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BOCR/ANP Framework to evaluate Policies for adoption of Rooftop solar PV

Dr. Amitabh Satapathy*

*Associate Professor, Xavier Institute of Management & Entrepreneurship, KINFRA, Off HMT Road, Kalamassery, Kochi 683503, Email: amitabh@xime.org, ORCID ID: 0000-0003-3152-4360

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Abstract
Despite the current fragile environmental situation prevailing across the globe, turning away from fossil fuel has been a tough challenge. Solar PV as an energy source holds key to future sustainability. The purpose of the study is to find out suitable government policies that should drive growth of rooftop solar PV through use of an improved framework, a combination of a BOCR (Benefit, Opportunity, Cost, Risk) ANP (Analytic Network Process) model.
Using thematic analysis of data collected through literature review and focus group discussion, different policies implemented across the globe were filtered down to a few important policies for further analysis. Policies identified are Feed-in-Tariff, Capital Subsidy, Net Metering, and Financing initial capital. BOCR ANP model was applied to rank the policies and suggest the most important policy that can drive the adoption of rooftop solar PV. Feed-in-tariff was identified as the most important policy.

Keywords: BOCR ANP, Rooftop Solar PV, Thematic Analysis, Policies, FIT

1 INTRODUCTION

Given the current concern about the environment and so much thrust on renewable energy, an unprecedented opportunity exists to study the better adoption of rooftop solar photovoltaic energy. The global economy depends heavily on extensive use of fossil fuel, and effect of fossil fuel on global environment and climate as well as on our health is quite well known (Tietenberg and Lewis, 2016). Owing to this, countries across the globe, whether economically developed or developing, are trying to switch from non-renewable sources of energy to renewable sources like solar and wind (Islam, 2014). Although a substantial number of countries have introduced various policies like subsidies and incentives, both at consumer and organizational levels, to foster large scale adoption of green innovations (Olson, 2014), the outcome has been far from encouraging. Evidences from various literatures indicate that in spite of financial support, the adoption rates of such solar innovations around different countries are very low (Bauner and Crago, 2013). What is surprising is that various government policies that augmented growth of solar PV in countries like Germany or Italy are not very effective in countries like India.

Despite several advantages, slow diffusion of rooftop photovoltaic solar energy continues to pose challenges to policy makers. A possible reason for slow adoption is that there is a gap between what the consumers want and what the policies address as policy decisions are made by governments, but decisions to adopt are made by consumers (Islam and Meade, 2013).

Frameworks for energy and climate policy planning are important for any country, more so for those depending heavily on fossil fuel as their economic developments are strongly connected to fossil fuel (Alizadeh, Soltanisehat, Lund, and Zamanisabzi, 2020). As one of the fastest growing major economies of the world, India can represent a highly relevant case in this context.

The objective of the study is to provide a framework to decide the best policies that would effectively address interests of all the stakeholders, most importantly consumers, government and distribution companies. An integrated approach involving a Benefit, Opportunity, Cost, & Risk (BOCR) model and the analytic network process (ANP), provides an improved framework to evaluate various policies and identify the ones that will encourage consumers to adopt rooftop solar PV. Combining both BOCR and ANP helps overcome pitfalls of each of the frameworks.

BOCR is quite a widely used framework for decision analysis using four indicators (Saaty and Ozdemir, 2003). ANP is also a comprehensive framework for analysis of social and corporate decisions, considering interdependencies (Saaty, 2004).

Quite a number of studies are carried out using MCDM framework to rank various renewable energy sources. A

study in India employed a combination of GIS and MCDM approach to identify suitable solar and wind energy sites taking into considerations technical, socio-environmental and economic factors (Saraswat, Digalwar, Yadav & Kumar, 2021). In another study in India, the researchers evaluated five renewable energy sources on six conflicting criteria, to propose the best among those using MEREC ((Method based on the Removal Effects of Criteria) integrated PIV MCDM model (Goswami, Mohanty & Behera, 2022). Using MCDM approach, researchers in India found out the best hybrid energy solution for a particular location considering key techno-economic-environmental criteria (Rajavelu & Madasamy, 2021). (Akpahou & Odoi-Yorke, 2023) used MCDM methods to prioritize five renewable energy sources; PV, CSP, bioenergy, hydropower, & wind energy for electricity generation in Benin. A similar study in Taiwan was done using MCDM methods to rank renewable energy sources (Lee & Chang, 2018). In Slovenia, MCDM approach was applied to assess different electricity generation resources (Bohanec, Trdin & Kontic, 2017). In neighboring Pakistan, a study was done to select the best renewable energy technology using MCDM framework (Amer & Daim, 2011). One more study that can be mentioned is one in Philippines to develop a method to prioritize renewable energies to enhance energy securities (Brahim, 2014).

