Assessing policy strategies for the promotion of environmental technologies: a review of India's National Solar Mission

Rainer Quitzow, Research Fellow, Chair of Innovation Economics, Technische Universität Berlin; Research Associate, Environmental Policy Research Centre, Freie Universität Berlin

Abstract

Studies have shown that markets for environmental technologies are highly dependent on government intervention, and, with few exceptions, they have been "policy driven." Moreover, there is widespread consensus that no individual policy instrument but rather a "smart policy mix" is needed to effectively drive the development and diffusion of environmental technologies. However, what exactly represents such a smart policy mix remains largely undefined. This paper takes this discussion a step further by developing a framework for assessing and comparing policy approaches for the promotion of environmental technologies. Introducing the concept of a policy strategy, the paper integrates findings from the literature on environmental innovation and technological change in a comprehensive assessment framework. The framework is then applied for the assessment of India's National Solar Mission, the country's strategy for promoting solar energy technologies. On this basis, key findings and implications for the potential and limitations of the proposed framework are discussed.

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1. Introduction

Scholars have increasingly pointed out the need for a policy mix to steer innovation towards environmentally-friendly solutions (Jänicke & Lindemann, 2010). Although the literature on policy and governance for environmental innovation and technological change offers a host of useful lessons for this purpose, no integrated framework for assessing policy mixes for the promotion of environmental technologies has emerged (Rogge & Reichardt, 2013). In this paper, we seek to take this debate further by developing a comprehensive framework for policy assessment, tailored to the specific challenge of promoting environmental technologies. To do so, we introduce the concept of a "policy strategy," further elaborating it based on lessons from the literature on the governance of environmental innovation and technological change.

The paper presents a short definition of a policy strategy followed by a synthesized assessment framework. A more detailed discussion of how this definition and the related assessment framework were derived from the relevant literature can be found in the full paper, which is forthcoming in *Research Policy*. To demonstrate the usefulness of the proposed framework, it is applied to a prominent example from India, the Jawaharlal Nehru National Solar Mission (JNNSM).

2. Towards a framework for designing and assessing strategies for promoting environmental technologies

The paper proposes a strategy concept composed of the following three building blocks:

- **Strategy content,** composed of policy objectives and the measures designed to achieve them;

- **Strategy process,** encompassing the process of policy development, implementation and adaptation;
- **Strategic capacity,** including capacities needed for policy development, implementation and learning as well as the engagement of stakeholders.

Based on the three strategy elements, the following table provides a synthesis of the assessment criteria derived from existing literature on environmental innovation and technological change. It integrates the generic concept of policy strategy and its focus on managing policy trade-offs with the more nuanced criteria related to the promotion of environmental technologies.

Table 1: Summary of the assessment framework

Strategy element	Assessment criteria
Strategy content	***Policy objectives*** • Trade-offs and synergies across objectives • Level of ambition and credibility of objectives ***Policy measures*** • Synergies and trade-offs between policy measures within the scope of the strategy • Trade-offs in the design of demand-side policies - Needed stringency of regulatory measures or level of support in financial incentives to enable development of target sector *versus* considerations to avoid unjustified economic rents - Flexibility in terms of technological choice *versus* differentiation in terms of actors and sectors - Predictability *versus* adaptability • Comprehensiveness in terms of supporting weak system functions • Consideration of time-strategic dimension • Consideration of international dimension
Strategy process	• Monitoring and review to facilitate policy learning • Stakeholder engagement to build legitimacy, access knowledge and engage in vision-building to align expectations and anticipate future developments • Horizontal and vertical coordination of actors within the policy sub-system
Strategic capacity	• Match between strategy content and existing governance capacities • Development of governance capacities needed to meet medium- to long-term objectives • Capacities for horizontal and vertical policy coordination • Capacities for accessing knowledge and engaging stakeholders, such as networks of strategic intelligence and private-public interfaces • Accountability mechanisms to avoid capture by private sector stakeholders

3. Assessing Phase 1 of India's Jawaharlal Nehru National Solar Mission

In the following section, the assessment framework outlined above is applied in an exemplary fashion to phase 1 of India's Jawaharlal Nehru National Solar Mission (JNNSM), spanning the time period from 2010 to 2013. A more detailed discussion including an additional section offering conclusions and questions for further research can be found in the full paper, forthcoming in Research Policy.

3.1. The policy objectives

The JNNSM was launched in 2009 within the context of the National Action Plan on Climate Change. The mission's broad-based goal "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" (GoI, 2010, p. 2).

The mission's specific policy objectives are to facilitate cost reductions to reach grid-parity by 2022 and parity with coal-based thermal power by 2030. In addition, it seeks to promote solar manufacturing capability in India. A set of official targets are outlined in Table 2. Divided into three phases, the JNNSM includes a number of flexible deployment targets, which may be adjusted based on progress made in previous phases. For the supply-side or other system-related indicators, the mission document does not define a corresponding set of quantitative targets (GoI, 2010).

