Chapter 2

Literature Review

2.1 Introduction

This chapter discusses various scholarly work published in refereed journals and articles on solar PV energy. A robust review of these published literature and data facilitated the researcher to find out relevant evidence specific to study which is under observation. This exercise helped researcher to develop a rich thought process and framework for the study.

Through literature review an effort is made to find out the progress of solar PV energy in the World, with special emphasis on India. This comprehensive review aided researcher in supporting the present study through identification of research gap in existing literature.

This chapter underlines the following aspects from various published literature relevant to the present study:

1. The evolution of solar PV in India since Independence in 1947.
2. Organizations involved in development and promotion of solar PV in the country.
3. Policies and regulations announced by Government of India in an initiative to promote solar PV in the country.
4. State specific policies to encourage grid connected solar PV power plants in their region (announced till January 2014).

5. Current issues for grid connected solar PV worldwide, identified as barrier and challenges, which can act as potential road block to promotion of grid connected solar PV power plants in India.

As discussed in chapter 1, India has tremendous potential for generating clean electricity through solar PV. On realizing this, GoI has introduced various policy measures to promote solar PV energy in the country. Hence, it becomes imperative for researcher to study the growth of solar PV energy in India.

The following sub sections discuss the evolution of solar PV energy in India since Independence by reviewing all national five year plans. The following sub sections also discuss about various organizations and promotional programs involved in growth of solar PV in the country.

2.2 National Five Year Plan (FYP)

Five-Year Plans (FYP's) are integrated nationalized economic programs which lays the foundation plans for economy growth of a country. Planning Commission is responsible for development, execution and monitoring of FYP's in India (Government of India, 1950). India's first 5 year national plan was released in year 1951 (Planning Commission, 2012), by the, then, Prime Minister Mr. Jawaharlal Nehru. Currently, country has just ended with 11th FYP (2007-12) and is in the first year of 12th FYP (2013 -17).

The following sections reviews various FYP's of the country since 1950, to find out how solar PV has evolved during these years.

2.2.1 1st FYP (1950 – 55) and 2nd FYP (1956 – 60)

On assessing 1st (1950 - 55) and 2nd (1956 - 60) FYP, it was identified that, energy mix of India for electricity generation comprises of coal (steam), Oil and Hydro. In the year 1950, India had a total installed capacity of 2300 MW and by the end of 1955 and 1960 the total capacity had increased to 3420 MW and 5700 MW respectively (Planning Commission, 1950; Planning Commission, 1956).

2.2.2 3rd FYP (1961 - 66)

It was during the 3rd FYP (1961 - 66) solar energy was discussed as a source for electricity generation. The electricity generation capacity commissioned during this FYP was 10170 MW through thermal, hydro and diesel (Planning Commission, 1961).

2.2.3 4th FYP (1969 - 74) and 5th FYP (1974-79)

4th FYP (1969 - 74) and 5th FYP (1974-79) had no discussion related to solar energy and thrust was laid upon Hydro, Tidal and Geothermal energy as priority areas for R&D in country. The total installed capacity for power generation by the end of 4th and 5th FYP was 18456 MW and 31000 MW respectively (Planning Commission, 1969; Planning Commission, 1974).

2.2.4 6th FYP (1980 - 85)

After almost 20 years since 1961 it was the 6th FYP (1980 - 85) which specifically addressed solar energy and its implementation. Developing solar energy was of particular interest for meeting energy demand of decentralized rural areas and potential industrial uses (Planning Commission, 1980).

Following are few initiatives undertaken during 6th FYP for promotion of solar energy:

A. *Department of Non-Conventional Energy Sources* (DNES) was formed on 6th September 1982 as a unit under Ministry of Energy (Planning Commission, 1983) . The objective of this department was to provide funding for strengthening research, development and demonstrations in the area of Renewable Energy Technologies (RET) covering all important RES such as solar, wind, bio-mass, geothermal energy etc.
B. *Commission for Additional Sources of Energy* (CASE) was formed in the year 1981 to promote and develop RES in the country. The organization encouraged and funded R&D activities. They also launched a program for manufacturing and sale of 10,000 solar cookers through subsidy, in twelve States and one Union Territory (Planning Commission, 1983).
C. *Solar Thermal Energy Centre* (STEC) was established with prime objectives to drive R&D, testing and demonstration activities of solar thermal devices and systems to achieve their commercial productions. During the period of 1981-83 around 25 solar water heater systems were installed in industries like textile, dairy, bakery, brewery etc. Solar Thermal Pump (STP) was also developed jointly by Bharat Heavy Electricals Limited (BHEL) and Dornier Systems (Planning Commission, 1983).
D. *National Solar Photovoltaic Energy Demonstration Program* (NASPAD) was implemented through Central Electronics Limited

(CEL). The program intended to bring down the cost per Watt peak (Wp) of modules through development and demonstration of low cost solar grade silicon material and by improving the efficiency of solar cells for electricity generation. NASPAD also supports CEL for R&D project of Multi-Crystalline Silicon Solar Cells (MSSC), and to develop Ultra-High Efficiency (UHE) solar cells (Planning Commission, 1983).

CEL was engaged in manufacturing solar PV cells and modules and it achieved a total capacity of 10.35 kW, 21.07 kW and 31.75 kW in the year 1980, 81, 82 respectively. Along with it CEL also manufactured 60 solar pumps for irrigation, drinking and water supply purposes. They manufactured Solar PV power packages for Indian Antarctica Expedition and Oil and Natural Gas Corporation (ONGC) for their offshore activities.

2.2.5 7th FYP (1985-90)

In the 7th FYP (1985-90) country saw an important development in the area of Amorphous Silicon Solar Cell (ASSC) technology. BHEL was given the responsibility to execute a plant with a capacity to manufacture of 500 kW of modules per annum and to achieve the cell efficiency of 13%-15% at laboratory level (Planning Commission, 1980).

2.2.6 8th FYP (1992-97)

In 8th FYP (1992-97) Government of India (GoI) showed the need of electrifying 10,000 villages through decentralized Solar Photovoltaic (SPV). These villages were remotely located to far-flung areas where possibility for load development was very little. The plan also laid importance on intensification and enlargement of low grade devices to meet the needs of cooking and heating in rural areas. In addition to this a central budget was approved to develop 1720 kW manufacturing capacity of Solar PV, along with solar pumps, solar lightings and solar cookers (Planning Commission, 1992).

A. *Indian Renewable Energy Development Agency* (IREDA) was formed on 11th March 1987 with an objective to operate a revolving fund for development, promotion and commercialization of New and Renewable Sources of Energy (NRSE). NSRE was financially assisted by Government of Netherland, World Bank, Asian Development Bank (ADB) and The Danish International Development Agency (DANIDA). IREDA acted as executive agency for NRSE program in coordination with state energy development agencies.

2.2.7 9th FYP (1997- 2002)

During the 9th FYP (1997- 2002) GoI encouraged private sector participation in power with an objective of mobilizing additional resources for power generation, transmission and distribution. Under this initiative, Independent Renewable Power Producers (IRPP) had the right to wheel power through existing transmission lines of State Electricity Boards (SEBs) on a payment of reasonable charge for selling the power to third party. This was done to encourage IRPPs to contribute in promotion of RES power generation and to set up power projects of any capacity and of any type (wind or solar). Greater emphasis was laid on improving the reliability and quality of power and for increasing access to electricity in rural areas (special importance was to electrify villages through decentralized energy resources) (Planning Commission, 1997).

In the year 1997 a Special Action Plan (SAP) was prepared for "Rapid Improvement of Physical Infrastructure", which included the solar PV programs. These programs were promoted in areas covered under Special Area Development (SAD)[8], Hill Areas Development Programme (HADP) and Western Ghats Development Programme (WGDP). (Planning Commission, 1997)

This plan also witnessed the successful technological development of solar photovoltaic cells under the program called "Programme Aimed at Technological Self Reliance" (PATSER) promoted by Department of Scientific and Industrial Research (DSIR) (Planning Commission, 2002-2007). PASTER aimed to support the industries through development and demonstration various indigenous technologies.

2.2.8 10th FYP (2002 - 2007)

During the 10th FYP (2002 - 2007) GoI planned to install a 140 MW of Integrated Solar Combined Cycle (ISCC) power plant at Mathania in Rajasthan. This project was unduly delayed due to its viability issues and availability of gas to run the hybrid plant during the periods of low radiation. (Planning Commission, 2002). Table 2-1 shows the actual install capacity installed against the planned capacity.