Although quite a number of studies are carried out using MCDM framework to rank various renewable energy sources, application of the framework in choosing appropriate policies has not yet been done.

2 LITERATURE REVIEW

Literature review was done on themes Rooftop solar PV, Solar PV Policies, and MCDM Framework.

Rooftop solar PV in India

The current renewable energy capacity in India was 132 GW as on October 30, 2023 (MNRE). Share of rooftop solar PV in this was only 11 GW. This was considerably lower than the target of installing 40 GW of rooftop solar by year 2022. This lower share of rooftop solar PV is quite opposite to what can be seen in China. China installed 87 GW of new solar capacity in year 2022, share of rooftop solar PV was 55 GW (Saur Energy). Due to almost year round solar radiation and low reliability of grid power in India, rooftop solar PV should be the obvious choice for the consumers. The reality is quite different.

Review of Global Solar PV Policies

Various policies were followed in different countries around the world for faster adoption of rooftop solar PV. As per a study (Timilsina, 2012), various policy instruments that support PV in many countries, are: Feed-in-tariff (FIT), Investment tax credit or Production Tax Credit, Subsidies, Renewable energy portfolio (RPS), Financing facilitation, Public Investment, and Net metering. A research by Satapathy, Jain, & Barthwal in 2019 indicated five important factors that consumers consider while evaluating adoption of rooftop solar PV and one important factor was financial attractiveness.
The main driver for a rapid growth in solar PV is economic benefits. Net-metering or net-billing policies were not sufficient to foster growth of solar PV till grid parity was achieved (Ordonez, Sanchez, Rozas, Garcia, Dominguez, 2022). A comprehensive study across countries identified the success factors in different countries and those were ; Renewable Portfolio Standard, Incentive like PURPA 1978, Investment Tax Credit, Production Tax Credit for USA; Feed-in-tariff & Subsidy in Canada; Feed-in-tariff, Credit terms, & tax incentives in Germany; Feed-in-tariff & targets in Spain; Feed-in-tariff, Green loans and tax incentives in France; FIT and Renewable energy law in China; National Renewable Energy Policy in Pakistan; Feed-in-tariff, subsidy and targets in Australia (Solangi et al., 2011).
A research paper by European Wind Energy Association concluded that to introduce renewable energy technologies to any market, FIT mechanisms were the most suitable policies, whereas to support immature technologies, investment and tendering systems were preferred.

Although many countries provided subsidies against the initial installation cost for faster adoption of solar PV, a study in China has brought out its flaws. Subsidy against an upfront cost encourages installation of solar PV, but it does not provide any incentive to produce electricity. This sometimes results in installation of low quality PV systems and cheating the subsidy programs. Since 2013, government instead has been following a performance based incentive or Feed-in-tariff (Li, Zhang, & Davey, 2015).

Experiences from many European countries confirm the importance of financial incentives in the growth of solar PV (Spertino, Leo, & Cocina, 2013). When Spain witnessed a drop in installation of solar PV due to change in incentive policy in 2011, other countries like Greece, Israel and Turkey noticed significant increase in solar PV market due to introduction of new incentives. In all these countries including Germany and Italy, role of Feed-in tariff was extremely critical. Germany's spectacular success in solar PV can be attributed to the "Thousand roofs programme" in 90's as it demonstrated technical feasibility and sent a positive signal to the PV industry. The programme also provided an impetus for the further development of the technology (Spertino et al., 2013). Thailand has introduced feed-in tariff to support growth of sola rooftop PV (Ninsawat, Hossain, 2016). There were different FIT slabs and the slabs were: 6.96 Thai baht (THB) per KW for households producing not more than 10 kW, 6.55 THB/KWh for those generating 11 to 250 kW and 6.16 THB/KWh for 251 kW or above. The feed-in-tariff was provided for a period of 25 years.

