

The Dynamics of Renewable Energy Transforming in Developing Countries

Technological Systems of Innovation in Renewable Energy Technology of Developing Countries

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Abstract

We explore the dynamics in the transition to renewable energy industries in several developing countries. Through this analysis we improve our understanding of the processes involved in the formation and growth of renewable energy systems of developing countries and identify the associated key challenges for policy makers managing the transformation process. We examine the development of the main renewable energy technologies in India and South Africa and compare the transformation approaches that took place in these countries. We use a technological systems approach in which we trace the evolution of actors, networks and institutions that have a bearing on the generation and diffusion of renewable energy technologies and closely consider the main inducements and blocking mechanisms in the transition to low-carbon economies. Current technological and innovation systems approach analysing the evolution of renewable energy systems ignores renewable energy industrial evolution of developing countries. We argue that developing countries have different learning stages of industrial development and different learning strategies, which need to be considered when evaluating renewable energy innovation systems, and which has remained neglected in existing studies. Most inducement mechanisms that are required and necessary in energy transitions towards renewable energy technologies are weak in South Africa as compared to India. India compares fairly well in terms of development of positive externalities, degree of legitimization and entrepreneurial activities. However the availability and effect of the inducement instruments in each country can vary from one renewable energy technology to another, and we explore only wind and solar energy technologies here.

KEYWORDS: renewable energy, innovation systems, low carbon technologies and energy transitions

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1. INTRODUCTION

This paper will analyze the transition to renewable energy technologies in India and South Africa³ which form two of the four BICS bloc countries. The BICS (Brazil, India, China and South Africa) countries are amongst the fastest growing economies in the world with tremendous growth potential. A trend is observed towards globalisation as well as the commonality of desire and choice among emerging economies to grow economically and free themselves from previous prolonged and deep poverty traps. Economic growth is known to have the strongest influence on emissions levels, usually putting upward pressure on emissions. At present, the four BICS countries are facing similar challenges in restructuring the economy, maintaining a healthy and sustainable growth and in achieving an inclusive, equitable and green development. This means being equally involved in mitigating climate change and GHG emissions as the rest of the developed world. The challenges are resonant of the questions which existing scholars of innovation studies and sustainability are grappling with - understanding if the tremendous pressures of economic growth and development can lead to low carbon growth trajectories in developing countries.

Global warming and other impending environmental issues call for a new technological paradigm (Altenburg et al., 2010). It is well acknowledged among the wider international community on climate change that addressing the impacts of climate change and reducing future climate risks will require new technological solutions (Morey et al., 2011). Such paradigmatic shift is, according to Kuhn (1962), a change in the basic assumptions, or paradigms, within the ruling theory of science. This has been elaborated by Dosi (1982) to “technological paradigm” to mean a 'pattern' for solution of selected techno-economic problems based on highly selected principles derived from the natural sciences. It is primarily grounded on problem-solving activities like ‘how to do things’ and how to improve them. For example, it implies shaping materials to adapt wind blades to specific wind conditions and maximizing technological performance.

³ Part of an ongoing research project exploring the transition in the BICS countries to low carbon technologies. As part of the initial exercise this paper investigates two countries – India and South Africa - both heavily dependent on coal as the cheapest and its most path dependent source of power generation.

Once a technological paradigm has been selected it shows a momentum of its own and develops along a defined “technological trajectory”. As renewable energy technologies are not entirely based on old industrial assumptions of production and consumption, they thereby require large-scale systemic and technological paradigmatic changes for transitions to occur. For example, solar energy technology has developed on the technological paradigm of solar space technologies but its manufacturing has evolved on integrated circuit (IC) manufacturing of the information technology industry that uses silicon wafers in production. Moreover,

Technological systems transitions involving technical change also tend to be path dependent contoured and channelled by technological paradigms, as the high costs of switching to new technologies discourage economic agents to abandon existing and established technological path. Especially when a technological trajectory is very "powerful" like energy systems, it might be difficult to switch from one trajectory to an alternative one (Dosi, 1982). Energy systems based on fossil-fuels are huge and powerful. Even with continued growth rates over the next two decades, wind and solar may only begin to replace the stock of conventional energy technologies well after 2020 (Jacobsson and Bergek, 2004). Besides, the proponents of the established energy system often attempt to block the diffusion of renewable energy technologies by influencing institutional frameworks.