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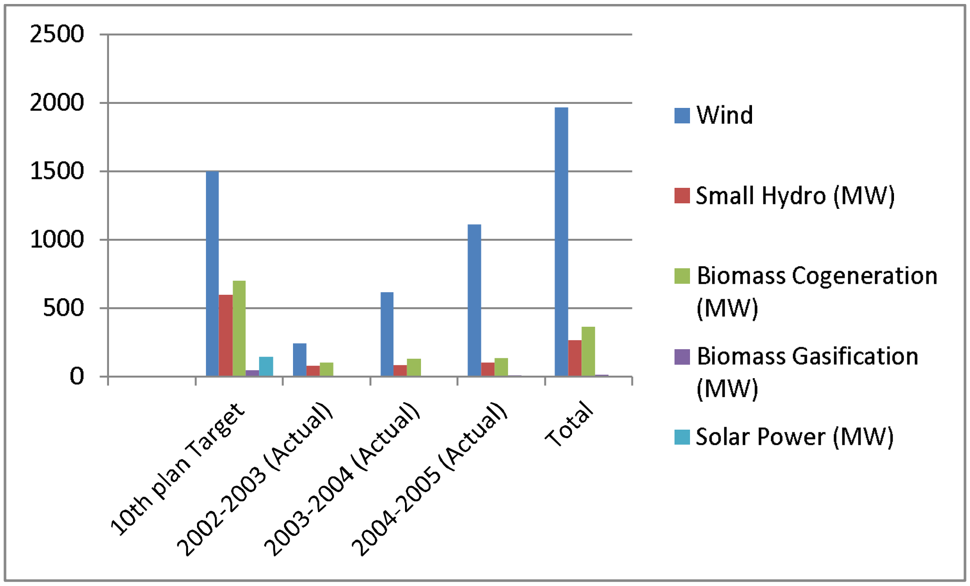
[8] *Special Area Programmes have been formulated to deal with the special problems faced by certain areas arising out of their distinct geo-physical structure and concomitant socio-economic development. Central Government is supplementing the efforts of the State Governments in this direction through Special Central Assistance under the programmes such as*

- *Hill Area Development Programme (HADP)*
- *Western Ghats Development Programme (WGDP),*
- *North Eastern Council (NEC),*
- *Border Area Development Programme (BADP),*
- *Desert Development Programme (DDP) and*
- *Drought Prone Area Programme (DPAP)*

Table 2-1 Achievements in for 10th Five Year Plan



Source: **Planning Commission 2007**

During this period 'Village Energy Security' program was approved by GoI to promote remote village electrification. Ministry of Non-Conventional Energy Sources (MNES) executed a few pilot projects by providing the villages with pumps of 900-3000 Wp capacity for horticulture activities. The estimated cost of a solar photovoltaic pump of 1800 Wp was approximately ₹ 2.7 lakh of which 2/3rd of the cost was subsidized by MNES and in case of certain areas they were granted 90% subsidy. Similarly IREDA was responsible for providing soft loans to meet the balance of cost of pump after availing MNES subsidy (Planning Commission, 2002).

During this FYP, GoI promoted community participation (people's participation) to meet and manage the energy requirements in their villages. This ensured the participation of panchayats, local bodies, cooperatives and NGOs[9].

In an effort to electrify 4000 villages a target of 5 MW Solar PV through decentralized installations was planned. In addition to this target, people were encouraged to use solar powered lanterns, SPV pumps, SPV generators, cookers, solar water and solar air heating systems (Planning Commission, 2007).

CEL developed Ultra High Efficiency (UHE) solar cells as planned under 6th FYP and further extended their R&D on 250 micron thick silicon wafers and manufacturing of 125 mm / 150 mm pseudo square multi crystalline solar cells. This was in addition to R&D work in the area of thin film PV and cells (Planning Commission, 2007).

CEL had also set a target to achieve cumulative solar PV production capacity of 25 MW per annum and to produce 40,000 phased control modules per annum during the same plan.

During this FYP, *Council of Scientific and Industrial Research* (CSIR) was engaged for development of material technology for solar power and battery application in power sector (Planning Commission, 2007).

During this FYP, Ministry of Non-Conventional Energy Sources (MNES) renamed as Ministry of New and Renewable Energy (MNRE) in 2006.

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[9] *Barefoot Solar Engineers (an NGO) one of the organizations which was engaged in promoting community participation in the rural area. This NGO taught the semi-literate and illiterate rural people on how to harness the sun with the help of solar powered lanterns and photovoltaic systems. It also taught them on how the system works and how it could be repaired. This initiative was also dedicated to disseminate the information to others in need and to those who can benefit from the green jobs opportunities* (Barefoot College, 2012).

Table 2-2 shows the cumulative installed capacities achieved through solar power and its application by the end of 10th FYP on 31st March 2007.

Table 2-2 Potential and achievement as on 31 March 2007

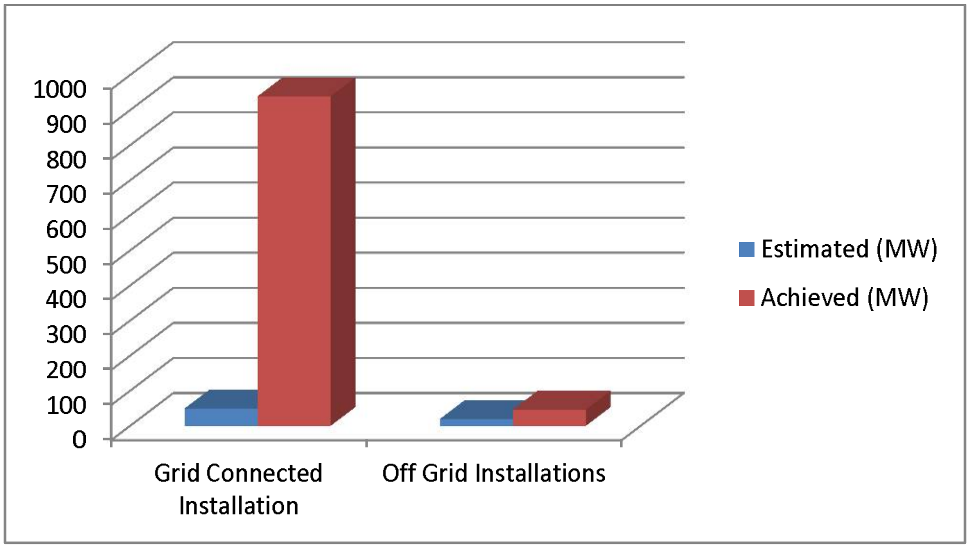
Sources		Units	Estimated Potential	Cumulative achievement
Solar Power		MW	50000	2.92
Remote village electrification		Nos	-	2821/830
Solar Photovoltaic Programme				
SPV		MW/sq km	20	-
a	**Solar street lighting systems**	Nos	-	61321
b	**Home lighting systems**	Nos	-	313859
c	**Solar laterns**	Nos	-	565658
d	**Solar Power plants**	kWp	-	1870
Solar Thermal Programme				
a	**Solar water heating system**	Million sq m collector area	140	1.9
b	**Solar Cooker**	Lakh Nos	-	6.03
c	**Solar PV pumps**	Nos	-	7068

Source: Planning Commission 2011

2.2.9 11th FYP (2007-2012)

The 11th FYP (2007-2012) suggested that solar power is an important source in attaining energy independence and help the country to reduce Green House Gases (GHG) emissions (Planning Commission, 2007). With increasing concern on Climate change and as a responsible developing country, India under the National Action Plan on Climate Change (NAPCC) launched Jawaharlal Nehru National Solar Mission (JNNSM) in January 2010. It was launched with a vision to promote solar energy in a very big way to mitigate GHG emissions and map plausible ways to secure energy security by 2022. The capacity installed by the end of 11th FYP which ended on 31st March 2012 is shown in Table 2-3. (Planning Commission, 2007)

Table 2-3 Total installed capacity through Solar PV (Grid and Off Grid connected) till 31st March 2012



2.2.10 12th FYP (2012 -2017)

The 12th FYP expresses that solar energy is extremely vital in view fact that, it is green power with minimum impact on the environment (Steering Committee, 2011). The GoI expressed the need of R&D in field of solar power to make it a success in coming decades (Planning Commission, 2011). CEL is engaged in manufacturing Dye Sensitized Solar Cells (DSSCs or Grätzel cells), which are considered as alternatives to silicon PV and Thinfilm technologies. CEL has also proposed to develop more steady design of micro-inverters for connecting to individual solar panels. CEL in addition plans to take steps to increase manufacturing capacity of solar PV from 10 MW to 80 MW per annum.