Feed-in-tariff that became synonymous with success of Germany's successful adoption of solar PV, was equally

effective in other countries like Italy, Japan, UK and USA. Since 2010 United Kingdom witnessed its PV capacity grow rapidly due to policies like FIT and renewable obligation certificates (Asif, 2016). On the contrary, in Brazil high tax of the PV equipment and absence of any kind of incentives for solar PV electricity generation still prevented large-scale use (Campos, Manrique, Kobiski, Casagrande, & Urbanetz, 2014).

A study in Dominican Island brought into light the flaws of providing subsidy on PV installation and recommended an R&D strategy over a market push strategy for faster adoption of solar PV for rural electrification in developing countries (Ericson and Chapman, 1995; Chaurey and Kandpal, 2010).

A study in India suggested the positives of relying more on product features than subsidies (Velayudhan, 2003; Chaurey and Kandpal, 2010).
Evidences from China suggested that for faster adoption of decentralized PV technologies, it was better to develop a local free market than a donor or government subsidy driven programme (Ling, Twidell, & Boardman, 2002; Chaurey and Kandpal, 2010).

Study of solar PV markets in Nigeria reinforced the importance of fiscal and financial incentives such as tax holiday, tax-free dividend, abolition of excise duty, etc. for growth of solar PV (Oparaku, 2003; Chaurey and Kandpal, 2010]). A research on net metering in India indicated that Capital Subsidies, FIT, Tax exemption or reduction and Net Metering were some of the most effective mechanisms for promoting solar PV installations around the world. However, net metering has some major issues like grid instability and lack of preparedness of distribution sector (Gupta, Sharma, & Jashuja, 2009). Malti Goel in her paper "Solar rooftop in India: Policies, challenges and outlook" identified the key factors in growth of solar PV in countries like Germany, USA, Italy, Japan etc and those are Feed-in tariff, Tax Credit, Subsidies, Soft loans and Renewable Purchase Obligations. However, among all Fee-in tariff was found to be the most important factors in the growth of solar PV (Goel, 2016).

Authors carrying out a case study on solar PV in Taiwan suggested that at the inception phase when the new technology was about to emerge, supply of resources in the form of research, development, demonstration programs was critical to success (Huang and Wu, 2007). The existing schemes in Taiwan include demonstration, subsidy on installation cost as well as purchase of electricity and financial assistance. One more study suggested that production of electricity from solar PV was erratic in nature and so difficult to implement in the energy system (Nam, Hwangbo, & Yoo, 2020).

As demonstrated across different countries and mentioned across various studies so far, feed-in-tariff has been extensively applied to encourage adoption of renewable energy (Lu, Khan, Alvarado, Zhang, Huang, & Imran (2020).

Here's a summary of policies implemented in some of the leading countries in terms of adoption of solar PV.
Germany: Germany is the global leader in rooftop solar PV with 70% of the total installed capacity of 82 GW coming from rooftops. Growth in solar PV was generally attributed to the German Renewable Energy Sources Act known as EEG (Erneuerbare Energien Gesetz). The first EEG in year 2000 and further changes were instrumental in growth of solar PV in Germany. EEG 2000 introduced a fixed Feed in tariff to be paid to the consumers over a period of 20 years with a purchase guarantee. The act ensured the transmission system operators to purchase all the electricity generated by solar PVs. The feed in tariff that PV producers were receiving was very high leading to an annual payment of around 10 – 11 billion euros to PV electricity producers (Fraunhofer ISE, 2018). This high feed-in-tariff resulted in high growth of rooftop PV between 2008 and 2012 (MNRE, 2016). Later the feed-in-tariff was dropped from as high as 0.47 Euro per unit to 0.12 Euro per unit due to drop in cost of installation and faster growth of rooftop PV. A portion of the payment came through a renewable levy that consumers pay and the levy was around 0.06 Euro per unit (Fraunhofer ISE, 2018). From the beginning of 2012, small rooftop PVs that were newly installed reached grid parity. Post grid parity, it was not possible for PV producers to make any profit from self-consumption through the difference in EEG feed in tariff and grid price. FIT played a crucial role not only in growth of solar PV, but in bringing down the cost and achieving grid parity. In 2013 the government also supported electricity storage system as further incentive to use rooftop solar PV. Apart from this highly successful feed in tariff policy, it is worth mentioning here the 100,000 rooftop scheme started in 1999, reduction in taxes, public investment and the government tender offer for renewable energy.

