Assessment of Key Contingency and Success Factors for Growth of Solar Sector in India and the Way Forward

A thesis submitted to the
University of Petroleum and Energy Studies

For the award of
Doctor of Philosophy
in
Management

BY
Kushagra Garg

November 2021

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Department of Energy Management
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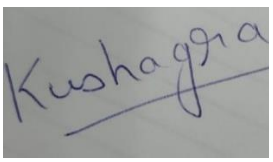
DECLARATION

I declare that the thesis entitled **Assessment of Key Contingency and Success Factors for Growth of Solar Sector in India and the Way Forward** has been prepared by me under the guidance of **Dr. Mohammed Yaqoot and Dr. Vipul Sharma**, Professor of School of Business, University of Petroleum and Energy Studies, Dehradun. No part of this thesis has formed the basis for the award of any degree or fellowship previously.



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CERTIFICATE

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ABSTRACT

In accordance with the COP-21 agreement, India has given an undertaking in the path of RE generation to grow its capacity to overall 175 GW that includes 100 GW solar photovoltaic (PV), 60 GW wind power and 15 GW biomass and waste energy projects. The energy generation through renewable resources like wind & solar PV has increased considerably in the recent past. In India, solar power is a fast-developing energy sector and the target of 20 GW was achieved 4 years ahead which was predicted for 2022. India is among those countries who are shifting to solar energy and the current architecture is making provision for PV circuitry in building plans and PV cells. Policy measures have opened new prospects for the achievement of solar goals by the year 2022 supported by MNRE in the country. The country is expanding its renewable market following an exponential trajectory but is facing many challenges beyond financing like trade protection and local content measures that are posing large uncertainties in the market. Literature survey showed that There is a lack of understanding about the PV technology that remains an obstacle in accepting the technology as an option for energy generation. India has high potential in solar energy generation, however, facing challenges in context to delayed payments by DISCOM, obsolete grid infrastructure that is delaying the country from meeting its solar target. The government needs to revise their solar policies and strategies in risk assessment that are associated with integration of solar energy on a large-scale in the country. There is a basic need to modify the business plan to gain popularity in renewable energy technology for achieving success in large scale solar installation. Despite taking giant leaps in solar PV technology, the conversion efficiency of solar PV technology is quite low and this is posing the biggest technological barrier in the development of solar PV systems. Technological barriers exist in terms of

kintermittent nature of solar radiations that hampers the PV system's ability to meet the demand of the consumers that affect the solar power generation performance. Component failure is another technological barrier that is affecting the PV systems performance in power generation. Economic barriers are the most challenging ones for the solar energy growth in India. There is no comprehensive solar energy policy statement for the parameters like shortlisting and capacity of new projects, state level agency's role, promoter's equity and scope of policy guidelines. Solar developers have outlined that Renewable Purchase Obligation (RPO) is not enforced legally at the state and federal level.

Although there is enormous research reported regarding the growth drivers and energy policies for solar PV technology development in India, there is currently a research gap in the understanding of key contingency factors or success factors that are influencing the solar sector in the country. There is more scope of research on how policies and regulatory framework could be formulated to address the limitations faced by the Indian solar sector. The literature review revealed that presence of contingency factors is disturbing the viability of solar projects and barriers which are growth impediments of solar power projects which are affecting overall growth of India's solar sector. Therefore, the study is aimed at evaluating the key contingency and growth factors and generate recommendations in context to several barriers faced by the Indian solar sector such as technological, financial and regulatory issues. For fulfilling these aims and objectives of the study, framework analysis based on the vast qualitative data generated through data collection has been conducted. The sample population was predetermined like policy formulators and regulators, Discoms/Transco's, project developers through questionnaire survey followed by conceptual framework evaluation and assessment in view of the statement of the problem. For the present research, open-ended questions were formulated in the form of semi-structured interviews. Vygotsky's theory of conceptual framework defined by Vygotsky's Sociocultural theory was adopted to address the contingency and success factors for the growth of the Indian solar sector in the present study.

The initial exhaustive transcripts identified were refined into wider categories which were analysed together to create initial themes and finally, the final themes deduced from the interview through framework analysis that led to the emergence of the central concept "Framework for Development of Solar Sector in India". The findings interpreted from collected data were then discussed in the light of relevant studies that led to the proposed framework comprising four provisions; policy and regulatory provisions, technical provisions, financial provisions and other provisions for determining the success and contingency factors for the growth of the Indian solar sector. Technical factors include integration of large quantities of solar energy into the grid system, inadequate transmission infrastructure and forecasting techniques that are important for studying the impact of the solar radiation and the climatic conditions that affect the solar projects and finances related to it. Policy and regulatory factors include various incentives and subsidies that are provided by the government for the promotion of solar projects and help people adopt the clean source of energy. However, poor financial health of the Discoms, declining tariffs for renewable sources of energy, net metering policy implementation for the rooftop solar projects is still lagging behind which is affecting the growth of solar power in India. Financial factors include financial crisis of DISCOMs, loans issues from big banks, low solar power tariffs, higher Capex (Capital Expenditure model) cost for the solar projects. In addition, other factors include low investment in R&D for solar projects along with lack of research incentives and need for domestic manufacturing of solar equipment in the country.

The recommendations for the central and state government for the successful completion of solar projects in India include; stringent policy formulation for solar sector in India, promote indigenous development of solar modules, investments in R&D activities that support facilities for improving the solar PV technology, ease of loans, increase awareness among the domestic consumers and stakeholders about the advantages of solar energy (clean energy source) and adoption of rooftop solar installation in the residential segment. Moreover, there is further scope for similar studies on the solar energy technologies like Concentrated Solar Thermal Power Technology and scope of study and implementation of global practices in the Indian scenario in the future.

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Firstly, I would like to express my sincere gratitude to my guides Dr. Mohammed Yaqoot, Dr. Vipul Sharma and Dr, Ashok Saini for the continuous support in my PhD work. Their guidance helped me in every phase of my research and writing of this thesis. It was a highly satisfying experience for me to work on this research. The topic of the study was close to my heart and delving deep into its nuances was a real enrichment at intellectual level for me. All this would not have been possible but for the active support of my guides. I am deeply indebted to them for guidance all through the journey from the stage of conception of the idea to the final thesis.

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(Kushagra Garg)

CONTENTS

ABBREVIATIONS

AD	Accelerated Depreciation
APTRI	Adani Power Training Institute
CERC	Crisis & Emergency Risk Communication
CSP	Concentrating Solar-Thermal Power
DISCOMs	Electricity distribution companies of India
GBI	Generation Based Incentives
GFS	Global Forecast System
GHG	Greenhouse Gases
GOI	Government of India
GW	Gigawatts
HDR	Human Development Report
ICT	Information and Communication Technology
IREDA	Indian Renewable Energy Development Agency
IRR	Internal Rate of Return
JNNSM	Jawaharlal Nehru National Solar Mission
LFR	Linear Fresnel Reflector
MNRE	Ministry of New and Renewable Energy
NBFCs	Non-Banking Financial Companies
NISE	National Institute of Solar Energy
NISE	National Institute of Solar Energy
NREP	National Rural Electrification Policies
NSDC	National Skill Development Program
NSM	National Solar Mission
NTPC	National Thermal Power Corporation
PPA	Power Purchase Agreement
PV	Photovoltaic
RE	Renewable Energy
RGO	Renewable Generation Obligations
RPO	Renewable Purchase Obligation
RRTP	Residential Real-Time Electricity
SECI	Solar Energy Corporation of India
SEZs	Special Economic Zones
SGC	State Grid Corporation
SHP	Small-Hydro-Power
UDAY	Ujjwal DISCOM Assurance Yojana

UNDP	United Nations Development Programme
UPES	University of Petroleum and Energy Studies
USOPIC	Overseas Private Investment Corporation
USTDA	US Trade and Development Agency

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CHAPTER 1 INTRODUCTION

BACKGROUND

Economic development is attained through energy. All the domestic needs such as Agricultural, Industrial, Commercial, and means of transport depend on the supply of energy in order to enhance the national economic environment. After the independence voices began to be raised for the implementation of economic development plans. Consequently, a light wave of proper consumption of energy touched the echoes of economic development sources and with the passage of time turned into the hilarious tides in all walks of life all over the country.

The above success gave rise to the rapidly increasing dependence and high prices of foil fuels like –Oil, Gas and Coal. The increasing demand and security of the supply of energy lead to concern deeply as shortages of potentiality would be a big threat in the future. In contrast, the increasing Fossil fuels demand is causing environmental problems both on local and global scales.

Therefore, in the above background, the need for renewable sources of energy and their promotion along with conservation became a herculean task. The country is now paving a new way for sustainable energy through sustainable but presumptuous ways.

The government of India is leaving no stone unturned in making the country capable as to put an example of being the best across the world to implement ministerial approaches for Non–conventional sources of energy. She (India) started it in the early1980s. She has become one of the highest the 5th largest producers of wind-power. In this, Germany, Denmark, the USA and Spain are ahead of her. India has presumptuous sources for generating power from the RE sources. Solar energy, Biomass, and Small-Hydro sources are burning examples.

The estimation of the Small-Hydro-Power (SHP) the potential of India is approx. 15000 MW. Solar-Photovoltaic, Solar-Thermal, Biomass Power are also other renewable energy mechanisms and technologies, growing as strong alternatives and spreading-out exponentially. High dependency and uses of renewable energy sources offer benefits like- mammoth economic development, happy socialism, and a secure environment. As of June 2017, 18% (approx.) of total installed power, i.e., 57.26 GW of 100% installed country capacity, i.e., 329.23 GW, is through renewable energy, and produced electricity is approximately 9%.

From the recent past, India has begun its renewable energy journey & usage of the same are in action, and the start has already been marked, by putting wheels on track of sustainable energy source's generation. Now, speeding up the motion at a fast velocity to meet up the target of the electricity demands of the country, and to make promise fulfilled i.e. 175 GW of grid integrated renewables by 2022, and by 2030 achieve a consumption of 40% of the total energy demand by renewable sources of energy. The way of reaching to such a big and ambitious milestone always demands three

essential things to be incorporated, which are technical expertise, financial support and a full-fleshed regulating framework. As said India has already been marked initial milestones and advancing the renewable energy installation in the recent past. The Govt. of India and private players have started reforming already to make it happened, and the fat sum of finances has also started flowing towards attaining the fast-paced growth rate for the same. To date, 57 GW (approx.) of renewable grid integration has been added by India as progress in this way of sustainable energy.

Considering the Renewable Energy (RE), the existence of RE sources have been observed from early 1970's, but was not popular due to high cost, immature technology and low production as compared to the conventional energy sources like fossil fuels, which were also causing losses to our surroundings already. The COP-21: the Paris Agreement has played a vital and immunity booster role to this era. This has resulted in the enormous growth of the Renewable source of Energy (RE) and to make technological advancement/growth. Means, after the COP-21: The Paris Agreement, having the main intend is to reinforce the response of the world towards the environment change threat; almost all the countries in the world have signed the agreement to protect the environment from Global Warming.

India has also given an undertaking, during and as per COP-21 agreement, to append and grow an overall 175 GW of the RE generation, including the big portion of 100 GW from Solar-Photo-Voltaic, the second high 60 GW from Wind Power and the last 15 GW from Biomass and Waste energy projects. In such a way, it will add following major benefits- It will add upfront energy-security, reduction in dependencies on fossil fuel-based energy utilization, and would be a go green initiative, enhanced waste-management approach & GHG emission reduction, technological enhancement. The amalgamation of such initiatives based on an unreliable source for energy generation may weaken the grid more because of poor grid stability. From the recent past, the addition of Renewable Energy sources and grid renewables integration has grown at an exponential rate in Power Grids.

Post to COP-21, there were large installations of Non-conventional (Renewable Energy) power plants e.g., Solar Photo Voltaic, Solar Thermal, Wind Power, Biomass & Waste Power Projects, and Hydro - small & scaled, etc. The Indian Power sector which was mainly concentrated on coal power plants till the signing the summit, now turned its way to RE production. There are various positive points in this like, reduction in global warming, an increase in capacity, reduction in the peak deficit, supply-demand gap reduction, etc. But there are some problems associated with it.

The Power Grid in India, which was constructed according to Coal based power plants, will start facing intermittency power supply due to the Renewable power source. Renewable Energy sources, rich countries like Germany, Denmark, Costa Rica and Iceland have its Grid modified long back when Renewable energy was introduced. There are lots of issues associated along with intermittency. The plan for 2022 is lot more ambitious. Integration of 175 GW of renewables into the system will definitely lead to fluctuation of power, blackouts etc. India has to make necessary changes in order avoid these problems.

1.1 EXISTING GENERATION SCENARIO AT GLANCE

The current energy generation in India includes majorly the thermal power plants-based energy generation, which is based on fossil fuel coal. The proportion of such thermal energy generation that is coal-based shares the major portion of the total, i.e., approx. 61% of overall capacity of generation means 76%. The comparative visual in the form of a pie-chart is given below to express it in a better way, as Fig. 1 and Fig. 2.

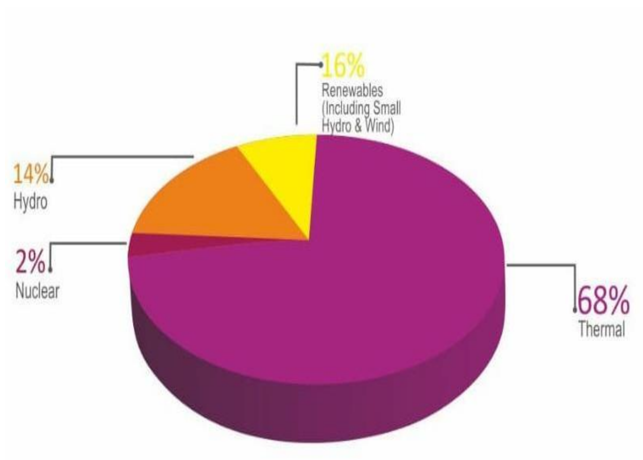


Fig.1. (Installed Capacity in India) Fuel Mix,
Source: CEA

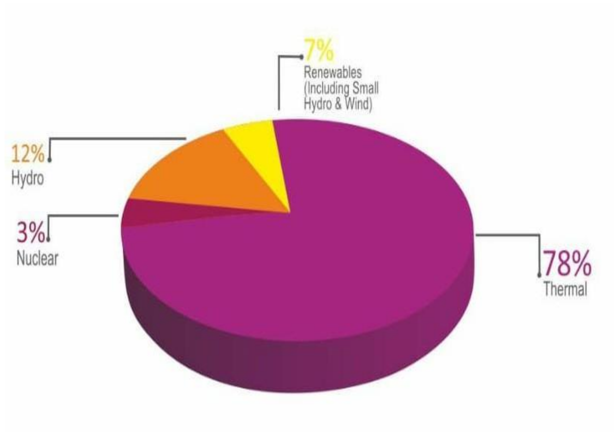


Fig.2. (Actual Power Generation in India), Fuel Mix
Source: CEA

As said before, fossil fuels are not capable enough to run a long track & also hazardous to our environment, and India marked its start in search & usage of Non-Conventional Energy resources. So, the COP-21 summit held at Paris, projected and estimated India as a forge in the instigation of the Solar-PV based energy generation. In Cop-21, India has also had promised that by 2022 its solar capacity will grow up to 100 GW, which has achieved the milestone of actual installed capacity of 18 GW, and within a short span of time, India has also enhanced the installed capacity of up to 5GW.

Dedicated provisions have been made in the FY 2015-16 budget to develop ancillary oil and gas fields in India, which could be a reason for domestic and cheap gas resources for electricity generation. A contract with Iran for gas through China is also under consideration, which may accentuate the need for thermal power plants based on natural gas available in the country. Being the cleanest fossil fuel, gas and gas-based plants also make and enhance sustainable grid in India. Gas-based power plants have been recommended to conquer uncertainties in RE generation like wind, solar and help in the building of the stable hybrid plant. The thermal power plants that are most efficient are also based on gas combined cycle power plants, having a capacity close to 70%.

In addition to this, the expansion and enlargement of nuclear power projects have also been focused on the current financial plan. For the same, India has a current installation of 5780 MW capacity; several different projects are under construction and under planning. However, the most of the nuclear power plants are at a standstill due to the consequences of the 2011 Fukushima disaster. The 1000*2 MW reactors (VVER Technology) is a collaborated effort with Russia, Kudankulam has been closed since 2002 due to fishermen from surrounding areas have great difficulty commissioning another reactor.

As far as the coal-based energy generation is concerned, India is working extensively in this category of power generation. India has increased its indigenous capacity of coal production which resulted in risk reduction and dependence on preferred and imported coal. By the implementation of some enthusiastic schemes like UDAY (Ujjwal DISCOM Assurance Yojana) [x1], there are plans to make coal management processes more efficient and effective as well. The standards of emission control aren't up to the mark and universal, until now, imported types of equipment have been used for universal standards, resulting in emission reduction from thermal power plants.

The renewable energy resources like biomass and wind are rarely noticed till date. Hence, the rate of expansion of such power plants is much slow than the rate of expansion predicted. Having a very high agricultural produce (for biomass), India has to realize more and invest in such resources. Additionally, India has a very large coastline for reliable off-shore wind power plants along with the better capacity factor than those on-shores. As the investment is quite low in these sectors, they can hardly prove to be a sustainable energy environment.

1.2 PRESENT SOLAR SECTOR TRENDS IN COUNTRY

After a record capacity has been witnessed, an addition of about 3 GW in FY16 (refers to the period April 1 to March 31), in Q1FY17, 1 GW and around 6 GW bid have been awarded since past 6 months, the solar sector is on a strong growth path. According to several estimates, India is all set to achieve the position of the 4th largest global solar market in 2016. The country will only be behind

USA, China and Japan, primarily on account of the Government of India's (GOI's) knock on remarkably enhancing the capacity of installed solar power plants to 100 GW by the year 2022. This has led to attracting interest from different players, both domestic and from overseas.

The sectors described are witnessing tremendous participation from developers and investors from large overseas, like EDF, CLP, ADIA, ENEL, Engie, Fortum, Goldman Sachs First Solar, etc. Along with them, major Indian business houses are also planning ambitiously for addition to solar capacity. Also, with the wind sector lately facing certain headwinds, primarily due to diminishing additional benefits such as reduced Accelerated Depreciation (AD) and expiry of the Generation Based Inventive (GBI) after FY17 and preferential feed-in-tariffs paving the path for competitive bidding, some of the prominent wind IPPs have also made foray into the solar power sector. The recent M&A activity, viz, Tata Power Renewable acquiring 1.1 GW of capacity (including 994 MW solar capacities) from Welspun Group, as well as CLP India's acquisition of 49% stake in Suzlon's 100-MW SPV setting up a project in Telangana is a reflection of the building of strong trust of crucial players in the solar sector.

In addition to the attractive plan of scaling up the country's solar capacity to up-to 100GW (40GW solar rooftop capacities included) by 2022, the Government of India has also surged the Renewable Purchase Obligation (RPO) trajectory in solar power generation upwards from a percentage of 3% to 8% by FY22. Stricter enforcement by states for RPO compliance by the Discoms is crucial for the sector. Furthermore, built up of evacuation infrastructure and timeliness in land acquisition would have important bearing on the capacity addition.

There has been a sharp decline in the cost of solar PV project in the last few years which have resulted in shift to competitive bidding from feed-in-tariffs (preferential) in the sector. Apart from declining costs of solar PV project, an addition of different players has resulted in a considerable uplift in competition. This additionally has resulted in significant declination in solar tariffs which can be seen from the fashion in the completed bids from last 1 year. The bids for

NTPC/NVVN and SECI projects (including in solar parks) have been more aggressive as compared with state policy projects.

The Average weighted tariff for the completed bids that was witnessed during FY16 remains still at Rs.5.26/unit (including VGF bids and excluding DCR projects), that may further reduce to approx. Rs.4.5-4.8/unit during FY17, increasing the competitive intensity and reducing prices. During January till July 2016, the cost of a Chinese crystalline module has witnessed a reduction of about 9%. With the slowdown situation in the Chinese demand and oversupply in coming future, the cost of module could soften further, which will result in reduction of cost for the developers who are tying up the supplies in the near term.

1.3 APPRAISAL OF PROJECTED CAPACITY, APPROX. 5.2GW IN FY17: THE PROLIFERATION

Out of the total RE capacity installed of 42.75 GW till March 31, 2016, the solar energy share has increased to 15.82%, as against 13.8% that in the last year. According to the National Solar Mission Scheme, cumulative solar installed capacity was accelerated to reach up to 20 GW by 2022; but, has been considerably revised to increase by 100 GW (including the 40 GW rooftop projects) by 2022 by the GoI. Various state governments namely, Chhattisgarh, Gujarat, Jharkhand, Andhra Pradesh, Karnataka, Orissa, Rajasthan, Madhya Pradesh, Punjab, Tamil Nadu, Uttar Pradesh, Telangana etc. have formulated state policies for encouraging solar power projects. Moreover, government entities like SECI, NTPC, etc. along with those in solar parks have come up with large capacity tenders in GW size.

From January 2015, there has been award of more than 10-GW capacity, with bids under various state power policies constituting 53% while remaining 47% were under JNNSM scheme (NTPC 25% and SECI 22%). However, during CY2016 (till July 14, 2016), 65% of the bids were for JNNSM schemes projects (NTPC 27% and SECI 39%), while remaining 35% were under various state solar schemes. Recently, the JNNSM bids in the state of Gujarat saw a muted response with total bids received for 160 MW of projects as against tendered capacity of

250 MW. The reason for such a response was due to relatively higher solar park charges (Charanka Solar Park) of Rs.0.96 lakh/MW than seen in other states like Rajasthan and AP.

Typical average time taken from bid award till commissioning of the capacity is around 18 months; however, there have been few cases wherein there were delays in signing Letter of Intent and PPAs as well as land acquisition, which could result in shifting of capacity addition by another quarter or so. Majority of the listed capacities are expected receive a commission by mid of FY18. During FY17, till June 30, 2016, there has been an addition of capacity of 1.03 GW and in FY17, expects an addition of capacity of approx. 5.2 GW.

1.4 DECAY, IN SOLAR PROJECT COST

The cost of capital for installing solar PV project has shown a slow down since past years. The cost of solar PV of benchmark project, CERC has reduced from Rs.6.1 crore/MW to Rs.5.3 crore/MW in FY16 and FY17 respectively. Additionally, declining the price of modules marginally whereas the cost of civil and others have witnessed deeper fall. Keeping aside the costs of module, in the past years, ancillary costs and the cost of *Balance of Systems* (BoS) have witnessed very sharp decline too. Module cost continues to form an important portion of a solar PV project's total cost. The average crystalline module (China) spot rates are hovering around 48 USD cents/watt (source: PV Insights), and players with larger orders have been able to source at around 42-45 USD cents/watt based on negotiations with suppliers.

1.5 ENERGY STORAGE TOOLS & TECHNIQUES

From about a century, one technology has dominated the energy storage in the power sector – pumped hydro power storage. It is beginning to change along with the rest of the sector. Deployment of RE and various policies to modernize the production of electricity and its consumption are driving various advancements, including increased battery storage. This technology can be made to locate at the site of requirement or at the grid level and chemically stores the energy. Its deployment and use will lead to larger amounts of renewable electricity that will contribute in the system reliability.

From technological view, battery storage is quite mature and hundreds of suppliers are coming up with reliable systems. Although, before battery storage is fully adopted in the form of mainstream option in the power sector, several barriers need to be overcome. These include safety and performance issues, utility acceptance and regulatory barriers. However, past trends have illustrated that these barriers can be surpassed and in many scenarios are being overcome. In multiple areas of application in the whole wide world, batteries are finding the great use to help in the integration of RE, especially solar and wind power. Both these resources are referred to as variable renewable energy too due to the fact that their production tends to fluctuate depending on resource availability. Prices are reducing, and technological progress is leading to improved performance.

Many experts are of the opinion that electricity storage can prove to be an important role player for using & managing electricity produced by Renewable Sources. Storage would mainly be crucial for distributed generation systems because of several reasons: Mainly generation of RE in combination with storage of electricity is an economically & technically strong substitute to usual diesel-generators. Secondly, storage is one of those very limited feasible solutions for the integration of solar-Photo Voltaic and wind energy into present power systems in distant / isolated areas and islands. As in these areas, interconnection is weak and there is a lack of flexible power sources. Thirdly combining renewable power with storage could enhance power system reliability and security.

A. TECHNOLOGIES

A large range of energy storage mechanism can be used to ensure various functionalities at various locations. The characteristics like the efficiency, output capacity, and lifetime and discharge time differ largely depending on technologies.

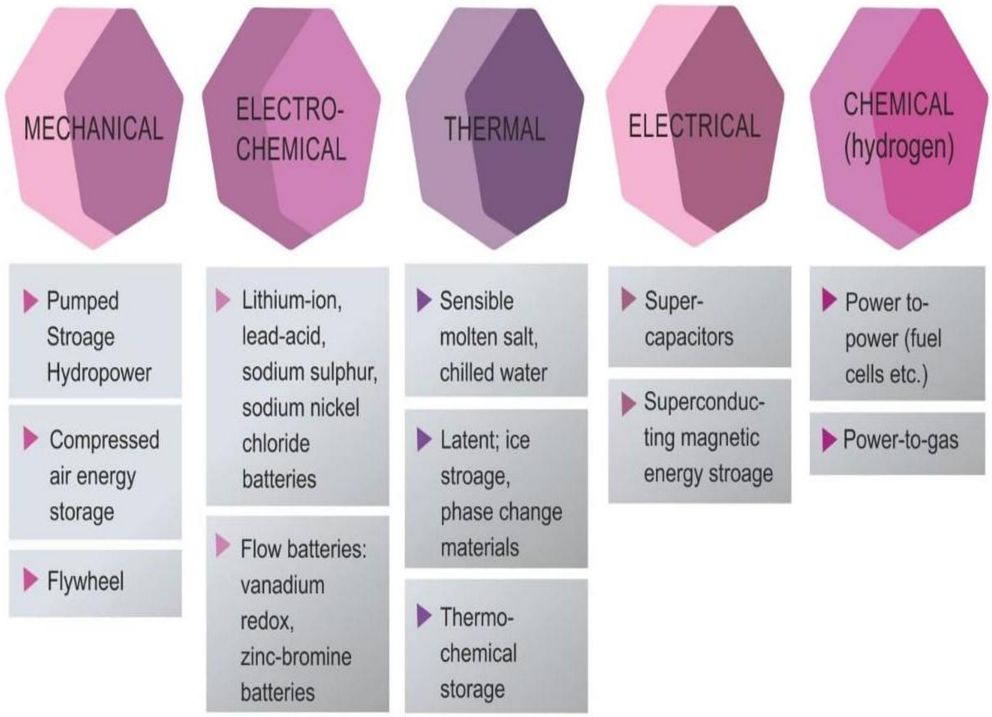


Fig.3. Energy Storage Technologies (Classification)
Source: Indian Smart Grid Forum Website

Not just a single electricity storage technology stands best in all dimensions and the choice of technology is dependent on mainly on the size of the system, electricity sources, a marginal cost of peak electricity and the specific service that is required. The storage technologies classification is shown above as Fig. 3.

In addition, various technologies for storage are at various maturity levels. The best mature technology is pumped hydro power which is technically and economically accepted worldwide. Pumped hydro power covers the large majority of worldwide electricity storage capacity to the level of 145GW in operation. It holds the capacity for significant increase but is unsuited for small-scale applications or residential areas.

The next most developed option after pumped storage are the electrical batteries. The battery storage system demand has been increased sharply since last years.

The growth has been driven by small yet fast growing market of electrical vehicles and also by considerable growth in renewable capacity generated. Some of the other technologies for storage are super capacitors and flywheels power-to-gas.

Table1: Types of Storage Technologies

Storage Type	Description
Pumped storage hydro	Uses excess electricity (e.g., produced at night by coal or nuclear power) to pump water from a lower to higher reservoir; stored energy then generates hydropower during high-demand periods. Has largest power potential (per system) of any storage option, and longest life expectancy. Discharge time up to 24 hours or more.
Compressed air energy storage	Requires large, low-cost natural buffers such as caverns to store energy by compressing air: the compressed air is used in gas-fired turbines to generate electricity on demand. Discharge time is up to 24 hours or more. Efficiency is relatively low. Expansion is limited due to lack of suitable natural storage sites.
Flywheel	Stores electricity as mechanical energy. Which is converted back to electricity when needed? Discharge time is seconds to minutes.
Batteries	Store electricity as chemical energy. Several types or batteries are available (see Figure 4.5). New materials and technologies are under development to improve performance and reduce costs. Discharge time is mostly 8-12 Hours.
Thermal storage	Includes a number of different technologies that accommodate a wide range of needs. Allow for excess electricity to be converted to thermal energy and stored (short-term or seasonal) for later use. Generally not converted back to electricity, Except in the case of concentrating solar (thermal) power technologies.
Super capacitor	Stores electricity as electrostatic energy: often combined with batteries. Relatively high efficiency, with discharge times below 30 seconds.
Superconducting magnetic storage	Uses super conducting technology to store electricity. More research is needs.

Source: www.energystorage.org

Various technologies are although open for storage but batteries have shown the most promising advancement from recent past, and are getting quite more attraction and attention. The competition is being driven by a large number of actors which represents variety of backgrounds such as battery manufacturers, utilities and renewable project developers.

In order to sustain renewable amalgamation and improvise steadfastness of energy supply, batteries are being used in mainly four application areas. The areas are: island systems off-grid RE for solar PV installed households, rural electrification, short-term and fast electricity that balances ancillary markets and RE smoothing and energy supply shifting. For example, in Germany about ten thousand rooftop solar-Photo Voltaic systems are being tied with battery storage mechanism.

Even, there is an important role of batteries in providing access to energy in this growing world, mainly when integrated with solar home systems and solar PV in lighting systems. As per the global electricity storage mechanism technologies' share is shown as Fig. 3.

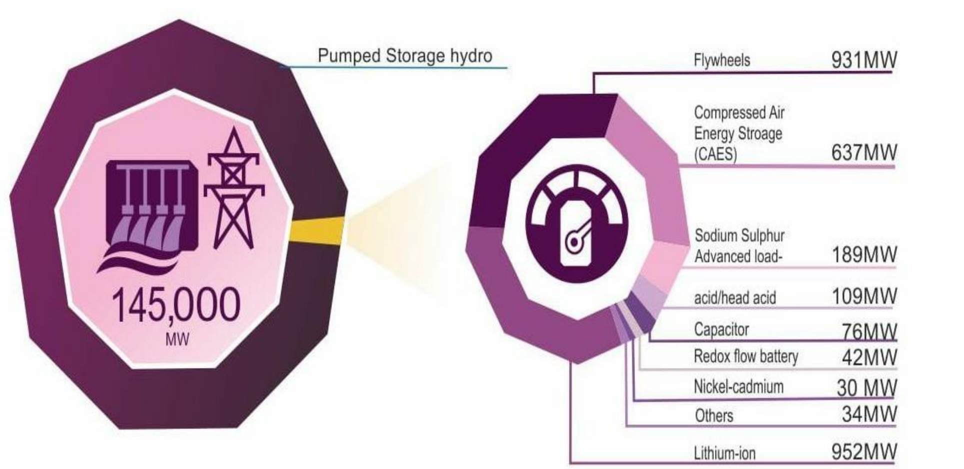


Fig.4. Storage Technologies' Share

Source: www.iea.org

The use of different batteries is different, but recently there has been a considerable shift from sodium sulphate to various other kinds, mainly lithium ion. The domination of lithium-ion batteries in the current storage market is due to their efficiency, energy density and comparatively longer life. In the year 2016, these batteries shared the market for nearly half new battery deployment having sodium Sulphur, advanced flow batteries and advanced lead-acid and too share the market significantly.

The lithium-ion batteries find a wide use in plug-in hybrids, electric vehicles and consumer electronics. They provide the benefit to produce large amount of energy in short stretch of time and the lesser amount of energy in longer stretch of time. These benefits make them perfect for mobile (electrical vehicles) as well as stationary (solar PV systems) electricity storage for applications and scales.

Utility-scaling systems were started in just a time of few months in the year 2016 in North America for grid-based projects. Additionally, lithium-ion batteries have started to be witnessed in various solar home system markets, which till date depended primarily on comparatively lower-cost deep cycle lead-acid batteries. By the year 2025, it has been predicted that use of lithium-ion batteries will consider to increase up to 80% share of the whole of the global electricity storage installations. The use of battery is expected to grow substantially in approaching few years, having wide markets in Europe, North America, and Asia-Pacific. Batteries are all ready to play a crucial role in integration of RE in currently active electric grids and major role in the continuing effort to give accessibility to those still living without electricity. It is predicted that pumped storage hydro power in 26-countrie would be in incrementing mode from 150 GW to 325 GW in 2014 till 2030 respectively. Over the same stretch of time, the total battery storage available for electrical energy will rise from 0.8 GW to approx. 250 GW.

B. COSTS, CHALLENGES AND BENEFITS

In the power sector, there are some challenges to resolve before the battery storage can be completely integrated in the mainstream option. Although, there exist promising signs of growth and progress. The main obstacles to the vast usage of storing electricity are: system costs, uncertainty on regularization cure, limitations on monetization of storage projects valuation, materials performance, and its use, utility acceptance and issues of safety. Additionally, many stakeholders are not able to understand the storage technologies or their existing advantages.

Prices are the most crucial hindrance. Having hope of conventional compacted air-energy-storage and pumped storage, the cost has confined large-deployment at large scale. Although, the price of new and the finest battery storage mechanisms are predicted to decline. This is because of the increasing demand (mainly for electric vehicles), expanding manufacturing capacity and international competition. Undeniably, costs of utility extendable storage and residential have considerably degraded and will fall successively, when the recital is getting higher & higher. In the year 2015, for instance, lithium-ion battery costs increased to USD 350/KWh, which means 65% decline from 2010. It is predicted to decline in next 10 years by USD 100/KWh. Battery storage can economically become viable for self-consumption supported by rooftop solar PV in residential areas having high electricity prices.

Despite further predicted reduction in the cost, it is possible that the electricity storage contribute largely to mechanism costs will raise significantly in forthcoming, particularly as RE energy generation prices falling down sequentially. However, storeroom gives a variety of services that are away from incorporation which are not surely & easily monetized. These contain reduction in incidence of service interruption and increase in system reliability and, increased efficiency and T&D network support. These additional advantages will surely be considered and quantified when evaluating storage as a scheme reserve.

The solar panels are also be proven helpful in reducing the environmental impact due to high volume battery recycling, as battery storage is one of the biggest challenges to ecology as well as from an economical perspective. It would be reduced up-to 40% in comparison with 50% recycling material usage. The most popular and demanded material, lithium which is very rare on the earth, and lithium-ion batteries need direct recycling. All other direct concerns like expenditure, social & personal wellbeing and relative difficulty in obtaining cobalt, has inspired and provoked researchers to research for advanced categories, lightweight, high-energy concreteness, and long-run batteries.

To reduce recycling, State Grid Corporation (SGC) of China is doing research and experiment to assess the durability of second-life of lithium-ion batteries, for providing support to grids. For enlarging rural electrification, it is quite likely to consume second-life batteries provided by mini-grids.

1.6 BUSINESS PROBLEM

The energy generation through renewable resources like wind & solar PV has been increased considerably in recent past. The same is also has worth share in grid's total energy generation, as observe above in background facts. There are some major barriers identified (as given below), and can be improved-

- The existing policies are somehow specific to a particular technology and cross-state-borders have changes & restrictions. Hence, a comprehensive national policy and legislative framework is not there.
- The two major reasons in acute shortage of creditworthy and willing buyers of renewable energy are, most of the financially stressed Discoms, who are major and bulk buyers of energy, have held back from buying renewable energy leading, due to delayed payments / renegotiation of PPAs.
- Higher interest rate is because of multi-stage qualms or in back down of solar power, means the high interest rates of 10-14%pa, which is almost thrice higher than interest rates in developed economies.
- Obsolete & outdated grid infra/formation have been affecting the solar sector and overall energy generation. The two major challenges like- Payment delay

by Discoms to solar generators and renegotiation of PPAs are hitting cash flows and affecting the viability of projects. In this same regard, two small case studies are being explained through monetary calculations, to demonstrate the breakage in cash.

CASE1: PAYMENT DELAY BY DISCOMS

Considering the case of 500 MW Bhadla solar parks, where tariff discovered through bidding route is Rs 2.44/unit. As per gathered information from various articles Rajasthan Discoms has delayed payments by 3 months. So, the loss scenario, with an assumption of 12% annual rate of interest and 3 months delay.

Table 2: Cashflow calculations for Solar Projects

Statement	Capacity (MW)	Unit Price(Rs)	Period (Months)	Total Amount (Cr.)
Cash Flow	500	2.44	1	**87.84**
			3	**263.52**

Source: Author's Calculations

Hence, if payment gets delayed by 3 months, then interest loss = **6.58 Cr**

CASE2: RENEGOTIATION OFPPASBY DISCOMS

In a recent case of Tamilnadu, Tamilnadu-Discom renegotiated price of 500 MW PPA from Rs 4.40 to Rs 3.47.

Table 3: Cashflow calculations under different tariffs

Statement	Capacity (MW)	Unit Price (old)(Rs)	Unit Price (new)(Rs)	Unit Price Difference (Rs)	Period (years)	Total Amount Difference (Cr.)
Cash Flow	500	4.40	3.47	0.93	1	**408**

Source: Author's Calculation

The above said small case studies and derived conclusions demonstrating the barriers and financial contingencies are affecting solar projects in India.

PROBLEM STATEMENT & SCOPE

Statement of the Problem*: Presence of Contingency factors is disturbing viability of solar projects affecting overall growth of India's solar sector.* ***Scope****: The study aims at assessment and identification of barriers and risks which are growth impediments of large scale (projects having capacity greater than 100 MW) solar power projects in India.*

1.7 SUMMARY & MOTIVATION FOR RESEARCH

The world operates through energy. From the fan in your room to the fan in the spacecraft, the whole development process of the country relies massively on energy. In a developing country like India, energy needs are escalating gradually to meet the set targets for economic development.