In this paper, the dynamics of the transition to renewable energy technologies, wind and solar energy, will be explored in terms of ‘technological functions’ within a technological innovation systems (TIS) (Jacobsson et al., 2008). Technological functions are factors that shape and direct the transition to renewable energy technologies and may include functions such as legitimation and entrepreneurial experimentation, among others. The framework used in this paper provides a detailed view of how the development and diffusion of renewable energy sources takes place and help identify system weaknesses. Although the two countries are evolving considerably differently towards renewable energy technologies, the paper will highlight the key technological functions that are important in any given context of an industrial transition and help identify system weaknesses and illustrates how transitions are (not) taking place in these countries.

The paper is structured as follows - Section 1.1 following the Introduction will provide the general conditions of fossil fuel and renewable energy patterns and CO₂ emissions of the two chosen countries. Section 2 will explain the technological innovation systems (TIS) framework and the functions that will be used in this paper. Section 3 will explain the methodology that will be used and Section 4 will provide the results of the data and analysis. Section 4 will highlight the broad policy implications of the study as a conclusion of the paper.

1.1 INDIA AND SOUTH AFRICA – THE BICS BLOC

India and South Africa are both heavily dependent on coal and are very large coal-producing economies. Such large coal-producing and consuming economies, like India and South Africa, will increasingly shape the global energy landscape. South Africa produced 255 Mt of coal and India 538 Mt in 2010 (World Coal Association). The IEA (International Energy Agency) estimates that 44 percent of CO₂ emissions in 2010 came from coal, 36 percent from oil and 20 percent from natural gas. South Africa accounts for around 1.2 % of global GHG emissions and 18% of emissions in sub-Saharan Africa, ranking 19th in the world (World Resources Institute, 2010). At an average of 9.2 tonnes CO₂ per capita in 2005, the per capita emission rate was above the global average of 6.8 tonnes /year and almost three times as high as the sub-Saharan average of 3.2 tonnes (Carbon Planet). It almost equalled the average per capita emissions of 10.9 tonnes in the European Union and was higher than in the cases of China and India. Around 90 percent of South Africa's power comes from coal and just 6 percent from nuclear fuel.

India accounts for 5.6% of global GHG emissions, more than double that of South Africa, ranking 5th in the world in terms of total emissions. However, the per capita emission rate in India is much lower than South Africa at 1.18 tonne per person/year (Carbon Planet). Coal presently constitutes a little over 50 per cent of India's total energy mix. Like in South Africa, coal has been the chief energy source for India because it is found in abundance and is cheaper to exploit than some of the other energy resources. It would be difficult to reduce India's coal consumption, not just because of issues regarding path dependence, but because any significant reduction in coal consumption (even in the presence of a viable option) will have social and political repercussions (Hosur, 2010).

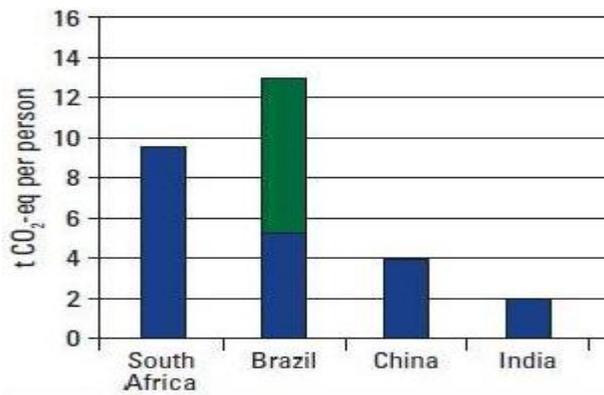


Figure 1: South Africa's CO₂ emissions per capita are high relative to the BRICS region and the rest of world, particularly in terms of carbon intensity of GDP. The green bar represents deforestation. Source LTMS, South Africa

So the transition to low-carbon technologies like renewable energy technologies in India and South Africa will be slow and challenging,

coupled with path dependencies and carbon lock-ins. A paradigmatic shift will be needed to avoid India and South Africa's fundamental requirement for coal and power generation based on fossil fuels in the future. These countries must deliberately harness paradigmatic shifts to develop early mover advantages and accelerate the transition towards renewable energy technologies.