USA: In USA, rooftop solar PV started back in 1978 with PURPA (Public Utility Regulatory Policies Act) to support energy alternatives. At present various federal policies are Production Tax Credit (PTC), Investment Tax Credit (ITC), Modified Accelerated Cost Recovery System Depreciation Schedule (MACRS) and DOE Loan Programme. As per PTC, tax credit equivalent to $11/MWh was provided for solar PV for the first 10 years of operation. As per ITC, 30% of the total investment could be taken as tax credit. Apart from the central level policies, various state level policies were also acting as drivers and these were Renewable Portfolio Standards (RPS), Renewable Energy Certificates (REC), Net Metering, Carbon Markets, State Tax Credits, Property Assessed Clean Energy (PACE) Programs, Property Tax Exemptions, Sales Tax Exemptions, Clean Energy Financing Program, Grants, Subsidized Loans, and On-bill financing. 29 states along with DC and 3 territories have a renewable portfolio

standard whereas 23 states and DC have RPS with solar or DG provisions (NREL, 2015).

China: With close to 400 GW of installed capacity, China has the largest installed capacity in the world. Through its five year plans, the country implemented various policy measures for the growth of renewable energy. In 2005 it introduced Renewable Energy Law (REL). In 2014 it introduced rooftop subsidy program to facilitate faster growth of solar PV and provided subsidy worth $2.4/W. Then the country launched Golden Sun Demonstration (GSD) program. Under this program support was provided depending on size of the PV system (Goel, 2016). Major policies that are in place in China are Feed in Tariff, Renewable portfolio standard, Government tendering, Tax incentives, Public investment and Energy production payments.

Japan: Growth in solar PV in Japan started in 2012 with the introduction of Feed-in-Tariff regime in July 2012. In year 2004 the country introduced a roadmap called PV2030 for achieving 100GW of PV by year 2030 (Goel, 2016). When the FIT regime was introduced, it was considered to be among the most generous in the world. The high FIT rates were coupled with long term purchase agreement. Through the participation of both large banks as well as small regional banks, financing of solar PV projects was made easy. Apart from bank loans, green rated project bonds were also introduced. Even the pension fund and insurance companies participated in financing renewable energy projects. Later in April 2017, the government has brought in amendment to its FIT regime with intention of bringing in more control, increasing competition and thus bringing cost down. Overall Japan's solar PV growth benefited a lot from its generous Feed-in-Tariff regime and also very low cost financing.

Italy: Italy was planning to install more than 30 GW of solar PV during the period 2020 to 2030. In year 2000, the country introduced net metering scheme and provided direct incentives to rooftop solar PV (Goel, 2016). The solar PV installed capacity almost tripled during the period 2010 and 2011. Much of this growth was due to the introduction of Conto Energia Feed-in-Tariff scheme in year 2005. Since its introduction in 2005, Conto Energia has undergone five modifications till year 2013. The minimum eligibility to receive the benefits were to have a system of minimum capacity 1KW, system should be grid connected and comply with a laid down technical standard. The feed-in-tariff was to be paid over a period of 20 years. Under Conto Energia 1, the feed-in-tariff was in the range of Euro 0.44 to 0.49 per Kwh. However, with subsequent amendments, the feed-in-tariff came down gradually and as per Conto Energia V that came into effect in 2012, FIT for rooftop solar PV was in the range of Euro 0.11 to 0.21 per KWh. Apart from feed-in-tariff Italy also provides tax credits as well as reduction in sales or other taxes (CaPRI).

Spain: Spain's performance in rooftop solar has been considerably lower than the other European countries like Germany or Italy. As per the regulation established under the Royal Decree (RD) 900/2015, there were two types of self-consumers (Prol and Steininger, 2017). One type of consumers was limited to less than 100 kW installed capacity are legally considered as consumers. They receive no reward for exporting any surplus electricity. The other type of consumers was legally treated as both consumer and producer. They can sell surplus electricity just like any other producer and don't receive any reward for the production coming from solar PV. Since 2016 Spain was following government tendering for renewable energy. It was also providing tax incentives.