Table 2: Official targets of the JNNSM1

S. No.	Application segment	Target for Phase I (2010-13)	Target for Phase 2 (2013-17)	Target for Phase 3 (2017-22)
1.	Solar collectors	7 million sq meters	15 million sq meters	20 million sq meters
2.	Off grid solar applications	200 MW	1000 MW	2000 MW
3.	Utility grid power, including roof top	1,000-2000 MW	4000-10,000 MW	20000 MW

Although the strategy document stresses the importance of supply-side development, the strong focus on deployment targets signals an implicit policy priority. This is consistent with the emphasis placed on cost reduction as a pre-condition for rapid diffusion. Given the relatively low levels of production in India2 compared to global leaders, more explicit supply-side targets would imply significant trade-offs to a focus on rapid and low-cost deployment. On the other hand, the development of a domestic value chain and related employment opportunities represent an opportunity to build political support for the strategy. The lack of a clearly defined and nuanced approach to addressing these synergies and trade-offs represents an important weakness of the strategy.

Similarly, the quantitative targets reveal that the level of ambition for the deployment of grid-connected solar power is significantly higher than for off-grid power, despite significant potential in India. Potential synergies with social policy goals have thus not been fully exploited, weakening political support among civil society (CSE, 2012; Deshmukh et al., 2010; Greenpeace, 2011).

1 Targets in the first row refer to solar thermal power, also known as concentrated solar power (CSP).

2 Estimated at 175 MW of cells and 240 MW of modules (ISA, 2010).

3.2. The policy measures

3.2.1. Demand-side measures

Following from the policy objectives outlined above, the focus of the JNNSM in phase 1 has mainly been on the demand-side. The most significant policy support has come in the form of a set of deployment policies targeted at different types of installations, though mainly multi-megawatt, grid-connected systems. The largest deployment program has been the so-called "bundling scheme", which serves as the main empirical example of this section. The scheme involves the procurement of approximately 500 MW of PV-based solar power and 500 MW of solar thermal power (also known as concentrated solar power or CSP) by the National Thermal Power Corporation (NTPC), the country's largest state-owned energy producer. To reduce the cost for state-level distributors, NTPC resells the higher priced solar energy in a blend with electricity from conventional sources (i.e. coal). In a bidding process implemented in 2010 and 2011, developers were requested to submit bids for the production of solar energy based on 20 year power purchasing agreements. Projects were subsequently allocated to the bids proposing the lowest average tariffs (World Bank, 2013, pp. 4-5).

Although the strong focus on the minimization of costs - and hence economic rents for project developers - is consistent with the policy priorities highlighted in the previous section, it also represents an important weakness of the bundling scheme. Firstly, due to the exclusive focus on cost as a selection criteria, the level of support emerging from the bidding process was very low, raising questions regarding the financial viability of projects (World Bank, 2013, p.31). Secondly, doubts emerged regarding the credibility of the instrument. The financial troubles of the state-level distribution companies, which are ultimately responsible for purchasing the electricity produced, were cited as an important financial risk. As a result the majority of projects suffered significant delays in securing the necessary financing. Only after the government made a number of ad hoc adjustments (i.e. setting up a state-backed guarantee fund for solar projects), was the majority of projects finally able to secure needed financing (Shrimali & Rohra, 2012, p. 6322).

Furthermore, deployment support has lacked predictability. A serious lack of continuity has resulted in high levels of uncertainty for investors and developers. After launching tenders for PV systems in 2010 and 2011, no tender was launched in 2012, creating a large funding gap for the sector. Additionally, the first PV-based tender for phase 2 of the mission, launched in October 2013, is based on a drastically revised financing mechanism, thus squandering the learning process stimulated in phase 1 (Balachandar, 2013).

3.2.2. Remaining system functions

While the mission document clearly subscribes to a systemic approach to the sector, in practice the strategy has focused mainly on the demand-side (i.e. market formation) and has largely failed to address important blocking mechanisms related to other system functions. Due to space constraints, a full assessment of system function (as suggested in Bergek et al., (2008)) and corresponding policy measures is not performed here. Instead the discussion is limited to weaknesses in two areas. They serve as illustrations of the importance of a comprehensive set of policy measures, addressing key system bottlenecks.

A first important bottleneck for system-building in India is the development and diffusion of knowledge. Requirements differ between the downstream (i.e. the demand-side) and the upstream (i.e. the supply-side) segments of the solar value chain. Concretely, India's solar sector suffers from scarcity of workers and professionals with relevant sectoral expertise as well as a lack

of reliable, site-specific data on solar resources. In both areas, investments have significantly lagged behind deployment support, so that the lack of skilled labor and solar irradiation data have represented an important bottleneck for the sector's development (CEEW & NRDC, 2012b; FICCI, 2013a; World Bank, 2013b).

