ana Beatriz Lopes de Sousa Jabbour,Samuel Fosso Wamba and Muhammad Shahbaz, 2018 "Effects of environmental strategy, environmental uncertainty and top management's commitment on corporate environmental performance: The role of environmental management accounting" Journal of Cleaner Production vol.180, pp.297-306

[47]. Huan Liu, Motoda, Hiroshi, "Feature Extraction, Construction and Selection: A Data Mining Perspective 1998. ISBN 978-1-4615-5725-8

[48]. Isabel Gallego-Álvarez, Luis Rodríguez-Domínguez, Raquel García-Rubio, 2013 "Analysis of environmental issues worldwide: a study from the biplot perspective". Journal of Cleaner Production vol.42 pp. 19-30

[49]. J. Christopher Westland "Structural Equation Models: From Paths to Networks (Studies in Systems, Decision and Control) 2015 , ISBN 978-3-319-16507-3

[50]. J.C. Gower and David J. Hand, "Biplots (Chapman & Hall/CRC Monographs on Statistics & Applied Probability)" December 1995

[51]. Jayanta Deb Mondol, Yigzaw G Yohanis, Brian Norton. Optimising the economic viability of grid-connected photovoltaic systems. Applied Energy 86 (2009) 985–999.

[52]. Jayanta Deb Mondol,Yigzaw G. Yohanis, Brian Norton. Optimal sizing of array and inverter for grid-connected photovoltaic systems. Solar Energy 80 (2006) 1517–1539.

[53]. Jenny Palm. The public–private divide in household behavior: How far into home can energy guidance reach? Energy Policy. Volume 38, Issue 6, June 2010, Pages 2858–2864.

[54]. Jenny Palma, Patrik Thollander, An interdisciplinary perspective on industrial energy efficiency. Applied Energy. Volume 87, Issue 10, October 2010, page 3255–3261.

[55]. Jincy Joy, Divya Joy, T.S. Panwar. People's Perception Study Renewable Energy in India 2014 Published by World Wide Fund for Nature (WWF)-India 2015.

[56]. John C. Gower and Sugnet Gardner Lubbe "Understanding Biplots" December 2010. Wiley ISBN: 978-0-470-01255-0

[57]. Jouni Korhonen, Cali Nuur, Andreas Feldmann and Seyoum Eshetu Birkie, 2018 "Circular economy as an essentially contested concept" Journal of Cleaner Production, vol.175, pp.544-552.

[58]. Julian Kirchherr, Denise Reike and Marko Hekkert, 2017 "Conceptualizing the circular economy: An analysis of 114 definitions" Resources Conservation & Recycling, vol.127, pp.221–232

[59]. K. Padmavathi , S.Arul Daniel. Performance analysis of a 3 MWp grid connected solar photovoltaic power plant in India. Energy for Sustainable Development 17 (2013) 615–625.

[60]. Kajsa Ellegård, and Jenny Palm. Who Is Behaving? Consequences for Energy Policy of Concept Confusion. Energies 2015, 8, 7618-7637; doi:10.3390/en8087618.

[61]. Kates, R.W.; Parris, T.M.; Leiserowitz, A.A. What is sustainable development? Goals, indicators, values, and practice. Environ. Sci. Policy Sustain. Dev. 2005, 47, 8-21.

[62]. Kirsten Jenkins, Benjamin K. Sovacool, Darren McCauley, 2018 "Humanizing sociotechnical transitions through energy justice: An ethical framework for global transformative change", Energy Policy, vol.117, pp. 66–74

[63]. Komali Yenneti. Case study the grid-connected solar energy in India: Structures and challenges. Energy Strategy Reviews 11-12 (2016) 41-51.

[64]. KPMG Report "Dispelling Myths: Rooftop Solar can Severely Impact Utilities", KPMG Advisory Services Pvt. Ltd. is the knowledge partner for this paper, Shakti Sustainable Energy Foundation Aug 1, 2017

[65]. Kuhlman, T.; Farrington, J. What is Sustainability? Sustainability 2010, 2, 3436-3448.

[66]. Labanya Prakash Jena, Vinit Atal, Gireesh Shrimali, and Vivek Sen "Rooftop Solar Private Sector Financing Facility Lab Instrument Analysis" October 2016 The India Innovation Lab for Green Finance (Shakti Sustainable Energy Foundation).

[67]. Manish Kumar Hairat, Sajal Ghosh. 100 GW solar power in India by 2022 – A critical review. Renewable and Sustainable Energy Reviews 73 (2017) 1041–1050.