Policy Landscape in India

India, although a slow starter, has undertaken the largest capacity expansion of renewable energy in the world with solar PV having the maximum share. Various policies, both at central and state levels were available for faster adoption of solar PV. As far as central government policies were concerned, the notable ones were Capital subsidy, tax benefits through accelerated depreciation and tax holidays, and low cost funding. The Ministry of New and Renewable Energy (MNRE) was offering subsidy up to 30% for residential and institutional consumers. So consumers can install solar PV technically at 70% of the cost. Apart from capital subsidy, tax benefits in the form of accelerated depreciation and tax holidays were being provided. Accelerated depreciation of 80% and 10 year tax holiday (MAT payable) were provided as incentives. The government also provided low cost funding through some banks. But the most important policy Feed-in-tariff that made solar PV adoption successful in so many countries, was absent in India after the state of Gujarat introduced it in 2010 and found the financial burden too difficult to handle. Since then no other state government got into this FIT scheme in India.

Several policies were enacted for faster adoption of solar PV of which Electricity Act 2003 is the most notable and a game changer. Also through its well documented 5 year plans, the government formulates plans for adoption.

ANP/BOCR Framework

Multi criteria decision making (MCDM) frameworks were widely applied in energy policy making that includes renewable energy planning and assessment of renewable energy sources (Kumar, Sah, Singh, Deng, He, Kumar & Bansal, 2017). MCDM makes use of several methods like weighted averages, weighted sums, priority setting, outranking, fuzzy theory, and also a combination of all (Alizadeh, Soltanisehat, Lund, & Zamanisabzi, 2020). It involves four primary tasks; selecting the strategic criteria, assigning weights to these criteria, evaluating the decisions, and aggregating. Each task can use different methods depending upon the context and objectives.

Complexity of decision making process increases when it involves several interrelated criteria, and uncertainties. In this paper, the author chose ANP method to evaluate various policies that have been there in different countries. The major advantage of ANP is its ability to handle dependencies among decision making criteria. The author extended the ANP framework to a hybrid one including BOCR and ANP.

The ANP is a multi-criteria decision making technique and it was introduced by Saaty(1996). Inside the network of criteria on which decision is made, ANP takes into consideration the interaction and interdependence of elements.

While using ANP framework, one major challenge is determining the criteria and sub-criteria for the problem that has not been fully investigated. Another such issue with ANP is that it's not easily comprehensible for the decision makers. Including BOCR to ANP makes it easier to understand the effect by studying the elements in cause and effect relationships. Considering the four basic elements, Benefits, Opportunities, Costs and Risks, BOCR framework offers a rich analysis of various alternatives in decision making (Wijnmalen, 2007).

3 METHODOLOGY

The objectives of this study are:

- Review of government policies in various countries through available literature.
- Find out the policies that are most suitable for India.

Rank the policies on their effectiveness

Approach: Cross-sectional Research. Qualitative and Quantitative Research

Data Collection Plan: Literature Review and Focus Group Discussion (FGD)

Data Analysis Tools: Super decisions software using BOCR ANP framework and Thematic Approach using nvivo software

3.1 Steps

1. Extensive literature review on policies for adoption of rooftop solar PV across the globe was carried out.
2. A focus group discussion was conducted involving subject matter experts to figure out a few important policies. Nvivo software was used to do a thematic analysis for identifying important policies.
3. Considering the important policies as alternatives, an ANP/BOCR framework was designed to assess the policies.

4 DATA ANALYSIS AND DISCUSSION

Data was collected from available literature and a focus group discussion.

From the literature, important renewable energy policies that are implemented in different countries around the world were found out. The policies thus found out were

- Feed in Tariff (FIT)
- Renewable Portfolio Standard (RPS)
- Capital Subsidy
- Tax Benefits
- Sharing of ownership with utilities
- Transfer of rooftop on lease
- Easy Financing
- Net Metering
- Gross Metering
- Green Electricity Scheme
- Public Investment
- Demonstration Projects
- Research & Development

A focus group discussion involving six experts from the field of solar energy was conducted. The participants have wide experience across different functional areas of solar energy in India. The author took up the role as the moderator. The potential benefits of the study were explained to gain their cooperation and establish an interpersonal relationship between the researcher and the participants. Focus group discussion guidelines were used during the study. Notes were taken and information was also recorded. The data were transcribed after the discussions and the final written report was checked with the participants.