The country is experiencing a shortage of reserves of non- renewable sources of energy and taking into account the growing pollution levels and deteriorating climatic conditions, RE sources are the need of the hour.

India set off on its path of sustainable forms of energy in the 1980s by setting up the Ministry of New and Renewable Energy (MNRE). The geographical location and physiographical features of India make it an appropriate candidate for the development of different sources of RE like solar energy, wind energy, hydro energy, geothermal energy and biomass energy. India is ranked at fifth position in the production of wind energy globally. There is a bright future for solar PV in India, and all we need the right framework to be devised on, as we are intended to.

1.8 STRUCTURE OF THESIS

CHAPTERS ORGANIZATION

The complete thesis contains a total of six chapters including the above-said introduction, which is all about demand & the current power generation scenario in India, traditionally available resources, technologies, challenges, initiatives towards renewable energy resources, break-down causes, business problem and motivation for study.

The thesis is categorized into listed chapters mentioned below.

CHAPTER2: LITERATURE REVIEW

Prior knowledge of the vulnerability of any study requires a proper investigation, and this is only possible through a review of the literature about that era. Chapter 2 examines the literature based on five criteria, including various available policies & regulations, contingency factors, techno-business issues, performance evaluation research, and operational challenges.

CHAPTER 3: RESEARCH METHODOLOGY

Chapter 3 is all about research formation and construction. It includes the research gap & its analysis, the formation of the research objective & problem, the research methodology, to be carried out, & design. The detailed research methodology is also demonstrated in this chapter.

CHAPTER4: QUALITATIVE ANALYSIS AND FINDINGS

Chapter 4 depicts the conceptual framework, data collection, analysis, evaluation approaches, its assessment in view of key contingency and success factors of RE resources, and generation. The analysis of the conceptual framework has been done here and based on the analysis and evaluation of the same by different approaches a final framework is created.

CHAPTER5: RECOMMENDATION AND CONCLUSION

Chapter 5 summarized the various initiatives Central and State Governments should take to promote solar technology in India. These initiatives are broadly classified into Policy and Regulatory Measures, Financial Support, R&D initiatives etc.

CHAPTER6: LIMITATION AND FUTURE STUDY

As usual nothing is perfect; our study is also having some limitation. Chapter 6 is all about some limitations of the underlying research.

RESEARCH CONSTRUCTION & FLOW

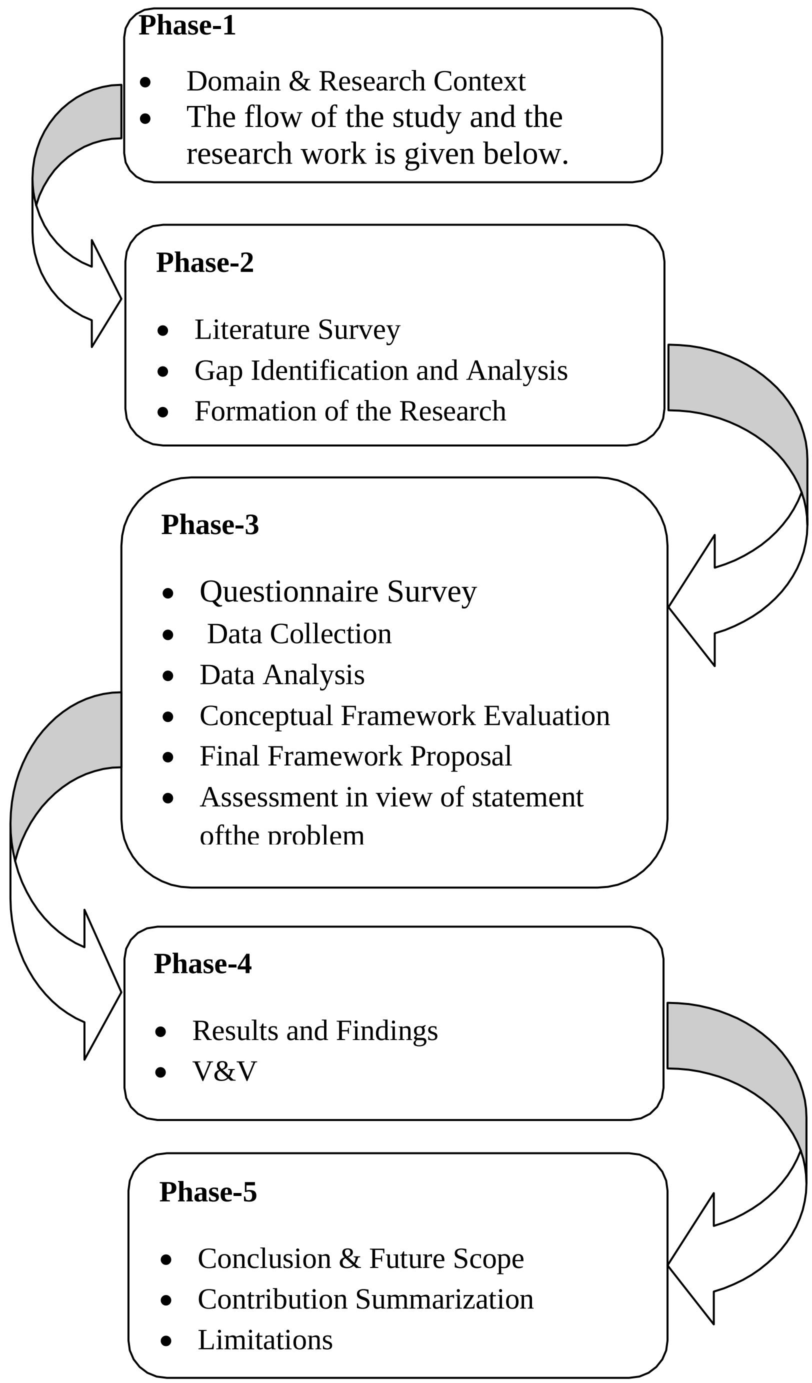


Fig.5.Research Flow

Source: Author's Work

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

In this chapter, the existing pool of literature that is related to the research topic will be reviewed by surveying the scholarly articles, academic journals, books, technical reports and other publications. The secondary sources of literature will be reviewed and thoroughly analyzed relevant to the solar sector in India and globally, challenges faced by the country in solar energy storage and power generation, key contingency and growth factors and regulatory policies for solar power development in India.

2.2 GLOBAL ENERGY SCENARIO

The Paris Conference of the UN Parties Convention on Climate Change made an international commitment to restrict the increase in temperature to 1.5 °C and pursue efforts to restrict the mean temperature globally below 2 °C. However, as per the trajectory of current emission, it is more likely to align with an increase in 4 °C in 2100. This Paris Agreement explores deeper options of decarbonization for the hardest sectors that aims to eventually cut down the CO2 emissions to zero. The global energy demand as per the assessments has dropped by 5% during the year 2020, energy related carbon dioxide emissions by 7% and 18% in energy investments (Gupta, 2016). These varying impacts are due to fuel and looking into the global energy trends, there is 8% fall in oil demand, coal use by 7% that stands sharp in contrast to slight increase in the use of renewables. RE sources of energy are growing rapidly in the power sector with solar being the core of the new constellation in the technologies of electricity generation. Globally, renewables meet 80% of the electricity demand where hydropower is still the largest RE source of power generation, however, recently, solar energy is becoming the main source of electricity generation setting new records followed by offshore and onshore wind. The pace with which the electricity sector is changing globally is adding onto premium costs on power grids, reliable supplies of critical metals and minerals, flexibility sources which are quite vital for their secure transformation (Elavarasan et al., 2020). The challenges faced in storage technologies still pose a hindrance in the flexible operation of these power systems where India is becoming the largest market in the usage of battery storage.

The past decades have witnessed strong rise in the use of RE technologies where the power sector has taken the lead and this is because of sharp reductions in the cost for wind and solar photovoltaic (PV). Renewables continues to generate electricity with an output of 450 terawatt-hours (TWh) in the year 2018 which is 7% increase than previous years claiming for more than three-fourth in the total generation of power. Wind, hydro and solar PV output claimed for the 90% rise where about 180 GW of energy capacity from renewables was added during the year 2018 that was possible due to cost reductions and advancements in digital technologies opening new opportunities for energy transitions. As per the State Policies Scenario, renewables account for the majority of the power generation where about 80% of the additions are made in the China and European Union with least additions in Middle East and Southeast Asia. Solar PV has the largest renewables capacity share including regions India and China (Avezova et al., 2019). Offshore wind has the greatest potential for meeting the electricity demand than onshore wind and solar PV due to larger turbines that tap more and higher reliable wind speeds far away from the shore. New records are also set for solar and wind installation with 47 GW and 94 GW in wind power and solar PV respectively that includes offshore wind 4 GW power. Between the years 2010 and 2050, solar PV is expected to have the highest increase ~230 times where as much electricity is produced by solar PV as compared to fossil fuels globally by the year 2050 (Gielen et al., 2019).

According to Islam et al., (2014) electricity generation by renewable resources of energy are becoming prevalent and are predicted to provide global demands of energy by half by the year 2050. For satisfying the future demands of energy, smart grid systems are considered as efficient systems for renewable energy generation and integration and an ideal solution to less greenhouse gases' emissions and climate protection. In developed countries, modern concepts and innovative technologies are being upgraded for enhancing energy efficiency being performance indicators from an international perspective. The world has increased the use of renewables by enhancing their installed capacity of power plants like solar PV, solar thermal, offshore and onshore wind, hydro-based, tide-based, geothermal, biomass and fuel cell-based power generation. Renewables have established themselves globally where above 90 countries have installed at least generation capacity of 1 GW and about 30 countries have exceeded generation capacity of 10 GW where solar PV and wind are further increasing their shares and in 2018, 2378 GW of power capacity by renewables have been generated globally.

As compared to hydropower, solar generation is a relatively modern source of renewable energy that is quickly growing in many countries across the globe. 2017 has been a historic year for the solar sector as PVs were installed and solar showed new capacity than nuclear and fossil fuels combined. This has led to over 400 GW solar power capacity globally exceeding the previous years 2015 and 2016. Simultaneously, in India, 2017 has been a remarkable year for PV where the country exceeded the installed capacity over 19 GW with net addition of 9.6 GW yearly and market growth by 127% as compared to the previous year having 4.3 GW. The year has set a record being the largest source of solar power capacity constituting 45% and took over Japan's place and became the world's third largest PV market and one trajectory to take the second place. Over the time, the solar PV electricity production globally has grown more by tenfold where it is supplying more than 2% since 2018 and by 2040, multiple projects will utilize solar energy for providing world's electricity by over 20% (Kannan & Vakeesan, 2016).

There has been a huge transformation in the energy system globally where the paradigm has shifted towards a high level of sustainability in compliance with the Paris Agreement on Climate Change Summit (COP-21). According to Breyer et al., (2017) the energy transition in the global scenario has resulted in a fast growth witnessed in installation of PV capacities and high level of energy share to total global energy demand worldwide. The long-term capacity of solar PV is expected to be about 42 TWh due to the cost reductions in battery and PV technologies and with this, solar PV is expected to have the minimum cost, largest and most pertinent energy source in energy supply globally. The Indian government is setting out ambitious targets for renewable energy where solar will undergo profound transformation and is planned that by the year 2022, total solar installed capacity will be 175 GW. This indicates 150 GW net growth from solar installed capacity where rooftop PV will contribute about 40% of the total solar power generation. To fulfill this future demand for energy efficiently, energy security and reliability should be improved. In addition, an effective solution for energy should be investigated. In this regard, solar energy is a promising energy solution due to its extensive availability. According to Devabhaktuni et al., (2013) solar power has a more competitive edge than other energy sources in terms of sustainability and cost. Moreover, solar PV and devices can benefit the economy of the developing nations as well as the environment. Therefore, factors like deployment costs, operation, maintenance and economic policies could help to promote solar energy system installations. As discussed above, the cost of technology for renewables have decreased significantly providing a sustainable and cost-effective means for meeting the electricity demand in middle-income and developing countries. For the significant expansion, implementation of electrical grids for transition power systems will reduce the integration costs in the long run. Many grid stability practices are being employed by many countries like introduction of ancillary services, improvement in content of gas and hydro based power plants, improvement in Demand Side Management (DSM) for controlling power consumption, installing large battery tanks, smart-grids implementation, regulatory policies, etc., for supporting installation of renewables power generation and reducing irregularities in demand-supply gaps.

2.3 OUTLOOK ON SOLAR ENERGY IN INDIAN SCENARIO

In India, solar power is a fast-developing energy sector and the country's installed capacity as of November, 2020 was 36.9 GW and the target of 20 GW was achieved 4 years ahead which was predicted for 2022. According to Srivastava & Srivastava, (2013) solar energy has tremendous potential of being a financially viable energy source with government rebates and tax incentives. India is among those countries who is shifting to solar energy and the current architecture is making provision for PV circuitry in building plans and PV cells. National Solar Mission (NSM) launched in 2010 is among those national level initiatives that are encouraging solar power generation and grid-parity for India's long-term and comprehensive strategy for energy supply. According to MNRE, India has surpassed Italy in solar power and every year ~5,000 trillion kWh fall over the country's land area where solar PV cells can effectively harness huge scalability. According to Rao et al., (2020) India is becoming one of the largest solar power markets in where it has received mass recognition for its solar power potential. In India, Gujarat is leading in context to solar power capacity installation with 36 GW potential followed by Bihar, Andhra Pradesh, Maharashtra, Madhya Pradesh, Rajasthan, Punjab, West Bengal and Orissa tapping for great potential in solar energy having location advantage. With the launch of Gujarat Solar Power Policy -2009, the state is set to achieve installed capacity of 500 MW and NSM tariff below levelized tariff made the state policy attractive to the developers. India's solar market is rising and its potential is real forecasting capital-equipment market of $6 billion to $7 billion by the next decade.

Due to increasing global population, fossil fuels are degrading and therefore, solar energy being a conspicuous energy source can fulfill the increasing demand. According to Dubey, Chamoli & Kumar, (2013) India is among the highest recipients of solar energy because it falls in the solar belt of 40◦S to 40◦N (between Tropic of Cancer and the Equator) aggregating 66 MWp of solar applications where 80% is from solar lanterns, solar water pumps and street/home lighting systems. According to Dawn et al., (2016) as per Indian perspectives, solar energy source has not increased power generation, however, has also expanded the energy reliability in aspects of social, environmental, financial and independent properties. Generation of solar power using grid technique is generally grouped into two forms i.e., rooftop PV and ground mounted PV. Many solar projects are being implemented by the Indian Government that is playing a central role in the generation of power fulfilling the country's energy requirement. This rooftop PV is not only fulfilling its own energy needs, rather generating surplus power in the grid. Rajasthan has the highest grid-based power supply with a capacity of 1199.7 MW and lowest number of grid-based solar power having capacity of 0.025 MW. Gujarat and Rajasthan have the largest solar park and solar power plant constructed. Until recently, the Indian government has launched solar power generation on rooftops and met the rapid development of power generation in context to solar energy.

Global energy mitigation and climate change are the vital factors in this era of modernization and globalization. The development and implementation of solar energy is being taken up by the Indian Government and common mass considering solar PV can provide more energy than other renewables. As highlighted by Sahoo, (2016) India has made significant progress in solar PV which comprises nine companies manufacturing solar cells, 60 companies are involved in system integration, 23 manufacturing modules and a capacity of 2 million wafers manufactured annually. The Government of India is providing financial support to increase solar efficiency and state, Himachal Pradesh is actively promoting the passive solar design into the building designs particularly at rural and peri-urban areas. So far, solar water heating systems have been installed in about 7 lakh square meter area and solar energy devices development and systems at Gurgaon. Moreover, a solar-steam cooking system which is the largest in the country has been set at Tirupati Tirumala Devasthanam which serves 15,000 persons per day and 30 MW solar PV products exported to outside countries.

Nagamani et al., (2015) provided a thorough review on the evolution and growth of the power generation by renewables in India in the sectors of solar and wind in particular. The solar PV sector has shown exceptional growth in India where the solar radiation is directly collected by PV modules and solar collectors and having a breakthrough. Solar PV applications are gaining much acclaim as the costs have decreased and recent advancements have taken place in the technology of power conversion along with its maintenance-free and eco-friendly identity. These applications range from few kW installations on small scale to large solar power plants that generate power in MW. PV plants are connected through inverters to the grids via two configurations, central and string where the latter are more popular. However, in India, the solar power plants are mostly of central inverter types with few having string type inverters. According to Majid, (2020) renewable energy deployment in India is advancing the economic development, improving access and security of energy and mitigate the problem of climate change. The Government of India is supporting the economic situation that has made India among the top players in the market of RE. The government is designing programs, policies to drive foreign investments that are ramping up India in the market of renewables rapidly. Southern states in India have the highest solar energy power generation having 49.121% of RE capacity followed by 29.742% in the Western region, 18.890% in the Northern region and 1.836% in Eastern region. 95% of renewable capacity (installed) comes from private companies followed by 2% and 3% from central and state respectively. The top solar power players are Tata Power Solar, ReNew Power and Suzlon in the country.

Policy measures have opened new prospects for the achievement of solar goals by the year 2022 supported by MNRE in the country. Amendments made in the National Tariff Policy includes provision for Renewable Purchase Obligations

(RPO) and Renewable Generation Obligations (RGO) requires power distribution companies that are state-owned to purchase 8% share of energy from solar by the year 2022 (Mundra, Arya & Gawre, 2020). Currently, India is supporting large-scale power generation of solar energy by developing industrial solar parks resulting in large PV projects and this has pushed India to become competitive tenders pushing tariffs down to a large extent. The backbone of solar PV expansion in India are the industrial solar parks where local distribution companies or state governments are facilitating Ultra mega power plant (UMPP) construction bearing the land acquisition risks and benefitting from the economies of scale. The rooftop solar installation capacity is between 1 GW and 2GW which is falling short of the original 5 GW target by 2018 and following the same trajectory, a goal of 40 GW in rooftop solar installations seems beyond limits (Goel, 2016). However, the growth prospects are quite vivid due to cheaper costs of solar as compared to grid power in industrial and commercial users. Moreover, solar power generation has a long way to go when combined with batteries providing back-up solutions for the companies in practice.

2.4 CHALLENGES IN SOLAR ENERGY GROWTH IN INDIAN SCENARIO

While the country is expanding its renewable market following an exponential trajectory but is facing many challenges beyond financing. Trade protection and local content measures are looming over the expansion in solar energy creating large uncertainties in the market. Financial difficulties are also faced by the Indian utilities and to establish energy policy frameworks in the residential sector, rooftop solar requires policy support for the huge potentials in growth and expansion. Policy harmonization in states is quite necessary for the further development of rooftop development that would aim for a 40 GW target for rooftop solar installation by the year 2022 (Nathan, 2015). According to Garg et al., (2018) India has high potential in solar energy generation, however, factors like obsolete grid infrastructure, intermittent nature, delayed payments by

DISCOM and other forms of barriers pose barriers in the solar energy production development and delay from target. The government needs to revise their solar policies and assessment of risk associated factors that brought hurdles in the path of solar integration on large-scale in India. The major challenges in the solar installations in large scale remains in the research and technology and policies. There is a basic need to modify the business plan to gain popularity in renewable energy technology for achieving success in large scale solar installation. One of the biggest threats faced by the Indian solar industry is the rising price of modules from China. The price of Chinese panels was falling behind year over year where it increased by 14% in 2017.

Raina & Sinha, (2019) highlighted the fact that various barriers pose hurdles in the viable utilization of solar energy and deployment of PV systems in India. Although solar PV technology has taken giant leaps, the conversion efficiency of solar PV technology is quite low as compared to the conventional conversion systems and this remains the biggest technological barrier in the development of solar PV systems (Hairat & Ghosh, 2017). Lupangu & Bansal, (2017) outlined the fact that PV plants do not provide immediate reaction to the load demand that do not happen with the conventional conversion systems. Although many solar PV technologies like battery banks are in use in the market, however, the efficiency of conversion is still low as compared to the conventional methods used in solar power plants. Other technological barriers include intermittent nature of solar radiations that hampers the PV system's ability to meet the demand of the consumers along with differences in real and standard conditions that affect the generation performance. Component failure is another technological barrier that affects the PV systems performance in power generation until the faulty component is replaced. According to Sharma et al., (2018) output mismatch and PV systems operating in high temperature from individual panels in an array result in hotspots creation reducing the PV plants efficiency. In the future, these hotspots cause severe panel deterioration, hence increasing the repair and maintenance cost. Quality check is important for the PV module for improving the quality and longevity of the PV modules.

Economic barriers are the most challenging ones for the solar energy growth in India. PV technologies involve high investment costs that often discourages PV solar developers to refrain from investing in these technologies as cited by Lupangu & Bansal, 2017). Proper financing mechanism is lacking that poses a barrier in the PV installations as huge investments are required for the developing countries like India. Dobrotkova, Surana & Audinet, (2018) stated in their research that the auction-based process of PV procurement may result in unviable prices that could result to weakened PV projects quality. Tax exemptions given for PV technologies; however, tax remains still an obstacle in the PV development in solar energy at low cost. In addition, energy production by PV technology is estimated through levelized energy cost and economics for the PV generation encompasses factors like battery sizing, PV panels cost, required power factor and peak load ratings. These costs are borne by the consumer increasing the investment costs for PV installation and in turn, discouraging the consumers to take interest in the PV solar technology.

Shahsavari & Akbari, (2018) in their article highlighted that in developing countries like India, environmental barriers also prevail as PV technology during PV panels manufacturing has an environmental impact because it uses toxic compounds during production. Kannan & Vakeesan, (2016) highlighted the fact that copper indium selenide and technologies using thin-film Cadmium telluride could harm the environment because of compound selenium present in them. Although, composition of crystalline silicon panels has non-hazardous waste, cadmium telluride and mass of the thin film comprises hazardous material that requires proper treatment adding to the e-waste collected from the PV plants. The recycling of these e-wastes also poses a big challenge to the development of PV technology. Social barriers also prevail in India that imposes hurdles in the improvement of India’s solar PV technology. There is lack of awareness about the PV technology poses an obstacle in the solar PV systems development. There is a lack of understanding about the PV technology that remains an obstacle in accepting the technology as an option for energy generation. Inadequacy of land for the large capacity construction of solar PV plants is a problem in India (Shahsavari & Akbari, 2018).

Apart from these big challenges that the country is facing in the path of development of solar PV systems, small magnitude auxiliary factors also pose challenges, but their effects are observed on a bigger scale. Salari & Hakkaki-Fard, (2019) outlined that inadequate cleaning of the PV panels and dust deposition also causes reduction in the solar PV panels efficiency. The deposition of dust blocks the incoming solar radiation from the sun and unavailability and uncertainties in weather data also results in improper designing of solar PV systems.

This in turn reduces the lifetime of the PV systems resulting in no or less return on the investment done by the developers. Lack of solar energy policies and legal framework for the private developers coupled with limitations on construction and siting also hinder the development of solar PV in the country (Jain, Jain & Vaughn, 2018). In addition, lack of shortage of some raw materials and storage technologies also poses hurdles and therefore, these barriers need to be dealt with to enhance the status of installations of solar PV in India (Sen & Ganguly, 2017).

Sindhu, Nehra & Luthra, (2016) in their research stated that among all the challenges that are faced by the country in the developmental path of solar PV technology, regulatory and political barriers are found to be the biggest challenge for the country's solar industry. Government policies plays a crucial role in the stimulation and sustenance of green technologies. Current solar policies lack clarity in their guidelines, lack of proper framework and installation plan for the solar PV technology promotion and there also exists lack of imposition of the existing policies. Many policies distort prices like high prices of electricity charged from the industries stimulate them to self-generate power using diesel generators and policy planners are partially unaware of these situations in solar energy generation as they lack specialists. Although central and state governments have proposed strong policies for the diffusion of renewables, regulatory issues still exist that could motivate investors to invest in solar energy as there is no consistent and clear alignment among the jurisdictions including uncertainty over the timeframe (Yenneti, 2016).

Rathore et al., (2018) also analyzed the key bottlenecks and barriers faced by the solar PV developers in attaining the growth and target in solar power generation. The primary technological barrier faced by the developers is shortage of manufacturing facilities and research & development (R & D) that are must for the set-up of large-scale solar power plants. There is no comprehensive solar energy policy statement for the parameters like shortlisting and capacity of new projects, state level agency's role, promoter's equity and scope of policy guidelines. Solar developers have outlined that Renewable Purchase Obligation (RPO) is not enforced legally at the state and federal level and when reviewed by various State Electricity Regulatory Commissions (SERCs) indicated that definitions of framework vary for all the SERCs. Legislation of RE is established in majority of the American states and moreover, Waxman Markey climate change bill is accommodated at 20% in 2020, however, in India, such policies are not implemented (Sharma & Khurana, 2018).

2.5 THE KEY CONTINGENCY AND GROWTH FACTORS FOR INDIAN SOLAR POWER

It is forecasted that India will rank third among the top energy-consuming countries by the year 2030. Although the per capita consumption is low, the country ranked fourth in the category of carbon emissions. India has already made distinguishing progression in the deployment of renewables as their climate commitments, however, there is a regional and temporal variation in installed capacity. According to Thapar & Sharma, (2020) the growth drivers for solar energy in India are policy variables, economic variables, infrastructure variables and techno-commercial variables. Feed-in-tariff may act as a pull factor for the PV solar investors and procuring renewables by obligations push utilities. Zonal implementation plans and tax credits as fiscal incentives can drive solar power generation as a part of policy enablers. Under economic variables, implementing generation projects can fulfill the energy demand supply and tariff competitiveness may drive consumers to procure green technology. Under infrastructure variables, accessibility to vast land resources and remote sites networked to the road can be helpful in setting up renewable projects. For setting up a renewable project, resource availability is a must along with grid connectivity for handling the intermittent power are the technical growth drivers for solar power generation. Lastly, investors and bankers look for utilities' credibility in context to repayment. Equipment and funds at low cost can help solar PV developers to invest in power generation at competitive rates.

Solar power in India is precisely an opportunity for wealth generation and economic development having bright future prospects. Ecological or environmental factors are drivers for solar power generation in the country. Ummadisingu & Soni, (2011) in their research highlighted the fact that as India lies in the world's sunny belt region, it has immense scope for thermal and power applications using solar energy. An average incident of solar radiation over India on a daily basis varies from 4 to 7 kWh/m2 and 2300 and 3200 per year of sunshine hours. This shows that the technical potential of India is huge in context to solar energy and receives enough solar energy for the generation of >500,000 TWh electricity every year if 10% of PV module conversion efficiency is assumed. With this view, a worthy investment for India will be technology of concentrating solar power (CSP) that has the capacity to generate approx. 7% of the total electricity demands predicted for 2030 and by 2050 about 25% if high-energy- efficiency and john-energy-saving scenario is taken into consideration. The various concentrators for India are the states of Rajasthan and Gujarat that have the potential for the CSP technology application for harnessing the solar radiation (Ummadisingu & Soni, 2011).

Government initiatives and schemes are being developed to support the growth and development of solar energy in India. The Indian government has launched the recently ambitious scheme Jawaharlal Nehru National Solar Mission

(JNNSM) for the promotion of use and development of power generation using solar energy in the country. During mid-2008, the Indian government has released National Solar Mission as a part of Climate Change-National Action Plan recognized as one of the eight crucial missions. This mission has twin objectives of contributing to ecological security as well as energy security of the country in the long run. This mission envisages to promote rooftop solar PV applications and solar tariff that regulators announce will be applicable for rooftop applications (Irfan et al., 2020).

As discussed above, R & D is a big challenge for solar power, this initiative aims to have a sound R & D program addressing the challenges that the country is facing in the path of solar energy promotion.

Another study conducted by Bijarniya, Sudhakar & Baredar, (2016) also emphasized on the Concentrating Solar-Thermal Power (CSP) technology being one of the promising solar technologies that Indian can avail in the future. The conventional power plants face issues like site availability, fuel scarcity and other ecological concerns, CSP can be utilized for harnessing solar energy and overcoming such problems. The major technologies in CSP include linear fresnel reflector (LFR), parabolic trough, solar tower, and parabolic dish that encompasses criteria of site selection. MNRE has begun to take initiatives like new research for Stirling engine and CSP in solar thermal electricity as a pilot project for testing Indian climate for assessment of contingency factors. Currently, in India, LFR and parabolic trough collectors are performing well rather than technology of solar towers (Purohit & Purohit, 2010).

Hegde & Ramachandra, (2012) analyzed the techno-economic drivers for the solar power technology and prospective wasteland utilization in the states of Karnataka and Kerala in South India demonstrating their immense potential for power generation and emission reduction. Both the states have great potential for harvesting solar energy in the form of plants having grid connected wastelands, solar PV plants, off-grid solar plants and decentralized solar-wind hybrid plants. In this regard, Sharma et al., (2014) studied that wasteland available in few states of India can be utilized for the generation of solar power between PV cells and thermal routes. The identification of suitable wastelands for the solar thermal power generation can act as a driving factor for the country. Considering all the wastelands utilized for wind power generation having 4 m/s speed, generation of solar thermal power accounts for 756 GW for 1800 kWh/m2 threshold DNI value and 229 GW for 2000 kWh/m2 threshold DNI value. As India is having vast areas of wasteland, appropriate prioritization methods should be developed for solar power and wind projects considering there is no conflict between the two types of energy for power generation as wind turbines are installed in close proximity of solar PV plants may result in shading affecting the performance greatly.

Apart from growth drivers, contingency assessment and planning also need to be considered to respond effectively to any unforeseen event in the solar power generation. A contingency plan is a must to ensure that the PV power systems are capable of providing electricity that is required for operating at full capacity. With the solar power parks concept introduced by the Government of India, lenders and developers are relieved as the contingency is removed and brought at the same level for them to compete. Moreover, the solar water parks eliminate the major risk of the evacuation process and land acquisition and also reduces the expenses related to infrastructure (Tripathi et al., 2016). The solar power tariffs have declined sharply due to decline in solar panels prices and better project structuring that also reduces the risk for the solar PV project developers and gives them better hedging deals making financing at competitive cost. The government of India has also looked into the investment risk in the long run through low tariff bids of solar projects. Although this low tariff bids may prove risky for the solar PV developers as the cost margin may dip the margins in operation, however, the solar business have shown remarkable results despite this risk and investments are increasing in the renewables sector in the country (Rohankar et al., 2016).

Chattopadhyay & Chattopadhyay, (2020) have outlined the contingencies in renewables power generation. In recent times, contingencies have not received much attention and that is likely to become a major issue for developing countries like India. Contingency size of renewables in GWh and MW and days (duration) may be larger than the security standards followed conventionally in planning of power systems. Hence, risks about the viability of solar energy must be understood and better integrated into the solar power systems planning. Grid planning and good operational practices are a must that reduces vulnerabilities in the renewable power systems. Moreover, as discussed above, there is scarcity of data on contingency analysis in renewables power systems, therefore proper criteria and methodology needs to be developed for incorporating in planning models for power systems.

According to Manju & Sagar, (2017) the future prospects of India in terms of renewable power generation is bright and with this view, significant progress is being made in the renewable energy sector where Indian has the geographical advantage of having abundant sources of renewable energy. After the JNNSM implementation, grid connected solar PV development has increased, having 1.22 GW manufacturing capacity of installed solar cells and 2.35 GW manufacturing capacity of solar modules. This indicates the manufacturing capacity of PV in India. Moreover, the National Action Plan (NAPCC) for climate change is aimed at implementing NSM and in 2020, 15% of energy production was contributed by renewables to fulfill the energy demands of the country. Moallemi et al., (2017) also discussed the future prospects of on-grid solar power development in India. The continuous political support for the power generation using renewables acts as a future driving force for the enhancement of solar power in India. The government is supporting the solar power generation through many international and national initiatives.

The Re-Invest Summit at New Delhi in 2015 has been a milestone for the solar sector as it connected developers, investors and manufacturers and also collaborated stakeholders (Ministries) together towards development of renewables. To realize on-grid solar electricity, India has announced Viability Gap Funding and Power Purchase Agreement as two important policies to fulfill the target of 100 GW by 2022. US Trade and Development Agency (USTDA) and the US Overseas Private Investment Corporation (USOPIC) have agreed for loans for clean India energy projects which is witnessed as another landmark to shape the future of renewable sources of energy, especially solar. The pledge that India took in the COP21 can also shape the future of the renewables sector in India giving it further momentum (Puri & Saxena, 2015).

2.6 REGULATORY POLICIES FOR DEVELOPMENT OF INDIAN SOLAR POWER

RE sources have immense potential in providing solutions to the longstanding problems in energy demands faced by India. In this regard, solar energy is considered an important plan for the country in not only enhancing energy security and building new capacity, but also considering the environmental concerns and helping India to lead in the massive market of renewables. In this regard, the Government of India has introduced several regulatory policies and initiatives to prioritize solar energy in India. In 2006, National Rural Electrification Policies (NREP) policy intends to provide electricity to all Indian households with 1 unit (kWh) per day of minimum level of consumption. This policy also deploys solar PV off-grid solutions wherever grid electricity supply is infeasible (Choudhary & Sharma, 2016). Semiconductor Policy (2007) encourages ecosystem and semiconductor manufacturing where solar PV is one of the components. The policy offers 25% capital subsidy and 20% manufacturing plants outside and inside Special Economic Zones (SEZs) (Sharma, Tiwari & Sood, 2012). As mentioned earlier, Solar Mission or JNNSM is one of the initiatives under the NAPCC envisioning a paradigm shift to renewables for energy from fossil fuels. The main objective is to harvest large scale solar energy providing a framework for solar energy investment and fulfill the 100 GW target of solar energy's installed capacity by 2022. National Tariff Policy, 2006 is a mechanism of RPO to fix those states should purchase a minimum energy consumption of 0.25% that should be exceeded to 3% by the year 2022 having special tariff for solar energy (Gupta & Anand, 2013).

Electricity Act, 2003 is a framework for the enforcement and development of the Indian electricity sector. It also provides preferential tariffs for opting renewables and most importantly, the mandatory procurement of solar energy for facilitation of on-grid connectivity and distribution of licenses in the country. Electricity Act 2003 also provides exemptions in tariff approval and requirements in licensing along with prescribing safety measures and technical standards for mini-grids in India (Malhotra et al., 2017). Power Purchase Agreements (PPAs) is a stable term between solar power seller (developer), prosumer (generator of solar project) and solar power buyer (distribution licensee). Generation Based Incentives (GBIs) were introduced for small grid (33 KW) solar projects that helped to bridge the gap between CERC tariff and base tariff (INR 5.5) put up as fiscal incentive (Das et al., 2020). Renewable Energy Certificates (RECs), 2011 is a market-based process introduced with an aim to enhance capacity of renewables. It levels the divergences of renewables power generation in inter-states and demand for obligated entities to fulfill the guidelines of RPOs with different prices for non-solar and solar (Girish, Singhania & Vincent, 2017). Many central policy schemes or initiatives for solar power have also been initiated in the country. The central government is providing tax benefits for the solar power projects within the first ten years of its operation. Moreover, state policy schemes or initiatives are also undertaken where the incentive schemes and tariff orders have been framed by the states in India where project developers may be interested in installing solar power projects. Before NSM was launched, Gujarat came with their own tariff order for the solar PV projects and developers will agree for the contract to supply solar power to the on-grid for the next 10 or 25 years based on their declared tariff preferred by SERC. CERC's tariff order is based on PV technology being lowest in all states except Haryana with higher tariff from West Bengal to Tamil Nadu. Miscellaneous charges exemption is an initiative where the charges are basically for banking and conveying of electricity in respective states, for instance, in Andhra Pradesh and Tamil Nadu, transmission and wheeling charges of solar power generators are not charged if the electricity is sold within the state. Chhattisgarh also provides subsidies on interest rate to solar energy developers involved in investment (debt) (Tarai & Kale, 2018).

This scheme of preferential tariff was coupled with a reverse bidding process initiated by the central government in the year 2010, after which, questions were raised whether the bidding would compromise with the solar project's financial viability and also maintain harmony. This indicates that although solar power got cheaper, saved the money of the nation and also achieved grid parity, reverse bidding initiated aggressive competition that forced developers to give up on their projects procured during bidding. Likewise, many states have introduced the reverse auctions policy, however, Gujarat is the only state in India having highest solar power installed capacity has never introduced competitive bidding for the allocation of solar power projects and only allocated projects to developers through Feed-in-Tariff for the last 25 years (Yenneti, 2016). Accelerated depreciation (AD) has also been introduced into solar power projects for enhancing financial viability through payment of low-income tax on the profit gained by solar power developers (Kapoor et al., 2014). In accordance with the 2003 Electricity Act, in India, every state has come up with a rooftop solar policy or net metering policy that outlines the modalities for the installation of small grid power plants or grid-connected rooftop solar (RTS) in the given state. This policy also determines how customers are compensated for the produced electricity by their solar systems (Goel, 2016).

Although many initiatives and policies have been introduced by the Indian government to encourage solar power generation, the country is still struggling to meet the RPO targets. Increasing the number of solar projects will not make India a solar power source as the green energy generated should be fed into the grid and utilized by consumers to substitute the utilization of non-renewable sources of energy. There is a difference in achievement of RPO targets among states as some are at 60% and some at 90% deficit. Therefore, it can be viewed that the "one size fit all" approach is required as a solution while designing the personalized initiatives and policy frameworks for resolving the issues in solar power. Lack of policy enforcement, payment guarantees, evacuation issues and energy transmission issues are some of the challenges that India is facing in meeting RPO goals. This shows the failure of solar policies at state level. Moreover, there is a need for strong policy support that would aid the advancement and development of the Indian solar sector (Kar, Sharma & Roy, 2016).