In order to cut down India's import dependence on silicon materials, CEL is setting up National Silicon Wafer production facility having a capacity to produce 1,000 MW per annum (Planning Commission, 2007).

CISR is planning to setup a new institute CSIR-Network Institute of Solar Energy (CSIR-NISE) which will focus on capacity building in the solar sector. On the other hand, Department of Science and Technology (DST) also plans setup a Solar Energy Research Initiative, under which it will support 250 doctoral level researches from different institutions. Also Department of Atomic Energy (DAE) plans for an experimental Solar Test Facility (SOTEF) (Planning Commission, 2012).

Government of India plans to change Solar Energy Centre to National Institute of Solar Energy as an independent institution for carrying out applied research, demonstration and development in the area of solar energy (Planning Commission, 2012).

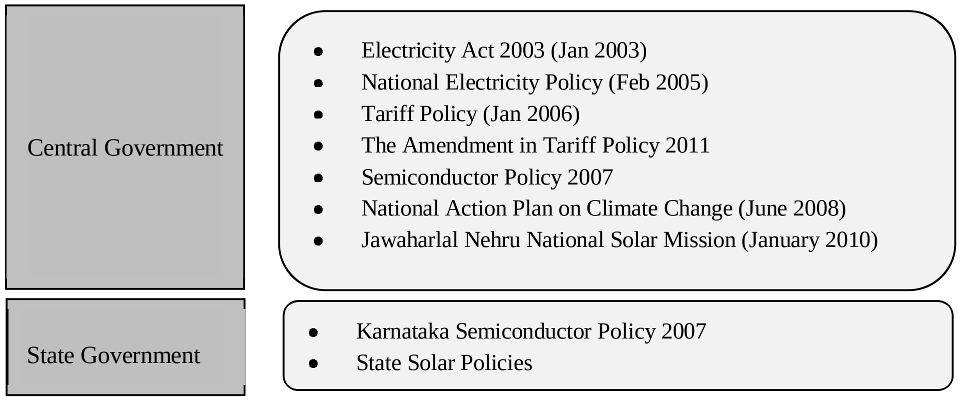
2.3 Policies and Regulations to promote Solar Energy in India

Since the year 2000, there were some major initiatives[10] taken by GoI to encourage solar energy in the country,

Figure 2-1 depicts different policies announced by central and state government to promote solar energy in the country, later on in the following sections salient features of these policies and regulations have been discussed.

[10] *Initiatives namely Electricity Act 2003, Tariff Policy 2006, its amendment in 2011, National Action Plan on Climate Change 2008, Semiconductor Policy 2007 and Karnataka Semiconductor Policy 2010, also 14 states have announced their state specific solar policies till date (2013)*

Figure 2-1 Snapshot for different initiatives by Central and State Government



2.3.1 The Electricity Act, 2003

The act mentions that cogeneration and generation of electricity from renewable sources would be promoted by State Electricity Regulatory Commissions (SERC) by providing suitable measures for connectivity with the grid, and also directs the SERC's to set Renewable Purchase Obligation (RPO) for its respective states.

It outlines several enabling provisions to accelerate the development of RE based generation (Government of India, 2003). Some of the salient features of Electricity Act 2003 are as follows

- (Section 3): (Part II) it states that "under the National Electricity Policy and Plan, Central Government in consultation with the State Government will develop policy and plans for development of power system based on renewable sources of energy and other conventional sources."
- (Section 61(h)): (Part IV) it states that "the appropriate commission shall specify the terms and conditions for

determination of tariff by Regulatory Commission which is to be guided by promotion of generation of electricity from renewable energy sources in their area of jurisdiction."

- (Section 66): (Part IV) "Appropriate Commission shall endeavor to promote the development of market (including trading) in power in such a manner as may be specified and shall be guided by National Electricity Policy in Sec 3"
- (Section 86(1) (e)): (Part X) "The State is to specify minimum Purchase Obligation from renewable sources of energy out of total consumption of energy."
- Section 86(1)(e) reads as "promote cogeneration and generation of electricity from renewable sources of energy by providing suitable measures for connectivity with the grid and sale of electricity to any person, and also specify, for purchase of electricity from such sources, a percentage of the total consumption of electricity in the area of a distribution licensee"

As per Regulation 10 of RE Tariff Regulation, 2012 issued by Central Electricity Regulation Commission (CERC) defines the Tariff design, which ensures an assured return with full cost recovery during debt repayment period for the developer. The tariff period for Solar, will be up to the useful life of the plant which is 25 years.

- Tariff Structure defined as the Single part tariff[11] consisting of the following components:

  (a) Return on equity;

[11] *The single-part tariff for a station was calculated so as to cover both the fixed cost as well as the variable (energy) cost at a certain (normative) generation level.* (CERC, 2014)

(b) Interest on loan capital;
(c) Depreciation;
(d) Interest on working capital;
(e) Operation and maintenance expenses;

2.3.2 National Electricity Policy 2005

Specify that, share of electricity from renewable sources would need to be increased progressively, purchase for distribution companies will rely on competitive bidding basis. Commission needs to determine an appropriate differential tariff to promote these technologies, as they will take some time to compete with conventional sources on basis prices.

2.3.3 Tariff Policy 2006

Central Government of India notified the Tariff Policy on 6th January 2006 in accordance with Section 3 of Electricity Act 2003, it provides that appropriate Commission (State Electricity Regulatory Commission) shall fix Renewable Purchase Obligation (RPO) and shall also fix the technology specific tariff for renewable sources of energy (Ministry of Power, 2006). Initially the appropriate Commission is to fix preferential tariffs for distribution utility to procure RE, in future, distribution utility to procure RE through competitive bidding within suppliers offering same type of RE. In long-term, RE technologies are expected to compete with all other sources in terms of cost.

2.3.4 The Amendment in Tariff Policy 2011

The Amendment (PIB, 2011) dated 20.01.2011 was made to the Tariff Policy 2006 which stipulates the followings

- SERCs shall fix separate RPO for purchase of energy by Obligated Entities from solar energy source
- Solar RPO to go up to 0.25% by the end of 2012-13 and further up to 3% by 2022
- Purchase of energy from non-conventional sources of energy to take place more or less in same proportion across different States
- Renewable Energy Certificate (REC) Mechanism may be one of the mechanisms to achieve such target

2.3.5 Semiconductor Policy 2007

This policy was announced by Government of India in 2007 in order to draw investments in semiconductor manufacturing sector. The policy provided special incentives for manufacturing semiconductors, solar cells and photovoltaic (Government of India, 2007).

2.3.6 National Action Plan on Climate Change (NAPCC) – 2008

It earmarks the National level target for RE Purchase from 5% of total grid purchase in 2010 to 15% by 2020 by increasing by 1% each year for 10 years (Government of India, 2008). Different SERCs of respective states may set higher target independently. It also authorizes appropriate authorities to issue certificates that procure RE in excess of national standard, which may be tradable, to enable utilities falling short to meet their RPO.

2.3.7 Jawaharlal Nehru National Solar Mission (JNNSM) 2010

The Mission has set an ambitious target of deploying 22,000 MW of grid connected solar power by 2022. It is aims at reducing the cost of solar power generation in the country through long term policy, large scale deployment goals, aggressive R&D, domestic production of critical raw materials, components and products with a vision to achieve grid parity by 2022.

The objective of JNNSM is to establish India as a global leader in solar energy, by creating the policy conditions for its diffusion across the country as quickly as possible. The Figure 2-2 shows the objectives of JNNSM through a snapshot.