[68]. Marteel-Parrish, Anne & Newcity, Karli M 2017, 'Highlights of the Impacts of Green and Sustainable Chemistry on Industry, Academia and Society in the USA', Johnson Matthey Technology Review, vol. 61, no.3, pp. 207-221; doi: https://doi.org/10.1595/205651317X695776

[69]. Martin Geissdoerfer , Paulo Savaget , Nancy M.P. Bocken , Erik Jan Hultink, 2017 "The Circular Economy e A new sustainability paradigm?" Journal of Cleaner Production vol.143, pp.757-768

[70]. Maximilian Engelken, Benedikt Römer, Marcus Drescher, Isabell M. Welpe, Arnold Picot. Comparing drivers, barriers, and opportunities of business models for renewable energies: A review. Renewable and Sustainable Energy Reviews 60 (2016) 795–809.

[71]. Michael J. Greenacre. Biplots in correspondence analysis. Journal of Applied Statistics. Volume 20, 1993 - Issue 2. Pages 251-269, Published online: 28 Jul 2006.

[72]. Md. Fahim Ansaria, Ravinder Kumar Kharb, Sunil Luthra, S.L. Shimmi, S. Chatterji, 2013 "Analysis of barriers to implement solar power installations in India using interpretive structural modeling technique" Renewable and Sustainable Energy Reviews vol. 27, pp.163–174.

[73]. Milchram, Christine; van de Kaa, Geerten; Doorn, Neelke; Künneke, Rolf. 2018."Moral Values as Factors for Social Acceptance of Smart Grid Technologies." Sustainability 10, no. 8: 2703.

[74]. Mr.Anil Jain, Mr. Rajnath Ram, Mr. Ashwin Gambhir, Dr. Anshu Bharadwaj, Mr. Deepak Gupta. Report of the Expert Group on 175GW RE by 2022. NITI Aayog formulated this Expert Group in June 2015.

[75]. N.M.P. Bocken, S.W. Short, P. Rana, S. Evans, 2014 "A literature and practice review to develop sustainable business model archetypes" Journal of Cleaner Production, vol.65, pp. 42-56

[76]. Nishant Rohankar, A.K.Jain, Om P.Nangia, Prasoom Dwivedi.A study of existing solar power policy frame work in India for viability of the solar projects perspective. Renewable and Sustainable Energy Reviews 56(2016)510–518.

[77]. Nitin Sukh, Raghavendra Mandavilli, YES Institute (YI), YES BANK Working Paper on Financing the Solar Photovoltaic (PV) Rooftop Revolution in India. January, 2016.

[78]. Ntanos, S.; Kyriakopoulos, G.; Chalikias, M.; Arabatzis, G.; Skordoulis, M. Public Perceptions and Willingness to Pay for Renewable Energy: A Case Study from Greece. Sustainability 2018, 10, 687.

[79]. P.A. Ertmer and T.J. Newby, "Behaviorism, Cognitivism, Constructivism: Comparing Critical Features From an Instructional Design Perspective" is reprinted from Performance Improvement Quarterly, 6(4), 1993, pp. 50–72. https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1937-8327.1993.tb00605.x

[80]. Padmanathan. K, Uma Govindarajan, Vigna K Ramachandaramurthy, Sudar Oli Selvi, T & Baskaran Jeevarathinam 2018, 'Integrating solar photovoltaic energy conversion systems into industrial and commercial electrical energy utilization—A survey' Journal of Industrial Information Integration, vol. 10, pp.39-54.,

[81]. Padmanathan. K, Uma. Govindarajan, Vigna K. Ramachandaramurthy; Sudar Oli Selvi. T. "Multiple Criteria Decision Making (MCDM) Based Economic Analysis of Solar PV System with Respect to Performance Investigation for Indian Market." Sustainability 2017, 9(5), 820; doi:10.3390/su9050820

[82]. Pansera, M and Sarkar, S 2016. 'Crafting Sustainable Development Solutions: Frugal Innovations of Grassroots Entrepreneurs'. Sustainability, vol.8, pp. 51.

[83]. Pansera, M.; Sarkar, S. Crafting Sustainable Development Solutions: Frugal Innovations of Grassroots Entrepreneurs. Sustainability 2016, 8, 51.