2.7 RESEARCH GAP

India has abundant potential for solar energy providing an attainable and clean replacement for the polluting and harmful conventional sources of energy. The chapter 2 was an overview of the literature that is relevant to the discussion of the growth, development, challenges faced and regulatory policies of the Indian solar sector. The status of solar energy consumption and current scenario were discussed in this chapter with respect to global and Indian context. Solar energy is a quite promising approach in India in meeting the energy demands and in fulfilling the commitment that the country has made in COP21 on climate change. Although there is enormous research reported regarding the growth drivers and energy policies for solar PV technology development in India, there is currently a research gap in the understanding of key contingency factors or success factors that are influencing the solar sector in the country. There is paucity of data on mitigation strategies that addresses the growth impediments of Indian solar power. There is more scope of research on how policies and regulatory framework could be formulated to address the limitations faced by the Indian solar sector. Therefore, this chapter is concluded with a research gap as in the study of key contingency factors and drivers for growth of the Indian solar sector along with drafting of strong regulatory solar policies for the growth of Indian solar power sector.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 CHAPTER OVERVIEW

In this chapter, research methodology is provided which is considered one of the most crucial parts of a thesis. Choosing the right methods aid in conducting research and forms the basis of the entire thesis (Supino & Borer, 2012). After the research questions have been clearly framed for the research, an appropriate research design and methodology can be helpful for conducting research (Creswell & Poth, 2016). Therefore, the following sections will provide the detailed research approach, need for the research, research method, research flow, conceptual framework, methods for data collection, study sample and ethical considerations for meeting the research objectives.

3.2 RESEARCH NEED

Currently, India has immense potential for solar energy. The country is harnessing the solar energy through solar photovoltaics (PV) which is providing high scalability and in meeting the energy needs for human consumption in both urban and rural areas. Distributed and decentralized applications of solar energy have benefitted millions of Indians in villages by meeting their needs like lighting, cooking and other uses in an eco-friendly manner. By the year 2022, India has an ambitious goal of installing solar capacity of 100 GW and to achieve this target, a ramping up of the annual targets is quite important for the country (Shrimali et al., 2016). Moreover, the country is facing immense challenges in the production of solar PV systems in terms of formulation of solar policy, technical barriers, financial barriers, lack of R & D investment and skill development and grid connectivity of low voltage of variable solar resources. There are issues being faced within the sector in terms of supply and demand. Delayed payments by DISCOMs and problems faced by power suppliers in terms of land availability and acquisition process, transmission infrastructure are posing challenges to the country in terms of solar power generation (Shukla et al., 2018). The growth drivers and contingency factors in context to the country's solar energy growth have not been fully explored in the existing literature that may be a step towards successful implementation of solar projects in India. Therefore, with this view, the present research is needed that can address the hurdles faced in the solar energy production in India leading to successful implementation of solar projects.

3.3 RESEARCH GAP

From the literature review, a research gap has been identified while unfolding the various stages of the review. The literature review has included existing research of journal articles, national government reports on wind and solar energy and also international bodies about the global outlook on solar energy potential of India. The research revealed that challenges and constraints are being faced by the Indian solar sector. It is quite evident that vast research exists regarding the energy policies and growth drivers for the solar PV systems development in India, however there remains a gap in research existing in terms of key contingency factors that can influence the solar sector in the country. There is a need for operations and management (O&M) planning considerations for the solar energy PV systems and key contingency plans in Indian solar scenario. The drivers for growth and contingency factors for the solar sector in India need further research for the successful implementation of the solar projects in India.

3.4 RESEARCH PROBLEM

In research methodology, research problems define a specific problem, knowledge gap or contradiction that the researcher aims to fulfill in the research. It reflects a certain area of concern or a situation that needs improvement existing in already published literature or practices indicating need for further deliberate investigation or significant understanding (Reiter-Palmon & Robinson, 2009). In context to the research topic, solar energy as a part of RE has penetrated into the power generation systems in India. Technologies are getting advanced to cope up with the variability that includes smart grid elements, battery storage and demand response developed over the years. Moreover, the energy regulators and planners need to devise ways to accommodate the variabilities and solar energy contingencies. The weather conditions may not support maximum yield like rainy or cloudy weather where the yield is below the mean level and it continues to be the same may be throughout the week (Chattopadhyay & Chattopadhyay, 2020). This may result in loss of significant production of energy from solar energy in a vast geographical location. Therefore, considering such situations is quite crucial and needs to be incorporated in planning that explores the renewable contingencies like persistent events that focus specifically on the solar resource in India and the challenges faced by the solar sector power system. The planning analysis in context to solar power in India has not yet embraced the concept of renewable contingency that would be helpful in recognizing the renewable contingency costs and put back-up generation resources in place. Therefore, it is crucial to analyze the potential significance of key contingencies and understand the driving factors that entail for the system of solar PV planning and operation for the successful implementation of solar projects in India.

RESEARCH PROBLEM STATEMENT

What are the key contingency and success factors which should be addressed for successful and effective implementation of a project?

3.5 RESEARCH QUESTIONS

From the review of literature conducted in the previous section, the below given questions need to be fulfilled for the successful implementation and integration of the solar power in India.

- What are the key contingency and success factors to suggest a framework for addressing the issues around growth of the solar sector in India?

3.6 RESEARCH OBJECTIVES

To develop a framework for the solar sector growth in India by identifying and evaluating the key contingency and growth factors.

3.7 RESEARCH DESIGN AND METHODOLOGY

This section will explain the research methodology that will be adopted for the present study.

3.7.1 RESEARCH APPROACH

Research approaches are procedures and plans that span from wide assumptions to the detailed process of collection of data, its analysis, findings and interpretation. The research approach selection is based on the nature of the issue or problem in research being addressed (Kothari, 2004). Moreover, the personal experiences of the researchers and targeted audiences are also considered while selecting a research approach. Three approaches to research are; qualitative, quantitative and mixed methods. For the present study, a qualitative research method will be utilized that will be suitable to justify the research objectives. A research approach is intended to define a research strategy that would be helpful in analyzing data, pinpointing major findings and in drawing conclusions (Singh, 2006). As the study requires a deeper understanding and exploration of the success and key contingency factors responsible for the successful enactment of solar power projects in India on a large scale, a qualitative approach is pertinent for the present study. This particular approach gives an in-depth understanding of the phenomena of contingency and success factors that will drive the solar power projects in India on a large scale.

3.7.2 RESEARCH METHOD

Framework analysis is a popular method for the analysis and management of qualitative data. This method has five distinct phases that form a rigorous and methodical framework. The phases are interlinked and help to understand and analyze data and gradually moves from descriptive approach towards a more conceptual analysis of what is actually happening from the data collected from the study participants. The phases include familiarization, thematic framework identification, mapping, indexing, interpretation and charting (Dixon-Woods, 2011). The early stage in framework analysis is to get familiarized with the collected data and sensitized into initial themes that helps researchers to understand the differences in the transcripts that might get lost before the commencement of the coding process. In this thematic framework phase, analysis is referred to as coding employed in qualitative methodologies. The key principle of this methodology is to identify key themes, discussion points or issues that are embedded in the participants' transcript which are delineated and a name or code is assigned that captures the core or essence of the issue or theme being identified (McGowan, Powell & French, 2020). Charting is described as a stage where the data is rearranged. This stage works on the principle of synthesis and development of the final coding framework through the abstraction process. In the mapping and interpretation method, all the themes are graphically and pictorially represented. This step investigates how themes are related to each other. This detailed exploration of the revised and developed thematic analysis framework helps us to gain an explanation and clear understanding of the bigger picture (Auerbach & Silverstein, 2003).

A framework approach is a broad set of concepts that guide qualitative research. Theoretical framework is a structure that imparts support or hold a research study theory. It usually describes and introduces the theory that explains why the research problem is being studied. This approach also offers a systematic structure to analyze, manage and identify themes that enables development and maintenance of data as it involves large volumes of text which is suitable for applying in different qualitative approaches (Smith & Firth, 2011).

In the present study, the aim is to evaluate the key contingency factors and generate recommendations in context to several barriers faced by the Indian solar sector such as technological, financial and regulatory issues. Therefore, developing a framework for the vast qualitative data generated through data collection in this research can help to fulfil the research objectives. As the sample population is predetermined like project developers, policy formulators and regulators, Discoms/Transco's, therefore, framework analysis for the qualitative data is the most suitable methodology for the present study.

3.7.3 SOFTWARE USED

This research performs coding activity in Qualitative Data analysis using a software ‘Atlas. ti’. The ‘Atlas. ti’ tool helps in arranging and analyzing large set of data in a systematic way. ‘Atlas. ti’ helps the user to analyze all type text documents, graphic and audio formats in a very simple way. User can do the coding part by simply dragging codes onto selected piece of data.

RESEARCH FLOW

The flow of the research is presented below:

Phase 1

Domain & Research Context

↓

Phase 2

literature survey

gap identification and analysis

formation of research

↓

Phase 3

Questionnaire Survey

Data Collection

Data Analysis

Conceptual Framework Evaluation

Final Framework Proposal

Assessment in view of statement of the problem

↓

Phase 4

Results and Findings

V & V

↓

Phase 5

Conclusion &Recommendations

Contribution

Limitations & Future Scope

3.8 CONCEPTUAL FRAMEWORK

Vygotsky's theory of conceptual development

A conceptual framework is referred to as an analytical tool that is used to organize ideas and draw conceptual distinctions. It is used to establish relationships among ideas generated during the research and shows how they are related to the research study. A conceptual framework is constructed providing a visual format much before the data collection process. Conceptual framework defines the relevant variables of the study and maps the relationship between them. Conceptual frameworks are formed in context to qualitative research design that presents a theory of phenomenon that is under investigation (Maxwell, 2012). A major point in conceptual framework is that the framework should be constructed from published theory, prior research or personal experience into a coherent representation of the research. The process of conceptual framework encourages a researcher to have a closer assessment of the variables in the study and their relationship. Based on that, the study participants are chosen and data collection methods are selected (Miles, Huberman & Saldana, 2018).

Conceptual framework is defined by Vygotsky's Sociocultural theory where it is considered a powerful framework within which a researcher explores and constructs meaningful concepts related to the study. The theory of concept formation by Vygotsky provides an appropriate framework through which a researcher can explore the challenge or issue witnessed in the study. Moreover, Vygotsky's conceptual framework has notions and constructs well suited to the explication of the relationships between the concept construction by the researcher and the socially sanctioned theories (Verenikina, 2010).

Concept maps form the foundation for the conceptual frameworks' development. They are the visual representations of the information in the form of graphic organizers, charts, flowcharts, tables, diagrams or Venn diagrams. These maps are a powerful strategy that provides a bigger picture of the concepts (main idea) that are narrowed down or branched to chunk information that are based on meaningful relations in the study and also used to compare, contrast and analyse information in a better way (Daley, 2004).

For the present study, developing conceptual framework is necessary as research objective suggests to address the contingency and success factors for the growth of Indian solar sector. Developing a framework would be suggestive for the Indian solar sector to grow that would be helpful in the large solar projects implementation in the country. Before the framework is developed, the ideas or concepts related to the study should be formulated. This development of conceptual framework is supported by Vygotsky's Sociocultural Theory with the use of concept maps which is a visual form of the thoughts and ideas derived from the established theories or prior research.

3.9 INSTRUMENT FOR DATA COLLECTION

Interviews of qualitative nature are a personal form of research as compared to survey-based questionnaires. In such interviews, the interviewer can ask for follow up or probe into the research questions of the participant being interviewed. This type of interview provides in-depth analysis of the problem or issue being investigated in the research. This form of interview also elicits detailed feedback from the study participants. Interviews are the most frequent type of collection of data in qualitative studies which are of three types: structured, unstructured and semi-structured (Qu & Dumay, 2011). Qualitative interviews are quite effective as they help the researcher to explore, understand and explain opinions, experiences and behavior.

It provides significant insights into an event or phenomena. In addition, qualitative interviews can be further studied and analyzed that impact business decisions. The questions to be formulated for an interview is dependent on the form of qualitative interview being needed for the study (King, Horrocks & Brooks, 2018). For the present research, open-ended questions were formulated in the form of semi-structured interviews and stage wise protocol has been explained in the subsequent section.

*3.9.1 **SELECTION OF SEMI-STRUCTURED INTERVIEWS***

As mentioned above, qualitative interviews belong to 3 categories. Structured interviews are administered questionnaires that are in verbal form where there are predetermined questions to be asked with no or little variation and no scope for further discussion or follow-up for elaboration. They are very easy and quick to administer, however, participant responses are limited and there is no such chance for in-depth analysis. Unstructured interviews do not reflect any preconceived ideas or theories and there is no such organization (Zhang & Wildemuth, 2009). The interview just starts with an opening question and therefore, can last for several hours. It is quite difficult to manage as it does not guide on what questions should be asked and only significant, in case, in-depth analysis is required. Unlike this, semi-structured interviews comprise key questions that guide to define the unexplored areas allowing an interviewer to diverge when a response or idea is required to be explored in more detail. This type of interview is quite flexible as compared to other types as it allows elaboration or discovery of information that is important to the sample participants which was not previously thought to be pertinent by the researcher (Schmidt, 2004). Moreover, the researcher can divert the questions into the area of research and helps in asking questions that revolve around the research topic providing more insight into the information.

3.9.2 CRAFTING THE PROTOCOL

For conducting an interview, the crafting of the protocol is very important. The protocol is viewed as a guide for an interview where the interviewer introduces himself and conveys the topic of the interview. The interviewer should explain to the interviewee about the data collection process and how the participant consent is collected for the interview. For the present study, the interviewer has assured confidentiality and privacy to the interviewee, asked for informed consent for the interview and the interviewee's willingness to participate in the interview where they can withdraw (Rabionet, 2011). The implications of the study results and the aim of the research has been clearly conveyed to the interviewee. The interviewer should be aware of what questions should be asked to the participants having an in-depth understanding of the subject matter. The interviewer considered the relevant literature published in the existing journals while formulating interview questions. While developing the protocol for the interview, the interviewer should consider the conceptual maps that were based on prior research and established theories (Hunter, 2012). For the present study, the drafting of questions was done based on the conceptual framework and was refined with the expertized help and research guides.

*3.9.3 **ANALYZING THE INTERVIEWS***

After the interview is conducted, it is quite vital to analyze the responses that the interviewer has received from the interviewee. The best way to analyze the interview responses is by framework analysis where the data is divided to generate themes by comparing cases between and within them. Large volumes of data gathered from the interview can be streamlined using framework analysis in matrix form providing an intuitive overview of structured summarized data (Roulston, 2014). For the present study, framework analysis was used where codes were identified based on the interview quotations and further, data was analyzed by developing relevant themes and categories. These themes were further streamlined to draw a final conclusion pertinent to the main concept.

3.9.4 PRESENTING THE FINDINGS

While presenting results derived from qualitative interviews, the interviewer should emphasize on the themes and key points that are related to the research question instead of reporting what has been said by the interviewee. The result findings were made based on the themes or categories derived from the interview responses. These themes and categories helped in formulating the main concept of the research. The themes identified by the researcher formed the basis for the recommendations to be made for Indian solar sector while the categories made became the sub steps for the parent stage identified individually.

*3.9.5 **RESPONDENTS PROFILE***

The respondents' profile is important as it provides information about the type and number of study participants to be included in the study. Moreover, it is a way to clarify the targeted audience and where the findings will be applicable, posing light on the generalizability of the study findings. For the present study, middle or upper middle level managers interviewed belong to organizations like

RENEW Power. Mahindra Susten, Kirloskar Solar, Sembcorp Green, Oriano, IREDA, PTC Financial and Shree Cement Ltd. The top managers belonged to developer and financier domains. The top managers who belonged to Atari Energy and PTC Financial were the validators for the present study. For the present study, eight middle or upper middle managers were interviewed and two other managers validated the interview.

3.9.6 ETHICAL CONSIDERATIONS

Ethical considerations in research attains highest importance where the researchers need to pay attention to the research ethics principle before commencing research. When the research ethics are followed such as confidentiality, anonymity and informed consent, it depicts fairness, principle of doing no harm to others and approved conduct which is of paramount importance in research having human affairs (Wiles, 2012). It also helps to promote the research aims and support the values of collaborative work like mutual respect. For the present study, the principle of research ethics has been preserved. The informed consent to participate in the present study has been obtained from the participants after they have been informed regarding the research aim and result implications. Prior to the data collection, ethical clearance has been obtained from the local ethical committee for conducting the research. Informed consent shows that a competent participant has understood and received all research related information and after that only provided their willingness to be a part of the research. In addition, for the present study, the researcher has maintained the confidentiality of the research subject where his or her identity or any personal information will be protected so that it is not discovered by others

CHAPTER 4
QUANTITATIVE ANALYSIS AND FINDINGS

The present chapter outlines the respondents’ demographic profile. Since, the aim of the research is to emphasize on the key contingency and success factors through qualitative research design, therefore, the sample population is inclusive of the top management, upper middle and middle management of the solar industry. The data will be analysed using the methodology proposed by Smith & Firth, (2011) for the framework analysis. The analysis is done in three steps. The first step is the reduction of data called data management, the second step is the theme identification called descriptive accounts and the last step is the mapping and interpretation of the data. The three steps have been explained in the present chapter in detail. The research questions have been answered in context to the interpretation of the result findings. The research questions have been further discussed for addressing the objectives of the study.

4.1 INTRODUCTION

Before the framework development, conceptualization has been done for the preparation of conceptualized framework. Qualitative studies have helped in the development of conceptual framework as it provides the key thoughts that evolved in the present study. This framework has helped in the drafting of the interview protocol which has been used for the exhaustive interviews of the respondents for the present study. The responses of the respondents have been noted with their permission manually and the quotations and transcripts have been analysed identifying the commonalities and differences found in the data so that relationships can be established between the data sets. Finally open codes were generated from each of the interviews and finally the explanatory and descriptive accounts were prepared using the Smith and Firth, 2011 framework analysis.

4.2 DEMOGRAPHIC PROFILE OF RESPONDENTS

For deciding the sample size, saturation is the most crucial factor in qualitative research. In the present research, 10 respondents have been included belonging to top management, upper middle and middle management level. The demographic profile of the respondents was based on the expertise, designation, domain and organization in which the respondents were working as at the time of collection of data. The study involves the analysis of contingency and success factors for the Indian solar power plants. Hence, for the purpose of the study, the solar sector professionals who work in solar power in India majorly from developer, EPC, financer and industry domains. Interview was done for 10 members, from these 10 respondents, 2 validators were interviewed for the validation of the protocol. As per the validated protocol, interviews were conducted until interviews reached saturation in data. Researchers experienced saturation while conducting the seventh interview and therefore, no further interviews were conducted.

4.3 DATA ANALYSIS

In qualitative research methods, framework analysis is apt for studying applied research in policy. In this type of analysis, the gathered data is charted, sorted as per the key themes and issues observed in five steps. familiarization, thematic framework identification, charting, indexing, mapping and data interpretation. This framework analysis was developed by the researchers, Liz Spencer and Jane Ritchie in National Centre for Social Research from the Qualitative Research Unit in the late 1980s in the United Kingdom used for policy research at a large-scale (Ritchie et al., 1994). It is a method to understand and interpret qualitative data and gradually move from descriptive accounts to a conceptual explanation (explanatory accounts) of what is derived from the data of the study participants. This framework moves data from the original source of data to transcripts going through categories and finally to themes. The analysis is done around themes drawn from explanatory and descriptive accounts. This approach identifies the differences as well as commonalities in the qualitative data prior emphasizing on the relationships between the various sections of the data where the researcher wants to draw conclusions from the themes (Ritchie et al., 1994). This framework analysis is widely used in health research also whose distinguishing property is the matrix output: columns (codes), cells of the summarised data and rows (cases) that imparts a structure that systematically reduces the data for analysing the data by code or by case.

4.3.1 DATA MANAGEMENT

Identification of new codes

As the research involves the solar power sector, so the research involved 8 industry experts. The respondents were interviewed for exploring their experiences for the purpose of the data collection. Each respondent was interviewed once for 1 hour by the researcher. Semi-structured interviews were done until the saturation of data had been reached. The methodology of framework analysis imparted flexibility for the analysis of data conducted at the time of the interviews. The interview transcripts in the appendix are the analysis of data after every interview. The in-vivo codes that have been generated for each interview were almost similar and the new codes that were gradually getting reduced for every next interview.

After interviewing the first respondent, 110 codes were generated and all codes are new in nature. After the second interview, 76 new codes were identified. A clear fall was observed in the emergence of new codes as the interview movie from third to fourth to fifth to sixth and seventh interview-107, 78, 44, 47 and 77 new codes were generated. After conducting the seventh interview, no new codes were identified that depicted saturation in the gathering of data. After this, the researcher did not conduct any further interview as the data saturation was observed at the eighth interview and the sample size for the study becomes 8.

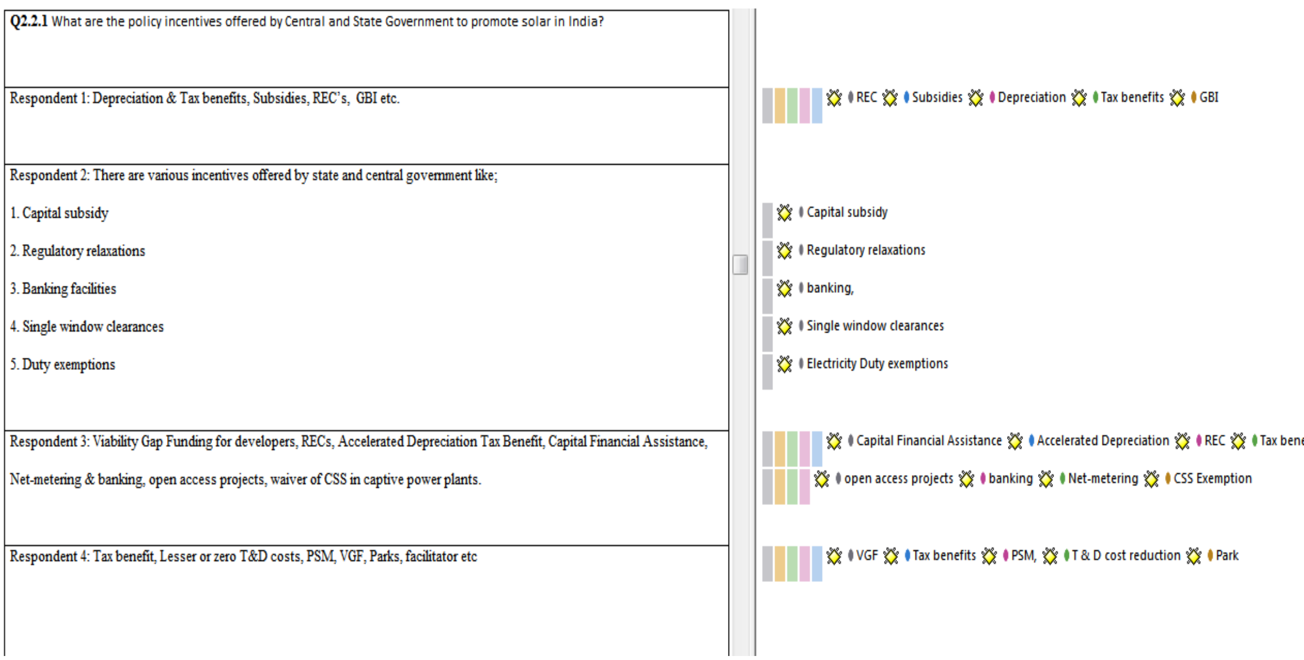
Developing categories

After reading different documents and conducting interviews for hours, through data management, the researcher got familiar with the interview transcripts obtained through interviews. A collective transcript was formulated as per the steps suggested in the framework analysis. In the process of management of data, the data was of qualitative nature obtained in the form of written notes and documents and the responses obtained from the discussions and interviews were converted into textual form. The important sentences or phrases of the documents (highly rich) were analysed in the form of quotations and summarization through development of the in-vivo codes or open codes. Based on the in-vivo codes and thoughts, development of 18 initial categories were done resulting in familiarization of data.

4.3.2 Descriptive accounts

Descriptive accounts in qualitative research are the generation of data that defines the state of the nature of the data at a point of time. It is basically used to describe the characteristics of a phenomenon being a more holistic approach. It often involves collecting rich data from the various sources that helps to gain a deeper meaning of the participants and their perspectives, opinions and attitudes (Merriam, 2002). In this, the initial codes that were generated were relooked and the coding gradually progressed to form ’20’ broader categories or refined categories and finally based on the similarities, the broader or refined categories were brought together consecutively to form the ’19’initial themes.

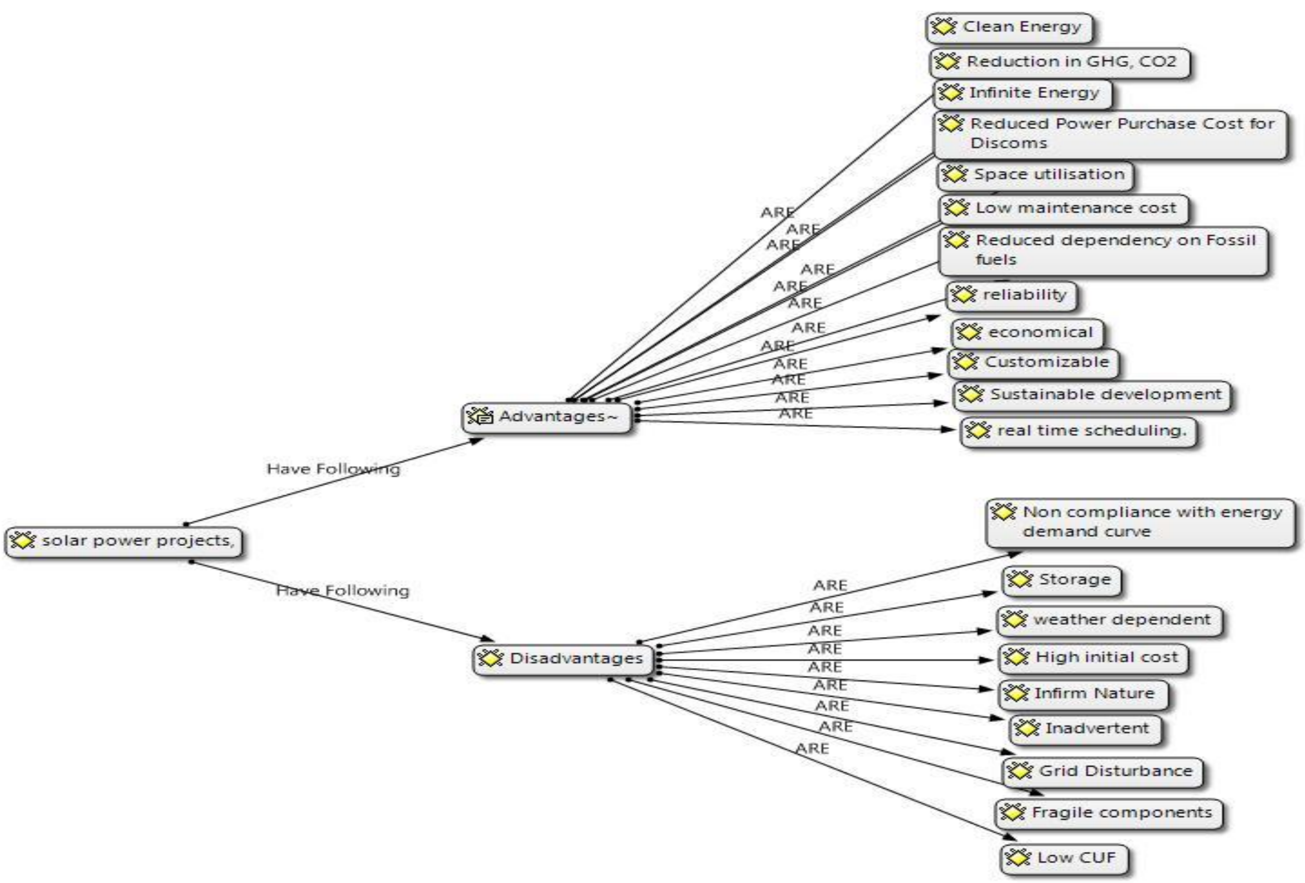
The diverse coded data is summarized and combined through refining of the themes and categories. For the refining process, brainstorming was done to analyse the establishment of relationships between the codes which was important. Furthermore, for reconciling the refining, there was an undertaking of two linked practices. Through refining of the initial categories, synthesis of data was done until the complete picture emerged. There was continuous going back to the raw data and checking of the meanings among the transcripts. After that, the abstract concepts were drawn via identification of the key dimensions in the synthesized data. The data was summarised by clubbing '19' Opening Categories into '18' Filtered Categories and finally into '15' Initial Themes. In the process of summarisation, final step led to development of '11' abstract concept or 'final themes'. There was also building of associations between the themes and concepts. The abstract concepts were developed and sorting of data was done in accordance with the finest refining of the themes that resulted in the development of the central concept 'Framework for Development of Solar Sector in India' (Pietkiewicz & Smith, 2014).



Q2.2.1 What are the policy incentives offered by Central and State Government to promote solar in India?	
Respondent 1: Depreciation & Tax benefits, Subsidies, REC's, GBI etc.	REC, Subsidies, Depreciation, Tax benefits, GBI
Respondent 2: There are various incentives offered by state and central government like; 1. Capital subsidy 2. Regulatory relaxations 3. Banking facilities 4. Single window clearances 5. Duty exemptions	Capital subsidy Regulatory relaxations banking, Single window clearances Electricity Duty exemptions
Respondent 3: Viability Gap Funding for developers, RECs, Accelerated Depreciation Tax Benefit, Capital Financial Assistance, Net-metering & banking, open access projects, waiver of CSS in captive power plants.	Capital Financial Assistance, Accelerated Depreciation, REC, Tax benef open access projects, banking, Net-metering, CSS Exemption
Respondent 4: Tax benefit, Lesser or zero T&D costs, PSM, VGF, Parks, facilitator etc	VGF, Tax benefits, PSM, T & D cost reduction, Park

4.3.3 Explanatory Accounts

It deals with the accurate presentation of the experiences and beliefs of the interviews and documents. It is an analytical stage where the original database is referred from where the themes have been derived (Cornelissen, 2017). This step minimizes the chances of misinterpretation where the core concept for the present study, "Framework for Development of Solar Sector in India" was generated through framework analysis. The study objectives aligned with the core concept in which interviews were conducted and the analysis of the documents were done. This method is basically drawing meanings of the different categories, themes and concepts that emerged from the interview. This was achieved by exploring the relationships between the existing literature, central concepts and theoretical understanding. After the establishment of the relationships and concepts, typologies emerged from the study that explained the various concepts.



4.4 Interpretation of the data

The reduction of data during the analysis of the gathered data helped in understanding the themes. The initial exhaustive transcripts identified were refined into wider categories which were analysed together to create initial themes and finally, the final themes deduced from the interview through framework analysis that led to the emergence of the central concept "Framework for Development of Solar Sector in India".

Given below are the category wise interpretation of the data management following Smith & Firth, (2011) framework analysis methodology.

Interpretation of Theme 1: Advantages and Disadvantages of Solar Energy

Solar energy is the key to a clean energy source as there is no release of green gas emissions into the atmosphere when solar panels are used for creating electricity. Solar energy has numerous benefits that makes this source of energy one of the most promising ones as it has amazingly low carbon footprints. With time, anthropogenic activities have increased that have resulted in the emission of greenhouse gases (GHG) and CO2 that has increased in the atmosphere of the earth. Unlike the combustion of natural gas, coal and distilled fuel that produces a large amount of carbon dioxide, however, solar systems emit no GHG and the energy source is carbon-free. The solar energy production is a clear way to diminish the dependency on fossil fuels and a solution to alleviate global warming by reducing the emission of fossil fuels. Every hour millions of kW of solar energy hit the surface of the earth and the amount of energy that is radiated in a day is more than the energy used by the population in the world in a year.

Owing to this characteristic, this source of energy is considered an infinite source of energy as it is sufficient to meet the energy demands of the world as it is a renewable energy source that is inexhaustible in nature. Moreover, the annual radiation which is the highest is about 2,000 kilowatt hours/m2 in the world. Solar power generation is the most sustainable source of energy as there is no exhaustion in this energy source. Solar power generation by photovoltaic (PV) cells is quite economical for the Indian solar sector. PV cells are the most economical solution for power generation being one of the most economical and reliable sources of energy for at least two-thirds of the global population. An energy-storage system is the main element of RE power generation. The discharging or charging periods of the PV cells battery are controlled effectively based on the generation of solar power and residential real-time electricity prices (RRTP). The process of PV cells that transforms sunlight into electricity not requiring any fuel and has no variable costs that makes it more economical for India.

Solar PV systems do not require a lot of maintenance as the most reliable manufacturers offer a warranty of 20 to 25 years. As the solar PV panels do not have movable parts, and so, there is no issue of wear and tear of the parts, except for the inverter that needs to be replaced after every 5 to 10 years as it is the main part that works continuously in converting solar energy into electricity. In addition, cables are also required to be maintained for ensuring running of the solar PV systems. After covering the initial cost of the solar PV systems, the spending on repair work and maintenance is quite minimal. Space utilization is another striking advantage of solar power generation as it can be introduced into the materials that are used for constructing buildings. Moreover, solar energy can generate electricity even on rooftops as solar PV panels do not require much space as they can fit on the space of the rooftop and have access to enough sunlight.

Solar energy, being a form of renewable energy, may be advantageous in reducing the financial distress that electricity distribution companies of India (DISCOMs) are facing in India. DISCOMs are already struggling with performance and financial issues and sit in a vortex of major losses and risks that have occurred across the supply chain. For the DISCOMs to enable a sustainable performance and attain economic recovery, there is a need to stabilize the financial viability of the power sector in India. Through the Rooftop Solar Program Phase II that is grid-connected can be advantageous for DISCOMs as they can avail the progressive government incentives up to 10% benchmark cost for the installation of rooftop solar PV system installations also providing competitive edge in the global renewable energy production market. The above points clearly show that solar power generation is quite advantageous and has bright prospects for India in the near future being a good source of RE for power generation in the country.

However, there are disadvantages associated with the solar sector in India. As solar power generation requires ample sunlight, rainy or cloudy weather with little or no radiation from the sun cannot generate the desired amount of power using solar energy. This makes the solar PV cells less reliable as a solution for energy production being weather dependent in nature. The locations in India that get good amounts of sunlight throughout the year are the most suitable locations for production of solar energy. Moreover, solar panels require storage batteries and inverters that convert direct electricity (DC) to alternating electricity (AC) for generating electricity. The initial cost of purchasing solar PV systems is costly like solar panels, batteries, inverter, installation and wiring. Solar technologies keep developing and the components of solar power generation are fairly high. The large batteries utilized in solar systems (off-grid) has the ability to get charged at the daytime so that the energy could be used at night. Although it is a good solution, the large batteries are quite expensive. Another challenge is the duck-shaped energy demand curve which is already visible in the renewable energy curtailment that is adding to the infirm nature of the renewable energy capacity. The 'duck curve' is a representation of the transition point for solar energy. As solar production is rising, a duck's belly shape is witnessed on the net load curve. As the sun goes up during daytime, the demand for solar power is high and as evening approaches, the demand for power is met by conventional methods of power generation that quickly ramp up. The degradation of the solar modules with increasing time and temperature adds to the solar panel final output. The degradation of the PV solar arrays and modules result in subsequent loss of the performance having an impact on the total energy production. Module encapsulant protects the solar PV cells and electrical connections internally against the moisture ingress. Sunlight breaks down the materials of the encapsulation slowly by ultraviolet (UV) degradation that makes them more plastic rather than elastic. Over time, it degrades the ability of a module to force out moisture and the properties of encapsulation determines the performance of these modules. The solar cells made of silicon are fragile and causes breakdown of the cell gradually that is visibly not seen, however, over time, it restricts the sunlight that hits the solar cells and as a result, a slight decrease is observed in the output of the cell. India has a major problem of low-capacity utilisation factor (CUF) as it ranges from 11%-31%. The grid of the country is quite unstable and weak and does not have a reserve margin (15% to 20% in the west), there is grid disturbance and shortfall in the range of 5% or may be higher. The Grid Code is modest and recommends only a margin of 5%. The grid remains afloat through the "load-shedding" or supply cuts at feeder-level.

Discussion

In present times, countries have been adopting renewable sources of energy rapidly. India is emerging in the global arena as a leading producer of renewable energy. Solar power generation is cheaper as compared to the electricity grid. It is a one-time investment. Solar PV installations in India are quite profitable as this source of energy is inexpensive, safe and eco-friendly in nature. Currently, in India, about 1.4 million homes have solar installations that can harness millions of kW of energy as India has ample sunlight throughout the year (Buragohain, 2012). Solar energy is abundant in India having geographical advantage as the country lies between 8°4′ to 37°6′ north latitude and 68°7′ to 97°25' east longitude and ranks the 7th in the world that has 2.9 million Km2 landmass (Pandey & Katiyar, 2011). This shows that Indian solar profile is quite rich and globally, average horizontal irradiance is approximately 5.0 to 5.5 KWh/m2/Day and this energy is sufficient for producing 6,081,709 (terawatt hour) TWh/year that indicates infinite energy making India among the top five countries across the globe (Sharma, 2011). Moreover, in the present global energy scenario, the energy generation by fossil fuels has serious concerns regarding degradation of climatic conditions, depletion of fuel resources, environmental degradation, emission of greenhouse gases (GHG) and CO2 and thus, adoption of renewable sources like solar energy for the global development of an electricity generation system which is sustainable in nature and reduces the dependency on the fossil fuels being a clean source of energy. Rooftop solar projects help in reducing the purchaser power of DISCOMs and also create a huge impact on reducing the overall carbon footprints and optimizing the cost of power procurement. This would indirectly help the Discoms who are financially burdened and helps to narrow down the gap between the average revenue billed and the cost of supply. In India, the solar PV technology based on the silicon wafers has gained >90% of the total share in the market as it is an efficient and more reliable technology as compared to other competing technologies (Gangopadhyay, Jana & Das, 2013). However, the research is still continuing to recognize solar PV technology as a part of the expanding energy needs challenge in India and close the gap between demand and energy supply.

