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Fostering Renewable Energy Sector in Sri Lanka via Effective Technology Transfer: Lessons from China and India

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ABSTRACT: *The objective of this study is to propose a feasible technology transfer and cooperation mechanism in order to overcome the barriers that the country face in developing the renewable energy sector of Sri Lanka. Two cases pertaining to the development of wind power sector in India and China were studied to propose a plausible renewable energy technology transfer mechanism to Sri Lanka. In the present context Sri Lanka imports most of the renewable energy technologies from abroad and the local value addition and adoption remains at very minor scale. This study proposes a procedure which could be used to transfer green technologies to Sri Lanka, while strengthening its technological capabilities over time. Importance of enhancing technological capabilities of the country along with the policy recommendations to foster renewable energy sector are discussed in the latter part of this study.*

Keywords: *China, India, Renewable energy, Sri Lanka, Technology Transfer, Technology Transfer Models*

I. INTRODUCTION

As an island in the middle of the Indian Ocean, Sri Lanka is blessed with year around sun, wind, rains and lush vegetation. Energy requirement in Sri Lanka are satisfied by local available sources and those sources from global energy markets. Biomass, hydro power, wind power and solar power are the four indigenous sources with a high potential for productive use in Sri Lanka, whereas petroleum and coal can be considered the two main sources readily available in the international market for importation. Biomass is the main source of energy, satisfying heating energy requirements in the country, particularly in the domestic sector [1].

Electricity remains the main secondary energy source. Considering the fact that Sri Lanka's large reserves of hydro power have already been utilized, the CEB had diversified to thermal power, resulting in a gradual shift in the industry power mix. As per the Sri Lanka Sustainable Energy Authority, the total amount of electricity generated during 2014 was 12,848.9 GWh out of which 62% was from thermal plants. In catering to the rapid demand growth, current electricity generation expansion plan of Sri Lanka is mainly concentrated on imported coal [2].

Energy security is a challenge for all the countries. The energy should be cheap, reliable and efficient. Sri Lanka as an emerging economy in the South Asian region has identified the necessity for energy independence for a sustainable future. There are quite a few governmental and non-governmental organizations that are working to attain the stated goal in this respect. Nevertheless, what is lacking behind the success of these attempts is that the absence of proper coordination, interlink between international organizations, scarcity of resources and non-existence of long term plan.

Under these circumstances international technology cooperation and transfer have been viewed as viable solutions to address the stated limitations. However as highlighted by scholars the current impediments in the renewable energy sector and associated technology transfer issues can be attributed to the lack of technology management capabilities of Sri Lanka [3]. Technology management addresses the effective identification, selection, acquisition, development and transfer of technologies needed to produce a product or a service. Thus the fundamental point that we need to understand on how technology is acquired is to know that the technology is not just a physical thing but also comprises knowledge embedded in hardware and software [4]. The acquisition of technological capability is therefore not a one-off process but a cumulative one in which learning is derived from the development and use of technology.

According to the Bennet (2001), there are mainly two types of technology transfers: vertical technology transfers and horizontal technology transfer. The vertical technology transfer refers to the technology transferred from research to development to production. It follows the progressive stages of invention, innovation and diffusion. In contrast, in horizontal technology transfer, the established technology is transferred from one operational environment to another [4]. As a developing nation, Sri Lanka still depends on renewable energy technologies which are primarily imported from foreign countries. With certain amount of technology adoption and value addition the country engages in a vertical transfer of technologies. In terms of technology diffusion governmental organizations like Sustainable Energy Authority and NGOs such as Practical Action, actively engages in disseminating technological know-how to a larger audience (horizontal transfer).

However, the existing technology transfer that is already taking place in the renewable energy sector of Sri Lanka (both vertical and horizontal technology transfer) has failed to reduce our dependency in fossil based energy sources. Rather the country is trying to sail against the renewable energy waves that are rising in many other developing nations such as China and India. Under the given backdrop, this study tries to identify feasible technology transfer and cooperation mechanism, taking examples from the renewable energy sector developments in two rapidly developing nations: China and India.

II. METHODOLOGY

In order to effectively address the research objective of the study, two different cases pertaining to the development of wind power sector in India and China were analysed. Taking the stated cases as examples, the study will look into different channels and the gradual steps of China and India. Apart from the two countries examples a comprehensive literature review on renewable energy development and examples pertaining to many parts of the world will also be used to reach the objectives of this study. This study will also look into popular technology transfer models in order to understand the technology transfer process better. Policy reforms, enabling factors, environment and framework used by other countries will be used to make propositions that are required to foster technology cooperation and transfer in the renewable energy sector of Sri Lanka.