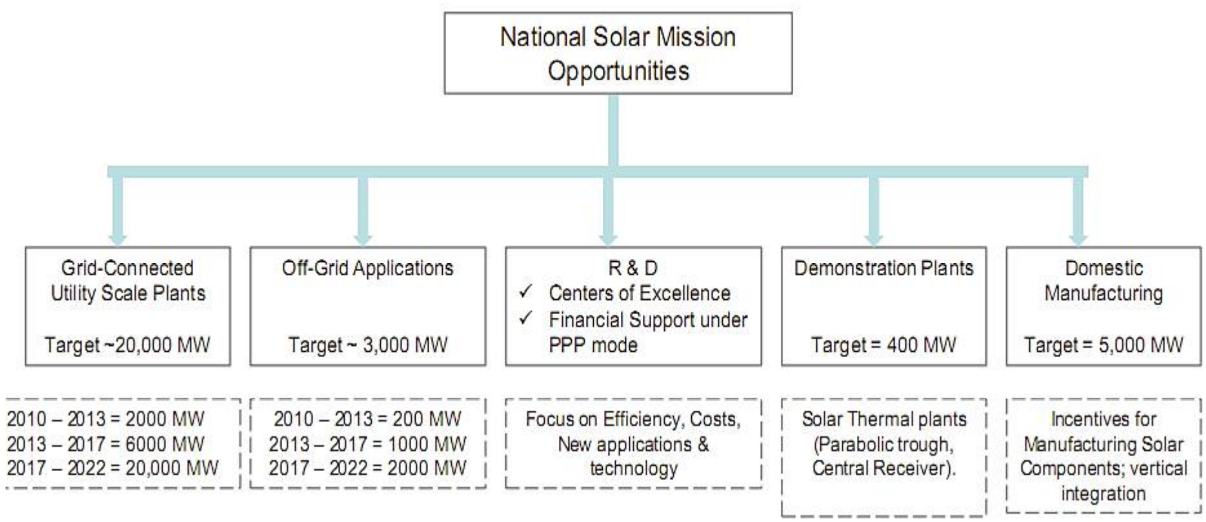


Figure 2-2 Snapshot of the objectives of JNNSM 2010

Ministry of New and Renewable Energy (MNRE) has introduced a mechanism named Renewable Purchase Obligation for each state as per the EA 2003 in which it has asked each state to set itself a minimum obligation for purchase of energy from RES and specifically from solar energy. Annexure 1 shows the States with their respective Solar Purchase Obligations in India

2.3.8 State specific Policies

2.3.8.1 Karnataka Semiconductor policy 2010

Government of Karnataka took an early mover advantage to become the first state to announce its semiconductor policy to encourage solar energy sector. The State government focused on entire value chain of solar energy, as it provided enabling policy to attract investments in manufacturing of Solar PV cell, Assembly-Test-Mark-Pack plant (ATMP) and Wafer production facility. Under the central policy for semiconductor, Andhra Pradesh and Tamil Nadu were having maximum investments because they provided additional incentives and subsidies to entice the firms, till Karnataka became a hub for production of solar products such as solar water heating systems, solar PV modules and various components required by sector, when it introduced its own state specific policy. The Semiconductor policy was supported by Karnataka Renewable Energy Policy which aimed at providing support and assistance to Solar PV manufacturing units in State (Karnataka Semiconductor Policy, 2010).

Karnataka Power Corporation (KPC) along with Karnataka Renewable Energy Development Limited[12] (KRDEL) plans to develop Solar Farms on Joint Venture / PPP mode in identified districts of Bijapur, Gulbarga, Raichur and Bellary. The State also visions to electrify schools with solar power through Education policy. The government further plans to create a

[12] *KREDL is the nodal agency for promoting the RES in the state*

core group for activities related to liaising with stakeholders to promote the sector in State.

2.3.8.2 State Solar Policies

In an effort to promote solar energy, some States took a positive step and announced their State specific solar policy. Gujarat was among the first State to announce its policy in 2009 and this initiative helped it to take a first mover advantage. The policy provided supporting and enabling investment environment for investors. Till December 2013, some 14 states have declared their solar policy. Table 2-4, 2-5, 2-6, 2-7 discusses all 14 policies under certain parameters, these are:

- Policy name
- Operative period for policy for which it will remain into power
- Capacity planned to be installed during that period of operation
- Tariff announced by the respective SERC's
- Category of the project under which power plants will be installed
- Current installed capacity of the State
- Off-taker for power produced or the agency to sign Power Purchase Agreement (PPA) with generator.
- Nodal agency in the State
- Incentives provided to the generator and
- Measured radiation for the respective states.

After GoI declared JNNSM in the year 2010, Karnataka and Rajasthan came up with their Solar policy in 2011, likewise Andhra Pradesh, Chattisgarh, Madhya Pradesh, Punjab and Tamil Nadu announced their solar policy in 2012 followed by Jammu and Kashmir, Jharkhand, Uttar

Pradesh and Uttrakhand who have released their policy in the year 2013. Currently Kerela and Odisha are waiting for approval on the draft solar policy which not finalized till the time this study was conducted.

Table 2-4 Comparison of State Solar Policies

S.No		Andra Pradesh	Chhattisgarh	Gujarat	Jammu and Kashmir
1	**Policy Name**	Andhra Pradesh Solar Policy 2012	Chhattisgarh State Solar Policy 2012	Solar Power Policy 2009	Jammu and Kashmir Solar Energy Policy 2013
2	**Operative Period**	2012-2017	2012-2017	2009-2014	2013-till further notification
3	**Capacity Planned**	No official Declaration	1000	500	No official Declaration
4	**Tariff (Rs/kWh)**	17.91 (w/o AD) 2011 -2012	9.16 (January 2013)	15.00 (first 12 years)	To be declared by J&K SERC
	Without Accelerated Depreciation (w/o AD)	14.95 (with AD) 2011 -2012		5.00 (13th to 25th year)	
	With Accelerated Depreciation (with AD)			**For MW Scale Plants:**	
				FY 2014-15: 8.97 (W/o AD), 8.03 (With AD)	
				FY 2012-13 (Jan-Mar): 10.37 (W/o AD), 09.28 (With AD),	
				FY 2013-14: 9.64 (W/o AD), 8.63 (With AD),	
5	**Category / Types of Projects**	Category 1 - Competitive Bidding	Category 1 - Competitive Bidding	Category 1 - Competitive bidding	NA
		Category 2 - Captive /Open Access	Category 2 - Open Access	Category 1 - Feed in Tariff	
		Category 3 - REC	Category 3 - REC	Category 2 - Open Access	
		Category 4 - JnNSM			
6	**Current Installed Capacity (MW)**	23.15	4	865	-
7	**Off Taker**	APDISCOM	CSPDCL	GUVNL	PDD
8	**Radiation kWh/m2/day**	5.5-6	4.5-5.5	6.5-7	4.5-7.5
9	**Nodal Agency**	NREDCAP	CREDA	GEDA	JAKEDA, LREDA, KREDA
10	**Other Incentives**	100% Energy Banking	Conditional Energy Banking	Exemption from Demand cut upto 50%	
		Electricity Duty Exemption	Electricity Duty Exemption	Electricity Duty Exemption	
		No Wheeling & Transmission charges	VAT, Stamp Duty, Land Registration, Interest	Cross subsidy surcharge not applicable	
		VAT, Stamp Duty, Land Registration refund			
		Exemption of Cross Subsidy Surcharge			