Solar power capacity of India suffers on account of overlaps. gaps and constraints prevalent in the present regulatory and policy environment. One of the biggest weaknesses of solar energy production is that solar power is available only during daytime and the PV cells convert solar energy into other forms of energy when there is sunlight. For this reason, there is a requirement of an energy storage system installed to supply power for the rest of the day in the absence of solar radiation which poses extra costs that make solar power generation expensive (Sandwell et al., 2016). Another technical issue is that Indian solar grids are weak, which includes lack of ancillary services that impart stability to grids instead of pricing kW hours and also absence of time-of-day pricing for the mass procurement of power. Overall improvements in the grid are required that include better grid balancing that would facilitate renewable energy sources like solar energy penetration. This problem is associated with the capacity problem in

India as the country is short of power making renewable energy falling short as compared to other countries like Europe, U.S., etc., As it is known that Indian peak demand is mostly required during the evening and during that time, the sun is not shining bright especially in some states (Sharma, Tiwari & Sood, 2012). Hence, if India adds 20 GW of solar, the country still needs additional capacity of 20 GW to meet the peak. This shows that renewable sources of energy are not quite as bleak as they offer some capacity value and a clean energy source as compared to conventional sources of energy.

Interpretation of Theme 2: Types of Stakeholders in Solar power projects

A commercial and successful solar PV project is a product of intense effort by collaborators and stakeholders. For expanding solar projects, stakeholder engagement is important for developing new programs and practices. In stakeholder engagement, the first step is to identify the groups and individuals that should be included who entails working with the electric utilities, local government officials, economic development boards, local workforce and businesses, financial and non-profits institutions and residents. In the second step, the key areas of interest for each of the stakeholders is determined in a community that varies by jurisdiction and region.

Financers typically provide loans and equity to people who look for installing solar projects. Financers also look for making returns on their investments and avoid borrower default. The primary goal of a financier in a solar project is to help project developers and customers improve their access to finance and terms that are favourable for their solar projects. Therefore, financiers should be aware of their roles and responsibilities of the solar market and need to be familiar with the solar projects and their associated returns and risks. Independent Power Producers (IPPs) or non-utility generators (NUG) are also stakeholders or private entities who own or operate facilities for generating electricity and then selling it to the central government, to a utility and end users. Individual IPPs sell electricity from the solar power plants to Perusahaan Listrik Negara (Persero)

PLN or State Electricity Company. IPPs may be cooperatives, non-energy industrial issues or privately-held utilities who are capable of providing ample energy into the power system. They invest in technologies that generate power and recover their cost from electricity sale that could provide help to the energy sector of India especially in cases when the public sectors does not possess the financing for investment. The Non-Banking Financial Companies (NBFCs) plays a vital role in driving the segment of Indian solar energy. Limited numbers of banks are unable to fulfil the financial needs of the huge population and sensing this gap, the NBFCs or private players have come into play. The biggest advantage of these private banks is that they have the ability to penetrate the rural areas and cater to individual needs as well as the small businesses who are otherwise unable to avail such benefits. For a country like India, NFBCs are a boon as solar power projects are greatly benefitted by these private banks. It is true that infrastructure projects like solar power projects are quite risky as they require huge funding and long-term investments and the reputed banks refuse to lend them. In such situations, lending by NFBCs to the solar power and infrastructure projects impart thrust for India in the solar sector.

One of the key stakeholders is the solar project developer who is responsible for the innovative business model. Although the developer varies from salesperson in engineering or at a large firm, procurement, and construction (EPC) to a firm or individual who own and work in this array. The project developer is held accountable for the viability of a solar project, acquisition and site selection, negotiation in contracts, selection of contractors who ensures that project is built. Project developers must comply with the rules and regulations instituted at the different levels. EPC manages the process of construction, procure the required materials and apply for permission, designing and engineering the solar array. EPC subcontracts out work and as a prime contractor, also responsible for the management and quality assurance of the subcontractors' work. The project developer works for the EPC firm and in some circumstances, the project developer solicits bids from an EPC for the management of the construction process. Another type of stakeholder in solar power projects is the business development manager and the team. The major role of this stakeholder is to develop growth strategies and plans while managing and retaining relationships with the clients. They are also involved at the various stages of a solar power project like execution and closure of the project. Most importantly, a business development manager performs activities related to business development that meets the sales plan defined for the solar power projects across the country. In solar power projects, the business development manager with this team builds high quality execution plans, leads new projects and increases scope of work for the ongoing projects using networking and strategic research. The progress reports are also regularly prepared regarding the solar project pipeline activities and also participates in the meetings regarding new business development for facilitating and leading teams in selling synergies in the region.

Discussion

Effective involvement of stakeholders in solar power sector planning is important for activities that drive the best possible results. As the decisions are complex, they cannot be resolved by a single governing agency or interest group or institution.

Moreover, the involvement of all stakeholders in the project planning helps in leading a successful project (Quitzow, 2015). Therefore, engaging various for any solar power project benefits from collaboration, greater communication and knowledge sharing. NBFCs drive the solar energy segment in India as it is expanding exponentially with a thrust on clean, green and renewable sources of energy by the government (Verma & Jagtap, 2014). The country has sun-kissed land that caters to the need of the energy demands through solar energy. However, setting up a solar plant requires a huge number of finances and solar companies may face hurdles. As per rough estimates, the cost of setting up of each MW solar power is approximately 6 crores and without debt, it is not possible, until a big player like NBFCs comes into the picture. Banks finances big and reputed solar companies and new entrants have to struggle in getting loans and financers like NBFCs cater to their financial needs in the solar energy segment in India, made it easier to get debt and has changed the landscape advertently (Thirumurthy et al., 2012). Another stakeholder, IPP also provides loans to end users for the installation and operation of their own solar energy systems. The fluctuation of demand across the regions that depends on the client profile, lengthy procedures in loan and therefore, IPPs provide constructive support to push green technologies like solar sector in the market. In India, about 26 export councils and 9 commodity boards of India are actively operating where the solar EPC contractors also called solar engineers construct, procure and contractors help a solar company in starting a solar project (Gupta, Singla & Agrawal, 2017). EPCs contract agreement in the field of construction where the detailed designs of the solar projects are carried out by the EPC contractors. The EPC market in India is facing heat of competition as players increase. Since integrated facilities and large IPP are likely to develop EPC capabilities internally for the cost optimization on the account of falling tariffs in the Indian solar market. This consolidation drive is likely to be experienced in the EPC market in Indian solar sector.

With the acquisition of the renewable portfolio, Tata Power is India's solar project developer with an operational utility-scale that accounts for over 850 MW (Garg, 2019). As a part of clean energy economy, the solar project developers are responsible for the development of solar energy projects that includes securing of land rights, building permits, interconnection rights and property tax agreements that works closely with the finance, engineering and commercial teams as the project moves to pre-construction phase and acts as lead sponsor in the project for the successful construction and financing of the project. Solar project developers maintain current knowledge of the emerging technologies, policy developments and relevant solar energy market (Steffen et al., 2018). Business development managers develop new business opportunities and ensure that it is pursued to their maximum potential. The role of a business development manager is to build strong relationships with the investment managers and project funders while building strong relationships with the key stakeholders throughout the solar market (Rathore et al., 2018). Moreover, generation and understanding of the strategies of the company and development of best business practices and preparation of financial model for the assessment of returns of the project and concise and clear reporting to the senior management.

Interpretation of Theme 3: Inadequacy of proper measures to promote solar in India

India wants a solar power capacity of 100 GW by the year 2022. During the year 2017-18, India's total peak electricity demand was 164 GW and is expected to have a capacity demand of 235 GW by the year 2021-2022. This demand involves building capacity of more than four times that existed in the last four years and as per the plan, the country is expected to increase its capacity by three-fourths to have a renewable energy capacity of 175 GW by the year 2022 that includes 100 GW of solar energy. This target could be achieved through implementation of rooftop solar (RTS) and solar ground mounted in the country. The large-scale implementation of RTS will quicken the transition to fossil-free power generation in the country. However, the RTS segment implementation seems poor and unlikely to meet the target of the country to have 40 GW by the year 2022. Till date, there is installation of only 6 GW and residential RTS installations account for 30% of this capacity, however, it has the slowest uptake in the country. The Government of India has responded to the tepid implementation of RTS with all measures in the country as 20% to 40% capital subsidy for the consumers and launching of the Sustainable Rooftop Implementation for Solar Transfiguration of India (SRISTI) scheme to incentivise DISCOMs to install RTS. DISCOMs play a crucial role as implementation agencies for the state and central governments’ policies related to RTS. Moreover, RTS is difficult to install as compared to ground-mounted solar plants as it requires engagement with multiple consumers for the implementation on a large scale. On the contrary, the solar-ground mounted implementation is fairly well as the country is targeting an investment of about US$100 billion. However, there are challenges faced by the country for the future growth of the solar ground mounted and fulfilling the target of 100 GW solar installation by the year 2022.

The challenges include too-aggressive bidding in the auctions for the solar power projects, inadequate grid capacity, poor financial health of the DISCOMs and relative neglect of the implementation of RTS segment. Despite the commitment from the government towards solar, the electricity generation through solar energy in India remains small i.e.,1% of the total energy production. From the current trends in solar energy, it is clear that India will be able to reach only 57 GW of the 100 targets by the year 2022. The competitive auctions for the solar power projects are to yield too-aggressive bids. This triggers an unhealthy race throughout the hierarchy in which the bidders with less stellar credentials for the project are pulled out and as a result, are cornered. The viability of the competitive bidding is dependent on the falling trend of the module prices. In addition, the on-going market consolidation is the second factor that allows cost savings through the scale and makes lower bidding more robust. Another challenge is the grid integration as a major barrier in the path of solar promotion in India. As per India's geographies, the locations are distinctly skewed. Seven states in India only account for more than 80% of the total generation of solar power in the country. These states represent less than 40% of the demand that results in localized power surpluses that are not transmissible to the external consumption sites. The ambitious Green Energy Corridor (GEC) project is aimed at strengthening the intra-state and inter-state transmission that not only includes the new transmission but also the renewable energy management centres to forecast better the actual generation from solar site and completion deadline was March 2020 with all inter-state transmission lines that commissioned by the end of 2018. However, the progress in GEC has been disappointing due to poor coordination between the regulatory commissions and government agencies for building of new grid capacity which is not in pace with the large infusions in the supply turning online. However, the central government has insisted on tracking to meet deadlines while delays in land acquisition happened in some states of India. This inconsistent execution and delay in large infrastructure projects in India that made GEC miss the targets and curtailment issues with the solar power projects that may persist for years.

The Central Electricity Authority (CEA) is a premier national body that is aimed at laying down the roadmap of the power to the citizens and the policy interventions to be made for the solar sector in the country. However, there is a lack of noticeable checks, coordination and balances in the implementation of solar policies in the country. Challenges exist in terms of solar policies in India that includes financing, policy that supports domestic industry, incentives for research and development, duty structure or inverted taxation, support for storage systems, schematic land use, capacity development and development of standards for the manufactured products made domestically are some of the gaps that exist in the current solar policies that requires immediate attention to be addressed effectively.

Discussion

India is making progress in the path of solar energy generation to limit the emissions of GHG which is critical in the achievement of the Paris Climate Agreement that has a target of containing global temperature rise to 2 degrees Celsius or below in the coming decades (Christoff, 2016). The deployment of solar energy at a large scale is critical for the country to curb the rise of GHG emissions and enhance the energy security and also air quality. The poor financial health of the DISCOMs, relative neglect of the RTS segment, inadequate grid stability, dependency on the imported modules, lack of transmission infrastructure and non-supportive solar policy and regulations (Sharma & Khurana, 2018).

The solar capacity of India has increased every year with new additions in GW since 2016 with further additions of 9 GW in the year 2017 (Kumar, Prakash & Dube, 2017). This shows the pace of the country is just 1 GW per year as compared to China, United States, Japan and Germany who added 34 GW, 13 GW, 9 GW and 1 GW respectively in the year 2016 (Wen et al., 2020). However, the scope of the solar sector in India has widened due to the solar deployment taken up by the new states in the South. RTS installation has finally begun to take off with a capacity of about 1 GW which is quite slow (Garg, 2019). It has been identified that the poor financial condition of Discoms is a major challenge for the entire solar sector in the country. Discoms are concerned about the perceived losses in revenue as consumers switch to RTS. Gross-metering policies are required that would dissuade consumers and will have a passive response to the solar PV technology promotion (Umar, 2017). Ground-mounted solar plants are easier to install and their implementation is happening at a steady pace.

On the contrary, hurdles have been found in the RTS implementation due to pushed investments towards the installation of ground-mounted solar plants. Looking into the poor financial health of Discom, the financial turnaround, Ujjwal DISCOM Assurance Yojana (UDAY) scheme was launched in the year 2015 as a revival package for the discoms in India with an aim to find a permanent solution to the financial debts that the power distribution is facing in the country. The UDAY results are mixed and Discoms are making losses and missing targets (Shrimali, 2020). Grid stability is another big challenge in scaling up solar in India. From the present statistics, ~28 GW is the total capacity of the renewable sources that represents unpredictable power including solar and wind that would touch ~125 GW by the year 2022 (Kappagantu & Daniel, 2018). This present share of renewables is about 11% of the installed capacity that is around 26% of the capacity that corresponds to about 12% to 13% in the energy content. This high percentage of unpredictable power imparting grid instability with a status "must flow" may not sound prudent in operating solar grids economically. Although power planners have indicated that Indian grid could sustain an unpredictable content of energy up to 15%, it is still doubtful about the unpredictable flow power that would come to the grid during the non-peak hours; solar during the daytime and wind during the night time.

With the expected demand for electricity over the coming decades, lack of distribution system and transmission infrastructure is another growing concern for solar companies in India. With a plethora of solar tenders including the interstate transmission system (ISTS) where availability of evacuation infrastructure is the biggest challenge. The renewable-rich states are not absorbing the renewable sources of energy that is produced locally and considering the solar intermittency, there is a requirement of strong grid stability and transmission which is vital (Hairat & Ghosh, 2017). Further expansion is required to double the electricity demand that would create an opportunity for the country to establish a smart grid that is internationally connected and capable of incorporating greater diversity in power production and managing increased demand supply that includes RTS installation and battery storage.

There have also been gaps witnessed in the renewable policies that are obstructing the growth and promotion of solar industries. The policy does not support the domestic industries by introducing anti-dumping duties for encouraging indigenous manufacturing. The major barriers in the financing policies for solar technologies are lack of expertise, Power Purchase Agreement (PPA), absence of authentic data on solar radiation and plant performance and uncertainty in policies (Sargsyan et al., 2011). There is a lack of investment in research and development (R & D) and solar training and the country does not have specific policy initiatives that are directed at incentivizing the storage technologies at grid scale like Germany and USA (Lucas, Pinnington & Cabeza, 2018). Policies also lack the systematic land use and acquisition by solar project developers and renewable energy policies lack expertise and skilled labour in the renewable energy sector and lack of support for the creation of a dedicated training and education of the individuals.

Interpretation of Theme 4: Lack of transmission system to support solar

In India, the power generation from renewable sources of energy often takes place through distributed generation (DG) which are small units that are located mostly in remote areas and are not centrally dispatched or planned and are connected to distribution grids operating at low voltage (LV) or medium voltage (MV) levels. In some cases, the large capacity of the RE generation is also connected to the transmission networks and hence, the power generation structure moves from large and centralized plants to a mixed pool for power generation that consists of traditional large plants and smaller DG units. As there is involvement of large DG technologies, the use of power electronic converters for the grid connectivity faces many technical issues associated with power system protection and operation control that is impacting the transmission system, generators and consumer devices. India has to look forward towards rapid addition of grid capacity in solar power generation. For the stability of the power grids, it is quite pertinent that there should be a balance between demand and supply of electricity at all times. Dip occurs when the demand exceeds supply and vice-versa and tripping of the entire grid unless load shedding carries.

Indian grid has two peaks-one smaller during morning time and a higher peak during evening. It has been witnessed that slight variations in the general pattern varying between states of the Indian grid takes place due to variations in weather and industrial development. For the optimum, efficient and economical operation of the grid, the strength needs to be increased so that the peak demand is met through storage technology, efficient transmission system and modification of grid code so that the base power that is required for the grid could be increased to be functional 24 hours and to some extent by the large power storage plants. The integration of 100 GW solar power on the current transmission grid is also dependent upon hybrid technology and IT infrastructure. The hybridization technology of concentrating solar power with conventional power generation methods may serve to mitigate the externalities in fossil fuel use. This could also be helpful in supporting the energy system of India; however, the future is uncertain to some extent as methodology is still under research. Many solar energy systems with storage could be very good for maintaining the reliability of Information and Communication Technology (ICT) infrastructure and delivery of digital services. ICT is a rapidly evolving sector that has many technologies analysis and development directions that manufacture, use and dispose of ICT equipment that contributes to 2% of the global emissions of CO2. ICT infrastructure could revamp the solar sector as solar PV technologies and storage batteries could be enabled by ICT tools and also demand supply cycles. The partnering of the power sector with technology providers could be helpful in building an ecosystem of capabilities that enhances the energy usage and its efficiency and for example, solar PV requirements could also be estimated from the Google Maps images of the rooftops.

Discussion

The target of adding 100 GW by the year 2022 may alter the impact of renewables on the strength and operation of the grid. Adding GW to may alter the scenario completely. Although the entire target may not fructify on Indian grounds, however, adding 60% to 70% of wind energy may provide additional capacity to fulfil the set target by 2022 (Chabhadiya, Ranjan Srivastava & Pathak, 2020). Electricity generation from renewables is entirely dependent on the vagaries of nature and also the operator has no control over it. Moreover, the energy accorded using the renewable sources is a 'must flow' status to the grid and should not be backed down. Apart from being a clean source of energy, the back down power obtained from renewables is financially prudent as it has negligible variable cost. The danger to the grid strength and stability arises from the status 'must flow' that includes solar and wind both. At any point of time, the demand and supply of power is evenly matched and at the same time, the share of the unpredictable power from the solar increases, then due to the status 'must flow', the power from non-renewables would be required to back down for stabilising the grid (Ajan & Kumar, 2015). This could in turn impact the coal-based power plants through increasing cost of generation as thermal power plants become less efficient on the lower PLF, Fixed Cost (FC) per unit, variable cost (VC) unit that would in turn increase VC because of lower efficiency and FC would spread over low units. This would ultimately increase the cost of electricity of the consumers and may result in unintentional cross subsidising power from solar energy (Ajan & Kumar, 2015). This shows that sufficient management of grid strength and adequate planning is required for controlling the backing down of base power plants that would happen.

The electricity transmission infrastructure of Indian solar sector is another big challenge that needs to be addressed and also handle the influx of new intermittent solar power generation to overcome transmission obstacles and work towards achieving the target (Moallemi et al., 2017). The GEC plan for addressing the lack of grid infrastructure is also running behind schedule which was hit by pandemic last year. Regardless of the installation growth of India in context to solar panels, without a capable energy transmission system, the country cannot fulfill the electricity demands of the end consumers that fails in its purpose. India hosts the biggest brownout that results in people living without electricity due to grid failure (Behuria, 2020). Therefore, a strong energy transmission system could provide electricity to all and could increase the capacity of solar power generation.

Battery storage is getting cheaper with an increase in the manufacturing capacity and also quicker to implement. However, it is cost-effective and solar developers wary about its large-scale implementations. As discussed above, there are constraints on the installed capacity of solar, the storage could be a viable option for India. It could help grid operators to manage the peak demand which is one of the constant challenges that the country is facing. In addition, a peculiar challenge of 'Duck Back' that is caused due to shifting of energy demand during daytime could also raise questions about the feasibility of solar energy in the long-run that could be ramped up by having large storage systems (Gorman et al., 2020). Battery storage could be a promising technology for the off-grid and microgrid applications and may be the future until cost parity of the pumped hydro comes in. Another game changer for India would be the renewable hybrid technology that would help the government fulfil its target to achieve 175 GW (100 GW solar and 75 GW wind). By combining wind and solar in a hybrid system with an additional storage during the time when the peak demand for power cannot be fulfilled by either solar or by wind. By storing energy during the maximum output hours and releasing it into the grid during the peak demand hours, the hybrid system could produce 24 hours clean energy in response to varying levels of demand throughout the day (Manju & Sagar, 2017). At the national level, solar PV technology needs a more focused and collaborative approach towards the supply chain, sharing of technical information to the stakeholders and consumers, manufacturers, investing in R&D and better IT infrastructure that could spur the solar PV technology and consumption of the solar PV products.

Interpretation of Theme 5: Inadequate mechanism for forecasting solar generation

Unlike conventional sources of energy whose generation dispatch can be controlled, renewable sources like solar and wind are completely weather dependent. Weather forecasting is a critical component that is important for solar generation in the future. It is possible to convert an accurate weather forecast into an accurate power generation forecast; however, an inaccurate weather forecast cannot be utilized to have accurate power generation. Currently, the weather forecasting methodology in real-time is accurate for present conditions, but these do not act as good predictors for the upcoming environmental conditions that are beyond 15 to 20 minutes. Numerical Weather Prediction (NWP) models forecast invariably which is accepted to be the baseline predictions run by mostly large government funded organizations. The U.S. has spent on a global forecast system (GFS) that went into the global forecast system and as of now, GFS ranks low for Indian region. There are no commercially or publicly available NWP models available for the Indian subcontinent. Regardless, these models are not so accurate for smaller regions over the short time scales under a few hours. Using these models, the parameters could range from 15% to 35% depending on the season and location. Clouds cause the largest deviations in the intra-day forecasting which is also R & D that is heavily funded.

The forecasting of renewable energy arrived at by combining the plant availability with the forecasting of weather for the location. Moreover, the impact of climate change is affecting renewable energy production in India. Within the energy sector, the solar energy generation is affected by the climate variables such as temperature, precipitation, wind or irradiation. Weather forecasting needs to be accurate for predicting the future of solar power in the next 15 to 20 years. The data obtained is presently very inadequate and reliable data is required to forecast solar energy production for the next 20 to 25 years. Different instruments, simulation software and satellite data are available for measuring the solar irradiation intensities, however, the accuracy and efficiency are quite different. Radiation data provided by NASA, Meteonorm is quite accurate and helps in predicting the radiation data for the solar for the next 15 to 20 years. Another major factor that generates inaccurate radiation data is shading due to soiling. The accumulation of dirt, snow, leaves, dust, pollen is soiling and the performance of a PV module is decreased due to surface soiling and subsequent power loss of PV increases due to an increase in the quantity of soil that settled on the PV module. This results in a decrease in energy production by the PV module. Therefore, high quality devices are required that measure the solar radiation at the solar plants in India.

Discussion

With the seasonal variations, the generation capacity of the renewable sources changes drastically and so the weather forecasting and scheduling responsibilities are required for the large-scale solar power generation that maintains grid security and stability. Forecasting and scheduling are now indispensable for the efficient solar power generation to be integrated into the major renewable market and considering the future of India in the renewable energy generation, forecasting and scheduling seems to be inevitable for India enabling higher offtake of renewable energy and minimizing curtailment (Mohanty et al., 2017). Solar generators expect uniform and clear regulations in the states and smoother and centre implementation where weather forecast is of paramount importance due to the impact of climate change (Kumar, Prakash & Dube, 2017). Climate change impacts the temperature and irradiance and therefore, alters the output capacity of the solar PV systems. PV systems present a negative and linear relationship between energy output and temperature change. Solar irradiance affects the performance of a PV module that is dependent upon the energy delivered by the module. Moreover, the solar radiation measurement devices do not provide accurate radiation data that could be beneficial in predicting the solar power generation in the next 15 to 20 years.

The environmental conditions like shading, soiling, bird deposits and cement deposits cause reduction in the power generation by solar PV panels in the heat form. Solar panels are in direct contact with the open environmental conditions and therefore, could get damaged causing heat and in turn, affecting the solar power generation and reducing the life of the component (Maghami, et al., 2016). The effect of soiling and deposition of soli, dust on the solar hotspots reduces the power generation in the solar PV panels. The industrial fumes and deposition of soil due to shading are some of the important factors that consider monitoring of the solar panels so that the performance of PV cells is not affected and accurate radiation data is obtained (Vidyanandan, 2017). These environmental variations hinder in getting accurate data; however, India has ample sunlight for achieving the optimum solar generation. The data provided by NASA and agencies like Meteonorm provide reliable data on solar radiation, however, the data is based on historical time series of temperature, irradiation, precipitation, humidity and wind (Paulescu et al., 2013). Hence, the data availability on solar radiation could be done by using high quality solar radiation measurement devices at the plants in India. This data could be helpful in forecasting solar energy data generation for the next 20-25 years.

Interpretation of Theme 6: Non-reliable source of power generation

Renewable sources of energy like solar, wind are great sources of intermittent power, however, these renewable energy sources are not reliable sources for electricity generation as these sources are weather-dependent. As compared to conventional power plants, the renewable sources are not able to supply baseload power generation as they cannot supply continuous energy demand in a particular region which is the foundation of any extensive electric grid. It has been determined that the physical, economic and environmental implications of solar power are not very reliable and efficient. Most of the solar power generated is during daytime when the demand for electricity is least. The solar facilities available currently are generally located far from the population and costly transmission lines are required to connect the facilities to the distant consumers. In addition, consumers generate their household solar power and sell the surplus that places mechanical stress on the grid as electricity flows both ways from home and thus, increases the maintenance costs. Environmental costs also make solar power less reliable and efficient as compared to conventional methods. Although solar energy power production reduces carbon emissions as it does not require a fuel source for the energy production, however, the intermittent nature of solar energy needs to be backed by fossil fuels. In this situation, the emission benefits of solar power get reduced as fossil fuels are burnt to maintain a constant supply of power.

For the solar power to be physically reliable, it should be consistently meeting the demands of the consumers without causing any detrimental effects to the grid infrastructure or operations. In such cases, solar energy struggles to meet all these criteria as compared to traditional sources of energy. Solar energy is inefficient, inconsistent and cannot meet the demands consistently. This demands expansion of new transmission infrastructure and grid stability and management techniques that would help India to make solar energy more reliable and efficient for power generation. The sunlight availability is inconsistent that makes solar power a low-capacity factor having poor energy output. This capacity factor is a measurement that compares the amount of energy a solar plant actually produces to the energy that would produce when operating at its full capacity for the same amount of time. The sunlight availability is inconsistent as there is no generation of power at night when the demand is maximum during the evening hours from 6 pm to 9 pm. On the contrary, solar power projects are efficient in many ways.

Unlike fuel cells or batteries, solar panel cells do not require fuel or utilize chemical reactions for producing electric power and electric generators, they do not have any sort of moving parts. Moreover, the solar cell does not require any material supply except for pure silicon that is the outer framing that encloses an array of the solar cells made of glass in each solar panel which is highly transparent so that sunlight can penetrate the frame. The execution time of the solar power projects is less and requires marginal operations & management (O & M). O & M is one of the most critical ways that ensures delivery of solar power without any sort of disruptions that maintains the economic value that is generated by each kW hour of production and proper output which is a critical component for ensuring optimal performance and minimizing risks of downtime. Solar panels require low maintenance as there are no moving parts in the solar PV system and the only maintenance cost is an inverter that is replaced after the solar system operates for 15 years.

Discussion

Over the last decade, the renewable energy industry has changed tremendously as the costs have fallen dramatically and the technologies are becoming more efficient with solutions integrated into electric grids. However, solar and wind energy cannot produce energy at every hour especially during the evening peak hours and therefore, the energy that is generated could be managed on the grid. Solar power production is variable due to the interrupted supply of energy and requires utilities and grid operations through operational practices, responsive loads, forecasting and infrastructure like transmission systems and efficient storage systems (Carnegie et al., 2013). This shows that solar power projects in India are not reliable and efficient enough as compared to conventional power plants. The grids are not modified or flexible enough to address this variability in electricity demand of the consumers and maintain balance between the production and demand and also maintain storage systems for any outrage on the solar PV system. Moreover, storage demand is required as solar power generation is not possible at night during the peak hours and, so investments in storage could address the demand during the evening peak time (Gulagi, Bogdanov & Breyer, 2017). The angle of the sun determines the energy output; when the sunlight is low due to haze and cloud, there is less energy output as less sunlight reaches the panel resulting in lower power output. The physical reliability is less as solar energy is unable to fulfil the energy demands. PV cells and concentrated solar power have lowest capacity factors as compared to any other major source of energy and these low-capacity factors indicate that solar sources rarely produce energy near to the conventional sources of energy (Sharma, 2011). Energy storage is required as peak demand for energy occurs in the evening when the sunlight is least and cannot be reliably used for meeting the demand and instead, conventional sources of energy can be utilized at any time of the year.However, the solar power projects are efficient as they have no moving parts like the electric generators and have relatively free maintenance as long as sunlight is received and the products are not faulty, they may become a reliable source of power generation in the next 25 to 30 years (Kabir et al., 2018). The requirement of raw materials is also less except for pure silicon and for making solar cells, silicon dioxide is only required that makes solar power projects reliable and efficient as compared to the conventional power plants.

Need of storage technology for solar to enhance reliability

Energy storage integration at the grid-level is one of the major takeaways wherein India has to understand the value of storage of solar energy including batteries that has not yet been recognized by the energy markets and the regulators in the country. The current scenario of solar energy in India suggests that storage is a viable option for the standalone power generation system in absence of grid connectivity and the diesel gensets generate electricity. Storage technology may enhance the availability and reliability of solar power projects and also reduce the solar intermittency. Storage through batteries is quite popular in India and the reason for storage is that it gives backup for four-hours during the peak hours of demand from 6-8 pm in the evening and with more states opting for time-of-day tariff; this backup would help the consumers avoid high cost of tariff that is applicable in these four peak hours. The increase in adoption of storage would help policymakers in devising policies that benefit stakeholders in promoting storage systems along with the solar PV systems.

Energy storage could solve the issues of reliability for the grid operators in India like the blackout that happened in Mumbai in 2020. The grid-scale lithium-ion battery is currently used for only demand side management (DSM) use cases and demonstrates that battery storage in India could play an important role in providing grid stability. The batteries could meet the peak demand on the grid that should not be overlooked and in India, there are only two daily peaks in demand, one in the afternoon and another around 8-10 pm at night. Storage batteries could fit during the evening peak and the energy storage market will grow quickly. India is facing challenges in bringing solar energy to scale through battery storage technologies. The Energy Storage Roadmap of India estimated that storage requirements for solar are expected to rise to three-fold from ~50 MWh to ~175 MWh by 2022 through storage solutions that will bring solar energy to scale. Storage options in solar energy are inevitable for mini-grid or off-grid systems which ensure round-the-clock access to power.

Rooftop solar systems also face an issue of net metering across the Indian provinces and storage systems would allow the rooftop consumers to consume more of the power generated and place more solar systems on-grid without having much to spend for expanding it. The high tariff charged during the peak hours would also be avoided by the consumers as in India, the solar power is not generated during evening which could help to better the DSM. Grid-scale energy storage would help to improve the management of the distribution networks, reduce grid congestion, costs, voltage variations and improve grid balancing, energy security and efficiency. Solar PV systems integrated with storage systems could be used to supply the peak load that is above the base load in a manner when sunlight is not available to produce electricity and the storage system could supply the peak load and thus, the demand charges get reduced for the consumers. Storage systems could also be used in utilities for better load management without restoring load shedding. However, one of the biggest challenges with the solar power storage systems is that storage batteries are very costly and quite large to handle and, in such cases, hybrid technology could also help in promoting solar technology. The hybrid combination of wind and solar energy will help to improve the overall availability of power during the peak hours and availability of renewable energy for 24 hours. In addition, Distributed Generation (DG) sets or distributed solar energy located on ground-mounted or rooftops could also be connected to the local utility distribution grid that has less costs comparable to cost of generation through storage.

Discussion

Depending upon the existing demand and supply for power and energy mix, India is exploring options that work on the supply. While pumped storage is the main source for storage identified in most simulations, it has been found that only 6 GW of pumped hydro storage has been generated in India (Rehman, Al-Hadhrami & Alam, 2015). Moreover, after the power outage nationwide in 2012, strict laws have been applied on the movement of power between the states and limited to as low as 150 MW which may not necessarily be in the same state as the power generated from renewable sources and thus, storage options for the country becomes more important. For the residential segment in rooftop solar installation, hybrid systems could be installed where the inverter is integrated with solar and grid systems with battery backup (Li, Chen & Zhang, 2013). Batteries are also critical components for the mini or micro-grid systems. Commercial consumers act as anchor loads for these grids as in their absence, total energy generated from the PV system could be stored in batteries for supplying power to the rural consumers during evening and night hours through storage batteries.

Power outages have been the key driver for the adoption of battery-based backup systems in the rooftop solar market as most of the Indian states still suffer from prolonged power outages (Dhaked, Gopal & Birla, 2019). In such cases, storage could enhance the availability and reliability of the renewable source generated electricity and people's access to electricity. With the increase in renewable energy in the national grid, there is an increase in opportunities for the advanced battery storage technologies for hitherto unexplored regions like grid stability, peak shaving, forecasting, ancillary services and solar integration to the grid (Rohit & Rangnekar, 2017). The government is looking into the grid scale storage of solar generated energy for maintaining grid stability and in reducing the grid dependency for electricity demands.

India ranks among the 15 nations around the world in context to installed solar capacity of 1.5 GW, however, the main drawback of the solar energy is the intermittent nature of the solar energy, Sunlight is available only for 6 to 8 hours during daytime and conditions like cloud and other weather conditions could create significant fluctuations in the solar energy output. Too much reliance on solar could affect the grid strength and stability and thus, could limit the development of solar energy. Integration of solar PV with the Energy Storage System (ESS) could make solar power more reliable, reduce stress on the grid and optimize the overall system resources (Rohit, Devi & Rangnekar, 2017). Moreover, ESS could also play an important role in the optimal sizing of the solar PV systems for off-grid usage. ESS integrated with PV solar could be used to supply peak load above the base load during the night-time when the demand is at peak reducing demand charges for the consumers. As the solar installers in the solar PV segment are highly costly, the back-up batteries (system) could increase the upfront cost of the storage system by up to 50% and also the replacement and maintenance cost associated with the batteries. This would make the storage less viable and economical and therefore, hybrid technologies could be helpful in supplying the power demand during the peak hours from 6 to 9 pm (Mellor et al., 2018). Net-metering policy is another reason, the solar rooftops are unlikely to drive demand for the energy storage solutions, in case power supply is required 24*7 and the grid remains reliable. Net metering converts the local grid into batteries effectively and in such cases, the additional storage solutions could ramp up the solar rooftop market to store the generated solar power on site like a captive solar unit.

Interpretation of Theme 7: Incentives by government to promote solar

Solar energy is being promoted by the private sector and corporates by the Government of India through tax relief that allows them to avail high rate of depreciation that is also termed as accelerated depreciation under the Section 32 of Income Tax Act. After the new budget policy on 31st March 2017, solar power plants have been commissioned for more than 180 days in a financial year and eligible for 40 + 20% depreciation and therefore, the asset owner could claim for 60% depreciation in the first year. This is a very big benefit as it incentivizes investment in the solar energy systems. Similarly, solar plants commissioned for less than 180 days in a financial year will be eligible for half of the full year depreciation rate where a collar asset owner could claim 30% depreciation. Income tax benefits are also offered for solar rooftop installations. The national target for solar power is 40 GW of utility-scale solar plants and 20 GW for the mega solar parks. Although there has been addition in the considerable capacity of these two segments, however, half of the target has been achieved. Solar rooftops lag behind as the situation could be improved with income-tax benefits and fiscal incentives that would shore up the solar rooftop solar segment like the U.S.

National Solar Mission (NSM) has introduced central and state government policies like VGF schemes, solar park schemes and tariff-based bidding to promote solar in India. Indian Renewable Energy Development Agency (IREDA) is the implementing agency for viability gap funding (VGF) that has supported 12 GW of the solar projects and are set up by the Central Public Sector Undertakings (CPSU) for government agencies use or self-use. Initiatives like feed-in-tariff, bundling schemes have been launched to promote the solar projects on a large scale. Fiscal incentives like excise duty exemption and tax holiday have also been introduced to reduce the tariff and grid infrastructure has been made available at free of cost until the year 2022. Green corridors for the solar parks have also been developed for providing evacuation and transmission infrastructure as solar parks are hassle-free for the development of solar projects. Banking facilities, open access and bidding are being provided for promoting captive generation. Net metering facilities are being provided by the government to promote rooftop solar and subsidies are there to promote rooftop and solar pumps and also small projects at the distribution level. Domestic manufacturing promotion is also conducted to shore up solar energy in India. Solar Panel Subsidy has been introduced by the government to encourage people to install solar power in each house so that every home roof will generate their self-energy and also support financially so that they install solar panels in their residential homes.

National Clean Energy Fund (NCEF) was introduced during the year 2010-2011 financed by clean energy cess on coal built on the principle of 'polluter type' to hold the emitters responsible for pollution and most importantly, the find finances clean and renewable projects and also promotes R & D and innovation in clean energy. So far, NCEF has financed many solar projects and included many renewable energy programs having a promising perspective so that India proceeds towards the path of sustainable development and reduces reliability on fossil fuels as energy carriers.

The government has launched the scheme of soft loan for the users and manufacturers of solar cookers under which the manufacturers would be able to avail loans at a concessional rate of interest for the establishment of production facilities. Corporate bodies would also get extended funds from Indian Renewable Energy Development Agency Limited (IREDA) to offer solar cookers to the employees on interest-free loans and also extended to the corporate societies urging them to take advantage of the soft loan scheme for the propagation of national tasks of solar cookers. Compact Secondary Substations (CSS) for all solar plants has been waived off for the waivers like wheeling charges, transmission, system operation and scheduling at about 50% of the conventional power. Zero Transmission and distribution (T & D) have also been provided for the solar energy generation that avoids or defers infrastructure upgrade costs while lowering the cost of supply (CoS).

Discussion

Typically, it has been seen that return on investment (ROI) is 45% or higher for a solar system and a payback of about 3 to 4 years. Most importantly, a good quality and highly reliable solar system has a life that lasts more than 25 years. Therefore, from a long-term perspective, investment and incentives in solar energy continues to be a very attractive investment plan for profit making entities that have income tax liabilities. To take up the NSM, promotion of solar energy is being initiated by the government in India by introducing various incentives and schemes (Khare, Nema & Baredar, 2013). Bundling, feed in tariff and VGF schemes promote solar projects under the RPSSGP scheme implemented by IREDA. Under bundling scheme, selection of projects is based on the tariff-based reverse bidding on the fixed tariff by the regulator and after bundling with the cheap coal power, the solar power has been allocated to DISCOMs being implemented by National Thermal Power Corporation Limited Vidyut Vyapar Nigam (NTPC-VVM) (Pratiyuksha, Sundararaman & Ranjitha, 2020).