The group tried to build its discussion on the various policies that the researcher has found out through literature review. Over the course of the discussion the group discussed the pros and cons of each policy from an Indian context. However, it became very difficult to zero in on any particular policy that should be chosen as the most suitable policy for India. Although feed-in-tariff is considered as a very important policy worldwide, the group unanimously agreed that in India offering a generous FIT was extremely difficult considering the financial health of distribution companies in almost all the states. A transcript was prepared for the entire discussion in FGD. Nvivo software was used to code the transcript (Figure 1 & Figure 2).

Figure 1: FGD Transcript Coding from Nvivo

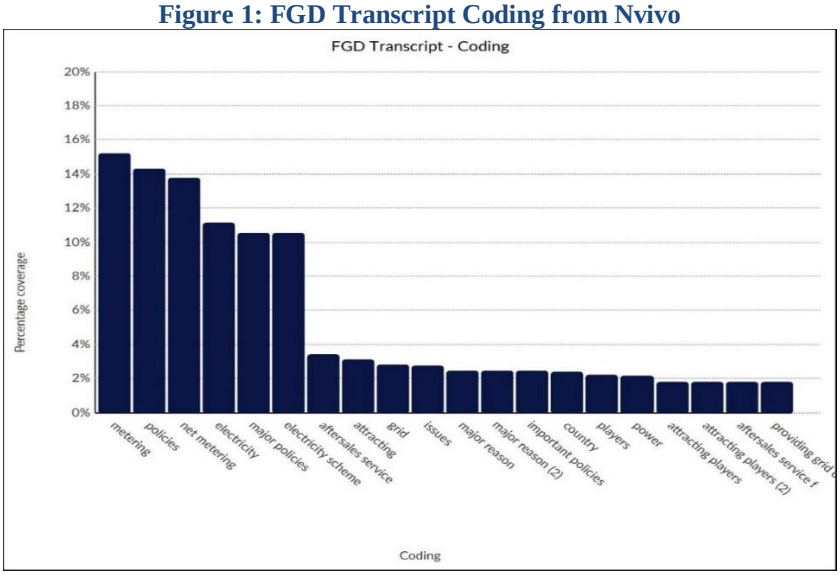


Figure 2: FGD Transcript Coding from Nvivo

A thematic analysis approach was followed to analyse the qualitative date on the transcript. While coding the transcript, four themes are identified, and those four themes are

- Facilitator of adoption, Fostering growth, Role of government, and Obstacles to adoption

A few important policies that seemed important from FGD are; i) Feed-in-tariff, ii) Net metering, iii) Capital subsidy, and iv) Easy financing

4.1 ANP BOCR Framework

The framework was applied to assess four policies that were identified to be important ones through the FGD analysis.