We analyse the wind and solar energy industries and in terms of resource potential both South Africa and India are comparable as they have immense resource potential in solar and wind energy. India shows large areas with annual average wind power densities of more than 200 Watts/m² at 50 meter above ground level (MAGL) (CWET, 2010). A study carried out by Mainstream's Energy Analysis Group confirms that South Africa has potential to generate over 70,000 MW of wind energy in total (2011). The Pew Charitable Trust (2010) did not profile South Africa as there was insufficient reliable data on installed capacity within the country. In 2010 India had 13065 MW of installed capacity of wind energy while South Africa is estimated to have a capacity of 8 MW (Darling wind farm and Eskom). In 2010, the total renewable energy capacity in India was 16 GW making it the 5th largest in the world (Pew Center, 2010).

2. TECHNOLOGICAL INNOVATION SYSTEMS AND FUNCTIONS

To further our understanding of the processes involved in the transition to new technological systems in the energy sector we analyse the transition in the main emerging economies of the world –namely Brazil, India, China and South Africa. We use the technological system of innovation approach to analyse the transition. A technological system is defined as a '... network(s) of agents interacting in a specific technology area under a particular institutional infrastructure for the purpose of generating,

diffusing, and utilizing technology (Carlsson and Stankiewicz, 1991). Technological systems are defined in terms of knowledge and competence flows rather than flows of ordinary goods and services. The approach suggests that the emergence of new technologies does not take place in a vacuum but rather through the interplay between firms and other organizations, such as universities, industrial associations and government bodies, and the process is greatly influenced by the institutional framework. A technological system is made up of three main elements: actors and their competences, networks and institutions, which are not necessarily technology-specific but may be shared by several technological innovation systems.

One must look at the TIS components as functional units⁴ providing support for technological development in seven dimensions (Bergek et al., 2010): knowledge development and diffusion; influence on the direction of search and the identification of opportunities; entrepreneurial experimentation and management of risk and uncertainty; market formation; resource mobilization; legitimation; development of positive externalities. These functions are not independent of one another, and changes in one function may lead to changes in others (Bergek and Jacobsson, 2003). Such an analysis of the TIS functions is expected to guide policy making process around these key dimensions. Comparing the various TIS, across nations, is a powerful way of improving the understanding for decision makers (Bergek et al., 2008). These functions have been compiled from a number of different innovation system approaches and provide a basis for performance assessment.

The concept of functions defined by TIS is appropriate for this study as it refers to the contribution of one or several actors within the system to the overall goal of developing, diffusing and using innovations within a particular field. There are seven functions that has been outlined and applied to map the key processes in technological innovation systems (Bergek, Hekkert and Jacobsson, 2006).

⁴ For a detailed description of the seven functions of a TIS please see Bergek, Hekkert and Jacobsson (2006) and Bergek et al. (2008)

3. METHODOLOGY

A process approach or sequence analysis has been used in this approach as suggested by Bergek et al. (2006). This approach conceptualizes development and change processes as sequences of events and takes the order of all relevant processes into account. The basis of the analysis is the event. For the analysis of this paper we have used these events to map changes and developments that have been taking place in the two countries. However, the events of the analysis have not been ordered but which will be done at a later stage of the project and once China and Brazil are added into the analysis.

Data for this analysis has been collected by following events that are reported at the system level (for e.g. news paper archives, industry reports and professional journals). These events can be workshops on the technology, the start-up of R&D projects, and even expression of expectations about the technology in the press. For instance, an expression of interest about the technology can be done using a weblog analytical method and which will be used later in the project.