Under the VGF scheme, predetermined fixed tariff has been specified by MNRE and selection of solar projects is based on reverse bidding on VGF implemented by Solar Energy Corporation of India Limited (SECI). As the tariff gets reduced under the average purchase price of solar power in India, this scheme supports the upcoming projects that have been withdrawn and introduction of bidding that is tariff-based (Kumar et al., 2018). Fiscal incentives like tax holiday, accelerated depreciation and excise duty exemption have also been introduced by the government to promote solar energy in India. A 10-year tax holiday was introduced along with all the power projects which were removed after April 2017. 80% Accelerated Depreciation (AD) was provided as a part of income tax regulation which was further reduced to 40% (Kapoor et al., 2014). 100% excise duty and custom exemption is provided for all the components and for all solar projects which after introduction of GST, duty exemptions were removed and solar equipment prices were kept lowest at 70% @5% and 30% @18% bracket. Solar parks have provided infrastructure support to the solar project developers where about 40,000 MW schemes have been launched for the development of solar parks (Sahoo, 2016). For the promotion of captive solar projects, various states in India came up with open access incentives like the Electricity Act. Moreover, waiver has been given on the wheeling charges and banking charges for the solar projects. Cross subsidy charges have also been waived off with net metering facilities and electricity duty. Rooftop solar projects are the best options for the DISCOMs as their power is consumed at the generation level and has no wheeling losses and no transmission charges (Quraishi & Ahmed, 2019). Moreover, 30% capital subsidy is also provided for the small-scale rooftop projects, large scale projects are also actively promoted with strong policy push and easier access to loans and ease in clearances and permits.

Interpretation of Theme 8: Solar Policies lack clarity and poor implementation by state government

Processes and regulations in grid interconnection remain challenging in most states of India despite announcing gross or net metering policies for the rooftop solar sector in the country. Although the rooftop solar system is making progress, implementation of net metering policy at the state level remains patchy. Urgent overhaul is needed for the policy framework as it has to be more consumer friendly and include evolving business models and technologies. Passive opposition from the DISCOMs, inadequate implementation of policy framework and lack of process protocols and appropriate training at the utility local level. The reasons behind poor implementation of net-metering policies in the key states are due to lack of clarity and process training, average time that has been taken from connection, DISCOM competence and support, meter availability and support for various business models. Project execution from mapping to implementation is never done and there remains a disconnect between the different government agencies in the key states that are tasked with overseeing and implementation support. Although there are many policies and regulations that support renewable growth, their implementation is still far from adequate. Central and State Nodal Agencies (SNAs) are providing multiple subsidy schemes for the solar PV system to exploit renewable energy. Net-metering and Capital Financial Assistance (CFA) is a complex path that involves several government agencies for its effective implementation. While renewable energy has been growing in the key states in India at an annual rate of 22% since the year 2011, there are challenges and a wide gap between the implementation of solar policies at the centre and state level. Regulatory and policy environment need to be strengthened in three main areas; overall incentives offered use of Renewable Purchase Obligation (RPO) by the state to the renewable sector, ease of doing business and notification of revised Renewable Purchase Obligation (RPO) trajectory as per National Tariff Policy and NAPCC. Increased variability in the power system because of the rising share of renewable energy in the electricity mix of the state. There is a difference in the implementation and success of solar market policies in various states of India. The findings indicate that there is no standard formula for the implementation of solar policies in the country and a combination of localized strategies and foundational policies could increase the installation of PV solar systems in any state in India. A variety of non-policy and policy-based factors influence state and the local markets in solar energy. Incentives are provided to the states by the finance commission for the promotion and increasing the share of renewable power generation in their respective states. MNRE guides the renewable energy industries who publish tariff based competitive bidding through the policy of National Tariff Policy, 2006. Special Economic Zones (SEZ) policy provides a 100% tax exemption on export income and also exemption from central and state sales and service tax. RPO or renewable purchase specification (RPS) has been announced in 25 states for the technology specific RPO for solar energy in the states. These RPOs schemes with a tradable certificate on renewable energy implemented in Indian states have also supported the development of the renewable energy space. Phased approach has been used by the Indian government for developing the solar industry in the country giving an initial push on domestic manufacturing followed by the focus on the deployment of solar power through progressive and more ambitious solar targets.

Discussion

Renewable Energy analysts provided a detailed report to understand better the reason for solar policies to be more successful centrally as compared to the state policies. The findings indicated that many localized factors play an important role in the implementation of these solar policies at the state level (Deshmukh et al., 2012). On the policy side, researchers have examined those two key factors are responsible for strengthening the solar market of a state in all contexts. Firstly, policies that define the procedural requirements or interconnection for connecting a PV system to the electricity grid and secondly, policies related to net-metering that enables utilities to compensate PV system owners through a simple billing process (Thakur & Chakraborty, 2016). Moreover, the non-policy issues also have implications for a solar market like amount of sunlight that is available for the potential power generation, community interest in generation of power through renewable energy and cost of the competing grid electricity that has been found to be the factors that affect the successful implementation of solar policies in local communities and state level.

The Indian states that have matched the solar policies to their suite of best-practice to their unique context have found to have excelled. The duration of time and the number of solar policies that have been implemented at the state level are important indicators for determining their success in the solar market in the country. The support provided for solar leasing and popular models of third-party ownership have also been witnessed to be the distinguishing factors in the success of solar markets in some Indian states, however, the economic factors are also favourable (Sargsyan et al., 2011). It has also been found that the demographic and economic background of the state is also important for determining the success of state solar policies in the country. The effectiveness of the state policies in India also depends on the extreme values of non-policy factors like solar resource, personal economic context, interest in sustainability that impact the rates of solar installations and competing electricity prices (Padmanathan et al., 2019).

Installation incentives are received by the solar industry that contributes to the successful implementation of the policy incentives in India. Financial incentives like Special Incentive Package (SIPS) were introduced in 2007 where tax incentives, subsidies and duty exemptions are being provided for the investments to be made in the solar industry (Raman et al., 2012). Modified Special Incentive Package Scheme (M-SIPS) is an investment-based scheme that provides financial incentives that are available for the solar investments to be made within the 10 years from the date of approval of the project. Financial institute training provides a number of state-backed funding sources like Rural

Electrification Corporation, Power Finance Corporation, IREDA who provide low interest loans for renewable energy sectors (Malhotra et al., 2017). Trade incentives like Local Content Requirements (LCR) are provided by the government for supporting and boosting the development of domestic manufacturing bases for the solar modules and cells. Other government support like the Indian Income-tax Act provides a weighted deduction for an inhouse solar R & D activity that entitles a solar manufacturer to claim 200% of the expenses except land and building expenses that have been incurred in the R & D in-house activity (Ansari et al., 2013).

Interpretation of Theme 9: Ineffective policies and regulations creating risks for long- term investors and consumers

Although many policies have been introduced by the government in response to the solar energy generation and production, the implementation is not proper yet. The solar policies are somewhat ineffective, creating risks for the investors to invest in the long run. The commercial investors are facing risks as the framework under which they invest is ineffective for solar to become more scalable and replicable to gigawatts of power. The long-term driver of solar growth seems to be cheaper as the technology is getting cheaper, however, the market is still not clear for the growth. The ability and intermittency of the existing grids to manage the new power still remains the issue in terms of location or transmission lines and when large volumes of power do not meet the peak demand. The investors are not finding confidence and getting comfortable with the new technologies or markets in context to solar energy. The commercial investors are nervous about the potential risks that are involved in launching a new technology for solar energy. Price risks and curtailment, resource and technology are becoming relatively more important for the investors before investing in a solar project.

The United Nations Development Programme (UNDP) Human Development Report (HDR) on India cited that there remains a disparity in the investments made in solar energy amongst the lower-middle income, low-income and high-income countries. The difference is due to the lack of access to funding in the developing industries that has a major impact on the competitiveness and pricing of green energy. In context to India, financing costs account for about 50% to 65% of the renewable energy tariffs in which solar tariffs have fallen since 2010. However, a high share of tariff is the cost of capital, and big declines in the cost of equipment could lower tariffs to some extent. The cost of capital is still high in the maturing market due to the perceived risks involved in the solar energy investments. There is market and policy uncertainty over the potential contract renegotiation by the off-takers and possible extension or imposition of duties on solar PV imports along with supply chain uncertainties,.Discoms financial weakness also gives rise to persistent investment risks along with timely land availability, evacuation infrastructure coupled with the heightened concerns over contract sanctity and uncertainty regarding impending trade barriers that locks the low-cost capital flows on a large scale. Discoms are in dire need for finances as they owe $16 billion to the generators and this is putting risk for the investors that need to be addressed urgently. The policies need to be implemented more stringently in the Indian states with the PPP model used for rooftop solar programs whereby from government to consumers, all agree that combination of one infinite source like solar energy and land (finite resource) could produce beneficial results. Another risk is the transmission and evacuation bottlenecks wherein the grid infrastructure for evacuating power generation is not available and also challenges related to integration of renewable energy generated into the grid. The open access charges are still in its early stage in which solar projects are becoming an attractive option for the power consumers in India to thrive where power tariffs are high, however, the returns from these open accesses remain at risk due to an unprecedented grid usage costs and future grid losses. They are being implemented in many states like Madhya Pradesh, Karnataka, Rajasthan and Andhra Pradesh as they are offering waivers in wheeling charges and transmission charges and exemption from cross subsidy surcharges.

Discussion

As India is facing shortages in energy demand and supply, renewable energy like solar could help to fill this gap. However, the commercial investors and banks are sceptical about the funding of the solar projects regarding the risks associated with the solar energy investment. As the solar project developers and other stakeholders are doing their best in offering competitive tariffs, the cash-stripped Discoms seem reluctant in signing new PPAs and this dire predicament is quite threatening and also delaying the solar progress of India (Verma et al., 2020). Moreover, the poor tariff designs are contributing to the parlous state of the finances of Discoms. Concerns about grid stability and transmission also make solar projects struggle to complete before deadline and require diligent working towards removal of such bottlenecks with signing of more PPAs. Issues like land acquisition could delay the commissioning of the process of infrastructure of transmission in India. There is a need for more involvement of the stakeholders for evaluating the situation holistically for improving the image of the state and stretched finances so that investors are willing to become the big players in the solar power projects (Eswarlal et al., 2014).

In addition, there is a need for consistency and clarity of policies and regulations at both the central and state levels. Policies need to be more conducive for the Commercial and Industrial (C & I) users as they are levied to pay additional significant surcharges at cross-subsidy that results in higher-than-average electricity tariffs. Policy risks like unfavourable power pricing rules and high costs, regulatory barriers, environmental externalities and frequent changes in the solar policies make the investors sceptical about solar project investments (Chaudhary, Krishna & Sagar, 2015). Unrecognized technology is also contributing to the perceived risk in investments which is new and evolving. Frequent revising of the open-access charges also prevents consumers from entering into the long-term contracts with the developers or generators. The intermittent nature of the renewable energy sources makes open access charges more challenging as it does not match the consumer demand leading to mismatch in demand and supply. A breakthrough in solar energy is the falling prices of silicon-based solar modules that is also making solar power cheaper than ever (Srivastava & Srivastava, 2013). The government is seeing an opportunity in a reverse auction scheme that is attracting big players like pension funds and leaving little for the mid-size domestic players.

Interpretation of Theme 10: High Initial Capital Cost

Solar energy programs in India may get a further boost as the capital cost norms for the solar projects have come down from Rs 6.05 crore to 5.3 crore per MW since 2016-17. The investment required for developing up a solar PV project has dropped to 80% at the fastest price in India between 2010 and 2018. India produces solar power at lowest cost as compared to other countries across the globe as analysed by IRENA. The reason behind the low capital cost of the solar projects is the substantial reduction in the polycrystalline, inverters, modules, racking and mounting those accounts for only half cost of the total cost that is required to build a solar PV system in India and the soft costs such as system designing and financing and installation includes the rest cost. This initial capex cost is less as compared to the conventional energy sources. During 2018, the cost reduction was supported by a decline in price of the crystalline silicon module between 26% and 32%.

The status of India where the country produces solar power at lowest cost is due to various reasons that include high potential of the country in harnessing solar energy that acts as an asset for the country and modules available at lowest costs. From a regulatory point of view, the procurement of solar PV is finance driven which means developers of solar projects draws in maximum efficiency in the financing costs and procurement of solar equipment. The Capex (Capital Expenditure model) cost for solar projects is still higher as compared to the conventional sources of energy as the consumer has to pay for the cost of the power plant upfront and then gradually gets saving with the electricity generated from the power plants during the lifetime and additional annual maintenance cost for the O & M of the solar plant is also taken up by the consumer. However, grid parity has been obtained by the country wherein the non-renewable and renewable sources of energy are both available at similar price based on per unit.

Discussion

Financing is important for the RE sources where it is crucial to understand the urgency and required scale of power generation in Indian solar sector. However, many challenges exist in terms of financing RE projects in India. As a result of high initial costs and debt, India remains a costly location for the investors in the RE sector (Kar, Sharma & Roy, 2016). Banks want to lend loans for short time for about 6 to 8 years which causes asset-liability mismatch and makes it less attractive for the borrowers who wish to look for low-cost long-term loans. Pension funds and insurance may act as ideal options for financing; however, they have a small fraction of the finances in solar projects in India.

Solar PV power plants in India have initial low costs in investment ~ 5-6 crores per MW) as compared to conventional power plants having high initial costs of ~11-12 crores per MW i.e., 50%-60% of thermal power plants. The decline in cost is drawing investments wherein, the capital cost plunged from INR 1800 lacs/MW to about INR 530 lakhs/MW as compared to INR 500 to 600 lakhs/MW coal replacement cost, the grid parity is gaining attention and the investors or utilities are gradually focusing on the commercial viability (Umamaheswaran & Rajiv, 2015). Huge amounts of capital investments are needed as the CAPEX cost is higher for the different solar projects in India. With anticipated advancements in PV technology and increase in solar PV panels supply, capital costs are likely to stabilize at lower levels (Purohit, Purohit & Shekhar, 2013). Low prices of solar PV modules and ongoing reduction in the balance of the solar PV remains the main driver for the reductions in electricity costs from solar PV in India.

Interpretation of Theme 11: Low financial viability for solar projects due to reduced tariff

Ultra-low solar power tariffs make it viable for the big players, however, it remains a risk proposition due to drop-in tariff rates and this is the reason, the future Internal Rate of Return (IRR) is still on stake. In India, the solar tariff has further dropped from Rs 2.36 to less than Rs 2 per unit in the past five months. This sharp decline in the tariffs is due to the import restrictions made in solar equipment from China and this is attributed to a drop in the prices and greater participation of the private and foreign equity-backed firms on account of easy access to the cheap foreign capital. This also leaves doubt about the viability of the solar panels and inverters as there is no guarantee for the viability of these Chinese modules for 25 years. The continuous drop in the tariffs of solar projects is deterring the investment in the RE sector. The dropping cost of solar panels have driven the down tariffs to even below INR 2.44 per kWh, While the low tariffs may seem lucrative for the DISCOMs, they are less viable for the investors and developers. The bids that come in the backdrop of fund-starved Discoms are unwilling to sign contracts with SECI as they had previously awarded projects at higher tariffs. Discoms are tariff-shopping and are quite reluctant to ink PSAs for these solar projects. However, even at lower tariffs as below as Rs 2 per unit, solar power projects are financially viable for the bug developers who have cheaper capital and also eye big projects that have to offer at least 200 MW being advantageous economies of scale. On the contrary, it remains hard for the small developers to match the aggressive bidding in the auctions. Simultaneously, quoting ultra-low rates is quite risky for the solar developers and in such cases, it could backfire, if the projected decline in costs defies the current trends. In addition, the low IRR in solar projects is due to the dropping tariff rates and stiff competition from the international players like Softbank who have made their entry into Indian solar power industry to make investments in the next 10 years.

Payback can be defined as the duration of time for the upfront solar investment made to pay for itself through the solar energy savings. Solar power projects have a payback of 2 to 3 years while the commercial clients and payback is quite longer for the ground-mounted solar projects as compared to the rooftop projects because of debt service components and equity payback is longer. The project benefit of solar projects (payback/IRR) is supporting the renewable sector to a large extent. With recent tariffs as low as 2.50/kWh, it has become quite difficult for the investors to finance solar projects, therefore, the future IRR of the solar projects is still doubtful.

Discussion

Payback period is defined as the time required for covering the initial investment that has been made in purchasing and installing the solar projects. The financial feasibility of solar projects in India is low due to the reduced tariff. Although the viability of a commercial solar setup is costlier than rooftop solar setup, the payback of commercial solar projects is almost 3 to 4 years as compared to rooftop having 10 to 11 years (Sharma, Palwalia & Shrivastava, 2019). This is due to the fact that debt service components are involved in the rooftop projects as compared to ground-mounted projects in India. Solar projects are viable; however, the IRR is on stake due to the low tariffs below Rs 2 per unit as it gets affected by the tariff below 3 Rs per unit (Chawla, Aggarwal & Dutt, 2020). This debt financing in renewable energy projects is drying up the reputed Indian banks and as a result, they are refusing funding of projects under which they are sold at less than Rs 3 per unit. The banks have become extra cautious while extending loans to the solar developers as they are doubtful about the financial viability of the projects that have been undertaken at extremely low tariffs (Umamaheswaran & Rajiv, 2015). Although electricity through solar is becoming affordable for the consumers making solar PV efficient, fund-starved DISCOMs are finding themselves at a place of bother. They are reluctant to sign PPAs and contracts with the Solar Energy Corporation of India (SECI) (intermediary procurers) for bidding at low prices (Tongia & Gross, 2018). This unwillingness to sign the power agreements for solar projects have further brought the tariffs down aggressively making it all too evident.

The decline in the prices of the solar components like bifacial modules and axis trackers helps to generate electricity more efficiently from the solar power as compared to non-renewable sources of energy which has further reduced the cost accruing to solar developers and hence, enabling them to quote for lower tariffs. For India to meet its solar targets, low equipment prices will not suffice, rather our policymakers should make finance cheaper for the solar developers so that they are able to invest in solar projects making them economically viable (Rohankar et al., 2016). The government should also look into the risks associated with low tariffs and also intervene and develop favourable policies for the developers to invest in solar projects.

Interpretation of Theme 12: Lack of low-cost financing mechanism for solar projects

Looking into the higher efficiency of renewable sources of energy, the private equity investment is globally investing into the solar projects from the developed countries. In the Indian context, the Cleantech infrastructure deployment is important as it addresses the current energy supply in India. Private Equity (PE) is a key player in the deployment phase of solar projects by investing as the big entrepreneurs who scale up the operations. The PE investment opportunities in India have been in various segments of the value chain like segment attractiveness, project-based investment, business models and also investment in value chain enablers. Banks are being sceptical about the viability of solar rooftop projects in India due to reverse auction and renegotiation of the PPAs and in such scenarios, NBFCs are financing the rooftop solar sector in India as they have been ignored by the large banks. They are providing finance to the consumers from their own books along with tying up with the NBFCs for meeting the upfront costs. The need for the upfront payment is a big constraint for the solar rooftop growth in India as the concept is new and people are hesitant in putting their money up front.

For providing finances to the solar projects in India, the availability of long-term, low-cost financing especially debt financing would be a viable option. It is important to understand the current finance and rules and regulations in banking in order to determine the availability and cost of the finance to the renewable energy projects and also potential of the regulations that enables mechanisms of low-cost financing through sector specific and targeted interventions. Banks in India are wary of lending finances to the renewable energy sector owing to the Rs 2 trillion worth of NPAs in the thermal power sector, however, the tide is turning. NBFCs and Public Sector Banks (PSBs) are becoming preferred choices for the investments in solar energy projects in India. Lenders are also worried about the low-cost tariffs in the renewable sector and are getting cautious about the loans that they are lending to the renewable sector that could turn into NPAs. They have stopped disbursing new loans to the solar energy companies due to hurdles like operational inefficiencies, stalled projects and high outstanding debt. Lenders are also worried about the regulatory changes like the Insolvency and Bankruptcy Code, 2016 as this code envisages a market mechanism that works to rescue firms which are under financial stress and also facilitates closure of firms in an economically distressing environment that works in accordance with the rules and regulations of the code that have been framed thereunder. Moreover, more funding is required for the solar projects in India as the major challenge for the solar projects is timely and adequate financing. These projects are capital intensive and securing of finance remains a crucial part for the project developers and there should also be easy access to the funds available for the solar projects in India.

Discussion

As India has revised its National Solar Mission (NSM) from 20 GW to 100 GW by 2022, there is a need for financing for the accomplishment of the target. The total capital required for this project has been estimated to be around INR 550,000 cr. comprising INR 165,000 cr. equity component and INR 385,000 cr. total debt requirement (Behuria, 2020). To finance this target, three aspects have been studied as banks are getting reluctant to provide loans; equity debt, NPAs, NBFCs are providing loans to finance solar projects in India. Recent financing patterns in solar India has revealed that private equity from the developed countries or third-parties like PE investors are making equity investment in the solar projects as India is moving towards project-based financing from balance-sheet. NBFCs are a boon to the solar projects in India as they are financing solar projects in terms of installation and other needs in rooftop solar projects in India. However, the big banks and lenders are reluctant to fund renewable sources as there are existing concerns of the sector. Power evacuation issues, falling tariffs and NPAs in the thermal sector are among the key reasons that are making lenders flinch in the RE sector (Anand, Toppo & Bandyopadhyay). The Reserve Bank of India (RBI) needs to decouple renewable energy from polluting fossil fuels and ease liquidity crunches. Due to the growing number of NPAs, the funds are drying up and it is getting difficult for the banks to provide finances to the renewable sector. The late payments by Discoms, growing number of NPAs, falling tariffs and problems of power evacuation are making lenders shy away from the renewable sector (Shrimali & Reicher, 2020). Some private banks have breached their threshold, but are continuing to lend and some decided not to lend further. To resolve this, the renewable energy source needs to be separated from the thermal sector lending now in the hands of RBI.

Interpretation of Theme 13: Non supportive Market response from Discoms

The government of India in January, 2021 cautioned consumers against the rooftop solar companies as they have claimed to be the authorised vendors for the implementation of grid-connected rooftop solar schemes. MNRE also declared that scheme would be implemented solely by DISCOMs who have empanelled vendors through the bidding process and rates decided for setting up a rooftop solar system. The Discoms are welcoming solar as they are getting clean technology at the rate of conventional power energy. Moreover, they are meeting the RPO obligations and the energy demands through solar energy. However, Discoms are not supporting renewable sources as they are losing revenue and not ready to implement the government policy. The poor financial health of the Discoms is making it reluctant to invest in renewable sources of energy. Commercial clients are giving a finance push for rooftop solar projects despite the rising financial stress of Discoms. They are offsetting the higher tariff for solar projects, however, there is lack of land acquisition and access to open spaces acting as hurdles in the progress of solar projects.

Industries are enthusiastic much to the surprise that they are exploring the benefits of rooftop solar projects and industries are willing to adopt the clean source of energy, however, policy uncertainties still remain. The industries are gradually recognizing the potential of rooftop solar projects as it has quick payback, no additional costs required for the installation as it requires roofs of the buildings and not large tracts of land which is quite sustainable and viable. The rooftop systems are being supported by the government as an attractive tax rate of 5% is offered by the government falling under the low tax category. Most importantly, the solar projects reduce the carbon footprint as there is no generation of heat-trapping gases contributing to global warming. Therefore, it can be said that market response is fairly good in response to the clean energy sector in India and requires Discoms reform to promote solar projects in India**.**

Discussion

Rooftop solar projects are a great approach to promote clean energy sources in India. The biggest advantage of solar rooftop panels is that it offers cost saving, quick payback and a secure investment. It is a green source of energy which is making the commercial consumers to invest in solar projects that are contributing to the preservation of the environment and even ready to pay higher as compared to grid power. Installation of rooftop solar PV systems is a viable option and worth for the country to make investments as 1 kW rooftop systems could generate about 1500 to 1600 units of power and money can be recovered in five to six years' time (Rathore, Chauhan & Singh, 2019). Although Discoms are the sole vendors of rooftop solar projects, their response towards them is not so impressive. They are refraining from investments to be made in the rooftop solar scheme because of the revenues drying up and are reluctant to sign the PPAs on the renewable energy sector (Yadav & Bajpai, 2020). The tariff of solar power has been quoted aggressively in the recent years and therefore, Discoms are reluctant to enter into any PPA in the long-term as it is a prerequisite for any financing of any new power project making it difficult to attract investors in the solar power.

The modular nature of the solar PV makes it highly adaptable for the vacant rooftops use and has multi-fold benefits. For a solar project developer, rooftop solar PV systems are beneficial as it includes reduced land acquisition and interconnected costs, higher tariffs due to increasing industrial and commercial tariffs and enhanced profitability (Arora, 2013). Solar PV systems assist the Discoms as it reduces the peak demand during daytime and decreases the losses in transmission and distribution (T&D) as the power is consumed at the generation point (Goswami et al., 2021). There is a need for Discoms to have proactive participation so that solar projects could be developed at large scale and, in this way, it would provide the best option for meeting the RPO obligations and the energy demand.

Interpretation of Theme 14: Poor R&D Facilities for solar space

MNRE is inviting proposals for the R&D in the solar PV technology involving industries, start-ups and R&D laboratories along with institutions or organizations that are involved in the R&D and demonstration of the solar energy related areas. To realise the vast potential of Indian solar energy, the country needs to overcome the major challenges of lack of R&D as the solar industry is bogged down by a catalogue of mismanagement posing hurdles for the investors in terms of technical difficulties. There is no real data on the regions in India having the highest incidence of sunlight, although the country is blessed with ample sunlight having geographical advantage. With 35 towns and cities having populations over 10 lacs, there is vast potential for the country to develop electricity from solar energy. However, there is no such reliable data on how to utilize the sunlight for efficient power generation. The solar power industry is an extensive technology driven industry that requires extensive research for improving the reliability, efficiency and stability of the system by the R&D and also improving the operational and maintenance process of the solar energy processes. Though India has a well infrastructure for the research activities, many barriers exist that pose hurdles in the path of research activities from maximizing itself.

The three main reasons for this situation of R&D in the solar energy sector are the raising of insufficient funds, lack of governmental support and also lack of support from the investors and stakeholders within the business in promoting research activities in the solar sector. The major issue is the lack of proper R&D policy for keeping research activities in place as India is in its nascent stage of R&D as compared to other developed countries. The R&D facilities are scarce in the country with major imports of solar cells from China. Innovations like hybrid technology, battery storage are some of the commercially viable options for encouraging funding from the government and financial institutions. However, it requires further research to bring in more innovative technologies for promoting the solar sector in India.

Discussion

With new investments made by SoftBank and others, the Indian government is focusing on the rooftop solar sector demanding for higher efficiency in modules expecting to unleash the industry potential of solar in India. There is a lack of research activities and facilities for performance testing with lack of geotechnical support for innovation and technology in the solar sector. Testing facilities are less with shortage of funding and a period of 3 to 5 months for test completion wherein the government and solar industry should come together in finding better solutions for simplifying these R&D issues and speeding up the implementation activities (Kar, Sharma & Roy, 2016). R&D incentive should also be considered as Indian solar sector should move towards the high manufacturing of latest PV module technologies that would provide more technologically and economically viable options for solar energy promotion in the country. India needs to work on the R&D for achieving solar targets and in sustaining it. There should be more funding from the government and other concerned authorities so that India ranks in the global solar market (Al-Sumaiti et al., 2019). Many hurdles are faced in the solar sector because of which the solar projects may get delayed and therefore, India should focus on research as it is the key to success of this sector in the country. Government subsidies should support the deployment of solar PV devices as R&D is a rapidly growing domain in energy research and the thrust should shift on the improvements in the thin-film technology, module efficiency and nanotechnology while developing new systems that reduce costs and help in meeting the set solar targets (Padhy et al., 2021).

Interpretation of Theme 15: Inefficient Technology development for solar plants

Technology is a dynamic process that operates in a fast manner. The country needs extensive R&D to be well-versed with the technologically advanced modules that efficiently suits the economic condition of the country, however, availability of silica seems to be a challenge. Grid integration, the efficiency of the solar projects and the pace at which it is providing higher efficiency is still lacking in the present growing solar market in the country. Moreover, the large-scale integration of the technologies is still lacking. There is a need for more exploration of technology like bi-facial technology that could improve the efficiency of solar technology. There is a need for newer technologies that could revamp and improve the existing solar power plants like tracking technology that has resulted in the improvement of power generation from solar projects. Technology is required to have viable options for efficient solar energy generation and also reduces energy losses at various stages of production. For a solar project to be successful, the set-up of the solar plant and evaluation of its latest technologies and equipment suppliers are important for reaching a fine balance between the initial cost and the durability of the solar plant in the long run. For a hot country like India, it is important to develop technologies that are economically viable and harness the abundant solar energy along with alternative energy systems and their environmental impact that need to be done urgently.

Discussion

Solar PV cells have emerged as a key technology in the solar sector that has gradually started to gain acceptability with efficient improvements in the price to such a level so that PVs could acquire the most dominant status in the world solar energy market. In the last ten years, global investment was more than $2.5 trillion that was installed with other generation technologies like the bi-facial technology and tracking technology for improving solar projects (Varun & Manikandan, 2020). Solar PV segments will outpace the other energy sectors in both capacity and growth and will be accompanied by more developments and innovations as the solar PV tariff dipped from Rs 15 kilowatt-hour (kWh) to Rs 2.44 per kWh (Bose & Sarkar, 2019). The country is already learning the art of installing solar power plants with capacity that may go up to thousands of MW. The solar modules having bi-facial sides generates power on both panel sides marked in separate colours in the background. These modules could be used for the rooftops commercially and have utility-scale after being used in some pilot projects.

There have also been innovations witnessed in the solar sector to develop technologies like silicon-based solar cells that is well-established technology in solar projects over perovskite solar cells, a hybrid synthetic organic-inorganic compound in may be 6 to 7 years. The progress of inverters is also commendable as there is an increase in compactness along with decreasing costs. For example, a 100-kW inverter could now be put in square metres and strong inverters have also transformed in generating 10 kW to 255 kW capacities (Kumar et al., 2018). The opportunities in innovation in the field of renewables and solar are immense as the decade is embracing anticipatory developments that are surprising the solar energy sector with path breaking innovations and discoveries. PERC (Passivated Emitter Rear Cell) technology is also becoming standard in recent years, dominating the solar cell production in China (Blakers, 2019). Bi-facial cell technology enables a reliable and fast upgrade of existing production lines providing installing, manufacturing and servicing equipment.

It is important for the consumers and industries to be aware of the pros and cons of the solar projects. Although they are aware of the merits and demerits of the solar projects in India, still more awareness is required especially among the domestic consumers. The awareness level is different among the consumers belonging to rural and urban areas as the people belonging to metro cities have a high level of knowledge about the solar projects like rooftop installation and the financial gain that is obtained from these installation projects. The awareness of the consumers towards domestic solar power systems is less as they are not aware of the environmental pollution and climate change that is being formed due to conventional energy sources as compared to renewable sources of energy like solar. Payback period is another benefit in solar power projects that the domestic consumers are not aware of and does not consider to be a motivating factor in taking up solar projects. The advantages of solar installation at homes like cost effectiveness, environmental concerns, and reduction in bills are some of the factors that people should be aware of while adopting solar energy systems for their residences.

The different government schemes that are launched to promote solar energy are not yet fully known by the people so that they work towards understanding and adopting solar projects. India is a perfect example of renewable energy source and awareness about renewable sources like solar power generation is good for the citizens of the country and in fulfilling the Paris Agreement of minimizing GHG emissions and reducing global temperature. The consumers belonging to smaller cities have less knowledge about the benefits of rooftop solar like reliability, affordability and environmentally responsible source of energy. Decentralization of solar projects could be of great help in electrifying rural areas and make consumers more acquainted with solar than ever before. This promotion of solar rooftops among the consumers could help them in adopting clean sources of energy like solar and fulfilling the target of 100 GW by 2022. affordability is the key to India's success in adopting renewable energy sources for power generation.

Discussion

MNRE and other government bodies are organizing workshops, seminars, conferences and exhibitions to promote solar energy in India along with agencies and institutions like Solar Energy Corporation of India, National institute of solar energy, etc., The awareness and attitude of the consumers is important in assessing the adaptability of solar energy in both rural and urban areas. The awareness level would also help to understand the willingness of the consumers in making payment for the solar energy system and choosing renewable energy sources over conventional methods (Luthra et al., 2015). In addition, the knowledge level of the consumers would also determine their level of concern about the environment as they would willingly pay a premium for the renewable energy as compared to consumers who have less knowledge about it. The anticipated attitudes of the consumers also determine the adoption of domestic solar power systems. Moreover, the factors like environmental motivation, economic consideration, demographic characteristics that influence acceptance and dissemination of innovation to other communities and individuals help them adopt renewable sources for their energy consumption (Padmanathan et al., 2019).

Environmental values may not be enough to motivate them and therefore, the payback factors should also be explained to help them adopt the solar home system as compared to people who have less knowledge about it. The knowledge about technical aspects of the solar energy system are somewhat missing among the consumers like capacity, cost, etc., as we are living in a technical environment (Chawla, Kowalska-Pyzalska & Skowrońska-Szmer, 2020). Stakeholders should also be aware of all the factors like cost-effectiveness, reduction in electricity bill and environmental concerns so that they proactively participate in the promotion of the home solar system especially among rural consumers (Deshmukh & Singh, 2020). Positive attitude towards the clean source of energy would increase the adoption of these sources like the solar energy system. For increasing the awareness level among the people about solar energy, the government agencies should work in collaboration with the rural people by organizing village fairs, exhibitions and in providing technical and practical knowledge about clean sources of energy through demonstrations. Dissemination of useful and relevant information about the government initiatives and schemes to people related to the solar energy system would help them to promote as well as adopt the clean source of energy (Yaqoot, Diwan & Kandpal, 2016). Active participation of media like more TV advertisements regarding solar energy projects and schemes would also help in increasing awareness level as well as promote the solar sector in India.

Solar energy is a clean energy source that replaces fossil fuels such as gas and coal for the electricity generation that causes air, land and water pollution. The utilization of solar energy could eliminate unclean and unsafe effects of using conventional fossil fuels. Therefore, it is important to promote solar energy which is only possible through proper training and awareness creation among stakeholders and in building man-power that is required for establishing and sustaining this large and growing industry. Moreover, it will also help the consumers to understand the aspects of adopting solar energy and the required actions on it. This training is provided by many training institutes and engineering colleges who churn out quality engineering students for the better understanding and promotion of solar energy and fulfilling the solar sector capacity of 100 GW by 2022. To achieve this target, skills have been identified for the students and engineers that are needed to help the country flourish in the solar energy market. The scaling up of solar energy will not only address the threats in climate changes and energy demands, but also add one million qualified technicians, engineers, maintenance workers, solar installers and maintenance workers to the existing workforce. There would reduce the gap in unemployment and fulfilment of the 2022 target which would only be possible through new training facilities and types of new jobs for the individuals in this particular discipline.

There is a growing need for skilled solar workers in India who would be trained with the necessary skills that support the solar market. In this situation, solar energy training is provided to the students called National Power Training Institute that provides training on renewable energy and makes them well-equipped with the skills so that they can work on numerous sources of renewable energy including hydro wind, solar, and bio energy. Moreover, training is also required for the corporate companies as they could train students and teach to bridge the knowledge gap which determines the success of any solar project. Government training program also teaches the graduate and diploma engineers about the components of a PV system, basics about the renewable sources of energy and how technologies are being used to generate power from the clean sources of energy. Therefore, MNRE and other industries should promote the importance of training necessary for training professionals and analyze the role of industrial institutes in training and development of the engineers in RE in India.

Discussion

For the successful completion of the solar projects, it is important every stakeholder should be well aware of the Indian solar power and also the importance of skilled labour to promote Indian solar power. Moreover, the consumers will also become well aware of the flourishing industry like the solar industry and the benefits associated with it. Quality training program could help to have skilled solar energy labour by making the engineers and students well-qualified and knowledgeable about the skills required in the solar industry (Kesari et al., 2015). Many certificates and specialized courses are also being introduced by the government on solar technology and renewable energies region-wise. India is working towards filling the gap in skill in the RE market of the country. Recognizing the vast number of jobs that are required for scaling up the RE market, the Indian government is taking domestic initiatives that support job creation, manufacturing and skills development in the clean energy market. An existing gap is creating challenges within the workforce of the country and therefore, skills are being constructed for reducing the skill gap that has been recognized as a barrier to realization of the country in meeting renewable energy targets (Venkateswaran et al., 2018). To support this, various training institutes and private organizations like NISE (National Institute of Solar Energy), UPES (University of Petroleum and Energy Studies), NISE (National Institute of Solar Energy), APTRI (Adani Power Training Institute) provide training to professionals and engineers playing a crucial role in the path of research and development in renewable energy market (Sengar et al., 2017). The government is also undertaking various programs that provide training in advanced subjects or specialized courses in renewable energy studies. The gap in knowledge gap could be bridged and would lead to the successful completion of solar projects in India.

To make solar workers, professionals and students skilled in renewable energy sources, National Skill Development Program (NSDC) is supporting them to develop skills that are required for rooftop PV installation and also enable them with the solar energy technology and also impart knowledge, proper training and enable people to become solar entrepreneurs and solar professionals (Yadav, 2018). This Skill Council is providing training to the students as per the skills criteria set by the power industries in the country and the curriculum is made in alignment with the skills as per the present job requirements in renewable energy sector. Many solar installers and companies are also taking initiatives to provide training and develop skills in the form of advanced training courses in renewable energy so that our workforce is skilled enough to resolve day to day challenges, come up with solutions and predict the future of the solar energy market in India

(Joshi & Yenneti, 2020).