III. LITERATURE REVIEW ON WIND POWER DEVELOPMENT IN CHINA AND INDIA

The two rapidly developing countries China and India have become frequently studied topic in many scholarly articles due to their global presence in renewable energy sector. Following many industrialized countries footpath, China and India use coal as the primary sources of energy in most of their electricity generation, and both countries have plans to increase their share of coal power capacity extensively in the future. Under such backdrop, China and India are possibly the most unlikely countries to find an accelerating renewable based power industry. However, today China and India are both home to firms among the leading global renewable energy technology manufacturing companies. China currently leads the developing world in the solar PV sector, while India leads the manufacturing of utility-scale wind turbines [5].

3.1 Chinese Wind Power Industry

China continues to be the main driver of growth in the global wind power market, setting a new record in 2014 with 23,196 MW of new installations, representing a 45% increase in the annual market. China's cumulative installations reached 114,609 MW, up 25.5% from 2013, the first country in the world to pass the 100 GW mark [6].

Wind power technology has been particularly successful in China due to excellent wind resources and rapid technological improvements in China's domestic wind industry [7]. With vast land and a long coastal line, China has abundant wind resources. As studies show, the offshore and onshore wind resources to be developed in terms of installed capacity are up to about 700–1200 GW, or even reach up to 2500 GW according to the latest evaluation report [8]. As of year 2014 China's main windy locations are the northern provinces (including autonomous regions) of Inner Mongolia, Xinjiang, Hebei, Jilin, Liaoning, Heilongjiang, Shandong, Jiangsu, Fujian and Guangdong. The current statistics indicates that the wind power industry in China has a solid resource foundation that may support it to become a significant part in future energy structure of this country. As is known from a comparative analysis of the five top wind power countries, China has almost as much wind resources as America, much more than India, Germany and Spain [9].

3.2. Wind Energy Policy Landscape in China

Relying on the abundant wind resources, China has implemented a series of policies for developing the wind power industry. A new era of policies to support renewable energy development began in China in 2005 with the launch of the National Renewable Energy Law. A key driver of wind development between 2003 and 2007 was the wind resource concessions for government-selected sites through a competitive bidding process to potential developers [7]. Guaranteed grid interconnection, financial support for grid extension and access roads, and preferential tax and loan conditions all granted to the winning bidder by the central government. Projects were usually 100 MW in size and had to use wind turbines over 600 kW in capacity that initially used 50% local content, increasing to 70% in later rounds of concessions. In 2005–2006, when Chinese wind power demand started to rise very rapidly most foreign technology suppliers were seeking access to the market. However, due to a 70% local content requirement policy and to some extent rising customs duties, market access was largely restricted to foreign companies willing to invest in factories in China [10].

In supply side the renewable energy development plan announced by the Chinese government in year 2007 state that the long term development plan includes the building of seven wind power bases with a minimum capacity of 10 GW each by 2020 [7]. On the demand side, concession projects, feed-in tariffs and wind energy obligations for electricity companies were introduced to create a stable and growing market for wind turbines [11]. In addition, a specific obligation was placed on any power producer owning a total generation portfolio of more than 5GW to increase its actual ownership of power capacity from non-hydro renewables to 3% by 2010 and 8% by 2020. Primarily this commitment was given to large power companies and it is one of the primarily reasons for these companies to develop large wind projects [12]. In addition, Chinese-owned manufacturers have been the most selected by the government in the concession of permits for projects. This has forced many wind turbine manufacturers to localize their manufacturing facilities [13].

3.3. Industry Structure and Key Players in China

The Chinese wind power developments began in the1980s and the primarily mechanism of acquiring the technology was limited to international trade. Turbines were imported from Europe, primarily through bilateral aid projects [11].

In the early stages, the Chinese wind industry was primarily developed by using licensed technologies from abroad. This led to a rapid development of the industry over a very short period of time [14]. The renewable energy law from 2005 spurred a dramatic boom in licensing activities. Leading manufacturers in China, such as Dongfang, Windey, Goldwind, Sinovel and Shanghai Electric have license agreements with international wind power producers [11]. Licensing agreements enabled Chinese turbine manufacturers to acquire basic knowledge of already approved technologies. Conversely, most license agreements primarily focused on production rather than design technology. Further, the licensed technology is often subject to certain restrictions, such as prohibiting the sale outside the domestic market [7].