The main indicators are based on the seven functions and examples of the type of functions are:

FUNCTION	EXAMPLES OF INDICATORS
Knowledge Development and diffusion	R&D Projects
	Patents
	Bibliometric
	Investment in R&D
	Learning Curves
	Number of workshops and conferences
	Size and intensity of learning networks
Influence on the direction of search	Taxes and prices in the energy sector
	Regulatory pressures (e.g. quota systems)
	Govt/industry targets regarding use of specific technology

	Estimates of future growth potential
	Articulation of interest by leading customers
Entrepreneurial experimentation	Number of new entrants
	Number of diversification activities if incumbent actors
	Number of experiments with the new technology
	Degree of variety in experiments
Market Formation	Number, size and type of markets (installed capacity)
	Timing of market formation
	Drivers of market formation (e.g. support scheme)
Resource Mobilisation	Volume of capital and venture capital
	Volume and quality of human resources
	Innovation index and sophistication
Legitimation	Attitude towards technology among stakeholders
	Rise and growth of interest groups
	Extent of lobbying activities
	Political debate in parliament and media
Positive Externalities	Strength of political power of TIS actors
	Activities aiming at uncertainty resolution
	Existence of clear division of labour/development of specialized intermediaries/development of pooled labour market
	Information and knowledge flows

4. RESULTS AND DATA ANALYSIS

Entrepreneurial Experimentation

India fares comparatively well in entrepreneurial experimentation in both the solar and wind energy industries. Entrepreneurial activities were recorded after India embarked on a massive economic

reform program in 1991 encouraging private-sector participation in many sectors of its economy. During this period the Government of India (GOI) shifted its focus of wind energy policy to stronger private-sector involvement, extending public finance to private-sector wind-power projects and providing fiscal and financial incentives to encourage private investments (Mizuno, 2006).

Local companies like RRB Energy were engaged in wind energy development (large-scale) activities as early as 1989 by absorbing skills that were transferred from the wind energy developed cooperation between the government of India and Denmark in 1986. In 1994 Suzlon was founded in a move to secure an existing textile company's energy needs but which soon emerged as one of the world's largest WTG manufacturers, with 7% of the world market share by 2010. Between the years 2004 to 2007, Suzlon bought two European companies that help expand its technological capability in gearbox manufacturing and gave access to the growing European market.

From the mid-1990s and until 2010, India has seen the entry of approximately 16 private wind energy companies and most of which were created through various technological collaboration with foreign companies, constituting world-class Danish and German wind turbine manufacturers. There were diversifications of local companies like NEPC India (wind and now solar PV) from electrical power Equipment Company; Moser Baer (solar PV) from the laser compact disc manufacturing industry; and Tata BP Solar from steel manufacturing. Shriram diversified from the financial sector into energy engineering 2001 and entered into a technological joint venture with Italian company Leitner technologies in 2007 to jointly manufacture and install large scale wind energy generators.

In South Africa there are no evidence of entrepreneurial experimentations in the wind and solar energy industry. Although several foreign wind and solar farm projects are currently developing energy farms with an aim to develop 1800 MW wind farms and 600 MW of solar by 2012. According to Pew Charitable Trust (2010) the 2012 target for renewable energy installed capacity is expected to be at 1667 MW for South Africa.

Influence in the Direction of Search

Influence in the direction of search by the South African government has been positive as the country has increased its target ceiling from 1200 to 1800 MW by 2012. Although a very popular policy

mechanism, feed in tariffs⁵, that has been historically pivotal in driving growth in European countries and in India, was scrapped for competitive price bids in mid-2011 and likely to dampen the industry take-off stage. This has elevated uncertainties and investment risks associated with market formation.

There are various industry targets and future growth potentials that have been put forward by the government of South Africa, namely the White Paper on Renewable Energy Policy (2003) and Long Term Mitigation Scenarios (2008) showing some evidence in its influence on the direction of search. Commitment by the government to renewable energy developed was shown in the Industrial Policy Action Plan (IPAP2) in 2010 but which showed that REFIT was linked to its development. But by August 2011 the government scrapped REFIT and introduced competitive pricing for renewable energy technologies making the renewable energy landscape investment riskier. Although targets to achieve 10 000 MW of wind capacity by 2020 shows the government's intention regarding the use of a specific technology, issues around how to achieve the targets have been ambiguous.

Market Formation

Attributes of market formation is weak in South Africa as compared to India. The first commercial wind power development project, Darling wind farm, began generating power in 2008 with 1.3 MW capacity and is currently at 5.2 MW. And the national utility Eskom's Klipheuwel wind farm started in 2003 today generates 3.16 MW of electricity. There is however no reliable evidence to ascertain if energy generated from these wind farms are connected to the electricity grid. There are no wind components manufacturing plants in South Africa though there are plans to set up by foreign wind manufacturing companies like Suzlon (India) and Goldwind (China). However, before which "markets will have to be first formed" in South Africa (Goldwind, 2011).