The above interpretation leads us to the following findings that are presented pointwise which are as follows.

4.5 Findings and Discussion

Based on the above interpretation, the findings of the study are summarized as follows as per the research question RQ: ―What are the key contingency and success factors to suggest a framework for addressing the issues around growth of the Indian solar sector?

The present study attempts to develop a framework based on the data interpretation collected by interviewing the Indian solar sector industry experts from top management, upper middle and middle management level. The exhaustive interviews of the respondents were analysed using Smith & Firth, (2011) methodology for the development of the framework. These findings interpreted from collected data are then discussed in the light of relevant studies that led to the following framework.

The proposed framework comprises four provisions comprising policy and regulatory provisions, technical provisions, financial provisions and other provisions for determining the success and contingency factors for the growth of the Indian solar sector.

Technical Factors:

- There are a lot of technical challenges while integrating large quantities of solar energy into the grid system that need to be addressed.
- Key challenges have been witnessed from the stakeholder’s interaction that includes inadequate transmission infrastructure, reliability issues and forecasting techniques.
- The lack of an adequate transmission system that is available at the solar PV systems still remains a big challenge for the developers.

- There are transmission bottlenecks that make power evacuation in solar projects quite costly and difficult.
- Weather forecasting needs to be more reliable as the assessment is necessary for understanding the viability of the solar projects.
- Accurate forecasting of the weather is important for studying the impact of the solar radiation and the climatic conditions that affect the solar projects and finances related to it.

Policy and Regulatory Factors:

- Various incentives are being provided by the State and Central Government in India to promote the Indian solar sector. The incentives include net metering, NCBFs, VGF, tax benefits for rooftop solar installation, etc so that people adopt a clean source of energy.
- Subsidies are also being provided by the government along with Accelerated Depreciation, 100% exemption in custom and excise duty and waiver has been given on the wheeling charges for the promotion of solar projects.
- Although the government is giving incentives and providing support for renewable sources of energy, the solar policies created need to be more stringent with easier access to loans, permits and clearances.
- Poor financial health of the Discoms is making them reluctant to sign new PPAs, risk associated with renewable energy developers, cancellations are making the investments severe and damaging.
- The tariffs for renewable sources of energy have declined drastically less than Rs 2 per unit and there are risks associated with the delays in signing of PPAs, renegotiation or cancellation in the agreements.
- The net metering policy implementation for the rooftop solar projects remains patchy as it lacks process protocols and clarity in implementation in the key states.

Financial Factors:

- DISCOMs are facing financial stress that is affecting the performance of the Indian solar projects as there is a requirement to stabilize the financial viability of the solar sector in the country.
- Big banks are refraining from giving loans to the developers as they are not sure about the viability of the projects.
- Installation incentives are also provided by the government to the solar industry where subsidies, tax incentives and the excise duty exemptions are provided for making investments in solar projects.
- The Capex (Capital Expenditure model) cost for solar projects is still higher than the conventional sources of energy having high initial cost.
- Due to the low solar power tariffs, the big players who are having deep pockets remain at risk and the IRR is still on stake deterring the investment in the clean source of energy. Due to this reduced tariff, the financial viability of the solar projects in India.
- Big banks lenders have become extra cautious while providing loans to the solar developers as they are not sure about the financial viability of the projects.

Other Factors:

- There is a need for India to invest in R&D for solar projects in India as the investments are less with no policy initiatives that are directed at innovation and technology in solar energy.
- There is also a lack of research incentives and activities that could promote R&D in the solar PV cells and innovations like battery storage and hybrid technology demanding funding from the government and financial institutions.
- There is a need for clarity of policies for the C&I users as they have to pay additional surcharges at the cross-subsidy that increases the tariffs and

moreover, no incentives are being provided to the Discoms. This is the reason Discoms are not so keen on promoting solar power and thus, deprives themselves of revenue from C&Is.

- India is largely dependent on imports from China for the solar cells and therefore, there is a need for domestic manufacturing of solar equipment in the country.

Policy & Regulatory Provisions		
Increased empowerment to MNRE	Enhanced collaboration	Simple Regulatory Framework
Longer Policy Duration	PPA with terms reducing risks	PPA contractually enforceable
Technical Provisions		
Dynamic Scheduling	Amendment in Grid Code	Improved Forecasting and Scheduling Techniques
Location Change for RE Plants	Improved coordination for RE Scheduling	Storage Technologies like Li Ion Batteries
Financial Provisions		
Feed In Tariff	Capping on Tariff Discovered in RA	Guaranteed Returns
Low Cost Long Term Debts	Investment from Pension Funds/Insurance Companies	Support from Banks/Financial Institutes
Stability and Taxes and Duties	Tax free bonds	Tax Credits
Capital Gain Tax Bonds	Payment Security Mechanism	Escrow Account
Other Provisions		
Improved Collaborative Efforts	Neural based estimators	Multiple Pyrometers,
Development of innovative BoS using Power electronics,	Development of equipment for PV,	Development of thin film solar cell technologies
Demand Creation	Promotion of Open Access	Sessions/seminars to create awareness

Figure 6: proposed framework comprising four provisions

Source: Author's Work

4.6 **Discussion on Findings**

The discussion on the summarized findings is presented here as per the Research Objective- 'To formulate a framework for the successful growth of the solar sector in India by identifying and assessing key contingency and success factors.

Renewable energy could power most of the country by the year 2040 that reduces the costs and emissions. India has enormous energy demands and has already committed to the ambitious goal of fulfilling the target of 100 GW by 2022. It has been found that to achieve the level of reliance on the renewable source of energy would reduce CO_2 emissions by 85% and the overall costs for solar power by $50 billion (Prakash, Ghosh & Kanjilal, 2020). Solar energy reduces the GHG and CO_2 emissions, having environmental benefits, highly reliable and economical energy generation. The Government of India started with the NSM to achieve a good number of targets in the solar projects. However, the government is facing challenges in achieving the target. The financial stress that the Discoms are facing are making them reluctant to invest in rooftop solar projects along with grid stability and lack of transmission infrastructure (Kumar et al., 2018). There have been serious concerns on the impact of intermittent nature of power that is generated from renewable sources and its implications on the grid strength and safety. The transmission system and present grid stability is not adequate and steps must be taken in improving the grid availability and strength that would ramp up the capacity in solar power generation. The lack of transmission infrastructure is making the plan run behind the schedule questioning the attainability of the March 2020 target. Discoms are financially stressed as the tariff hikes do not cover the rising cost of supply and the bill collection and poor metering efficiency results in high commercial and technical losses (Keeley & Keeley, 2016). As a result of these losses, defer payments to the producers creates a series of delays through the value chain. Discoms have attempted renegotiation and signing PPAs with the renewable power energy producers or curtailed to lower the overall costs (Srikanth, 2018). This dent the confidence of the investors as they are doubtful about the project returns and dampens the future investments. Therefore, it is important to improve the resiliency and financial health of the Discoms to bailout the losses and future investments in the solar projects. Another factor that determines the optimum generation of electricity using solar energy is solar forecasting. It is a way for the grid operators to predict as well as balance the energy generation and consumption. The solar sector uses PV simulation models for forecasting the performance of an PV plant under the environmental conditions like irradiance, wind speed, relative humidity and temperature. The data obtained through weather forecasting is not accurate to determine the viability of a solar plant in the next 15 to 20 years coupled with problems of shading and soiling due to industrial fumes (Mohanty et al., 2017). There are numerous challenges witnessed for the efficient and reliable solar energy integration. Short-term uncertainties could be managed by many solutions that include increased demand side participation, deployment of flexible although expensive resources like energy storage and greater coordination between balancing areas. It is important to forecast the expected power output so that the efficiency and reliability of the system could be determined. Solar forecasts are used by many stakeholders in the solar industry as it helps to schedule generation of energy, procurement of the operating activities and ensure that sufficient flexibility is there to manage the changes in the output (Prakesh, Sherine & Bist, 2017). Thus, reliable weather forecasting is required for India to manage the country's solar power generation portfolios as the amount of solar power has a strong impact on the prices in the solar market. However, solar power is not considered reliable as it is dependent on the weather having sunny days and is not operable during night-time at the peak hours from 6 pm to 8 pm. Moreover, the actual output is always low as compared to the amount of radiation incident on the solar panels. To fulfil the demand during the peak hours, the storage technology is required which is reliable, replacing the base load and solar intermittency (Bijarniya, Sudhakar & Baredar, 2016). The dependency on the grid can also be reduced providing power to remote areas through storage technology. However, in India, storage is in a nascent stage and the Li-ion batteries provide storage up to 4 hours and are unable to replace the conventional energy sources completely (Rohit, Devi & Rangnekar, 2017).

Financing is another key factor that needs attention for the successful growth of the solar sector in India. Financing in the renewable sector in India is facing multiple conundrums that are largely established with the current financial condition in the Indian solar market. The short tenure of the loans, lack of adequate debt financing, high capital costs are raising significant issues for the renewable sector in the country (Sarangi, 2018). Challenges in solar policies, R&D, solar technology and training also need to be addressed to keep the sector powering ahead. The policies are not clear enough to the investors and financiers and this makes them reluctant to invest as it seems risky to them in the long run (Shrimali et al., 2013). Discoms are facing financial constraints that are making them refrain from investing in solar projects. Big banks are sceptical about the financial viability of the solar projects due to the reduced tariffs. There is also lack of proper funding and space for R&D activities in the solar sector and latest technologies in the light of solar PV technology as the country is heavily dependent on imports for China and requires domestic manufacturing of the solar cells (Ulsrud et al., 2011). Simultaneously, solar training is also being provided by the government of India to make engineers, solar workers and professionals to get well-equipped with the latest solar technologies and develop skills to have jobs in the solar sector through skill development training (Rathore et al., 2018).

Chapter 5

RECOMMENDATIONS AND CONCLUSIONS

The present study suggests the following recommendations for the central and state government for the successful completion of solar projects in India.

- Solar sector in India should have a policy push for the successful development of Indian solar sector.
- India should promote indigenous development of solar modules as the ongoing solar projects should be protected from imports. This import has a sizable impact on the cost of solar projects.
- There is a need to clarify on the safeguard duty availability on the imported solar cells and modules as delay in signing of PPAs may lead to paying of customs duty if import of the equipment posts the deadline.
- The policy regime for solar energy in India needs to go through amendments that ensure the continuous transition of energy in the country.
- India needs to invest in R&D activities that support facilities for improving the solar PV technology and reduction in cost of imports for solar components. Healthy collaborations with developed countries can help in diffusion of new technology into our country.
- Availability of loans with easy access, innovative financing for investments in the solar sector could help to boost the solar sector in India.
- There is a need to raise awareness among the stakeholders and the domestic consumers about the advantages of solar energy and support them in adopting clean energy options.
- The adoption of rooftop solar installation in the residential segment would help to maximize the solar sector in the future.

India's solar power has immense potential and is aiming that by 2022, 100 GW of solar energy is achieved. The country has abundant solar irradiance availability and receives sunlight throughout the year. This imparts enormous opportunities for the country to utilize the solar energy in those parts of the country that receives the maximum. Moreover, the government has taken numerous initiatives with the MNRE to drive the market and promote the solar energy market. However, there are some major challenges that the country needs to address so that solar energy could be fully exploited to its potential replacing the conventional sources of energy. To achieve this, India needs to bring about major reform in the financing structure to revamp the flow of capital into the solar sector for achieving the ambitious target by 2022. Overcoming the financial challenges will lead the country to significant growth and uncover its potential with climate change adaptation and financing of clean energy avenues. Investments need to be made in the R&D and solar technologies supported by the financial institutions taking the lead. India must also focus on the solar and energy policies, between coordination between the stakeholders, health demand growth, a robust financial system supporting the solar sector and a stable regulatory framework that would help in creating an optimum solar ecosystem. The energy landscape of India has shifted in the last five years which is a proof to the realization of the future of RE and a factor of time until the target is achieved.

Chapter 6
LIMITATIONS AND FUTURE STUDY

The present study focuses only on the Megawatt Scale Solar PV (Grid Connected) Power Plants and there might be chances that the influence of the identified success and contingency factors may change under the different geographies and environment. The study has limitations in disclosing the respondent names and project names.

There is further scope for similar studies on the solar energy technologies like Concentrated Solar Thermal Power Technology and there is further scope to study the global practices and if these global practices could be implemented in the Indian scenario.

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ANNEXURE 1
INITIAL PROTOCOL

Q.No.	Questions	Respondent1	Respondent2
	Introductory		
1	What is your opinion about Solar power Projects?		
2	Have you ever been a stakeholder/Involved in the development of Solar power Projects in India? If yes, kindly share your mode of involvement		
3	What are the advantages and disadvantages of Solar power Projects?		
4	What is your opinion about GOI "100 GW by 2020" Solar Installation target?		
2	**Contingency and Success Factors**		
2.1	**General Questions**		
2.1.1	What is your take on barriers and opportunities associated with Solar Power Projects?		
2.1.2	How do these barriers impact the viability of solar power projects in India?		
2.1.3	What are the parameters involved framework?		
2.2	**Technical Factors**		
2.2.1	What is your opinion about integrating 100GW in firm solar power on present transmission grid?		
2.2.2.	What is your view on availability of solar radiation data for predicting solar generation for next 15-20years?		

2.2.3 .	What is your take on reliability and efficiency of solar power projects compared to conventional power plants?		
2.2.4	Do you think backup/ storage technology is need of hour to promote solar projects in India? If yes, please share your views.		
2.3	**Regulatory/PolicyFactors**		
2.3.1	What are the policy incentives offered by Central and State Government to promote solar in India?		
2.3.2	Share your experience regarding implementation of these central and state policy incentives.		
2.3.3	Are the present Central/State Policies effective enough to promote solar in India? Please share your views.		
2.4	**Financial Factors**		
2.4.1	What is your opinion about initial capital cost of solar projects when compare to conventional projects?		
2.4.2	Are the project benefits (Payback/IRR) supporting development of solar projects in India?		
2.4.3	What is your take on available financing mechanism for solar projects? Are they sufficient to support development of solar projects in India? Please share your views.		
2.5	**Other Factors**		
2.5.1	How is the market response (Industries/Discoms/Commercial)		

	on solar projects?		
2.5.2	What is your view on R & D in solar sector in India?		
2.5.3	What is your opinion on technological aspects of solar projects?		
2.5.4	How do you see awareness of Indian consumer regarding pros and cons of Solar projects?		
2.5.5	How do you see the role of training institutes in promoting solar in India?		
3	**Remedial Measures**		
3.1.	Based on your experience, suggest three most important remedial measures to address the barriers associated with the development of large-scale solar power projects in India:		
	1)		
	2)		
	3)		

ANNEXURE 2

VALIDATION OF INITIAL PROTOCOL BY SECTOR EXPERTS

Q.No.	Questions	Respondent1	Respondent2
	Introductory		
1	What is your opinion about Solar power Projects?	Relevant However, Question could be more specific. May be in terms of advantage and disadvantage.	Relevant, but the question is open-ended, try to make it more precise.
2	Have you ever been a stakeholder/Involved in the Development of Solar power Projects in India? If yes, kindly share your mode of involvement	**Relevant**	**OK**
3	What are the advantages and disadvantages of Solar power Projects?	Irrelevant CanbemergedwithQ 1.	Not RequiredExten sionofQ1.
4	What is your opinion about GOI "100GWby 2020" Solar Installation target?	**Relevant**	**Relevant**
2	**Contingency and Success Factors**		
2.1	**General Questions**		

2.1.1	What is your take on barriers and opportunities associated with Solar Power Projects?	Irrelevant Need more data. Barriers & opportunities for whom and which stakeholder.	OK
2.1.2	How do these barriers impact the viability of solar power projects in India?	In line but question seems incomplete. Can be more precise.	Irrelevant, Question is too generalized
2.1.3	What are the parameters framework?	Irrelevant, Needs more detailing	Relevant
2.2	**Technical Factors**		
2.2.1	What is your opinion about integrating 100GW in firm solar power on present transmission grid?	**Relevant**	**Relevant**
2.2.2.	What is your view on availability of solar radiation data for predicting solar generation for next15-20 years?	**Relevant**	**Relevant**
2.2.3.	What is your take on reliability and efficiency of solar power projects compared to conventional power plants?	**Relevant**	**Relevant**
2.2.4	Do you think backup/ storage technology is need of hour to promote solar projects	**Relevant**	**Relevant**

	in India? If yes, please share your views.		
2.3	**Regulatory/Policy Factors**		
2.3.1	What are the policy incentives offered by Central and State Government to promote solar in India?	Inline	Apt
2.3.2	Share your experience regarding implementation of these central and state policy incentives.	Inline	OK
2.3.3	Are the present Central/State Policies effective enough to promote solar in India? Please share your views.	Inline	OK
2.4	**Financial Factors**		
2.4.1	What is your opinion about initial capital cost of solar projects when compare to conventional projects?	Inline	Apt
2.4.2	Are the project benefits (Payback/IRR) supporting development of solar projects in India?	Inline	Apt
2.4.3	What is your take on available financing mechanism for solar projects? Are they sufficient to support development of solar projects in India .Please	Inline	Apt

	share your views.		
2.5	**Other Factors**		
2.5.1	How is the	Inline	OK
2.5.2	What is your view on R & D in solar sector in India?	Inline	Inline
2.5.3	What is your opinion on technological aspects of solar projects?	OK	Relevant
2.5.4	How do you see awareness of Indian consumer regarding pros and cons of Solar projects?	OK	Relevant
2.5.5	How do you see the role of training institutes in promoting solar in India?	Apt Question	Apt
3	**Remedial Measures**		
3.1.	Based on your experience, suggest three most important remedial measures to address the barriers associated with the development of large-scale solar power projects in India:	Inline	Required
	1)		
	2)		
	3)		

ANNEXURE 3

FINAL QUESTIONER

Q.No.	Questions
1	**Introductory**
1.1.	**What is your opinion about Solar power Projects in terms of advantages and Disadvantages?**
1.2.	**Have you ever been a stakeholder/Involved in the development of Solar power Projects in India? If yes, kindly share your mode of involvement**
1.3	**What is your opinion about GOI "100GWby2020" Solar Installation target?**
2	**Barriers and Issues**
2.1	**Technical Barriers**
2.1.1	**What is your opinion about integrating 100 GW infirm solar power on present transmission grid?**
2.1.2.	**What is your view on availability of solar radiation data for predicting solar generation for next 15-20 years?**
2.1.3.	**What is your take on reliability and efficiency of solar power projects compared to conventional power plants?**
2.1.4	**Do you think backup/storage technology is need of hour to promote solar projects in India? If yes, please share your views.**
2.2	**Regulatory/Policy Barriers**
2.2.1	**What are the policy incentives offered by Central and State Government to promote solar in India?**
2.2.2	**Share your experience regarding implementation of these central and state policy incentives.**
2.2.3	**Are the present Central/State Policies effective enough to promote solar in India? Please share your views.**

2.3	**Financial Barriers**
2.3.1	**What is your opinion about initial capital cost of solar projects when compare to conventional projects?**
2.3.2	**Are the project benefits (Payback/IRR) supporting development of solar projects in India?**
2.3.3	**What is your take on available financing mechanism for solar projects? Are they sufficient to support development of solar projects in India? Please share your views.**
2.4	**Other Barriers**
2.4.1	**How is the market response (Industries/Discoms/Commercial) on solar projects?**
2.4.2	**What is your view on R & D in solar sector in India?**
2.4.3	**What is your opinion on technological aspects of solar projects?**
2.4.4	**HowdoyouseeawarenessofIndianconsumerregardingprosandconsofSola rprojects?**
2.4.5	**How do you see the role of training institutes in promoting solar in India?**
3	**Remedial Measures**
3.1.	**Based on your experience, suggest three most important remedial Measures to address the barriers associated with the development of large-scale solar power projects in India:**
	1)
	2)
	3)

ANNEXURE 4

OPEN CODING

Q1.1: What is your opinion about Solar power Projects in terms of advantages and Disadvantages?	Codes
Respondent 1: To achieve grid parity, tapping non-conventional & renewable energy sources, reduction in GHG, CO2, Environmental benefits and energy mix to reduce dependency on conventional/thermal power. However, main disadvantages can be Space constraint & Technology development, grid disturbance and Infirm power supply Reduction in GHG &CO2,reduce dependency on conventional/thermal power, space constraints, grid disturbance, infirm power	grid parity; reduction in GHG Enviornmental Benefits space constraint; Infirm power; Technology development; Grid Disturba
Respondent 2 Advantages: 1. Energy from renewable source 2. carbon emission during energy conversion process 3. Low maintenance cost 4. Better use of idle land/roof Disadvantages: 1. Need huge space 2. High initial cost 3. Depends on weather 4. Need of storage system for continuous operations	Space utilisation; Low carbon emission; Low maintenance cost weather dependent; High initial cost; space constraint; Need for solar s
Respondent 3 Solar PV has emerged as a major renewable energy source across the world. Solar energy has many advantages of which the major three reasons are it is reduces carbon emissions, highly customisable and is economical. The disadvantages are 1. Low CUF compared to other sources 2. Does not comply with the energy demand curve (duck curve). 3. Generation is depended on climatic factors. 4. Uses vast amount of space. 5. Fragile components 6. Fairly new technology and only a few utility scale projects are 20+ year old. My opinion is solar has a bright future in energy sector because of its adaptive nature. Solar is now a proven reliable energy generation technology from small portable products to MW & GW scale utility projects. As per recent renewable trends in India solar will surely lead the way for achieving carbon emission targets	Low carbon emission; economical weather dependent; Low CUF; Non compliance with energy demand curve Technology development; Fragile components; space constraint
Respondent 4: Good. Time to ensure they reach the deep corners of the country, to ensure DISCOMs reduce their power purchase cost, to make consumers more responsible.	power purchase cost,; DISCOMS
Respondent 5: Solar power projects have several advantages over conventional power 1) Non- polluting 2) Infinite supply of raw material i.e. sun shine 3) Cost competitive	Non- polluting Infinite Energy economical
Respondent 6: Advantages- low O&M, Green power, availability of sunlight in abundance in india, abatement / reduction of GHG emissions Disadvantages – High upfront cost, higher cost of capital, scarcity of cheap capital, high hedging cost, environmental impact after decommissioning,	Reduction in GHG, CO2; ample sunny days; green power; low o&m High initial cost; low cost debt funds; high hedging cost; High Initial (
Respondent 7: Electricity is the one of the major commodity for the economic growth of any developing nation. In my opinion, with the economic growth we also need to focus on sustainable development. Solar power is one renewable sources of power generation which has huge potential in India considering 330 days average sunshine, and as a responsible nation, it is our responsibility to provide supplement for the conventional energy sources	Sustainable development 330 days average sunshine

Respondent 8: Solar can cater to the so called Peak demand of the country as it is in perfect sync with the present load requirements. However, due to inadvertent nature, it poses risk to the Grid. Although the ever-so falling Capex has made it very attractive, however, in the absence of regulations on Feed in tariffs, the industry presently is at the cusp of transition and with the reverse auctions in vogue, the solar industry serves only players with deep pockets. To accompalish what has been targeted would need changes in the present approach of the Govt towards Reverse auctions only	peak demand; Inadvertent; Grid Disturbance; Feed in tariffs,; Reverse Auctions
Q1.2: Have you ever been a stakeholder/Involved in the development of Solar power Projects in India? If yes, kindly share your mode of involvement	
Respondent 1: Yes. In the consumer perspective , reduction in energy cost is main parameter and for developer perspective to get the max return on Investment.	Return on investment
Respondent 2 Yes, I am part of business development team and involved at various stages like execution and closure of the project. Business, development, execution, closure, project	business development; execution

Respondent 3: I was involved in a 3.5 MWp roof top solar project development for an Airport. My involvement in the project was in the complete sales operations. I was involved in the PPA documentation & signing, client-contractor discussion, completion of documentary formalities, creating SPV, contracts documentation & signing. My employer (EPC company) formed a SPV after winning the project in a bid. The airport signed a PPA with my then EPC company for 3.5 MWp solar PV plant.	client-contractor; PPA documentation; documentary formalities; contract documentation; SPV
Respondent 4: Yes. We are an IPP. IPP	IPP
Respondent 5: Yes, we are EPC providers to projects of about 200 MWp	EPC
Respondent 6: Yes, as an official of IREDA, a leading organization providing financial assistance for RE projects including Solar Power Projects (SPP).	financial assistance
Respondent 7: Yes, I am associated with an NBFC (Infrastructure finance company), which is into financing infrastructure project such as powe projects including but not limited solar power projects, Transmission line, Roads, Ports etc	NBFC; solar power projects,; Transmission line; roads; ports

Respondent 8: I have been involved as a developer and as a lender to Solar power projects

Q1.3 What is your opinion about GOI "100 GW by 2020" Solar Installation target?

Respondent 1: GOI started the mission with good pace and achieved good amount of target in Solar ground mounted but lacking in solar rooftop segment. But now GOI facing challenges in further implementation because of poor discom health by losing their big consumers, grid stability and policy framework can affect the future development and can't achieve the target

Poor discom health

Grid stability | policy framework

Respondent 2: 100 GW is next to impossible to achieve with current regulatory and infrastructure support framework. Govt. need to work on one policy on nation kind of scheme to make it successful. Financially solar is viable but regulatory aspects and discouragement from distribution companies is big hindrance.

infrastructure support

regulatory aspects

Q2.1.1 What is your opinion about integrating 100 GW infirm solar power on present transmission grid?	
Respondent 1: IT in power will play the major role in future for integration of solar system and also accurate forecasting & scheduling will help to grid in coming time.	forecasting; Grid integration; scheduling
Respondent 2: Present grid is not that much strengthen but government is continuously working on measures to improve grid strength and avalabiltity.	grid strength; Weak Transmission system and Grid
Respondent 3: Grid when punctured with multiple projects with a unified technical standard reduces grid stress. Utility scale projects will cater to major industrial base load however, solar energy is unavailable during the second peak demand surge which is between 6-8pm. This will create pressure on other existing generating systems.	grid; solar energy; base load; peak demand
Respondent 4: Challenging.	Challenging
Respondent 5: Transmission infrastructure is currently not adequate. Lot of work is on the same. But the main growth that will be coming will be in off grid & storage	transmission infrastructure; Storage; off grid

Respondent 6: Grid codes and response of grid needs to be modified to accommodate intermittency of the solar generation. Simultaneously, scheduling and dispatch of solar power also required to be reviewed as compared to existing practices.

Grid code, scheduling, intermittency of solar, dispatch of solar power

grid code
scheduling
solar power dispatch
intermittency of solar

Respondent 7: In my opinion, integrating 100GW infirm solar power on present transmission grid will affect the grid stability. Grid Integration is a major technical challenge to achieve the ambitious target of 175 GW renewable and 100 GW of Solar, because the nature of source is not reliable and is periodic. Till the time, the share of renewables is less in the total energy mix there won't be any significant effect for the grid stability, but as the share of renewables increases managing the grid stability is surely a challenge.

Grid integration
Grid stability
Infirm solar power

Respondent 8: 100 GW of Solar in the absence of proper Storage poses a challenge for the grid. Various State Governments have started addressing the same. The Word Battery has been replaced with Storage in the Wind Solar Hybrid policy of the Govt, clearly indicating a clear push towards storage.

Storage
Wind Solar Hybrid
Storage

Q2.1.2 What is your view on availability of solar radiation data for predicting solar generation for next 15-20 years?

Respondent 1: Variation of environmental conditions will be the part for not getting accurate data but India having ample sunny days to achieve optimum generation.

ample sunny days
accurate data
environmental conditions
variation
optimum generation.

Respondent 2: With advanced technology it is easy and reliable to predict solar radiation. But only problem is industrial fumes and other waste which create soiling losses.	advanced technology, solar radation, reliability, industrial fumes, soiling losses., waste
Respondent 3: Many of the irradiance data provide estimated statistical value. Large variation in forecast & actual is due to various reasons such as instrument calibration, climate change, dust, wind flow and air quality	irradiance data, climate change, air quality, dust,, wind flow
Respondent 4: Not going to change much.	
Respondent 5: The data is highly accurate and there are various vendors providing the same namely NASA, meteonorm etc. The only problem is it is all based on history and climate changes in the future will not be captured in the same. It's a good base figure to start work or work without any data.	accurate, data, base figure, climate change
Respondent 6: Data available presently is inadequate for prediction of generation for next 20 Years.	generation, data, prediction, inadequate

Respondent 7: Availability of reliable Solar radiation data is very important for prediction of solar energy generation in a particular area. This can be done by using high quality solar radiation measurement devices at the plants. Reliable data can be of great help for forecasting solar energy generation for 20-25 years.	solar radiation · prediction · reliability · data · energy generation
Respondent 8: Although no large scale Solar project has witnessed a 15-20 year cycle to predict the reliablity of the radaition data of the past, however improvements in the Solar studies on account of actual generation data from the existing farms will calibrate the future predictions	Radiation data · reliability generation · data prediction
Q2.1.3 What is your take on reliability and efficiency of solar power projects compared to conventional power plants?	
Respondent 1: Solar power is not physically reliable because it is inconsistent, inefficient, and cannot meet electricity demand. Because sunlight is not always available, the actual energy output of solar plants is much lower than their potential output compared to conventional power plant.	Physically reliable · solar power · inconsistent · inefficient · electric energy output · non availability
Respondent 2: Solar projects are extremely reliable if designed properly. Conversion efficiency is not as good as conventional plant has.	conventional power plant · conversion · reliable · designed · effici

Respondent 3: Solar power plants on a broader view are reliable power generation sources because of no moving parts, no raw material supply, marginal O&M, and speed of project execution. Efficiency wise solar is at a lesser advantage as it doesn't produce energy during night. Hence overall CUF of solar power plant is less.	no raw material supply; reliable; power generation project execution; marginal O&M Low CUF; efficiency; Less advantage
Respondent 4: Lesser reliable, but with hybrid models, storage and DISCOMs being more stringent on grid stability the questions will be answered in next 3- 4 years	Hybrid; Grid stability; Less Reliable; Storage
Respondent 5: As somebody who is erecting solar plants I would say they perform as per the stated design and execution.	execution; solar plants; Design
Respondent 6: Reliability of SPP is moderate considering the intermittency and availability of SPP. However, it is expected to increase with advancement of energy storage technology and maturity of energy storage market. Efficiency is low but it is expected to increase with advancement in technology,	SPP; intermittency of solar; availability efficiency; Storage technology technology

Respondent 7: The reliability and efficiency of solar power projects compared to conventional power plants is very less, due to the fact that solar project is totally dependent on nature and as such reliable data from metrological department is not available. This is the reason the PLF of a solar plant do not exceed 17-18%.	conventional power plant; reliability; PLF
Respondent 8: Compared to Solar, conventional power projects are more reliable. However, unlike its other popular counter part "Wind", solar is perceived to be more reliable	reliable; conventional power
Q2.1.4 Do you think backup/ storage technology is need of hour to promote solar projects in India? If yes, please share your views.	
Respondent 1: Yes. It can up to the certain extent. Storage technology will replace the some part of base load of consumers and reduce the dependency on grid and will get certain relief in policy hurdles.	Storage technology; base load; Policy; grid
Respondent 2: Yes. 1. To maintain grid stability backup is required 2. To provide power in remote areas where distribution network is a problem	Grid stability; Remote areas; distribution network
Respondent 3: Yes is definitely required to boost up the market and solar to reach its potential especially rooftop projects.	Market; rooftop projects; Solar; Potential

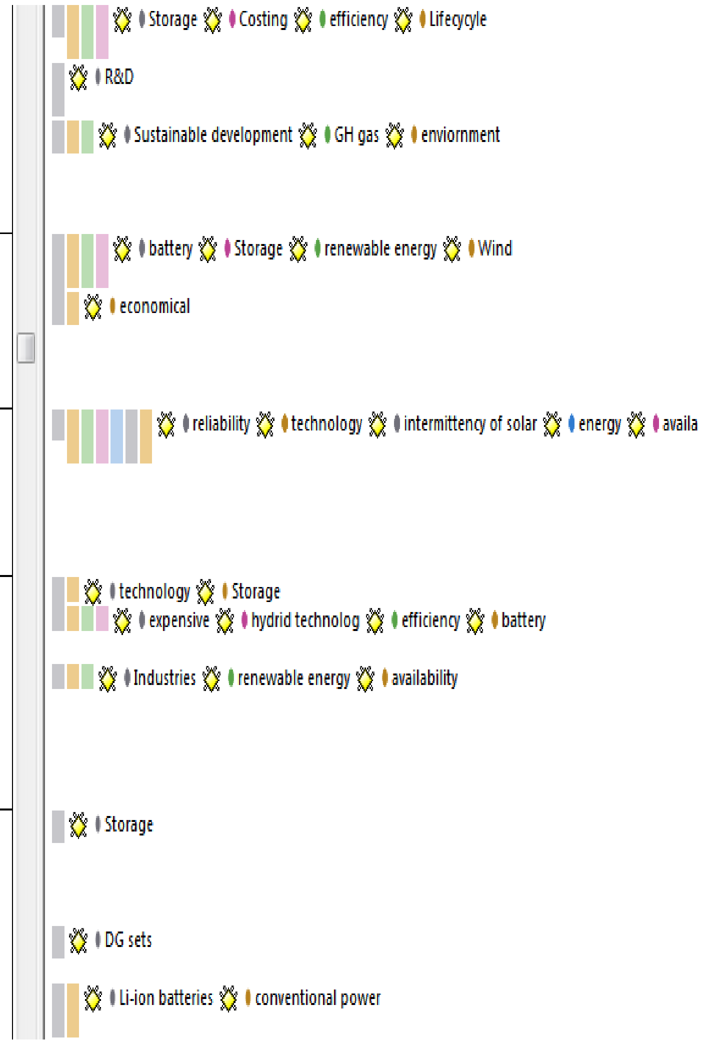
Respondent 4: Storage is still nascent in India, the lifecycle efficiency, the costing still not lucrative in India at present. Of course it will take of in the early 2020's but needs careful attention and R&D. Also, one needs to address whether storage will help reduce GH gas. The whole idea is to be more sustainable in terms of environment.

Respondent 5: Storage is going to bring a whole new wave in renewables and all the forms like wind etc will also benefit from batteries being economical

Respondent 6: Yes, energy storage technology with enhance reliability, availability of SPP and reduce its intermittency.

Respondent 7: Yes, there is a need to promote the backup/storage technologies of Solar projects in India, to improve overall utilisation of solar projects and improve their efficiency. As battery storage is very expensive at present, hydrid technology is also advised to promote Solar technology. For Example: Solar and Wind- this hybrid combination shall help to improve overall availability of renewable energy and can be of great help for industries where plant is operative for 24 hours.

Respondent 8: Absolutely. Storge will address the larger concern associated with the solar projects of catering to the requirements for particular hours. However, at present, the cost of generation through stoarge costs about Rs 12/unit which is exhorbident and can be comparable with the DG sets. Also storage through batteries is popular in India, however, storage capabilities last for 4 hours max for Li-ion batteries and can therefore cant replace the conventional power completely.