Developing a competitive solar manufacturing industry would require even more ambitious support for knowledge development and diffusion, most importantly investments in cutting-edge R&D. In this vein, the mission document proposes "a major R&D programme" (GoI, 2010). De facto, this R&D programme has received a significantly lower level of attention compared to deployment policies. Although two National Centers of Excellence for CSP and solar PV technologies have been established, their specific roles remain unclear and the process of developing a proposed Solar Technology Development Plan has made little progress (FICCI, 2013b).

A second, even more crucial weakness of India's solar energy sector relates to the mobilization of resources. Initially, MNRE relied exclusively on the described deployment support measures to catalyze investments in the sector, resulting in serious bottlenecks in generating the needed financing for solar energy projects. As already alluded to, only in response to fundamental challenges to the bankability of projects were a number of ad hoc measures taken. While these unplanned measures helped alleviate concerns regarding the credibility of power purchase agreements, important obstacles in enabling project-based financing persist (World Bank, 2013b).

This not only represents a constraint for the intended scaling up of deployment in phase 2 and 3 (World Bank, 2013b). It has also revealed itself as an important gap in the efforts aimed at mobilizing resources for upstream segments of the PV supply chain. A key measure in this regard has been the inclusion of a domestic content requirement (DCR) for traditional silicon-based PV modules, thus reserving this segment of the market for domestic manufacturers. Instead of procuring domestically produced modules, however, close to 70 percent of developers opted for foreign thin film modules, which were not subject to the same restrictions (World Bank, 2013, p.19). This compares to a global share for thin film modules of under 15 percent (Johnson, 2013, p.20).

While this result also reflects efforts to circumvent the DCR, difficulties in attracting financing is an additional factor in driving investments in thin film-based installations (World Bank, 2013b). Foreign and in particular US export financing has played an important role in facilitating competitive financing to Indian project developers, which resulted in a disproportionately strong performance of American thin film modules not only in the bundling scheme but also in solar projects supported by the state government of Gujarat without a DCR (Sahoo & Shrimali, 2013).

3.2.3. Time-strategic dimension

Time strategic considerations are addressed by the phased approach to the JNNSM, which allows adjustments in response to changing circumstances. The specific design of phase 1 appears to be largely blind to time-strategic considerations, however. Despite very different levels of maturity in the PV and CSP sectors, the JNNSM has followed the same approach for both technology fields. Both sectors are mainly being promoted on the basis of a highly cost-sensitive bidding process. While the PV sector has a high demand-side potential in the short to medium-term, India's potential as a leading manufacturer of PV technologies is relatively low, due to the maturity of the sector (Johnson, 2013). Less mature CSP technologies have a lower demand-side potential in the short term, but they offer a considerable potential for India to establish itself as a global manufacturing hub (World Bank, 2013a).

3.2.4. International dimension

International considerations appear to have played only a minimal role in the design and implementation of phase 1 of the JNNSM. Most importantly, India's industrial policy strategy, centered on the DCR, does not take into consideration that India's PV industry has traditionally been export-oriented (ISA, 2010, p.33). Both to compete successfully and to provide cost-competitive modules to the domestic market, an industrial policy strategy cannot be limited to protectionist measures. In fact, as many successful East Asian industrial policy experiences have demonstrated, linking domestic market protection to continued export performance is a key to developing a competitive local industry (Wade, 1990). Similarly, in the sphere of R&D policy, in phase 1 only a very limited focus has been placed on acquiring knowledge from abroad, a key to catching up to leaders in the industry (Quitzow, 2013).

3.2.5. Selected synergies and trade-offs

As already mentioned in 5.2, the JNNSM suffers from an important unresolved trade-off between the goal of cost-effective deployment, on the one hand, and the goal of establishing domestic manufacturing capacity, on the other. This trade-off is also visible at the level of policy measures. In particular the problems surrounding the DCR reveal that the chosen path does not achieve an effective balance between the two objectives. At the same time, potential synergies in the sphere of rural electrification remain largely unexploited. While MNRE promotes off-grid solar applications through the JNNSM and its Remote Village Electrification Programme (RVEP), the Rajiv Ghandi rural electrification scheme (RGGVY), which represents approximately 95 percent of the budget for rural electrification, has not incorporated any policy for the promotion of solar energy (Greenpeace, 2011).