Table 2-5 Comparison of State Solar Policies

S.No		Jharkhand	Karnataka	Kerala	Madya Pradesh	Orissa
1	**Policy Name**	Jharkhand Solar Policy 2013	Karnataka Solar Policy 2011	Kerala Solar Power Policy 2013 Draft	Madya Pradesh Solar Policy 2012	Odisha Solar Policy 2013-Draft
2	**Operative Period**	2013-2018	2011-2016	2013-2017	2012-2017	2013-2017
3	**Capacity Planned**	500MW - 2017	350MW	500MW	No official Declaration	No official Annoucement
		1000MW - 2022		1500MW - 2030		
4	**Tariff (Rs/kWh)**	17.96 (w/o AD) 2010	8.40 (2013-2018)	17.91 (w/oAD)	10.70 - upto 2MW (2012-2014)	17.80 (w/o AD) (2012-13)
	Without Accelerated Depreciation (w/o AD)	14.98 (with AD) 2010		14.95 (with AD)	10.44 - above 2MW (2012-2014)	14.77 (with AD) (2012-13)
	With Accelerated Depreciation (with AD)					
5	**Category / Types of Projects**	Category 1 - Competitive Bidding	Category 1 - Competitive Bidding (200MW	Category 1 - Rooftop	Category 1 - Competitive Bidding	Category 1 - Competitive Bidding
		Category 2 - Captive /Open Access	Category 2 - Captive /Open Access		Category 2 - Captive /Open Access	Category 2 - Captive / OA / IPP
		Category 3 - REC	Category 3 - REC (100MW)		Category 3 - REC	Category 3 - REC
		Category 4 - JnNSM	Category 4 - Bunddling Scheme (50MW)		Category 4 - JnNSM	
6	**Current Installed Capacity (MW)**	16	14	0.025	11.25	13
7	**Off Taker**	JSEB	ESCOM	KSEB	MP Discom/ MP Power Management Co Ltd.	GRIDCO
8	**Radiation kWh/m2/day**	4.5-5.5	5.5-6.5		5.5	5.4-5.6
9	**Nodal Agency**	JREDA	KREDL	ANERT	Office of Commissioner New & Renewable Energy. MP	OREDA
10	**Other Incentives**	100% Banking		Conditional Electricity Banking	50% exemption on Stamp Duty	Electricity Duty Exemption
					10 years Electricity Duty & Cess charges exemption from COD	
					100% Electricity banking	
					VAT, Entry tax Exemption	
					Wheeling charge exemption - 4% grant in terms of energy injected	

Table 2-6 Comparison of State Solar Policies

S.No		Punjab	Rajasthan	Tamil Nadu
1	**Policy Name**	New & Renewable Sources of Energy Policy 2012	Rajasthan Solar Energy Policy 2011	Tamil Nadu Solar Energy Policy 2013
2	**Operative Period**	2012 - 2017	2011-Till further annoucement	2012-2015
3	**Capacity Planned**	200	200 MW- Phase 1 (upto 2013)	1000MW - 2013
			400 MW -Phase 2 (upto 2017)	1000MW - 2014
				1000MW - 2015
4	**Tariff (Rs/kWh)**	10.39 (w/o AD) (2012-16)	10.45 (w/o AD)	18.45 (w/o AD)
	Without Accelerated Depreciation (w/o AD)	9.35 (With AD) (2012-16)	9.63 (with AD for Plant comissioned by 31 Mar 2014)	14.34 (with AD)
	With Accelerated Depreciation (with AD)			
5	**Category / Types of Projects**	Category 1 - Competitive Bidding	Category 1 - Competitive Bidding	Category 1 - Competitive Bidding
		Category 2 - Captive /Open Access	Category 2 - Captive /Open Access	Category 2 - REC
		Category 3 - REC	Category 3 - REC	
		Category 4 - JnNSM	Category 4 - JnNSM	
		Category 5 - RPSSGP	Category 5 - RPSSGP	
6	**Current Installed Capacity (MW)**	9.5	443	17
7	**Off Taker**	PSPCL / DL	Rajastan Discom	TANGEDCO
8	**Radiation kWh/m2/day**	4.5-6.5	6.5-7	5.6-6.0
9	**Nodal Agency**	PEDA	RREC	TEDA
10	**Other Incentives**	Conditional Energy Banking	Eligible for incentives under Industrial policy	Electricity Duty Exemption for 5 years from COD
		Electricity Duty Exemption	Electricity Duty Exemption	50% Stamp Duty exemption on Government Industrial Parks
		VAT, Octroi, Stamp Duty, Land Registration, Entry Tax Exemption		Tax concession as per Industrial policy of Tamil Nadu
				Exemption from Demand Cut

Table 2-7 Comparison of State Solar Policies

S.No		Punjab	Rajasthan	Tamil Nadu	Uttrakhand	Uttar Pradesh
1	**Policy Name**	New & Renewable Sources of Energy Policy 2012	Rajasthan Solar Energy Policy 2011	Tamil Nadu Solar Energy Policy 2013	Solar Energy Policy of Uttrakhand 2013	Uttar Pradesh Solar Power Policy 2013
2	**Operative Period**	2012 - 2017	2011-Till further annoucement	2012-2015	2013-Till further notification	2013-2017
3	**Capacity Planned**	200	200 MW- Phase 1 (upto 2013)	1000MW - 2013	500MW - 2017	500MW -2017
			400 MW -Phase 2 (upto 2017)	1000MW - 2014		
				1000MW - 2015		
4	**Tariff (Rs/kWh)**	10.39 (w/o AD) (2012-16)	10.45 (w/o AD)	18.45 (w/o AD)	11.10 (w/o AD) (2013)	NA
	Without Accelerated Depreciation (w/o AD)	9.35 (With AD) (2012-16)	9.63 (with AD for Plant comissioned by 31 Mar 2014)	14.34 (with AD)	10.15 (with AD) (2013)	
	With Accelerated Depreciation (with AD)					
5	**Category / Types of Projects**	Category 1 - Competitive Bidding	Category 1 - Competitive Bidding	Category 1 - Competitive Bidding	Category 1 - Competitive Bidding	Category 1 - Competitive bidding
		Category 2 - Captive /Open Access	Category 2 - Captive /Open Access	Category 2 - REC	Category 2 - Captive on private Land	Category 2 - Captive / OA
		Category 3 - REC	Category 3 - REC		Category 3 - Captive on Government Land	
		Category 4 - JnNSM	Category 4 - JnNSM		Category 4 - JnNSM	
		Category 5 - RPSSGP	Category 5 - RPSSGP			
6	**Current Installed Capacity (MW)**	9.5	443	17	5.05	12.375
7	**Off Taker**	PSPCL / DL	Rajastan Discom	TANGEDCO	UPCL	UPPCL
8	**Radiation kWh/m2/day**	4.5-6.5	6.5-7	5.6-6.0	4.5-5.5	4.5- 6.5
9	**Nodal Agency**	PEDA	RREC	TEDA	UREDA	UPNEDA
10	**Other Incentives**	Conditional Energy Banking	Eligible for incentives under Industrial policy	Electricity Duty Exemption for 5 years from COD	VAT, Entry Tax Exemption	
		Electricity Duty Exemption	Electricity Duty Exemption	50% Stamp Duty exemption on Government Industrial Parks		
		VAT, Octroi, Stamp Duty, Land Registration, Entry Tax Exemption		Tax concession as per Industrial policy of Tamil Nadu		

2.4 Issues to "Growth of Solar Energy"

Since independence, India had witnessed many initiatives and programs specific to solar PV which were an attempt to address energy security and simultaneously reducing carbon footprints. However the impacts of these programs were very marginal. It is apparent from the review of FYP's, government policies and regulation that grid connected solar PV in India has been actively promoted only since 2009 through solar specific policies at national and state level.

The current capacity of solar energy in India stands more than 2.21 GW (inclusive of grid and off grid installation) and largely is achieved through Solar PV (MNRE, 2014). Under the country's ambitious initiative JNNSM aims to install 22 GW of capacity by 2022 (MNRE, 2010). But this roadmap will not be easy as there are many barrier and challenges.

The following sub section tries to identify potential barriers and challenges which are hindering the growth of grid connected solar PV in different countries.

2.4.1 Barriers and Challenges

Across the World there are many issues for promotion of grid connected solar PV power plants, such as, technology barrier, infrastructure barrier, policy and regulatory challenges, land acquisition challenges etc. The aim of researcher is to find out potential barriers and challenges for grid connected solar PV across the world.

The following review focuses on variables hampering the improvements, promotion, and development of grid connected Solar PV in different countries. Through this review, researcher found many variables (barriers and challenges) of diverse nature. These variables were holistically classified as economic, cultural, political, governmental, technological, social, institutional, financial and infrastructural, and have been found to be chronic in nature across countries. Some of these variables need to be assessed in India as per its demographics and market.

The following sub section(s) summarizes the identified barriers and challenges into different categories such as Technical barriers, Policy barriers, Socio-economic challenges and Institutional challenges.

2.4.1.1 Technical Barriers

The technology is itself surrounded by many technical uncertainties. Technology and system risk are perceived to be very high during the transition of technologies from pre-commercial phase to supported commercial phase (Foxon, 2005). Mezher (2012) mentions that, risk related to the technology performance is a serious constraint in development of RE. The level of technological maturity has been quite low (Ghosh, Shukla, Garg, & Ramana, 2002; Sharma M. P., 1994) because of which the efficiency of crystalline silicon has also been one of the technical concerns (Timilsina, Kurdgelashvili, & Narbel, 2012; Gandhi, 1995).