[84]. Phil Marker, Mudit Jain, Rakesh Jha, Jasmeet Khurana, Vivek Mishra, Vinay Rustagi, Shilpi Samantray and Jay C.Shiv, 2015 "Solar Rooftop Policy Coalition Unleashing private investment in rooftop solar in India" The Climate Group, The Nand & jeet Khemka Foundation, the UK Department for International Development, The Climate Group, Bridge To India, Meghraj Capital Advisors and the Shakti sustainable energy foundation . The Climate Group (Suite No.1203, 12th Floor Chiranjiv Tower, Nehru Place, New Delhi, Delhi 110019) & The Nand & jeet Khemka Foundation (1st Floor, Khemka House, 11 Community Centre, Saket, New Delhi-110017, India)

[85]. Prabhakar Yadav, Peter J. Davies, SabahAbdullah, 2018 "Reforming capital subsidy scheme to finance energy transition for the below poverty line communities in rural India. Energy for Sustainable Development vol.45, pp.11–27

[86]. Pratheeksha, Mercom India Research's, India Solar Market Update. "Solar Installations in India Reach 6.6 GW in the First Nine Months of 2018" Published on 10th December 2018 Markets & Policy, https://mercomindia.com/solar-installations-6-6-gw-first-nine-months-2018

[87]. Press Information Bureau, Government of India, Ministry of Power (http://pib.nic.in/newsite/PrintRelease.aspx?Relid=174171)

[88]. Proskuryakova. L, 2018 "Updating energy security and environmental policy: Energy security theories revisited" Journal of Environmental Management, vol.223, pp. 203–214

[89]. Rakesh Kumar Tarai and Paresh Kale , 2018, "Solar PV policy framework of Indian States: Overview, pitfalls, challenges and improvements", Renewable Energy Focus, vol. 26, vol 26, pp. 46-57

[90]. Ranajoy Bhattacharyya, Amrita Ganguly, Cross subsidy removal in electricity pricing in India. Energy Policy 100 (2017) 181–190.

[91]. Rasmus Luthander, Joakim Widén, Daniel Nilsson and Jenny Palm, Photovoltaic self consumption in buildings: A review, 2015, Applied Energy, (142), 80-94.http://dx.doi.org/10.1016/j.apenergy.2014.12.028.

[92]. René Vidal , Yi Ma, Shankar Sastry "Generalized Principal Component Analysis (Interdisciplinary Applied Mathematics)" May 2016. Springer, ISBN 978-0-387-87811-9.

[93]. Robert A. Holland, Nicola Beaumont, Tara Hooper, Melanie Austen,Robert J.K. Gross, Philip J. Heptonstall, Ioanna Ketsopoulou, Mark Winskel , Jim Watson and Gail Taylor, 2018, "Incorporating ecosystem services into the design of future energy systems" Applied Energy, vol.222, pp.812–822

[94]. S.D. Lang, L.-J. Mao and W.L. Hsu. 1999. Probabilistic Analysis of the RNN-CLINK Clustering Algorithm. In: Belur V. Dasarathy. Data Mining and Knowledge Discovery: Theory, Tools, and Technology. SPIE Proceedings Vol. 3695.

[95]. Sander van der Linden, "The Social-Psychological Determinants of Climate Change Risk Perceptions, Intentions and Behaviours: A National Study", Ph.D dissertations, Department of Geography and Environment of the London School of Economics and Political Science (LSE) in London, May 2014.

[96]. Sapan Thapar, Seema Sharma,AshuVerma, 2018 "Analyzing solar auctions in India: Identifying key determinants" Energy for Sustainable Development vol. 45, pp. 66–78

[97]. Scott Victor Valentine, Benjamin K. Sovacool, Marilyn A. Brown, 2017 "Frame envy in energy policy ideology: A social constructivist framework for wicked energy problems" Energy Policy, vol. 109, pp.623–630

[98]. Seth B. Darling, Fengqi You, Thomas Veselka and Alfonso Velosa. Assumptions and the levelized cost of energy for photovoltaics . Energy Environmental Science 2011, 4, 3133–3139.

[99]. Shareef, M. A., Mukerji, B., Dwivedi, Y.K., Rana, N. P., & Islam, R. (2017), Social media marketing: Comparative effect of advertisement sources, Journal of Retailing and Consumer Services (in press). Available at https://doi.org/10.1016/j.jretconser.2017.11.001

[100]. Siddharth Sareen, Håvard Haarstad, 2018 "Bridging socio-technical and justice aspects of sustainable energy transitions" Applied Energy vol.228,pp. 624–632

[101]. Solar power potential mapping and Physical Progress (Achievements) in India Available online: http://mnre.gov.in/mission-and-vision-2/achievements/ (accessed on 23 February 2017).

[102]. Sonal Punia Sindhu, Vijay Nehra, Sunil Luthra. Recognition and prioritization of challenges in growth of solar energy using analytical hierarchy process: Indian outlook. Energy 100 (2016) 332-348.

[103]. Sonal Sindhu,Vijay Nehra and Sunil Luthra, 2017 "Investigation of feasibility study of solar farms deployment using hybrid AHP-TOPSIS analysis: Case study of India", Renewable and Sustainable Energy Reviews, vol. 73, pp. 496–511,

[104]. Sonal Sindhu,Vijay Nehra and Sunil Luthra, 2017 "Solar energy deployment for sustainable future of India: Hybrid SWOC-AHP analysis" Renewable and Sustainable Energy Reviews, vol.72, pp.1138–1151.