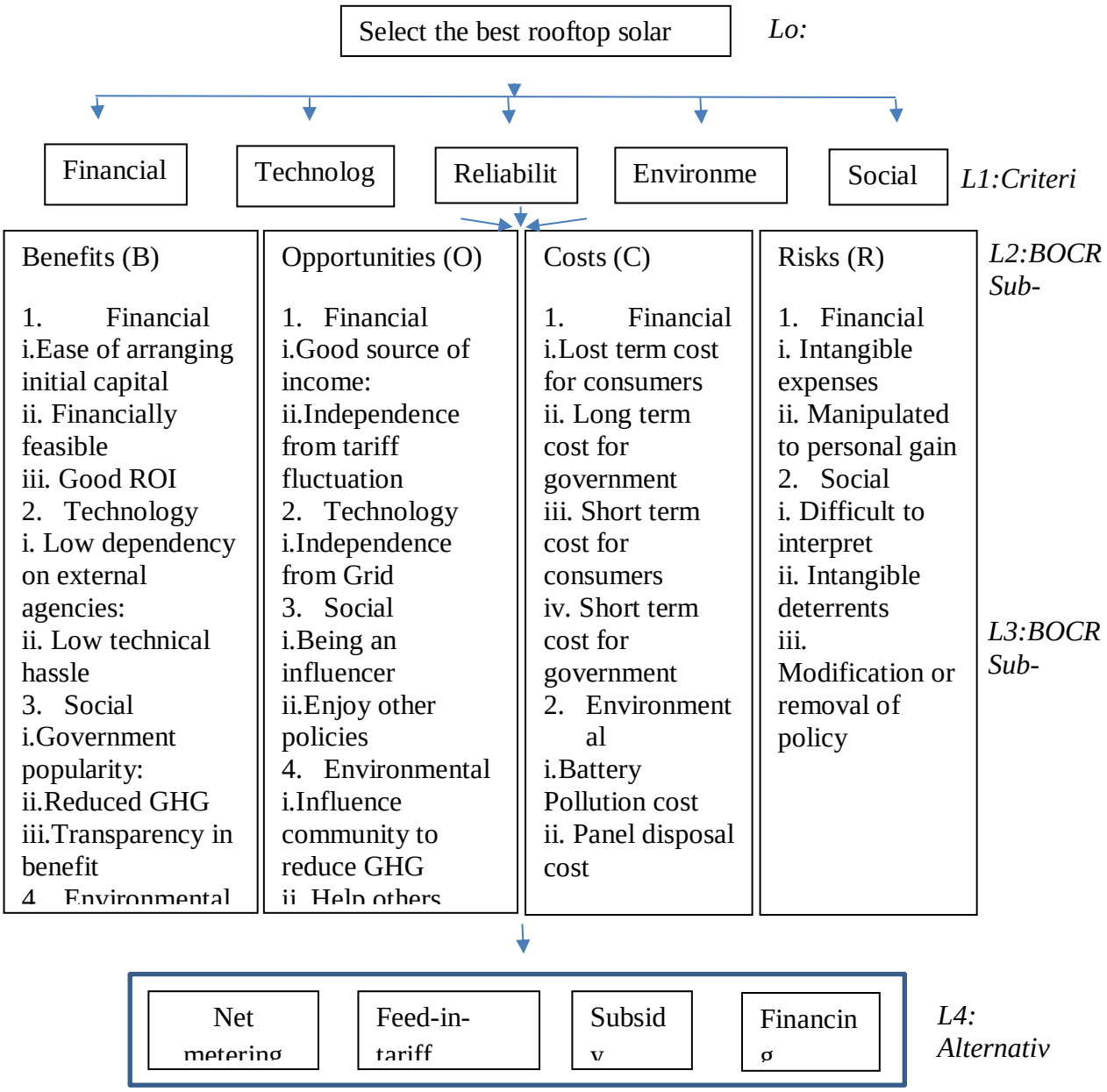
4.1.1 The process:

Step 1: Set up an expert team
Step 2: Finalize the hierarchy of the ANP framework, find out the strategic criteria and subsequent sub-criteria to evaluate various alternative policies
Step 3: Assign weight to each of the strategic criteria by applying pair wise comparison with respect to goal
Step 4: Determine the weights of BOCR through pair wise comparison with respect to strategic criteria
Step 5: Assign weights to BOCR sub-network again through pair wise comparison with respect to BOCR elements
Step 6: Assess the alternatives by synthesizing the weights of alternatives with respect to each sub-criterion.

4.1.2 The expert team

A team of four experts including the author was formed. The author has more than two decades of experience in energy sector with several research work in the area of solar PV. The other three are chosen as one from the distribution company, one from industry having vast experience in installation of solar PV, and one a director of an educational institute having experience as a user as well as academic research. The team used the software package Super Decisions to quickly implement the ANP framework.

4.1.3 The hierarchy of ANP Framework



The expert team identified five strategic criteria for Benefits, Opportunities, Costs and Risks related to various government policies. These five criteria are i) Financial, ii) Technological, iii) Reliability, iv) Environmental, and v) Social.

The first strategic criterion, Financial includes financial attractiveness for the consumers and financial feasibility for the government and distribution companies. The technological criterion includes technical feasibility for both the consumers as government. Any policy, however good it may be, if requires complicated technical requirements, will fail to yield desired outcome. Reliability of any policy is a key factor in its being effective as consumers would like the policy to remain in place for a long period and government should find it easy to sustain over years. It also includes how easy it's to interpret and implement. Environmental criterion includes the effect of the policy on both local and global environment. The effects considered are reduction in GHG and disposal of polluting material. Social criterion

considers ability of the policy to provide social approval and also diffusion through the influence.
The five such criteria chosen for BOCR represent high level factors to assess various policies that need to be evaluated.