The Balance of System (BoS) faces performance related issues, as a result of which the overall efficiency of system is affected (Timilsina, Kurdgelashvili, & Narbel, 2012). Solar energy being intermittent in nature, becomes quite difficult for solar PV to generate continuous power (Sovacool, 2009; Martin & Rice, 2012; World Bank, 2010) and in order to have continuous operations, solar PV systems requires a mechanism which delivers continuous power to the grid, resulting in an increase of overall cost of power generating system (Ghosh, Shukla, Garg, & Ramana, 2002; Martin & Rice, 2012). As discussed above, solar being an intermittent source of energy, it requires storage which is again bounded by many challenges (Rio & Unruh, 2007).

Few other things such as inadequacy of information on and reliability, of data available on DNI (Chhabara, 2009) have always been a matter for debate for many stakeholders. Due to some of these concerns it becomes difficult for grid connected solar PV to be competitive with other established sources of energy. A few countries have also faced problems regarding to the exchange of knowledge for development of technology. Al-Badi (2009) states that, countries like Oman faced difficulty in technology transfer for the development of solar energy in that region.

The availability of silicon for manufacturing the solar PV cells would be another challenge in near future as its demand increases. The resource curse of raw silicon in some countries makes them more vulnerable towards import dependency (Timilsina, Kurdgelashvili, & Narbel, 2012).

The table 2-8 list the probable Technical Barriers for development of grid connected solar PV.

Table 2-8 Identified list of probable Technical barriers for grid connected Solar PV through literature review

Technical Barrier	Variables	Inference
Technology	Intermittency of source (World Bank, 2010)	
	Storage issues (Martin & Rice, 2012)	
	Low efficiency (Effendi & Courvisanos, 2012)	There is low level of technological maturity Performance risk is associated with the technology. Availability of parts and ancillaries
	System and Technology risk (Foxon, 2005)	
	Diffusion of foreign technology	

	(Mezher, Dawelbait, & Abbas, 2012)	
	Design and ease of operation (Gandhi, 1995)	
GHI / DNI	Lack of reliable of data (Kinab & Elkhoury, 2012) (Oikonomou, Kiliasb, Goumas, & Rigopoulos, 2009)	
	Lack of accurate data (Al-Badi A. H., 2009)	
Infrastructure deficiencies	Evacuation system (World Bank, 2010)	Remote area grid connectivity
	Non up gradation of substation (Martin & Rice, 2012)	Interconnectivity issues
	Road, water supply issues (Rao & Sastri, 1987)	
	Limited rooftop area and building integration (Timilsina, Kurdgelashvili, & Narbel, 2012)	

2.4.1.2 Policy and Regulatory Barriers

For an effective growth of solar PV sector, it requires efficient policies and regulatory environment. Lack in clarity of policies and regulations can adversely affect the long term development plans of a country. Investors will show reluctance and uncertainty, if they perceive risk in the sector. Moreover, it could be assured through strong and attractive policies for development of market.

A report by EPIA (2012) states that, under right policy conditions the competitiveness of PV can prosper in electricity sector. Though, solar PV technology has shown remarkable progress in reduction of cost it is still in developing stage. It needs the support of enabling policies to prosper to become one of the main sources of energy (IDFC, 2011).

In many countries, solar energy sector is in its developing and learning stages. These countries lack policy measures to promote solar PV technology (Oikonomou, Kiliasb, Goumas, & Rigopoulos, 2009). It is further learnt that countries like Greece, UAE, Hong Kong and Pakistan lack the national policy for development, promotion and installation of solar PV technology (Oikonomou, Kiliasb, Goumas, & Rigopoulos, 2009; Mezher, Dawelbait, & Abbas, 2012; Zhang, Shen, & Chan, 2012; Bhutto, Bazmi, & Zahedi, 2012).

These countries also have weak governance, which lack strong policy guidelines to provide incentives, making it more difficult for solar PV to prosper (Al-Badi A. H., 2009; Al-Badi, Malik, & Gastli, 2011; Martin & Rice, 2012; Mondal & Hossain, 2010; World Bank, 2010).

The growth of solar PV energy faces tough challenge from conventional energy sources, such as fossil fuels, which are supported by policies to subsidize them directly or indirectly (Al-Badi A. H., 2009; Ghosh, Shukla, Garg, & Ramana, 2002; Martin & Rice, 2012; Surendra, Khanal, Shrestha, & Lamsal, 2011).

Studies also showcase that, lack of regulatory framework and absence of defined roles of regulatory authorities hinders the growth of grid connected solar PV (Kinab & Elkhoury, 2012). The lack of effective legal agendas can pose a serious regulatory risk for growth of solar PV sector (Foxon, 2005; Ghosh, Shukla, Garg, & Ramana, 2002; Timilsina, Kurdgelashvili, & Narbel, 2012).

The table 2-9 list the probable Policy and Regulatory barriers for grid connected solar PV identified through literature review.

Table 2-9 Identified list of probable Policy and Regulatory barriers for grid connected Solar PV through literature review

Policy and Regulatory Barriers	Variables	Inference
Policy	Issues in clarity of policy (World Bank, 2010)	There are policy uncertainty among the stakeholders Issues in clarity of installation plan policy
	Absence or inadequate specific policy and legal support framework for promotion of the technology (Mezher, Dawelbait, & Abbas, 2012)	Lack of country assistance strategies Lack of suitable support mechanism can the causes of it
	Lack of financial incentives (Oikonomou, Kiliasb, Goumas, & Rigopoulos, 2009)	Lack of appropriate financial intermediaries and incentives for small scale decentralized energy services
	Policy for market creation, capital grants (Nalan, Murat, & Nuri, 2009)	
	Lack of strong implementation / enforcement of policies (Ahn & Graczyk, 2012)	
	Water allocation issues, Land allocation issues (World Bank, 2010)	
	Lack of adequate financial incentive mechanism (Oikonomou, Kiliasb, Goumas, & Rigopoulos, 2009) (Martin & Rice, 2012) (Al-Badi, Malik, & Gastli, 2011)	Issues and access to funds and subsidies by the government
	Easy access to cheap fossil fuels (Effendi & Courvisanos, 2012)	Direct and indirect subsidies to competing fuels/ conventional fuels
Regulatory	Capital cost benchmarking by the regulator (World Bank, 2010)	
	Utility interconnection issues (Mezher, Dawelbait, & Abbas, 2012)	Issue in integrated power sector reforms
	Lack of effective laws and regulation for power generation (Foxon, 2005)	Adequate legal guidelines for independent power producers
	Regulation for strong enforcement of guidelines (Yusoff & Kardooni, 2012)	

2.4.1.3 Socio-Economic Challenges

The Socio-Economic challenges have a strong impact on the development of solar PV, as it leads to less adoption and acceptance of technology. It's a fact that, technology requires huge investments which cannot be supported through sovereign funds alone. Hence, there is a need for private investment, which can be assured through incentives for the investor to invest in technology. There are concerns on availability of affordable credit from the market, as technology is not matured, it becomes difficult to win the trust different stakeholders.

RET's have shown a notable improvement in terms of cost in last few decades. Especially solar PV has seen a declining trend in the cost, which helps solar PV technology to be competitive with other sources of power generation (Solar-Worx, 2011). Due to the continuous efforts in R&D there has been a significant reduction in cost of solar PV at World level, but still high capital cost and massive investment is one of the toughest challenges faced by many stakeholders in this sector (Foxon, 2005; Ghosh, Shukla, Garg, & Ramana, 2002; Kinab & Elkhoury, 2012; Martin & Rice, 2012; Surendra, Khanal, Shrestha, & Lamsal, 2011; World Bank, 2010; Mezher, Dawelbait, & Abbas, 2012; Bhutto, Bazmi, & Zahedi, 2012; Nalan, Murat, & Nuri, 2009; Timilsina, Kurdgelashvili, & Narbel, 2012). Many governments, developers, and other stakeholders across the globe face similar issues to arrange finance for grid connected Solar PV (Ahn & Graczyk, 2012; Byrnes, Brown, Foster, & Wagner; Nalan, Murat, & Nuri, 2009).