Imports of technology components like wind turbines and solar products are treated as capital goods and are therefore 100% tax exempted in South Africa. In India, there are import tax exemptions that have been increased to 100% for some wind turbines components (GWEC, 2011). Accelerated tax depreciation of 50% of capital cost in year 1, 30% in year 2 and 20% in year 3 exists for all renewable energy projects in South Africa. In India there is an accelerated tax depreciation of 80% along with

⁵ A feed-in tariff (FIT) is a policy mechanism designed to accelerate investment in renewable energy technologies. It achieves this by offering long-term contracts to renewable energy producers, typically based on the cost of generation of each different technology. Technologies like wind power, for instance, are awarded a lower per-kWh price, while technologies like solar PV and tidal power are currently offered a higher price, reflecting their higher costs.

feed in tariff rates for large scale wind and solar technologies (GWEC, 2011). A 100% FDI investment is allowed in renewable energy generation projects in India.

	India	South Africa
Total RE Investment (2009)	US\$ 2.3 billion	US\$ 125 million
5-year growth rate	72%	NA
Installed Clean Energy (2009)		
Total RE capacity	16.5 GW	NA
Total power capacity	9%	NA
Growth rate	31%	NA
Total installed capacity (2010)		
Wind	12 GW	8 MW
Solar	15.2 MW (12.3 MW GC)	NA

Source: G-20 Factbook, Pew Charitable Trusts (2010) and Indian RE Status Report 2011, Ren21. Abbreviations:

GW = Gigawatt and MW = Megawatt and GC = grid connected

Legitimation

As far as articulation of interest and legitimation by stakeholders are concerned, Eskom of South Africa is the sole purchaser and distributor of power generated from renewable energy and not municipalities (Davie, 2008). It currently supplies 95% of power but unable to keep pace with growing energy demand. Although Independent Power Purchasers (IPPs) have been assigned to generate 30% of South Africa's total electricity output, Eskom can determine the price at which they can buy electricity from IPPs. In addition, there is no legal-framework around power buy-back between Eskom and the end customer and municipalities. Because the private sector is prevented from securing power purchase agreements that reflects their cost of investment in power plants, the market was not only uncompetitive (Eberhard, 2008b) and far from being conducive for the development of renewable energy technologies.

In 2010, the World Bank approved a \$3.75 billion fund for a new 4800 MW coal-fired power station proposed by Eskom through its Clean Technology Fund, which clearly had provisions for other energy

technologies like wind and solar. This indicates that the larger political debates involving various stakeholders are not engaged in discussions about climate change and there are no visible political attempts to make deliberate transitions to low carbon technologies.

Sasol is a major oil and gas, and mining company dominating the energy industry and accounting for roughly 35% of South Africa's liquid fuel needs and producing over 4% of the country's GDP. Sasol is currently one of the biggest carbon emitters in the country, along with national energy utility Eskom, because of their dependence on power derived from the burning of coal. Clearly, the firm's technological paradigm is based on cutting-edge coal-to-liquids (CTL) and other fossils fuels-based technologies. Because of Sasol's sheer size, political prowess and enormous subsidies it receives in the country it will find it difficult to switch to other technologies of lower performance and new and expensive technologies.

In India there is visible political will to move to low-carbon technologies as made apparent by the creation of a national institution, the Ministry of New and Renewable Energy Technologies, in 1992. However, the processes involved in transiting to low-carbon technologies in India are often bureaucratic in nature and steeped in red-tapism preventing stakeholders from taking action. There is considerable resistance among state-run utilities to grant "third-party sale"⁶ facility to wind power producers (Kristinsson and Rao, 2006) as the 30-odd states of the country have their own independent power generation and distribution facilities owned and managed by state-run utilities. According to GWEC (2011), there is lack of an appropriate regulatory framework to facilitate purchase of renewable energy from outside the host states; there is inadequate grid connectivity in India (in South Africa grid connectivity is 95%); high wheeling cost⁷; and bureaucratic delays in acquiring land and obtaining statutory clearances.