3.3. The strategy process

3.3.1. Policy learning and adaptation

The phased approach of the JNNSM places an important emphasis on a dynamic, process-oriented perspective and signals a strong commitment to policy learning and adaptation. It allows for adjustment of targets and policy measures based on progress made in previous phases. Moreover the mission document states that each implementation phase will be concluded with a review process followed by an adjustment of specific goals and measures. For phase 1, this review process has been conducted by the World Bank on behalf of MNRE and involved two consultations with stakeholders in early 2013 (World Bank, 2013b). As a result, important issues, including financing challenges and the need for a more a nuanced approach to supply-side support, are being debated. A broader approach to policy learning, including the systematic engagement of other ministries and state-level governments, is not being pursued, however. In particular, an exchange of experience with those Indian state governments with their own solar energy policies could generate valuable lessons for the JNNSM.

3.3.2. Coordination of actors in the policy sub-system

A degree of horizontal policy coordination has been achieved with ministries represented on the JNNSM steering committee, while vertical policy coordination has been largely absent. For phase 1, the most significant outcome of coordination represents the agreement between MNRE and NTPC (under the auspices of the Ministry of Power) on the "bundling scheme", the core deployment measure of phase 1. The failure, on the other hand, to continue this cooperation in phase 2 represents a critical weakness of the mission. In its place, MNRE and the Ministry of

Finance have cooperated to enable the provision of funds from the National Clean Energy Fund (NCEF) to finance the new viability gap funding scheme (Panchabuta, 2012). An important gap in coordination exists between the JNNSM and the Ministry of Power's rural electrification programs (as already alluded to in section 5.3.5). Moreover, coordination with the ministries responsible for innovation and industrial policy (i.e. Ministry of Science and Technology and the Ministry of Commerce) has not played a prominent role. Equally important is vertical coordination between the central government and state-level governments who are responsible for relevant planning procedures and for the provision of supporting infrastructure for (solar) energy projects. The lack of streamlined procedures at this level has been an important stumbling block for many projects (World Bank, 2013, pp.16-17).

3.3.3. Stakeholder involvement

While stakeholder engagement has taken place throughout the development and implementation of the JNNSM, it has remained largely reactive rather than representing a more strategic approach to knowledge acquisition and vision-building. In the initial phase of policy development, formal stakeholder involvement took place via the high-level Prime Minister's Council on Climate Change. This helped in shaping the initial vision and provided the JNNSM with a political mandate, which extended beyond the government itself. Engagement of stakeholders by MNRE, on the other hand, has remained mainly informal and appears to have a had fairly limited influence on the final policy document (Deshmukh et al., 2010). This lack of systematic stakeholder involvement has continued during the initial phase of implementation. Only after serious concerns arose regarding financing issues and the DCR, MNRE reacted by organizing ad hoc consultations with industry bodies3 (Economic Times, 2013).

3.4. Strategic capacity

As the analysis above has shown, the JNNSM reveals a strong focus on the central deployment support mechanisms with important weaknesses in pursuing supply-side objectives and in supporting other system functions, in particular resource mobilization and knowledge development and diffusion.

This is also reflected in the organizational capacities, which were mobilized for strategy implementation. Most importantly, NVVN, a subsidiary of NTPC, was charged with implementation of the bundling scheme. Corresponding capacities for addressing financing bottlenecks or supporting knowledge development and diffusion were not in place during phase 1 of the mission. First steps towards building corresponding capacities may be underway with the development of a Solar Energy Corporation of India (SECI), which aims to promote R&D and technology development along with deployment4. For now, however, it has mainly assumed the administration of bidding procedures in phase 2.

Capacities for policy coordination were created in the form of a high-level steering group. As mentioned above, coordination has been limited, mainly focused on cooperation on the bundling scheme between MNRE and the Ministry of Power. A corresponding committee at the operational level is missing. Moreover, key sectoral agencies, such as the Indian Renewable Energy Development Agency (IREDA) and Central Electricity Regulatory Commission (CERC), are not included in this formal mechanism for policy coordination. Similarly, no formal capacities

3 Based on interview with a representative of the Confederation of Indian Industry, October 20, 2011.

4 See http://seci.gov.in/content/innerpage/objectives.php

have been created to facilitate vertical coordination with state-level governments and relevant agencies, in particular the so-called State Nodal Agencies for promoting renewable energy development.

Officially, capacities for engaging stakeholders and accessing sectoral knowledge have been created in the form of a Solar Research Council, an Industry Advisory Council and a "High Powered Task Force", to advise the government on matters concerning the promotion of solar PV technology and industry (MNRE, 2013). However, to date, none of the bodies has assumed an important role in facilitating systematic exchange with sectoral stakeholders, and no official information regarding council activities has been released, signaling a corresponding lack of mechanisms to ensure accountability. Overall, the lack of institutionalized and transparent "public-private interfaces" represents an important weakness of the JNNSM.

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