Solar being intermittent in nature, as an effect of which, the storage and back-up facility of energy increases the cost of solar PV system due to which the payback period for developer increases (Gandhi, 1995; Ghosh, Shukla, Garg, & Ramana, 2002; Nalan, Murat, & Nuri, 2009; Timilsina, Kurdgelashvili, & Narbel, 2012; Zhang, Shen, & Chan, 2012).

In case of RETs the cost of technology from demonstration phase to its commercialization phase is very high (Ghosh, Shukla, Garg, & Ramana, 2002; Mezher, Dawelbait, & Abbas, 2012). Foxon (2005) states that UK is one of those countries which has relatively frail industry network for RE. Countries like India who is very keen to have indigenized capacity (Gandhi, 1995) will continue face challenges of high cost, till the time they have encouraging policies to develop the market.

There are various other challenges to weak industry networks such as existence of immature market, market insecurities and implementation challenges (Foxon, 2005; Nalan, Murat, & Nuri, 2009; Surendra, Khanal, Shrestha, & Lamsal, 2011). In absence of effective regulatory system for controlling the market, there are possibilities of increase in number of informal and unqualified manufactures of solar PV (Taele, Mokhutsoane, Hapazari, Tlali, & Senatla, 2012).

There are few challenges, when country imports solar PV and its equipment, the quality and sustainability are questionable (BTI, 2012).

The other major challenges posed are awareness among different stakeholders (like consumer, developer, financial institutes, industry, banks, academics, communities etc.) and the level of sufficiency of information on solar energy among them (Bhutto, Bazmi, & Zahedi, 2012; Nalan, Murat, & Nuri, 2009; Zhang, Shen, & Chan, 2012).

The social & economic challenge also covers issues related to land which is one of the most important infrastructure asset for development of grid connected solar PV power plants. The land requirement for a 1 MW of grid connected solar PV power plant is approximately 3-4 hectare of land (Government of Rajasthan, 2011). Some of the generic problems concerned with land are land acquisition, land access and its use (World

Bank, 2010). The land owner is not ready to share the land for development of power plants because they feel that it does not add value to it (Zhang, Shen, & Chan, 2012). Information on land is also a matter of concern, because of complex area zoning and planning by local government (Martin & Rice, 2012). As Zhang (2012) and Rao (2007) states that there are issues to acquire adequate space for installations, infrastructure support and services facilities. Hence presence of strong infrastructural support facility and policy for govern of land and water plays a vital role for encouragement of development of solar energy in a country (Rao & Sastri, 1987).

The countries which are rich in fossil fuel resources and are heavily dependent on its usage are ones who have a very strong biasness towards the use of fossil fuels (Timilsina, Kurdgelashvili, & Narbel, 2012). Much is not known about the risk associated with consumption of fossil fuels due to lack of assessment carried in this area, as result of which, it is observed that fossil fuels are maximum used in the World (Martin & Rice, 2012; Mezher, Dawelbait, & Abbas, 2012). Also there is a lack of investigation conducted on impact of fossil fuels on the environment and living beings (Oikonomou, Kiliasb, Goumas, & Rigopoulos, 2009). For such reasons there is high level of ignorance for the use of RET for a sustainable growth.

The table 2-10 list the probable Socio-Economic Challenges for grid connected solar PV identified through literature review.

Table 2-10 Identified list of probable Socio-Economic Challenges for grid connected Solar PV through literature review

Scio-Economic Challenges	Variables	Inference
Financial	High initial capital cost (Rogers, Chmutina, & Moseley, 2012) (Packer, 1979) (Kardooni & Afghah, 2012) (Byrnes, Brown, Foster, & Wagner)	
	Limited access to affordable credit (Oliver & Jackson, 1999) (Yusoff & Kardooni, 2012)	Difficulty in availing buyer's credit
	Difficulty in availing project finance (Ghosh, Shukla, Garg, & Ramana, 2002)	If project finance is available then it is at a higher interest rate. Long payback period of the project
	Difficulties related to bankability of the project related agreements (Margolis & Zuboy, 2006) (Moreira, 2003)	e.g. Bankability of Power Purchase Agreement for solar power project
	Transaction cost is high for technology commercialization (Ghosh, Shukla, Garg, & Ramana, 2002) (Beck & Martinot, 2004) (Mezher, Dawelbait, & Abbas, 2012)	Dependency on national budget. There are limited financial incentives.
	Weak industry networks (Foxon, 2005)	It raises the market insecurity
Market	Existence of informal and unqualified PV manufacturers and operators (Taele, Mokhutsoane, Hapazari, Tlali, & Senatla, 2012)	This a cause of less in number of local manufacturers
	Difficulties in technology dissemination due to inadequate market infrastructure, sales and service networks (Ghosh, Shukla, Garg, & Ramana, 2002)	Which is a cause of weak industry networks
	Challenges related to supply of silicon (Timilsina, Kurdgelashvili, & Narbel, 2012)	Many countries are dependent on imported silicon
	Lack in numbers for similar kind of projects (Timilsina, Kurdgelashvili, & Narbel, 2012)	It is because there are less number of demonstration projects and their low replication
	The fragileness of partnerships for solar development (Timilsina, Kurdgelashvili, & Narbel, 2012)	This leads to high risk perception of private investor
	Lack of community participation (Oikonomou, Kiliasb, Goumas, & Rigopoulos, 2009)	Theft and vandalism of equipment can be one of the results of it
	Issues with social and cultural attitudes (Gandhi, 1995)	There is still low social acceptance for solar technology. Local level disturbance leads to hindrance in the solar market. Lack of social policy

Awareness and Acceptability	Lack of technology awareness among different stakeholders and its benefits (Bhutto, Bazmi, & Zahedi, 2012)	
	Political instability at different levels (Margolis & Zuboy, 2006)	Conflicting political priorities can br reasons of it.
	Lack of attention by the policy makers (Zhang, Shen, & Chan, 2012)	Lack of vision among the politicians and their advisors
	Unwillingness of Power utilities to adopt innovative approaches (Boyle, 1994)	Unawareness towards the impact on environment and society by conventional source of energy Biasness towards conventional energy
	Affordability by weaker section of the society because of low income (Surendra, Khanal, Shrestha, & Lamsal, 2011)	
	Cost of storage or backup utilities is high (Nalan, Murat, & Nuri, 2009)	
Cost	Risk related to pre-investment cost (Ghosh, Shukla, Garg, & Ramana, 2002)	
	Cost of balance of system (BoS) are somewhat saturated (Timilsina, Kurdgelashvili, & Narbel, 2012)	
	Exclusion of environment externalities in cost of generation of electricity from fossil fuel (Mezher, Dawelbait, & Abbas, 2012) (Ghosh, Shukla, Garg, & Ramana, 2002)	Lack of fuel risk assessment by respective agencies Comparison of cheap fossil fuel to free renewable fuel on base of technology cost
	Preference towards centralized source of energy generation (Oliver & Jackson, 1999)	
	Import tariff (Nalan, Murat, & Nuri, 2009) (Ghosh, Shukla, Garg, & Ramana, 2002)	Trade barriers impose high import duties
Land	Lack of land availability (Rao & Sastri, 1987)	Continuous land for large solar projects. Contour of land
	Non availability of adequate data on land title/ ownership (Oikonomou, Kiliasb, Goumas, & Rigopoulos, 2009)	Lack of data on land/ property registry
	Complex area zoning and planning by the local government (Martin & Rice, 2012)	Difficulties in acquiring land
	Lack of data on potential sites (Al-Badi A. H., 2009)	
	Ease of right (Rao & Sastri, 1987)	Access to land and its use. Right of Way & wWater (RoW),
	Reserved or protected area in proximity o projfect (Martin & Rice, 2012)	Use management of protected areas
	Inadequate installation space and service infrastructure (Zhang, Shen, & Chan, 2012)	

2.4.1.4 Institutional Challenges

Yusoff (2012)states that, both government and non-government organization play a very vital role in development and promotion of solar PV sector in a country. In India, organizations like IREDA, CASE, CEL and SAP etc. have been formed with an objective to promote solar PV, but their impact was not very substantial. A well-functioning institution can alone solve many challenges for steady growth of solar PV.