Knowledge Development and Diffusion

In 2004, a South African National Energy Research Institute (SANERI) was started to focus on indigenous research and development of energy technologies and its demonstration, including renewable energy. It has created and funds specific research and learning network by collaborating

⁶ Third party sale facility amounts to allowing wind power producers to use the grid infrastructure to sell power to any industrial client at any mutually agreed rate

⁷ Wheeling is the amount charged by one electrical system to transmit the energy of another electrical system

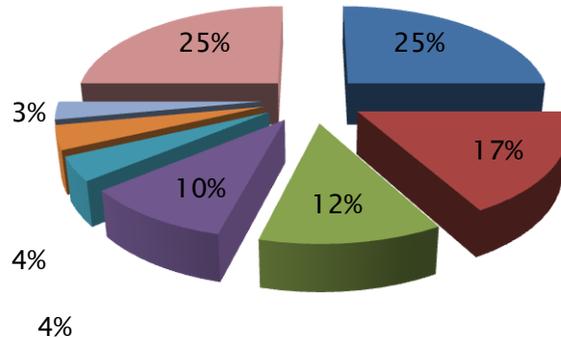
with the University of Johannesburg on the R&D on thin film solar PV and the Nelson Mandela Metro University on solar PV projects. It is funding a project on ruthenium dyes for dye sensitised solar cell with Fort Hare University. The total R&D funds that were allocated by SANERI amounted to 29.4 m ZAR totalling 31 research projects in 2007/2008. SANERI focuses on several other energy technologies like carbon capture and storage and coal-to-liquids, a breakdown of each project cost per technology was not available. Presently, SANERI is mapping the Wind Energy Atlas with technical assistance and funds from Risø Labs of Denmark.

In India, the learning networks are more in number and broader in research scope than in South Africa in wind and solar energy technologies. The National Aerospace Laboratories (NAL) of India have been involved in the research and development of wind turbines adapted to the conditions of India as its wind speeds are lower than the average European wind speeds (Kristinsson and Rao, 2006) These learning networks are often instrumental in driving new knowledge and diffusing renewable energy technologies. Two Environmental Training Centres in 1994 and the Center for Wind Energy Technology (C-WET) in 1998 were set up by MNRES as autonomous training and R&D institutions respectively. Risø Labs, a similar testing and certification centre to C-WET, has been instrumental in driving the technological development of the Danish wind energy industry since the 1970s (Douthwaite, 2002). The two training centres were developed in co-operation with Denmark to provided training to regulatory authorities, municipalities and companies in India.

South Africa is the 7th largest recipient of technology indicated by patent flows in solar PV and thermal technologies and India is way down below. However, India is among the four countries in the world in which solar PV patents exceeds solar thermal, not including South Africa. Patent flows and activities indicate the extent of knowledge development and diffusion processes in a country.

Licensing and IP-based commercialization activities involving Clean Energy Technologies (CETs)

■ China ■ India ■ Brazil ■ Russia ■ Malaysia ■ Thailand ■ South Africa ■ Others



Source: OECD, 2009

Resource Mobilisation

According to the Global Competitiveness Report (2010-2011) in terms of quality of scientific research institutions India is ranked at 25th and South Africa is ranked 42nd globally while in terms of higher education and training India is ranked 38th and South Africa 42th. Quality and volume of human resources indicate the capacity to mobilize a country's resources. An additional factor that drives such resource mobilization and knowledge development and diffusion is the degree of innovation and sophistication levels in a country. India and South Africa ranks 39th and 44th respectively and the indicator imply that firms in these countries design and develop cutting-edge products and processes to maintain their competitive advantage. There is sufficient R&D by the private sector making the environment conducive to innovative activities.

In terms of total private investment in renewable energy, South Africa has invested \$ 125 million upto 2009 and of which 2.4% has been invested in wind energy projects, 53.5% in biofuels and 44.1% in other renewable (Pew Charitable Trust, 2010). India on the other hand invested \$ 2.3 billion by the year 2009 and of which 59.5% has been invested in wind and 4.2 % in solar. India has mobilized its resources better than South Africa in terms of the volume of private investments and volume and quality of human resources.