Q2.2.1 What are the policy incentives offered by Central and State Government to promote solar in India?	
Respondent 1: Depreciation & Tax benefits, Subsidies, REC's, GBI etc.	REC; Subsidies; Depreciation; Tax benefits; GBI
Respondent 2: There are various incentives offered by state and central government like; 1. Capital subsidy 2. Regulatory relaxations 3. Banking facilities 4. Single window clearances 5. Duty exemptions	Capital subsidy Regulatory relaxations banking, Single window clearances Electricity Duty exemptions
Respondent 3: Viability Gap Funding for developers, RECs, Accelerated Depreciation Tax Benefit, Capital Financial Assistance, Net-metering & banking, open access projects, waiver of CSS in captive power plants.	Capital Financial Assistance; Accelerated Depreciation; REC; Tax benef open access projects; banking; Net-metering; CSS Exemption
Respondent 4: Tax benefit, Lesser or zero T&D costs, PSM, VGF, Parks, facilitator etc	VGF; Tax benefits; PSM,; T & D cost reduction; Park

Respondent 5: There are various incentives 1) Govt of india is the biggest buyer through SECI, NTPC, and other PSU creating a large pool of demand 2) For residential, hospital,school there is subsidy to the the extent of 30%	Biggest Buyer; Demand creation; NTPC; SECI Capital subsidy
Respondent 6: GOI provided central financial assistance and Generation based Incentive along with states like Gujarat providing preferential tariff of Rs. 15 per Unit for first 12 years. However, as Solar PV has reached grid parity in recent auctions, these incentives were withdrawn lately	Prefrential tariff; financial assistance; GBI grid parity
Respondent 7: Feed in Tariff, Renewable Purchase Obligation, Renewable Energy Certificates, Generation based Incentives, Soft Loans from IREDA, Capital Subsidies, Accelerated Depreciation, Income Tax Exemption, Exemption of Transmission and Wheeling charges, National Clean energy fund, Tax free bonds are some of the policy incentives offered by Central and State Governments to promote solar power in India	soft loans; GBI; RPO obligation; Feed in Tariff-; REC Open access charges exemption; Capital subsidy; Accelerated Depreciation Tax free bonds; National Clean energy fund
Respondent 8: Histroically, the feed in tariffs were the largest incentives which were offered by the State and Central Govt. Other fiscal benefits include Tax Holiday, Accelerated Depreciation, Generation Based incentives etc	FIT GBI; Tax holiday; Accelerated Depreciation

Q2.2.2 Share your experience regarding implementation of these central and state policy incentives.	
Respondent 1: Implementation of Central level policies were more clear & transparent than state level policies. Successful Implementation at state level is still big challenge to get benefits to end consumers.	clear & transparent; Central policies; State policies; consumers; Challennges
Respondent 2: It depends on state to state bur over all implementation is not that good as expected. Government need to focus on implementation part to promote solar.	State; implementation; solar.
Respondent 3: Capital Financial Assistance an net metering are often time taking & complex	Net-metering; Capital Financial Assistance
Respondent 4: Been good. Need to work on the same. Need to wait for a few years to see how the post project execution experience will be.	project execution
Respondent 5: Not applicable for us	
Respondent 6: I was not involved in implementation of abovementioned central and state policy incentives	Central policies; implementation; State policies

Response	Codes
Respondent 7: Both the State and Central Government are offering several incentive schemes for developing the Solar Power in India, however there is a gap in implementation of these policies on ground. The incentives do exist on paper, but implementation in latter and spirits is still a challenge. E.g. Karnataka, Maharashtra and MP where incentives offered on solar energy has now been reduced/removed	incentives, schemes, solar power, Gap in implementation
Respondent 8: The incentives were well received by the Industry	Industries

Response	Codes
Q2.2.3 Are the present Central/State Policies effective enough to promote solar in India? Please share your views.	
Respondent 1: Not fully effective. Policies are not clear enough and Investors will always be at Risk for long term. New Government policies are superseding the previous one and best case is latest regulation at Karnataka about waiver of open access charges.	Risk, long term, Lack of clarity, Ineffective, Investors, waiver of open access charges, Government policies
Respondent 2: No. more focus required. Policies are in place, but implementation is not good. Discom and ground people don't have that awareness level.	Discom, policies, Focus, awareness

Respondent 3: Existing policy implementation is faced with many hurdles because of lack of clarity. DISCOMS are also losing out on revenue and forced with higher complexities because of which projects are delayed. Faster clarifications and reverent amendments in the policies will increase adoption of solar	Discom, Lack of clarity, implementation, Policy, Projects, revenues, complexity
Respondent 4: States need to be proactive. Involve stakeholders. Improve their image. Try PPP model if possible, etc. Also, with central holding bids for states it's not a bad way moving forward at the moment but largely depends on states role in future. Also, large scale projects are market driven now. States and Centre are being facilitators mostly.	PPP model, stakeholders, market driven
Respondent 5: My views are govt incentives/ policies have limited role in a technology whose time has come. Eg USA inspite of stated policy of president to promote coal, solar is progressing faster	Policy, incentives, technology, coal
Respondent 6: With Solar PV reaching tariff lower than APPC of electricity, Solar PV is placed reasonably well. But in longer term, policy interventions are required to resolve transmission bottlenecks and maintain stable investment environment	APPC, solar taiff, Solar PV, transmission bottlenecks, Stable investment enviornment
Respondent 7: No, the policy need to be more conducive for C&I consumers also. The policies needs a clear visibility, better implementation to involve C&I consumers in this capacity building process	policies, Clear Policy framework, C, capacity buildin

Respondent 8: India as a country was experiencing energy shortages when Solar was introduced to the energy basket on a large scale basis. The earlier project resulted in higher tariffs and Banks were sceptical in funding such projects. Over the years, the pricing of silicon has gone down bringing down the solar prices with it. The Govt seeing the opportunity has therefore shifted from a FIT regime to reverse auction scheme attracting players with deep pockets like pension funds etc leaving little for the mid-size domestic players	energy basket, energy storage Silicon pricing, Higher tariff solar policy domestic players, FIT, reverse auction, pension funds
Q2.3.1 What is your opinion about initial capital cost of solar projects when compare to conventional projects?	
Respondent 1: Initial capex cost is still higher than conventional in terms of return.	cost, capex, return, conventional
Respondent 2: Capital cost required is less in solar projects as compared to conventional cost. It is almost 50%-60% of thermal plant	thermal plants, Capital cost, solar power projects, conventional
Respondent 3: Initial CapEx costs is quite less as compared to conventional power plants, however availability of low cost long term funds is a barrier for investment.	conventional power plant, low cost debt funds, Initial capex, availabilit long term funds
Respondent 4: Lower than fossil fuel based energy. Solar is the new conventional now.	conventional power, fossil fuel, energy

Respondent 5: We have received grid parity i.e conventional and RE are both at similar price on per unit basis	conventional · RE · grid parity
Respondent 6: Initial project cost of SPP is very high acting as one of the barriers for investment in Solar Projects	SPP · Solar Projects · Project cost
Respondent 7: Presently, the initial capital cost of solar projects when compared to conventional projects is less, this is because of substantial reduction in polycrysatline, module prices, which constitute approx. 60% of the total project cost.	Initial capital cost · conventional projects module prices · Project cost · polycrysatline
Respondent 8: Solar in the second quarter of 2018 costs about 30 cents per watt for polycrystalling with the overall capex around 4-4.5 cr/MW as against 6-7 cr/MW for conventional	capex · polycrysatline conventional

Q2.3.2: Are the project benefits (Payback/IRR) supporting development of solar projects in India?	
Respondent 1: Yes. It was supported a lot in development but future IRR is still on stake because of lowest tariff expectation.	IRR · tariff
Respondent 2: Yes. Solar projects are financially viable now	financially viable · Solar Projects

Respondent 3: For commercial clients who pay more than Rs. 10-12/ kWh have a quick payback of approx. 2-3 years. However, due to stiff competition, IRR for investors in BOOT projects is reduced. For ground mounted large scale projects, the equity payback is longer than roof top projects because of debt service component. For equity IRR, the returns in case of asset flipping in 4 years is quite lucrative and is supporting development of ground mounted utility scale projects.	payback, commercial equity payback, IRR, BOOT projects, Ground mounted asset flipping, debt service component., rooftop projects, equity IRR
Respondent 4: Yes. Depends on the cost of project, logistics, trade barriers, global economic conditions. But at present yes	logistics, global economic conditions, trade barriers, cost of project
Respondent 5: Yes	
Respondent 6: With tariff below Rs. 3.00 per unit for SPP, payback and IRR have been affected. But with market achieving maturity, cost of generation is expected to stabilize slightly lesser than this tariff, which in the long run will assist the development of SPP in India.	payback, IRR tariff, Generation cost

Respondent 7: As a financer I would like to see DSCR i.e. debt service coverage ratio of the project during my loan life cycle. Generally the buffer between surplus cash and debt obligation should be at least 20%. With recent tariff which has come to as low as 2.50/kWh and imposition of safeguard duty etc, it is really difficult to finance the project. Additionally the project has other obligation other than long term debtor's payment such as coupon rate of CCDs/CCPs holders etc. This leaves very little margin to create MMR (Monthly Maintenance Reserve) for replacement of solar panels and invertors, as nobody knows how these Chinese solar modules would behave for 25 years

DSCR | loan life cycle
surplus cash | Debt obligation
safe guard duty
Inverters | MMR | solar panels
solar modules

Respondent 8: The payback and IRRs have gone down and cater to foreign player like soft bank with lower expectations on return on equity

return on equity | IRR | payback

Q2.3.3What is your take on available financing mechanism for solar projects? Are they sufficient to support development of solar projects in India. Please share your views.

Respondent 1: I will yes. There are lot of financing channel to develop solar projects and all developed countries are ready to invest in the country.

invest | financing | developed countries | Solar Projects

Respondent 2: There are many equity investors, banks and NBFCs. Government has asked banks to provide solar loans at lower interest

low rate of interest | NBFC | Investors | equity | Banks

Respondent 3: Currently financing for projects is provided mostly by private equity backed by debt. Current mechanism allows investment preference for projects with higher returns. To achieve the targets set by Govt, low cost long term debt financing coupled with flexibility options such as lease rental financing will increase adoption of projects.	investment, financing, Projects, debt, equity long term debt financing, higher returns lease rental financing
Respondent 4: It is good compared to fossil fuel based plants. In the age of PE based investments and funds coming in from across the globe it is not a bad time for Solar. Also, with grid reaching parity, NPAs in thermal plants. Banks have slightly changed the approach towards conservatism.	PE thermal plants, grid parity, NPA
Respondent 5: Yes, the industry would not have reached this size without financing	financing, industry
Respondent 6: No, more funds are required to achieve the target of 100 GW SPP in India by 2022. Further access to these funds is still not easy and higher cost of these funds are also among the barriers hindering development of SPP.	100 GW SPP barriers, Higher cost

Respondent 7: Capital structure has two components Debt and Equity. Generally, in India Debt is being financed by various banks/NBFCs. It is the equity which is structured into different forms rather than plain vanilla equity to make the transaction tax efficient. Generally the borrower (SPV who has come for loan to banks/NBFC), infuse its promotor contributing in the form the CCDs/CCPs/NCDs/Unsecured loan. The instruments through which the promotor infuse money ha nature of debt & equity both, called as quasi equity. There are many ways to get quasi equity in thr project. Most popular of which is through private equity investors. The SPV/project return pre-defined coupon rate to quasi equity holder.

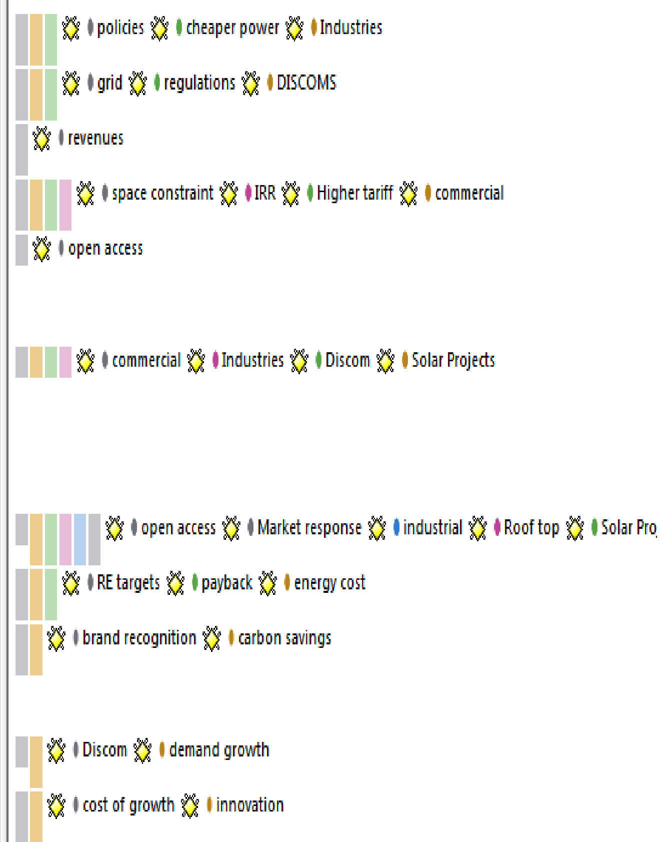
Now generally the PE investor gives loan to the holding company of the SPV and the holding company infuse it into different SPVs in the form of equity (CCDs/unsecured loan etc). This results into increase in overall leveraging of the group. With the current financial situation of distribution company, any slippage/default by SPV, may result into the situation of default of group. So I would say the transaction per say is sufficient to development but with recent development in regulatory regime such as Insolvency and Bankruptcy Code, 2016, lenders have to be very cautious while funding to groups having high leverages and no certainty on future cash flows to upstream the available surplus cash

debt, equity
tax efficient, NBFC
/CCPs, CCD, /NCD, Unsecured loan
quasi equity
coupon rate
PE investor
regulatory regime
future cash flow, surplus cash

Respondent 8: Banks and FIs are presently not only sceptical in funding projects based on reverse auction, they also fear the Security adequacy of their already funded projects, in the eventuality the PPAs are renegotiated by the DISCOMs. The earlier project funded by these FI's will not fetch the same price at which they were funded in the eventuality, the PPAs are terminated/renegotiated by the Govt

reverse auction, Banks, project funding
PPA Renegotiation
PPA termination

Q2.4.1: How is the market response (Industries/Discoms/Commercial) on solar projects?
Respondent 1: On industries point of view, they are happy to get the alternate cheaper power source but threatened by policies, regulations & Discoms. Also, dependency on grid still be there. Discom's are not ready in the government vision and they are losing their revenues and not ready to accept the changes. Also, Discom is not ready to implement government policies in positive way. Commercial consumers are more happy as they are offsetting the higher tariff and more IRR but space constraint & open access charges are still big hurdles.
Respondent 2: Industries and commercial establishments are keen to do solar projects but Discom's response is not that much encouraging.
Respondent 3: Market response in roof top and open access solar projects for industrial and commercial consumers is quite good. Industries and commercial consumers are quite interested because of quick payback, energy cost savings, achieving RE targets, carbon savings, and adding brand recognition.
Respondent 4: Mixed. There is a need for demand growth. Also, DISCOMs need to involve the participants more proactively so that the cost of growth, innovation solely doesn't lie on the DISCOMs.



Respondent 5: Industries are pretty positive with several committing to go 100% on RE. Discoms have legacy relationships with coal but they are slowly realizing that it is in their interest to have all types of power	RE. · positive · Industries DISCOMS · power · coal
Respondent 6: With newly discovered tariffs, Industry and discoms are comfortable. However, lenders are critical about the viability of these projects which is creating problems in financial closure	tariffs · industry · DISCOMS financial closure
Respondent 7: Discoms are welcoming setting up of large scale solar projects in the state because they are getting green power at the rate of conventional power. As such it is the best option for them to meet the RPO obligation and energy demand. Industries and Commercial consumers are willing to go green, however policy uncertainty for banking, group captive etc.is a matter of concern. They are as such exploring smaller rooftop projects but for projects of larger capacities the approach is cautious	DISCOMS · green power · Solar Projects energy demand · conventional power · RPO obligation banking · Industries · group captive · commercial rooftop projects
Respondent 8: The DISCOMs are by and large averse to the solar generation and the enabling provisions like banking, captive/Group captive have been frequently challenged by the DISCOMs.	banking DISCOMS · captive/Group captive

Q2.4.2: What is your view on R&D in solar sector in India?	
Respondent 1: R & D in solar in general topic as it is not covering the macro aspects of it. So, R&D topic should be the one part of solar and detail thesis on it.	Solar

Respondent 2: India is dependent on import as far as technology is concerned. Don't have good R&D facilities in India.	technology
Respondent 3: R&D sector for solar in India is in nascent stage as compared to other countries leading solar PV adoption. India needs to increase its R&D for achieving targets and self-sustenance.	PV adoption. self-sustenance. targets
Respondent 4: Not meeting the requirement. With solar costing lesser than fossil fuel based energy it was high time we had our own demand supply fulfillment of panels. Anyways, optimistic about new tech innovation with higher efficiency, battery storage etc. Hope we don't reach a technology lock in situation.	fossil fuel Solar efficiency panels. battery storage tech innovation
Respondent 5: Non-existent. Very poor	
Respondent 6: R&D in solar sector in India is in nascent stage and it needs more encouragement & funding from institutions and government	institutions funding encouragement government
Respondent 7: There is a need for improved R&D in solar sector. There is a need for focus on storage and hybrid technologies. Improved R&D in my opinion shall help in bringing new technologies at a commercially viable rates which would be easier to adopt on a mass level.	hybrid technologies solar sector Storage commercially viable

Respondent 8: India, by and large imports its solar cells from China and R&D facilities are scarse in the country.	solar cells, R&D facilities, Imports
Q2.4.3: What is your opinion on technological aspects of solar projects?	
Respondent 1: It is changing & growing in very fast manner but availability of silica will be the challenge.	silica
Respondent 2: No Response	
Respondent 3: India needs more of R&D to develop technologically advanced modules suited to Indian conditions.	modules, Indian conditions, Technology advanced, R&D
Respondent 4: Challenges - Grid integration, efficiency of the projects, pace at which states meet the T & D requirement/up gradation to of take the energy. Etc	T&D requirement, Grid integration, efficiency
Respondent 5: There are a lot of new things which are coming up like PERC, bi facial etc	bi facial, PERC
Respondent 6: Solar technology is still maturing with more R&D required to improve efficiency of the Solar modules.	solar modules, efficiency

Respondent 7: In the recent times Solar PV Sector has witnessed a technological breakthrough. Technology like tracking technology has resulted in improved generation from solar projects. However, there is a need to explore more in the field of Modules, Inverters etc. to improve overall performance and reduce losses at various stages.	tracking technology; Solar PV; technological breakthrough; modules; generation; Inverters; performance; losses
Respondent 8: Bi-facial technology is the most talked about in the present market owing to higher efficieny. However owing to vulnerability of the glass breaking, the large scale integration is yet to happen	higher efficiency; bi facial; Market; large scale integration; glass breaking

Q2.4.4: How do you see awareness of Indian consumer regarding pros and cons of Solar projects?	
Respondent 1: Most of the consumers are not aware as their main focus on only financial gain	financial gain; consumers
Respondent 2: Awareness is good. MNRE and other government bodies organize exhibitions and workshops frequently. India is attraction when we talk about renewable energy	MNRE; exhibitions; governnment bodies; workshops; renewable energy
Respondent 3: A very minor segment of consumers are aware about pros and cons of solar projects.	Solar Projects; consumers

Respondent 4: Consumers are mostly aware of the solar system. Consumers are keen on accessible, affordable, reliable and environmentally responsible power. Meantime, in India affordability still holds the key.	affordable, consumers, solar system, reliable, accessible enviornment, power, affordable
Respondent 5: We have to educate most of the customers we meet as they are not aware of pros and cons of solar	customers, educate
Respondent 6: In metro cities awareness have increased gradually but in smaller cities awareness needs to be increased especially with regards to solar roof top projects	metro cities solar roof top
Respondent 7: Energy intensive industries and consumers are well aware about the pros and cons of solar projects. But more awareness is needed for domestic consumers. Decentralised solar projects could be of great help in rural electrification.	Solar Projects, Energy intensive, Industries, consumers rural electrification, domestic consumers, Decentralised solar project
Respondent 8: The consumers are more acquainted with solar than they were ever before. Govt is also promoting rooftop solar on a large scale thereby making it a talking point amongst consumer	solar roof top consumer

Q2.4.5: How do you see the role of training institutes in promoting solar in India?	
Respondent 1: Yes. It will helping out the consumers to understand and action on it.	consumers

Response	Codes
Respondent 2: Currently their role is very limited as all promotional activities are managed by industries and MNRE.	MNRE; promotional activities; Industries
Respondent 3: Training institutes has helped in a lesser significant manner as it was planned for. Gaps in assessment of knowledge base and uniform content for solar projects have proven an average success. Many companies and solar installers have emerged out of such initiatives. Currently the need for training is more into advanced subjects or specialized courses will increase	knowledge base; companies; Solar Projects; advanced subjects
Respondent 4 They do make an impact. Need to be solution based with day to day challenges being resolved and predicting the future changes. Also, should be addressed by people who are in the field in corporate companies and are keen to train and impart knowledge	solution based; impart knowledge; corporate companies
Respondent 5: There are lot of engg colleges churning out quality engg and with skill india and other programmes training at lower level has also been provided. Skilled manpower is not a problem in the industry	skill india; engg. colleges; skilled manpower
Respondent 6: Training institutes are expected to play very significant role in creating awareness among various stakeholders to promote solar power in India.	

Respondent 7: NISE(National Institute of Solar Energy), NPTI (National power training Institute), APTRI (Adani Power Training Institute), Tata Energy research Institute, UPES (University of Petroleum and Energy Studies) etc., are some of the training institutes or private organisations which are playing a vital role by giving trained professionals to the sector and also promoting research in this field which is helping the sector to grow in a fast pace and also reducing the time and cost for training and development.	NISE, APTRI, NPTI UPES, Tata energy research institute promoting research training development.
Respondent 8: Training institutes play a very important role in building the man-power required for such a large and growing industry.	growing industry.
Q3.1: Based on your experience, suggest three most important remedial measures to address the barriers associated with the development of Large scale solar power projects in India:	
Respondent 1: Policy & Regulatory issues Reduction in IRR & poor health of discom/consumers to pay on time space & technology constraint	Policy and Regulatory Issues IRR, Poor discom health space constraint Technology constraint

Respondent 2: Simple regulatory framework

Discom's support

Awareness level

Respondent 3: Faster approval and signing of PPA

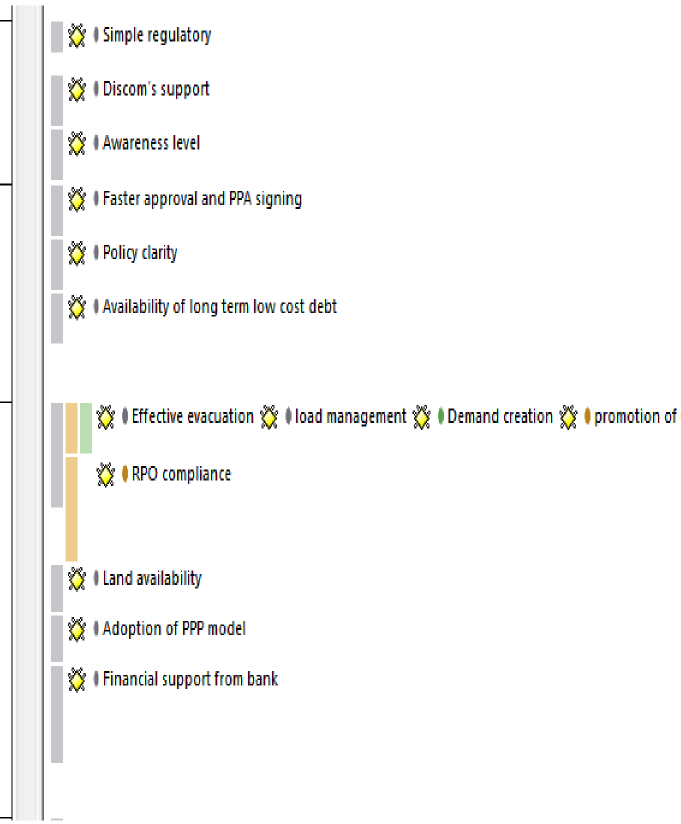
Clarity and quick improvements in policy

Availability of long term low cost debt funds

Respondent 4 : Demand creation in all the parts (ESCOMs) of the state, promotion of OA by DISCOMs, effective evacuation and load management by DISCOMs to ensure there is no over loading of energy/PPAs to a particular DISCOM. Stringent action against utilities not fulfilling RPO.

Land, tranches of ownership is a hurdle. – Institutions (govt, pvt) should step in to provide parks or ownership of land in a large manner. More on a PPP model – not a bad way to ensure both the DISCOMs and Investors are in a win-win situation

At present Solar industry needs to be given a push. Support from institutions (Banks, Utilities) is imperative, but there has to be a balanced approach keeping in mind all the stakeholders involved.



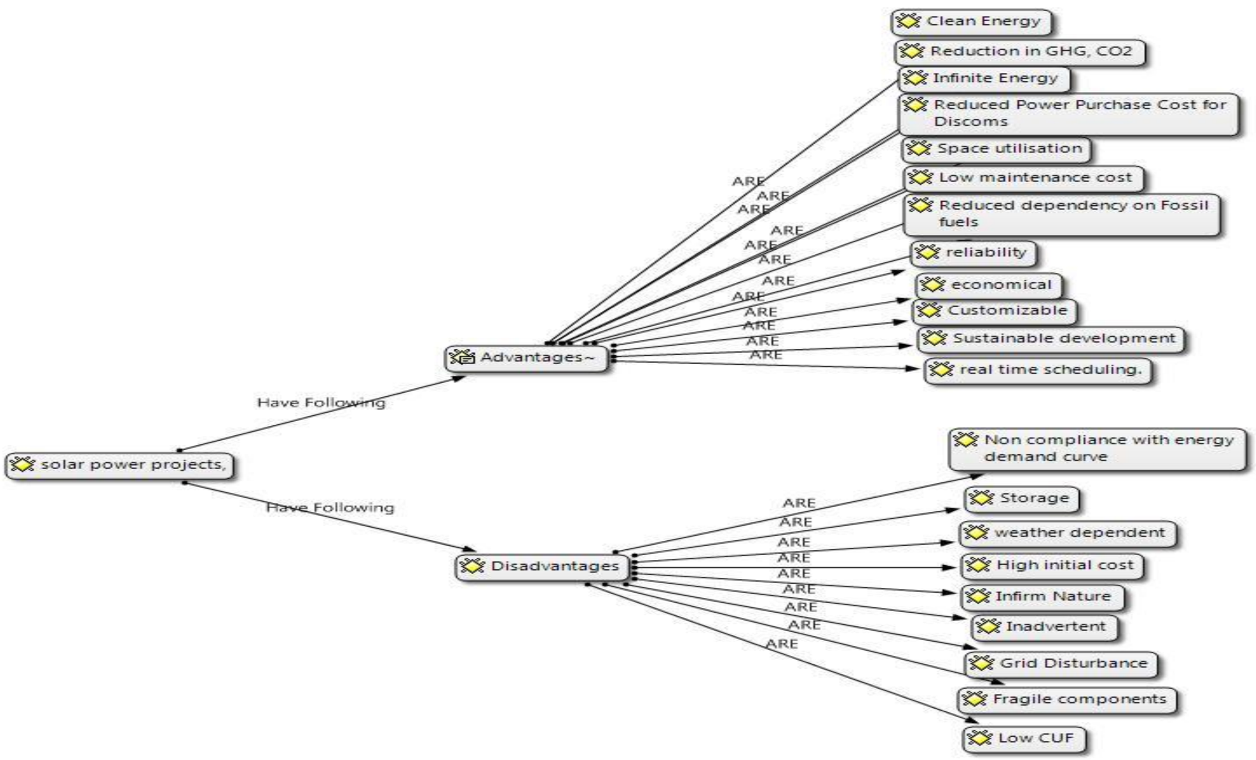
Respondent 5: PPA with terms reducing investor risk	Reduced PPA Risk
grid stability	Grid stability
stability in taxes and duties, fiscal benefits	fiscal benefits; stability in taxes and duties
Respondent 6: Development of grid codes and norm for integration of solar power in India	Stable Grid codes
Increased focus on R&D in India, to improve efficiency of solar generation.	Increased R&D to improve efficiency
Focus on creating a conducive investment environment for investors so that expected debt and equity shortfall is bridged and target of 100 GW is achieved.	Condicive investment enviornment
Respondent 7:	
1) Conducive policy and regulatory framework with a visibility to make projects financials attractive.	Policy and Regulatory stability
2) Improved Grid Infrastructure to accommodate large capacity of infirm solar power. Improved forecasting and monitoring technologies for more reliable real time scheduling.	Improved grid infrastructure
3) Focus on new technologies like – Storage and Hybrid to improve reliability of solar generation	Focus on technology- Storage & Hybrid
Respondent 8:	
Removal of Reverse Auctions	Removal of Reverse Auction
Promotion of Storage	Promotion of storage
Fiscal Benefits-clarity in GST and other Govt policies	fiscal benefits

ANNEXURE 5

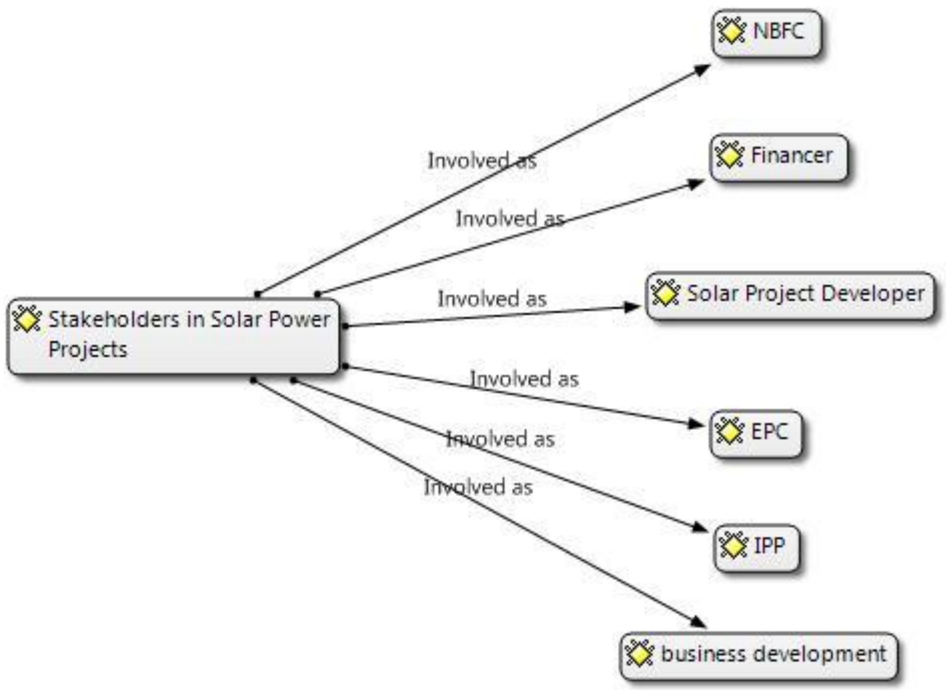
AXIAL CODING

1. Introductory

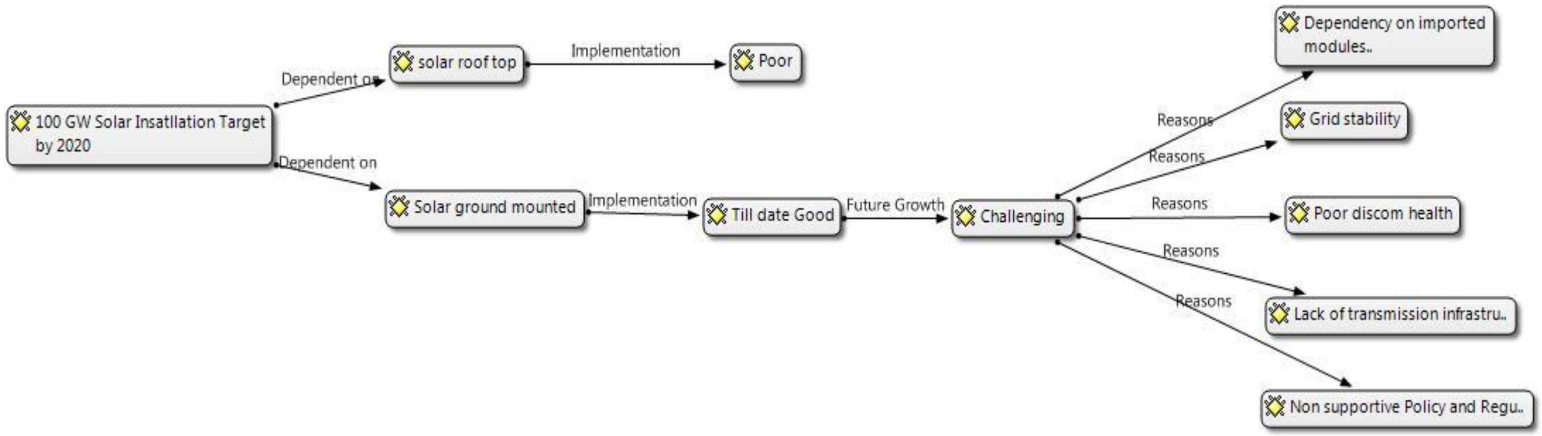
Q1.1. What is your opinion about Solar power Projects in terms of advantages and Disadvantages?



Q1.2. Have you ever been a stakeholder/Involved in the development of Solar power Projects in India? If yes, kindly share your mode of involvement.

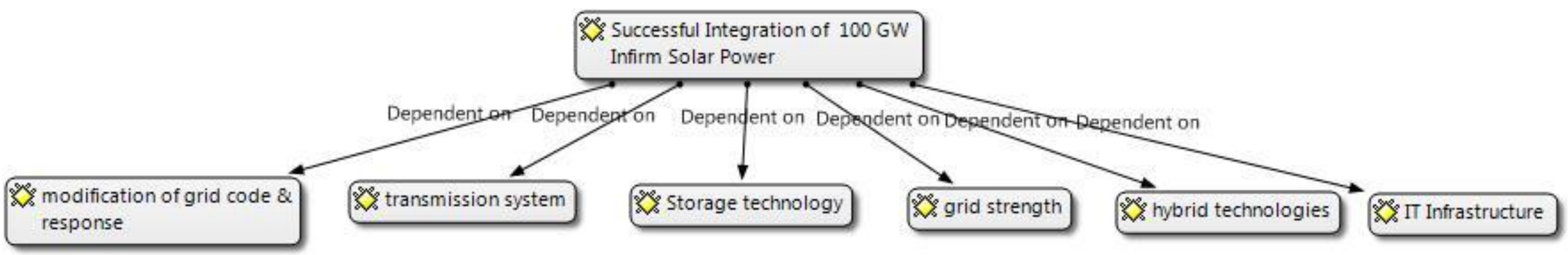


Q1.3. What is your opinion about GOI "100 GW by 2020" Solar Installation target?

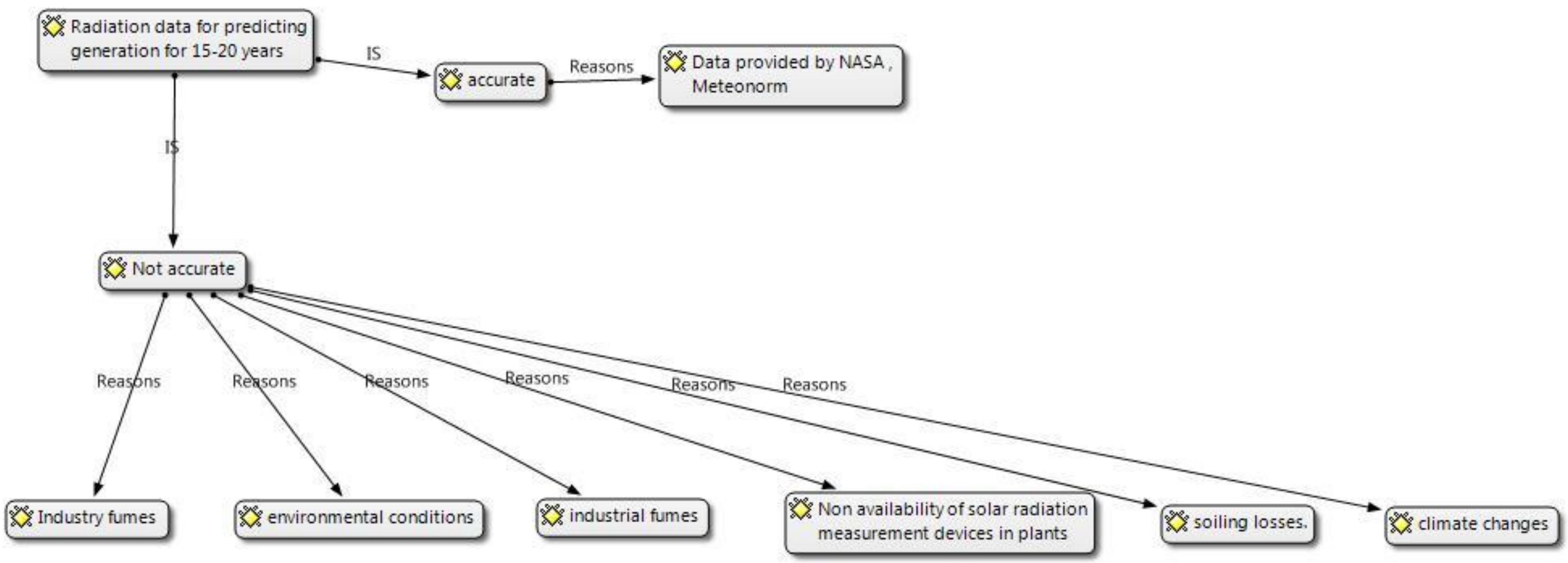


2.1 Technical factors

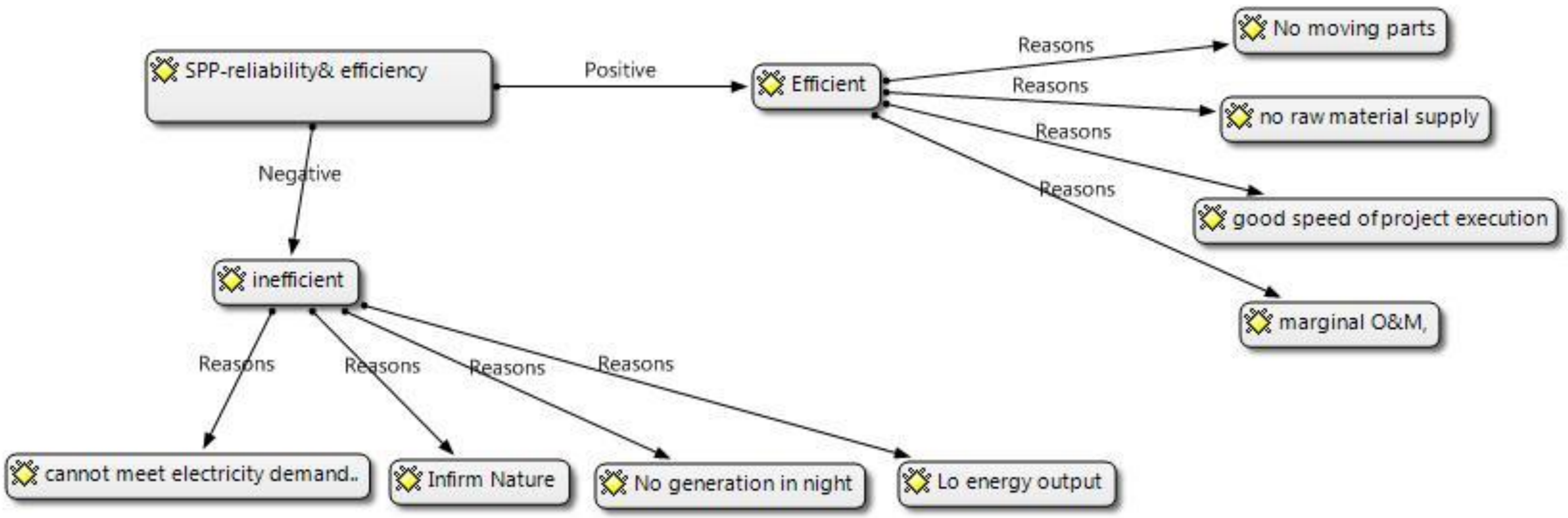
Q2.1.1: What is your opinion about integrating 100 GW infirm solar power on present transmission grid?