To drive the growth of a solar PV sector there is a need for skilled human resource and there is a lack of capacity building which has been a matter of concern. Some of the important skills required are technical knowledge on repair and maintenance of plant, information on installation and its operations, specialized engineering skills etc. (Al-Badi A. H., 2009; Bhutto, Bazmi, & Zahedi, 2012; Foxon, 2005; Gandhi, 1995; Martin & Rice, 2012; Mezher, Dawelbait, & Abbas, 2012; Mondal & Hossain, 2010; Nalan, Murat, & Nuri, 2009; Surendra, Khanal, Shrestha, & Lamsal, 2011; Taele, Mokhutsoane, Hapazari, Tlali, & Senatla, 2012)

Serious questions have been raised on lack of information exchanged among communities by many researchers throughout the globe (Bhutto, Bazmi, & Zahedi, 2012; Kinab & Elkhoury, 2012; Martin & Rice, 2012; Surendra, Khanal, Shrestha, & Lamsal, 2011; Timilsina, Kurdgelashvili, & Narbel, 2012; Zhang, Shen, & Chan, 2012) and on the kind of information flow among the different communities across the globe (Foxon, 2005). Mondal (2010) points out concerns on degree of knowledge dissemination among academia (universities) and industry along with the extent of gap they have among them for sharing this knowledge.

Another challenge faced by stakeholders is the amount time consumed in getting clearances on RET projects (Martin & Rice, 2012; Timilsina, Kurdgelashvili, & Narbel, 2012; World Bank, 2010; Mezher, Dawelbait, & Abbas, 2012; Mondal & Hossain, 2010; Oikonomou, Kiliasb, Goumas, & Rigopoulos, 2009). The stakeholders have also faced challenges for not having a standard format for power purchase agreements (PPA) (Mondal & Hossain, 2010), as a result of which they are not able to negotiate a bankable PPA with respective institutions (Martin & Rice, 2012; World Bank, 2010).

The acquisition of reliable and accurate data on potential sites which has high radiation potential, information on registered land and its use in case of protected areas are some of the challenges (Al-Badi A. H., 2009; Oikonomou, Kiliasb, Goumas, & Rigopoulos, 2009).

The lack of activities and facilities are also a challenging front for many countries like Oman, Nepal, and Bangladesh etc., (Al-Badi, Malik, & Gastli, 2011; Mondal & Hossain, 2010; Surendra, Khanal, Shrestha, & Lamsal, 2011).

The researcher also identified that, introduction of favorable policies by the respective governments alone cannot assist the development of solar PV energy in a country, but there is a need to establish dedicated institutions and organizations which will contribute to promotion of solar PV.

The table 2-11 list the probable Institutional Challenges for grid connected solar PV identified through literature review

Table 2-11 Identified list of probable Institutional Challenges for grid connected Solar PV through literature review

Institutional Challenges	Variable	Inference
Resource Development	Insufficient training and research institutes (Taele, Mokhutsoane, Hapazari, Tlali, & Senatla, 2012) (Gandhi, 1995) (Rogers, Chmutina, & Moseley, 2012) (Rio & Unruh, 2007)	Limited ability to train adequate number of technicians
	Lack of specialized courses on RET engineering (Surendra, Khanal, Shrestha, & Lamsal, 2011)	Insufficient expertise to specific technology Lack of information on installation and maintenance training
	Shortage of commercial and technical trained workforce (Martinot, 1999) (Byrnes, Brown, Foster, & Wagner) (Zhang, Shen, & Chan, 2012)	
Research and Development	Lack of financial support and incentives to R&D activities (Mondal & Hossain, 2010)	Limited interest towards RET R&D in country. Limited prospects in R&D
	Difficulties in RET technology exchange across borders (Surendra, Khanal, Shrestha, & Lamsal, 2011)	Lack in responsibility towards RET R&D
Information Exchange	Lack of experience and understanding among financial institutes (Yusoff & Kardooni, 2012)	Knowledge diffusion barrier among financial institutes/ banks for RET
	Lack of knowledge sharing between different stakeholders towards RET (World Bank, 2010) (Foxon, 2005)	
	Limited efforts to disseminate information/knowledge on benefits and adverse effects (Health, Environment, Economy) (Surendra, Khanal, Shrestha, & Lamsal, 2011)	Insufficient sources for information diffusion
	Limited access to information on successful projects (Surendra, Khanal, Shrestha, & Lamsal, 2011)	
Institution	Multi-tiered government approvals (Timilsina, Kurdgelashvili, & Narbel, 2012) (Martin & Rice, 2012)	Lack of information on true RET cost Complex administrative procedures Long delay in authorization Lengthy regulatory and permit approvals
	Non-standardization of technologies leading to low level of reliability (Zhang, Shen, & Chan, 2012) (Oliver & Jackson, 1999) (Yusoff & Kardooni, 2012) (Ghosh, Shukla, Garg, & Ramana, 2002)	Lack of common code or standards

	Non-functioning of agencies at local level (Al-Badi, Malik, & Gastli, 2011)	Poor management of state enterprises Lack of coordination among federal and states
	Lack of specialist/experts among decision or policy makers (Taele, Mokhutsoane, Hapazari, Tlali, & Senatla, 2012) (Yusoff & Kardooni, 2012)	
	Insufficient centers for measuring accurate radiation for a place or specific latitude and longitude (Al-Badi A. H., 2009)	

2.5 Research Gap

Development of solar PV sector in India has been visible, through different initiatives, ever since independence. Since 2009 solar saw a transition from a mere obligation to uplift society to a stronger socio-economic growth opportunity in India.

Through this review, the researcher has made an attempt to showcase the evolution of solar energy in India along with the initiatives to promote solar PV in the country. The study has tried to list out various organizations and institutions involved in promoting solar PV technology.

Further, researcher has discussed various central and state policies and regulations to promote grid connected solar PV power plants in the country.

Today, total capacity stands close to 2 GW of which more than 70% has come up in Gujarat and Rajasthan (Annexure 2).

The researcher has searched various databases to find out, why other states of the country except Gujarat and Rajasthan, were not able to find opportunities to promote grid connected solar PV in their regions.

(Though fact remains that some of the states have independent solar policies), but during the document analysis, he was not able to find any literature which answers the above.

Based on the literature reviewed, researcher has identified the following research gap, which further motivates researcher to carry out the proposed research.

- There is no list of identified barriers and challenges for grid connected solar PV in India.
- It is not clear through an extensive review that in the presence of several barriers and challenges how and why state(s) of Gujarat and Rajasthan were able to attract maximum investments in their regions.

The current research would attempt to fill the gap of absence of barriers and challenges for grid connected solar PV in India. Further it provides the answers and discussion that how and why state(s) of Gujarat and Rajasthan were able to mitigate these barriers and challenges. This thesis also highlights the best practices for mitigating various barriers and challenges by keeping these States as a benchmark.

2.6 Research Questions

1. What are the various barriers and challenges that impact the growth of grid connected Solar PV installations in India?
2. What has been the role of identified barriers and challenges on the growth of grid connected Solar PV installations in State of Gujarat and Rajasthan?

2.7 Problem Statement

Since there is no significant study on identification of leading barrier and challenges to growth of grid connected solar PV power plants in India, there is need for comprehensive study to be conducted.

Furthermore, despite of having specific policy for solar energy development at National and State level, why grid connected solar PV has seen a promising installation growth only in Gujarat and Rajasthan.

2.8 Research Objectives

1. To identify various barriers and challenges that impact the growth of grid connected Solar PV installations in India.
2. To find out how the State(s) of Gujarat and Rajasthan have responded to the role of identified barriers and challenges on the growth of grid connected Solar PV installation in their respective region.

2.9 Epilogue

The present chapter discusses various scholarly work published in refereed journals and articles on solar PV energy. Review focused on the evolution of solar PV sector in India since 1950, it was found through the review that various initiatives were taken to promote solar in the country only but results have not been that significant. The chapter further discussed the policies and regulations at central and state level, through which it was learnt that currently we have in total fifteen solar specific policies to promote grid connected solar PV power plants in the country. A robust review of published literature and data was done to find out various barrier and challenges that impacted the growth of solar PV in various countries. This exercise helped researcher to develop a rich thought process and framework for the study.

In later sections chapter mentions the gap in literature found through extensive review and based on that research problem was identified, further research questions and objectives were framed.

The next chapter discusses the philosophical stand for the current study, it explains the rationale for using mixed method as research design, and furthermore it explains the methods of data collection and tools used for analysis of data and showcase the results of first objective.