Development of positive externalities

The availability of funding options can be seen as a means to reduce market uncertainties. The Indian Renewable Energy Agency (IREDA) has played a significant role in the promotion of renewable energy, attracting bilateral and multilateral financial assistance from world institutions and the private sector (Karlsson and Rao, 2006). In 1993-1994 the World Bank provided IREDA with financial assistance of \$ 43 million for wind energy alone. Soon after, a dozen financial institutions entered the renewable energy market, local and international. Namely, the Industrial Development Bank of India (IDBI),

However, there are a multitude of regulatory agencies in India that adds to the confusion and aims little at resolving uncertainty for stake-holders. For example, the Central Electricity and Regulatory Commission (CERC) and each of the states have their own set of guidelines for determining the feed-in-tariffs from renewable energy sources (GWEC, 2011).

In South Africa, the International Development Corporation (IDC) is financing large-scale renewable energy projects (over US \$100,000) with a budget of US\$3.7-billion investment over the next five years (Nkosi, 2011). Few renewable energy projects in wind are already under development through its financing mechanism.

5. CONCLUSIONS AND POLICY DISCUSSION

For a long time the rationale and scope for policy intervention in industry has been highly controversial. Yet it is evident that they are not only widespread in developed and industrialized countries, such interventions have become increasingly important in low carbon technologies. Low carbon technologies like renewable energy technologies are often in-adept in competing with established and highly subsidized conventional technologies based on fossil fuels like oil and gas, and coal. The complexity of industries arising from the systemic nature of technologies (complementarities of technologies and the inter-relatedness of technological trajectories within the same industry) have equally given rise to modern policies that incorporate a wide-range of industrially relevant measures including those of science and technology policies, standardization measures, formation of early markets (like procurement policies).

Because the seven functions of a TIS can act as an inducement or blocking mechanisms in the transition to low carbon technologies, the study points out to several policy lessons: first, entrepreneurial experimentation is crucial for the formation of renewable energy markets and to locally-induced industrial growth. The inability of the South African renewable energy industry to experiment with entrepreneurial activities and allow local firms from other industries to diversify and venture into renewable energy industries has prevented the country from creating a renewable energy industry. Because these technologies evolve under considerable uncertainty, entrepreneurial experimentation reduces market and industrial uncertainty by introducing new entrants, allowing local firms to diversify and experimenting with different types of applications.

Second, market formation that is tightly linked with entrepreneurial experimentation and is important for any new industry. This is because initially market places do not exist and customers may not have their demands articulated. These market places act as “learning spaces” or “nursing markets” where actors within the TIS learn and develop, and where expectations about the new technology are built.

Third, for driving growth in any industry it is important to understand the attitude of the different stakeholders towards the technology. Stakeholders have varying political will and sometimes a stronger political stakeholder may drive discussions away from national priorities such as energy security and development of renewable energy. This was evident when World Bank invested a coal-fired project in South Africa from its Clean Technology Fund in 2010. Along with debates in the parliament and media about the technology, the level of lobbying activities in a country are good indicators telling us about the level of awareness of the technology in the country. Policy makers can take cue from such indications in determining the legitimacy of the technology. Legitimacy is a matter of social acceptance and compliance with relevant industries influencing expectations among managers and their strategy.

Fourth, legitimation has implications on the influence in the direction of search too. Policies especially modern ones that take into account science, technology and innovation policies are important in driving the direction of search. Such guidance is particularly important for fledgling technologies like renewable energy technologies that not only need a lot of policy support but also support and legitimation from consumers and suppliers alike. There are opportunities that are available when markets are newly formed, and it will be important to drive firms and other stakeholders to not only

understand these new changes but help them perceive the new opportunities and take part in the change. When a government sets a target to achieve an amount of installed capacity from a particular technology through regulatory pressures, it not only endorses the use of the specific technology but it also creates market potential by reduces uncertainty.

Fifth, a study of the comparisons of countries illustrates what inducement mechanisms have worked before and what can be learning from the other country. This is particular important for policy makers trying to improve the pace of the industrial development. The various inducements mechanisms explored above help a country to move to low-carbon technologies.

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