[105]. Sourabh Jain, Nikunj Kumar Jain,W. Jamie Vaughn, 2018 "Challenges in meeting all of India's electricity from solar: An energetic approach" Renewable and Sustainable Energy Reviews vol. 82 pp.1006–1013

[106]. Sovacool BK. Energy studies need social science. Nature 2014;511(7511):529

[107]. Subhojit Dawnn, Prashant Kumar Tiwari, Arup Kumar Goswami, Manash Kumar Mishra. Recent developments of solar energy in India: Perspectives, strategies and future goals. Renewable and Sustainable Energy Reviews 62(2016)215–235.

[108]. Suhr, D., 2006. The Basics of Structural Equation Modeling. University of North Colorado

[109]. Sunil Luthra,Sachin Kumar Mangla, Ravinder K. Kharb.2015, "Sustainable assessment in energy planning and management in Indian perspective", Renewable and Sustainable Energy Reviews vol. 47 pp.58–73.

[110]. Sunil Luthra, Kannan Govindan, Ravinder K. Kharb, Sachin Kumar Mangla, 2016, "Evaluating the enablers in solar power developments in the current scenario using fuzzy DEMATEL: An Indian perspective" Renewable and Sustainable Energy Reviews vol.63 pp.379–397

[111]. Timothy Teo , Myint Swe Khine "Structural Equation Modeling in Educational Research: Concepts and Aplications (Contemporary Approaches to Research in Learning Innovations), May 2009. Published by: Sense Publishers, P.O. Box 21858, 3001 AW, Rotterdam, The Netherlands. ISBN 978-90-8790-787-7

[112]. Vanesa Castán Brotoa, Idalina Baptistab, Joshua Kirshnerc, Shaun Smitha, Susana Neves Alvesd 2018 "Energy justice and sustainability transitions in Mozambique" Applied Energy vol. 228 pp. 645–655

[113]. Whetten, D. A. (1989). What constitutes a theoretical contribution? Academy of Management Review, 14, 490-495; Suddaby, R. (2014). Editor's comments: Why theory? Academy of Management Review, 39, 407-411

[114]. William H. Day and Herbert Edelsbrunner. 1984. Efficient Algorithms for Agglomerative Hierarchical Clustering Methods. Journal of Classification. Volume 1, pp. 1-24.

[115]. Wuensch, Karl L. (October 4, 2005). "What is a Likert Scale? and How Do You Pronounce 'Likert?'". East Carolina University. Retrieved April 30, 2009.

[116]. Yang Liu, Diwei Lv, Ying Ying, Felix Arndt, Jiang Wei, 2018, "Improvisation for innovation: The contingent role of resource and structural factors in explaining innovation capability" Technovation, vol. 74–75 pp.32–41

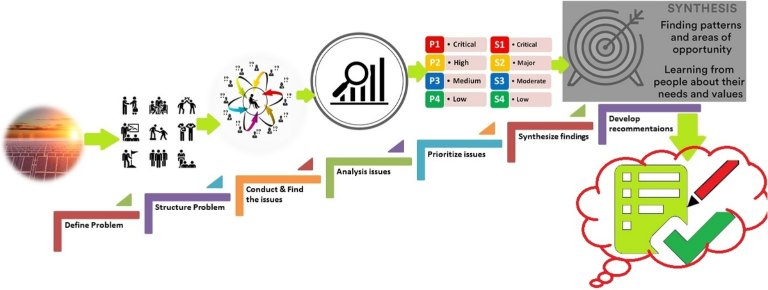
[117]. Yingfeng Zhang, Shan Ren, Yang Liu, Shubin Si, 2017 "A big data analytics architecture for cleaner manufacturing and maintenance processes of complex products" Journal of Cleaner Production, vol.142, part.2, 20, pp.626-641

[118]. Yudi Fernando, Poh Swan Bee, Charbel Jose Chiappetta Jabbour, Antônio Márcio Tavares Thomé, 2018 "Understanding the effects of energy management practices on renewable energy supply chains: Implications for energy policy in emerging economies" Energy Policy vol.118, pp.418–428

Highlights

- Rethinking: Sustainability and progress of solar energy sector in India.
- Key influence on energy policy and solar PV energy system.
- Energy policy-strategy set leveraging statistical methods for participatory planning.
- Policy implication for Solar PV energy system on the basis of pan-India survey.
- Identified major challenges associated with solar energy policy implementation.

CLASSIFICATION OF SOCIOCULTURAL STUDY ON SOLAR PHOTOVOLTAIC ENERGY SYSTEM IN INDIA



Identified obstacles and respective recommendation for solar PV energy development in India