4.1.4 Weights of strategic criteria

The expert team assigned weights to the five strategic criteria taking into consideration the importance of each criterion with respect to the goal of prioritizing various government policies for supporting growth of rooftop solar PV. The weights are determined using pair wise comparison, which is done by finding the preference of one criterion over the other criteria using Saaty's 1-9 scale. The Super Decision software (Saaty, 1996) was used to find out the inconsistency rate for each comparison matrix. Because of complexities involved in this decision-making process, the author accepted inconsistency up to 10% during pairwise comparison. If inconsistency ratio goes above that, the pairwise comparison needs to be modified.

4.1.5 Weights of BOCR

The expert team determined the weights of each element of the BOCR. Linguistic variables suggested by (Cheng, 1997) were used to compare importance of the BOCR elements. The scale such used is given in Table 2:

Table 2: Scale for BOCR elements weight

Scale item	Value
Excellent	1
Above average	0.6643
Average	0.3061
Below Average	0.1263
Poor	0.0647

Weight of each BOCR factor is calculated using the weighted average approach. To find out weight of each factor, the value of each factor corresponding to the strategic criterion should be multiplied with the weight of the strategic criteria and summed up for all the strategic criteria. The weights thus calculated are given in Table 3.

Table 3: Weights of BOCR elements

			0.412	0.079	0.203	0.075	0.231
	Total	Priorities	Fin.	Env.	Rel.	Social	Tech.
1.Benefits	0.776	0.401	1	0.664	0.664	0.306	0.664
2.Opportunities	0.609	0.315	0.664	0.306	0.664	0.306	0.664
3.Costs	0.348	0.180	0.664	0.126	0.126	0.126	0.126
4.Risks	0.200	0.104	0.306	0.126	0.126	0.126	0.126

4.1.6 Weights of BOCR sub-network

The same pair wise comparison using Super Decisions software was done by the expert team to find out the weights of BOCR sub-network. The summary of BOCR with sun-network weights are provided in Table 4.

Table 4: BOCR sub-network weights Summary

Total (100%)	B (40.1%)	O (31.5%)	C (18.0%)	R (10.4%)
Financial	51.4%	53.4%	75%	83.3%
Technical	18.5%	19.7%	25%	0
Environmental	22.6%	18.6%	0	0
Social	7.5%	8.3%	0	16.7%

4.1.7 Prioritization of alternatives

Finally, effectiveness of each policy was determined. There are 27 factors in BOCR sub-network. Pair wise comparison of these factors with respect to four alternative policies were made using again super decision software. Feed-in-tariff was found to be the most effective policy for growth in adoption of rooftop solar PV. Overall ranking of the four alternatives are summarized in Table 5.

Table 5: Overall Ranking of alternatives

Graphic	Alternatives	Total	Normal	Ideal	Ranking
	Financing	0.5397	0.2488	0.8120	2
	FIT	0.6646	0.3063	1.0000	1
	Net metering	0.5081	0.2342	0.7644	3

	Subsidy	0.4571	0.2107	0.6878	4

5 VALIDATION

The ANP-BOCR framework output was verified with the members of the FGD later for validation. Although FIT leads to financial burden on government and distribution companies, the experts agreed that that is the best way to incentivize rooftop solar PV over a long period. Only net metering is not likely to make the installation attractive for the consumers, especially when electricity tariff is subsidized. Subsidy and financing are short term measures that are not expected to keep the interest alive.

6 CONCLUSION AND POLICY IMPLICATIONS

Delay in implementing net metering with long term feed in tariff seems to be a major reason for the slow growth of rooftop solar PV in India. High feed in tariff has done wonders in countries like Germany and that seems to be the best policy to foster growth of rooftop solar PV in India. Although higher feed-in-tariff will bring long term financial burden for the government, research should be done to calculate the environment benefits coming out of rooftop solar PV and compare that with costs arising out of higher feed-in-tariff. Other policies like capital subsidy and easy financing are important, but Fed-in-tariff sounds like the driver.

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