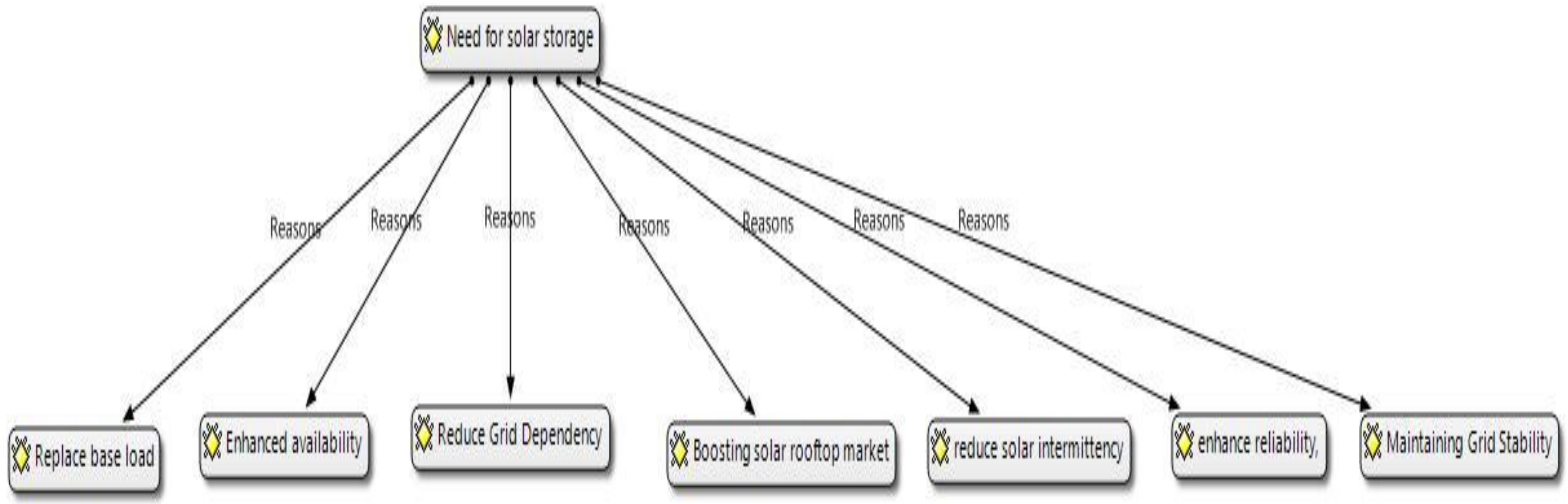
Q2.1.2: What is your view on availability of solar radiation data for predicting solar generation for next 15-20 years?



Q 2.1.3: What is your take on reliability and efficiency of solar power projects compared to conventional power plants?

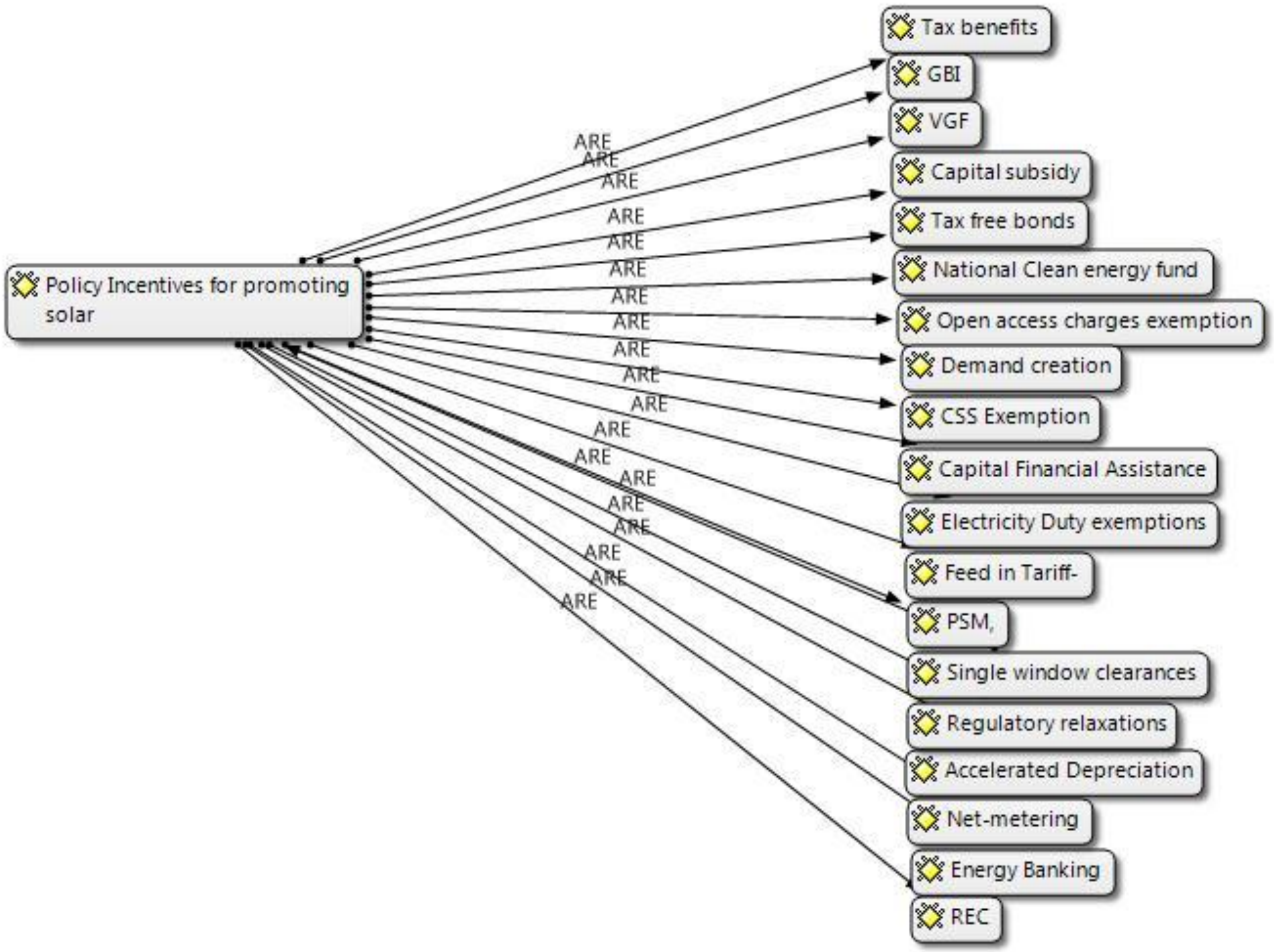


Q 2.1.4: Do you think backup/ storage technology is need of hour to promote solar projects in India? If yes, please share your views.

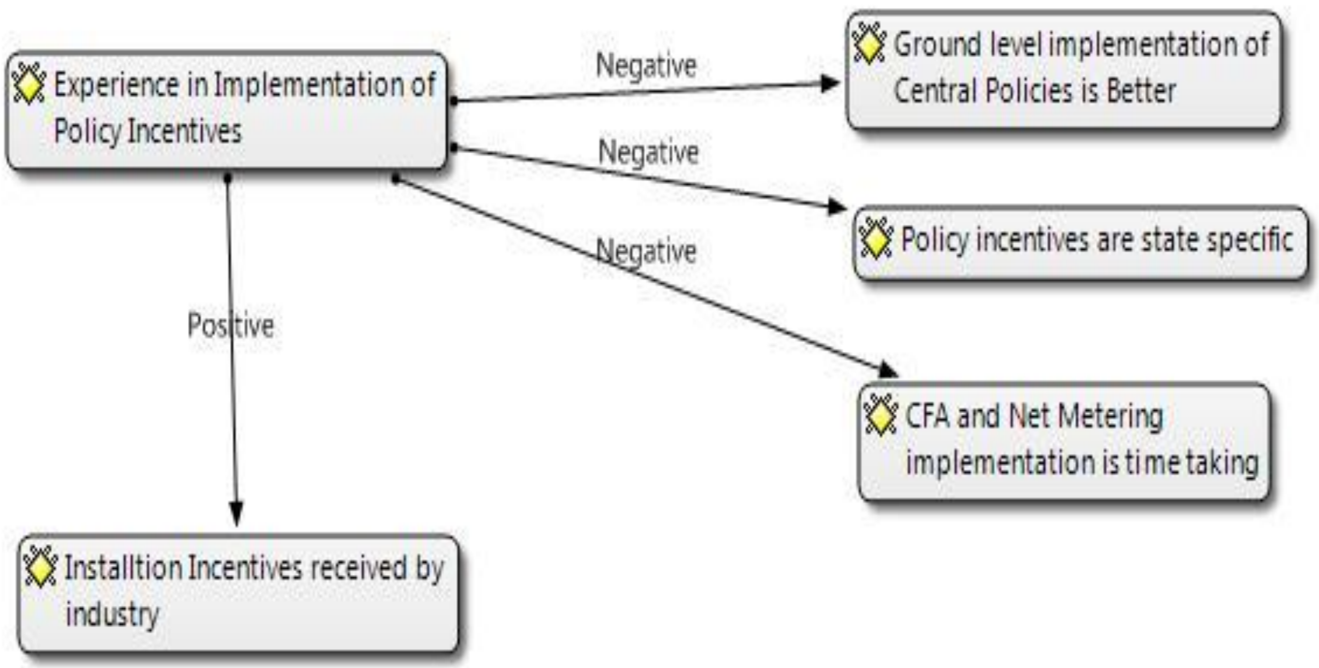


2.2 Regulatory /Policy factors

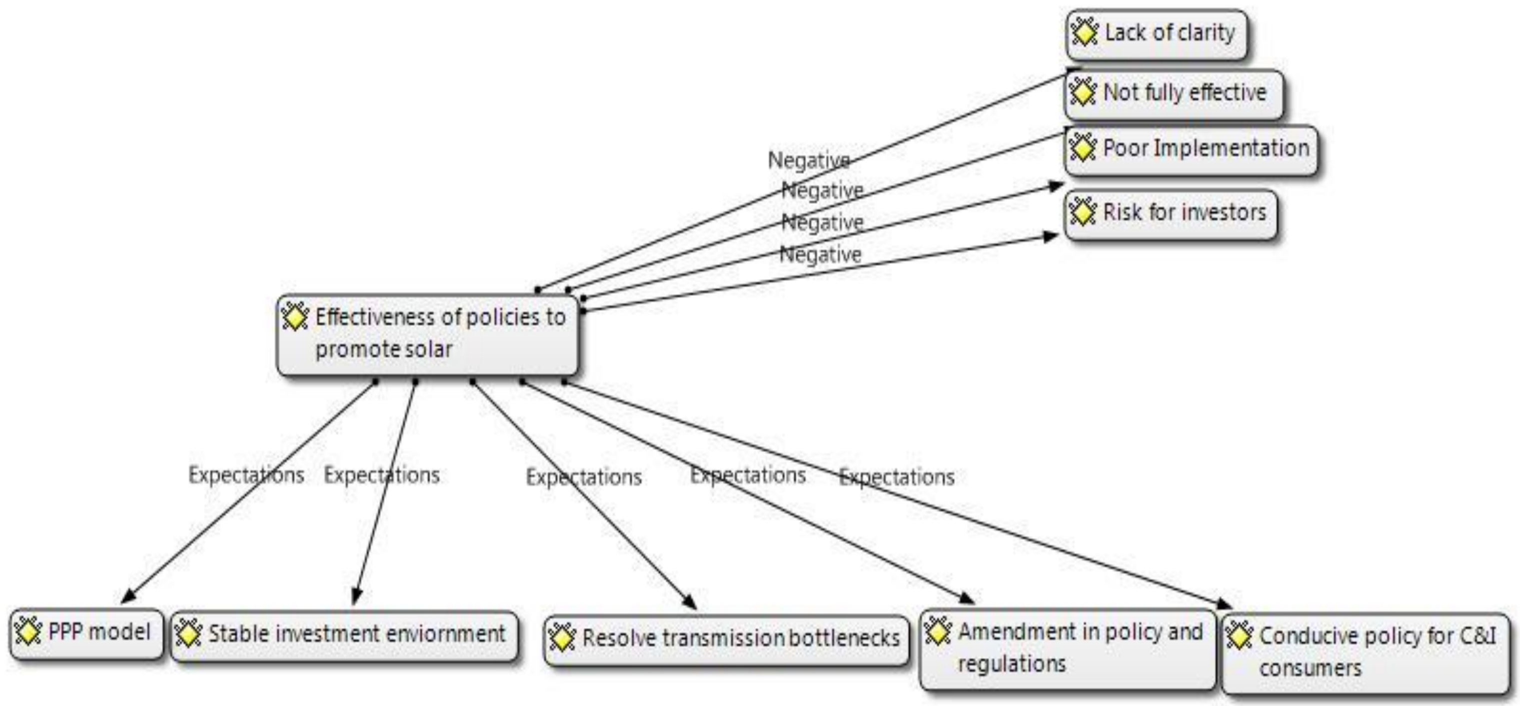
Q2.2.1: What are the policy incentives offered by Central and State Government to promote solar in India?



Q2.2.2: Share your experience regarding implementation of these central and state policy incentives.

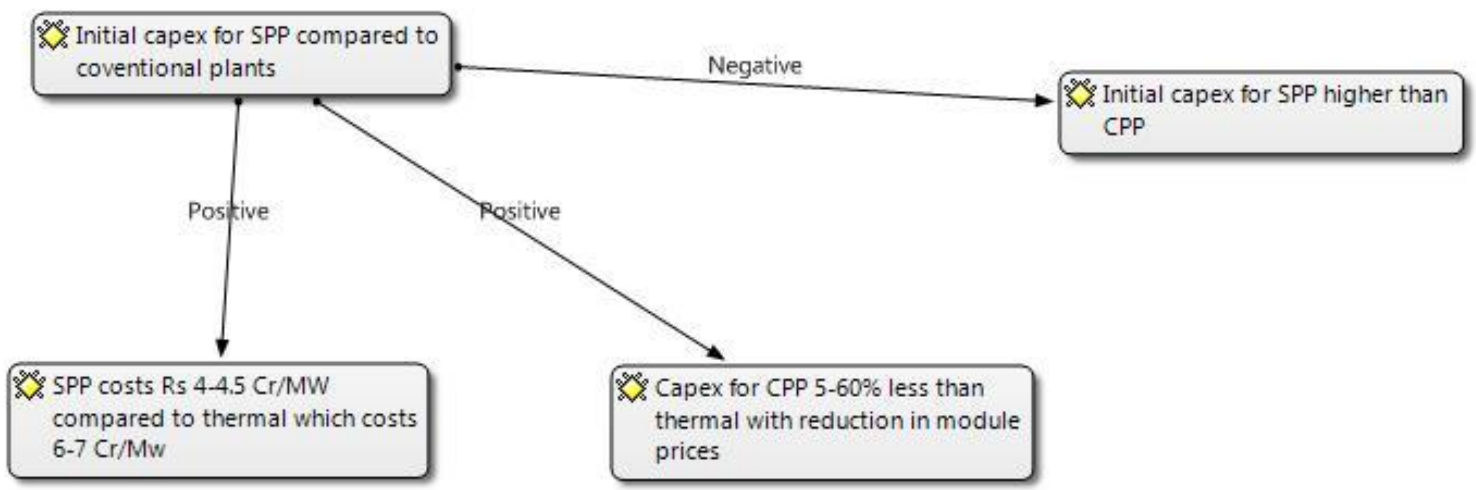


Q 2.2.3: Are the present Central/State Policies effective enough to promote solar in India? Please share your views?

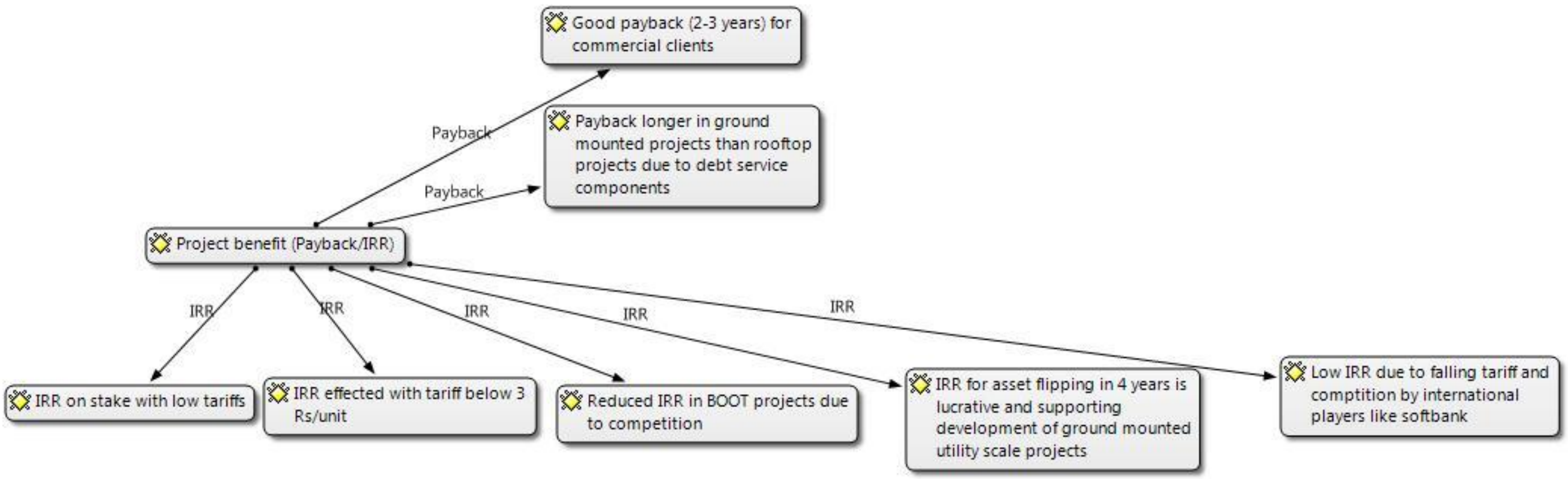


2.3 Financial factors

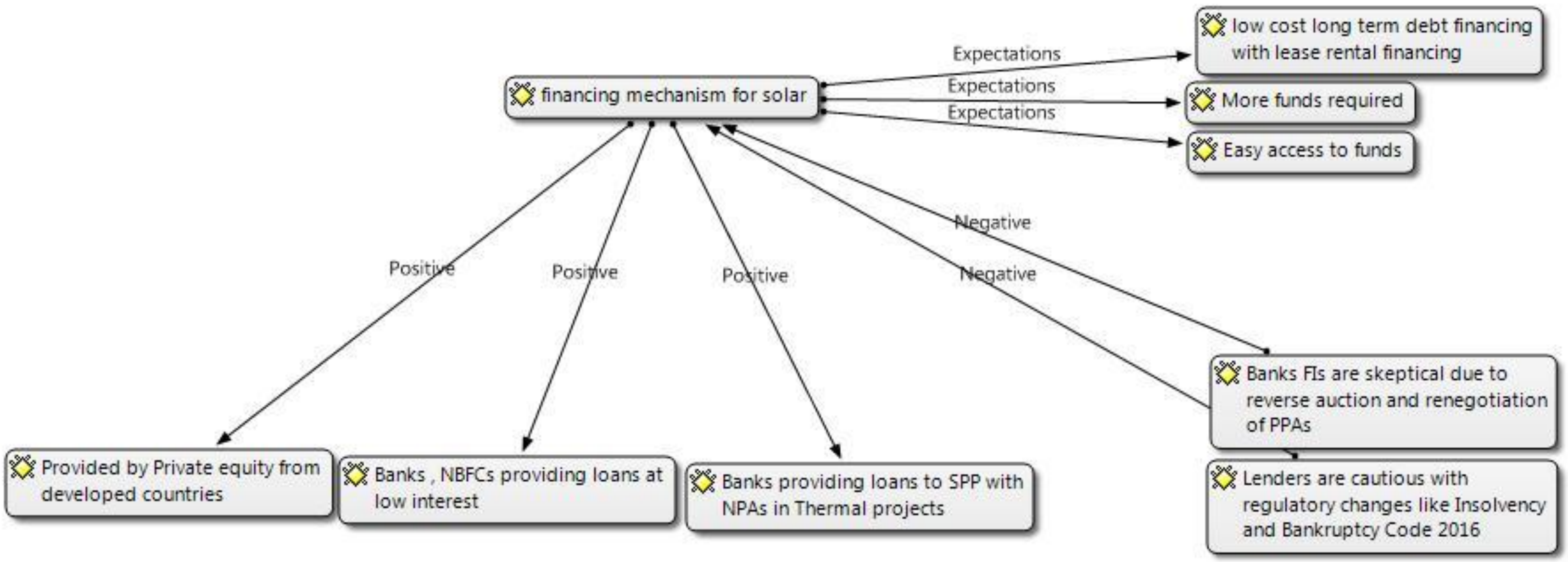
Q 2.3.1: What is your opinion about initial capital cost of solar projects when compare to conventional projects?



2.3.2: Are the project benefits (Payback/IRR) supporting development of solar projects in India?

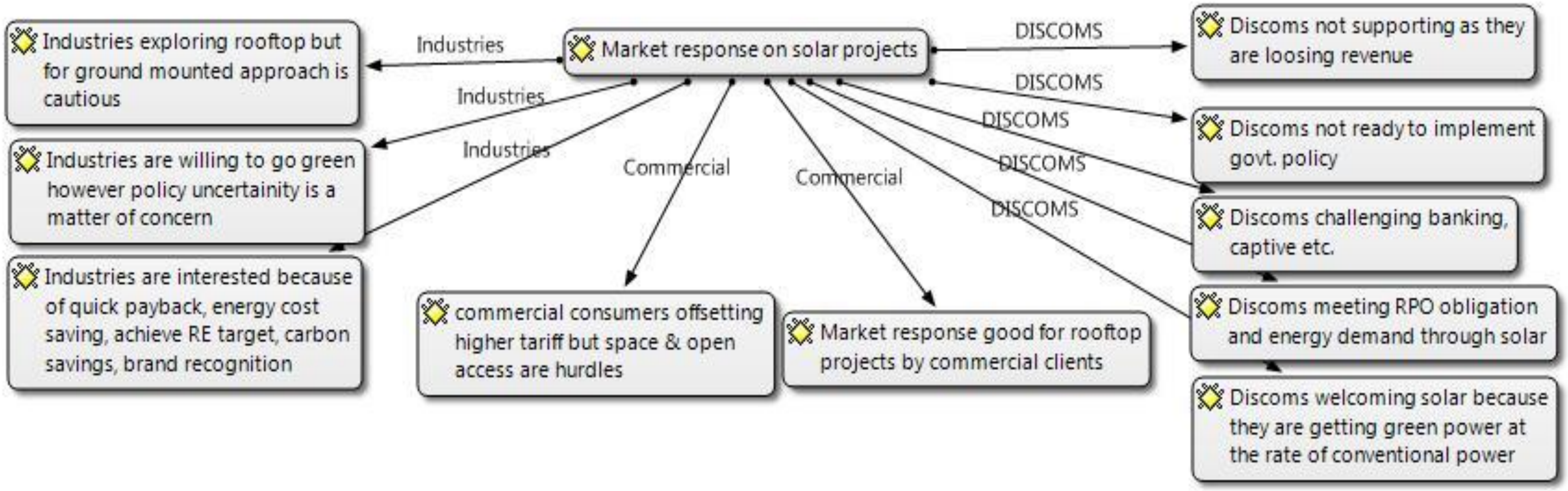


Q 2.3.3: What is your take on available financing mechanism for solar projects? Are they sufficient to support development of solar projects in India. Please share your views.

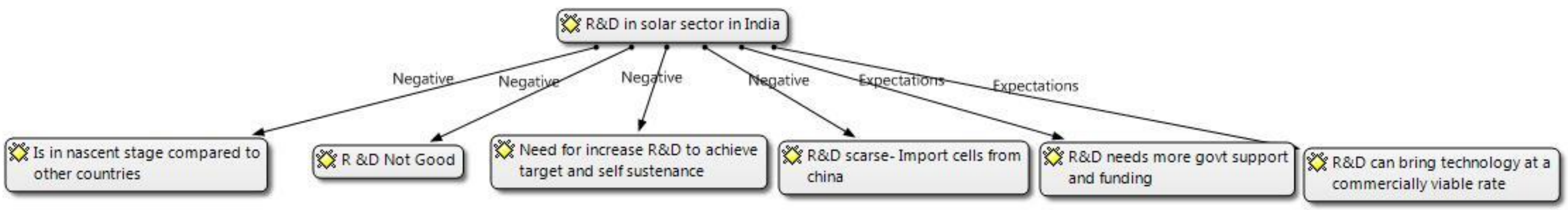


2.4 Other factors

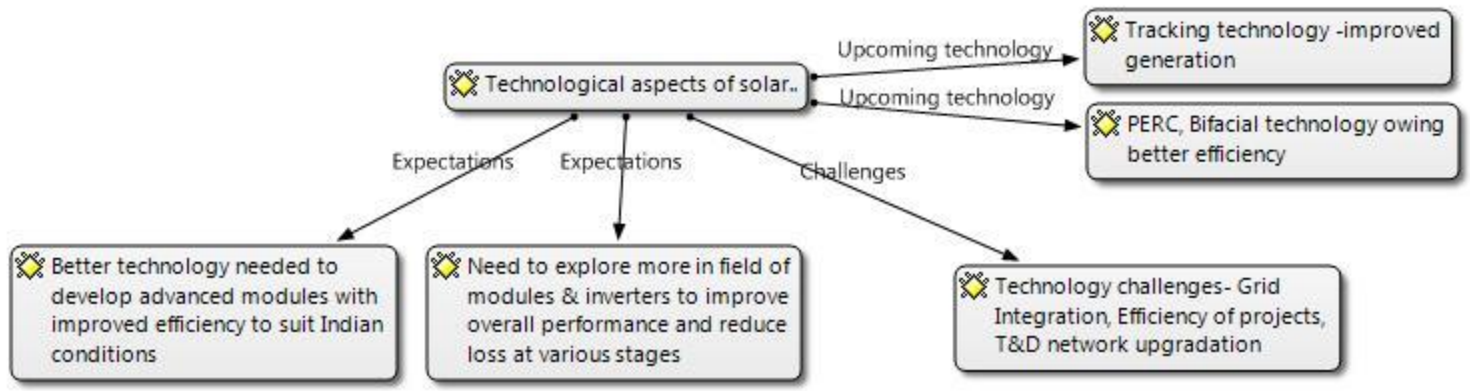
2.4.1: How is the market response (Industries/Discoms/Commercial) on solar projects?



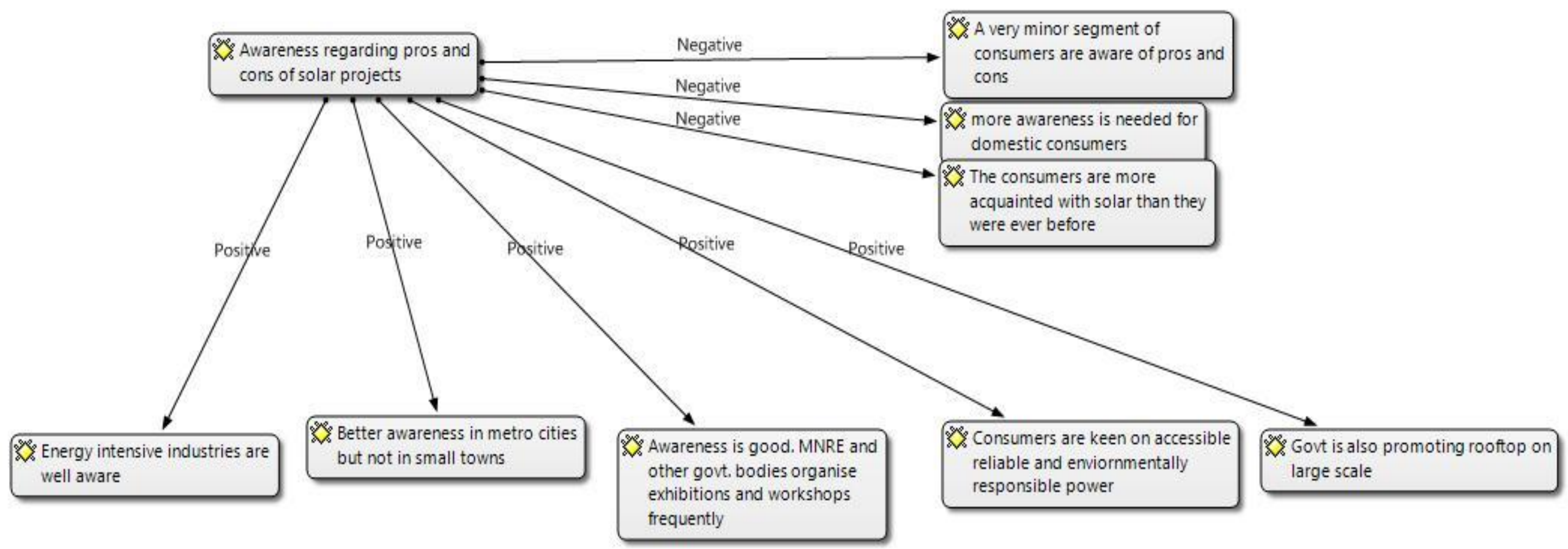
2.4.2: What is your view on R&D in solar sector in India?



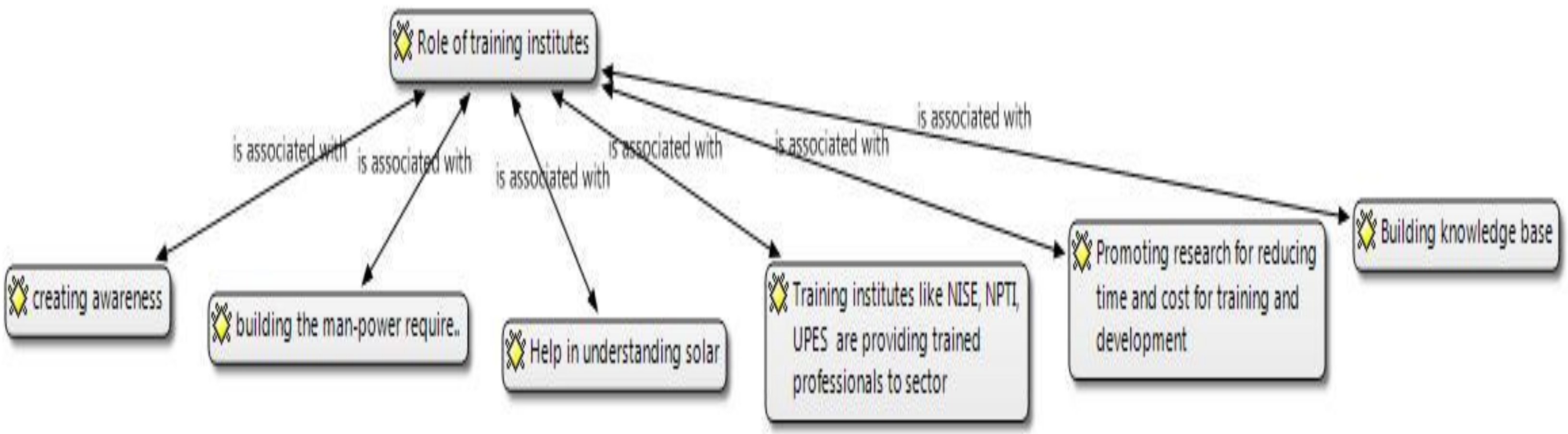
2.4.3: What is your opinion on technological aspects of solar projects?



2.4.4: How do you see awareness of Indian consumer regarding pros and cons of Solar projects?

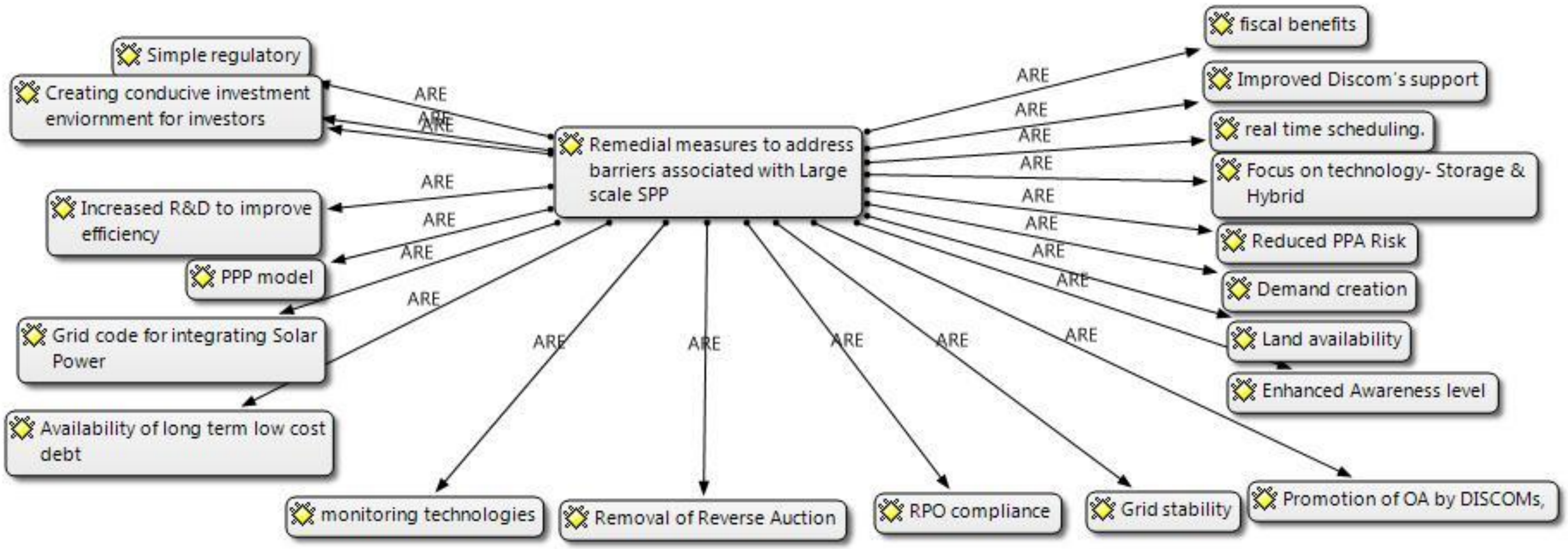


2.4.5: How do you see the role of training institutes in promoting solar in India?



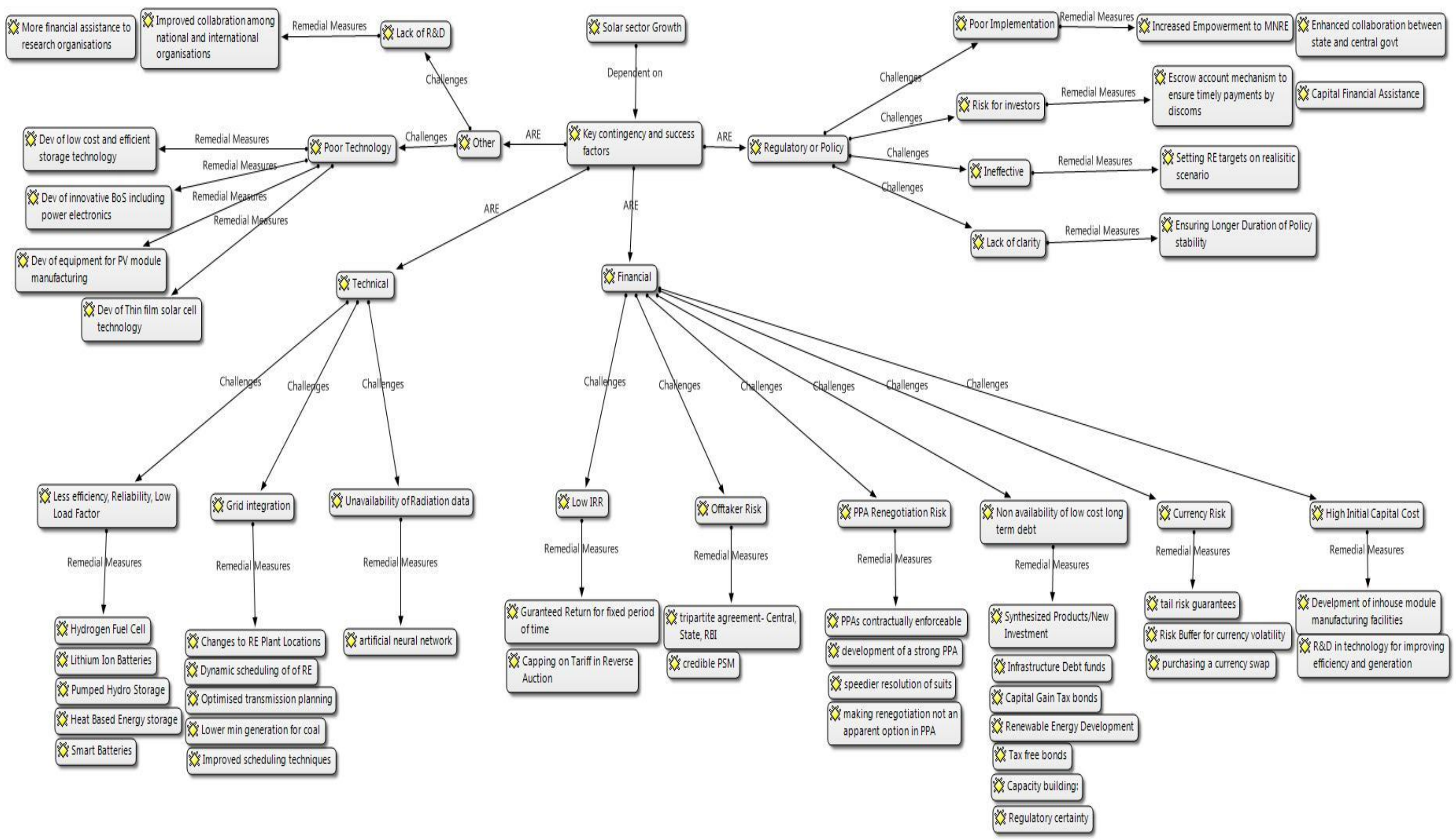
3. Remedial Measures

3.1: Based on your experience, suggest three most important remedial measures to address the contingency and success factors associated with the development of Large scale solar power projects in India:



Annexure 6

Selective Coding (Framework)



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A thesis submitted to the
University of Petroleum and Energy Studies

For the award of
Doctor of Philosophy
in
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BY
Kushagra Garg

November 2021

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