Concerning the above limitations in the technology licensing and joint ventures (JV) were more attractive for the Chinese companies when transferring wind power technologies. Joint development has the advantage that there are no initial concerns about market competition and that each JV partner brings a different set of experiences and knowledge into the partnership [14]. Another benefit is that the Intellectual Property Rights (IPRs) of jointly developed technologies are shared among the partners and potential issues can be excluded in arrangements prior to the partnership [7]. Identifying the benefits to the mainland, Joint ventures were further encouraged by government directed market-access [11].

Foreign Direct Investments (FDIs) also played a prominent role in transferring the technologies in the wind power sector. Such agreements can be seen in all major wind companies such as Vestas, GE Wind, Gamesa, Suzlon and Nordex. By year 2005, Chinese wind power demand started to escalate promptly due to foreign suppliers mounting interest. But Chinese government regulations such as 70% local content requirement controlled such movements [10]. Strict regulations imposed by the Chinese government resulted with Chinese firms overtaking foreign firms in terms of market share in 2006. The majority of Chinese wind manufacturers initially produced turbines based on license agreements with foreign technology developers. Today number of Chinese companies develop local technology by investing own resources in R&D and jointly with foreign partners [15].

3.4. Indian Wind Power Industry

As of 2014, India ranked 5th in the world after China, the USA, Germany and Spain in cumulative wind power installations with a total capacity of 23,439.26 MW [16]. It was also the fifth-largest wind market in the world in annual installations in 2014 behind China, USA, Germany and Spain with 2300 MW installed that year alone. Similar to many other developing nations, India also has plenty of alternative energy sources such as solar, wind, hydro and biomass. However, as on May 31st, 2014, the total cumulative contribution of renewable energy (excluding large hydro) was about 32.8GW; out of which wind contributed about 21.26GW (65. 85%).This is an indication that wind has been playing the most important role in renewable market developments in India [17]. The Centre for Wind Energy Technology (C-WET) first estimated the onshore wind energy potential in India at around 45,000 MW and was recently increased to 49,100 MW at 50-m height and 102,800 MW at 80-m height [18]. The recent announcements by the Indian Ministry of New and Renewable Energy (MNRE) indicate that India plans to achieve 60,000 MW in total wind power installations by 2022.

The importance of renewable energy was recognized in the country in the early 1970s. Yet during 1970–2000, the focus was mostly on large hydropower projects. Therefore, the share of renewable energy was dominated by hydropower during the above-mentioned period [17]. India's wind power industry began to take off in the early 1990s, though it has experienced periods of boom and bust over the past two decades. In the late 1990s in particular, the industry experienced a slowdown, reportedly due to the reduction in government tax benefits, delays in processing land approval and technical problems related to poor installation practices in the preceding years. In 2003, growth started to take off again with the 2003 Electricity Act [7].

3.5. Wind Energy Policy Landscape in India

The Commission for Additional Sources of Energy (CASE) in the Department of Science and Technology was responsible for the formulation of policies and their implementation, creation of programs for the development of new and renewable energy, and coordinating R&D in Indian renewable energy sector. Following the two restructuring exercises in 1982 (as Department of Non-Conventional Energy Sources) and 1992 (as Ministry of Non-Conventional Energy Sources), in October 2006, the Ministry of New and Renewable Energy was formed, which is the principal authority of the Government of India for all matters relating to renewable energy [17].

India, as part of its obligations to the UNFCCC, released a National Action Plan on Climate Change (NAPCC) [19]. In June 2008 Ministry of New & Renewable Energy (MNRE) laid out the government's vision and mission with specific strategies for a sustainable and clean energy future. The Indian Government has been supporting R&D in wind power technology since the 1980s. Tax exemptions and accelerated depreciation for up to 80% of project costs in the first year, in addition to a Generation-based Incentive (GBI) scheme, have served as key incentives for wind power development [17]. In addition to the MNRE incentives, many Indian states have set attractive feed-in tariffs to promote wind power electricity generation sector (E.g. Tariff rates range from 3.14 rupees per KWh in Kerala to 4.5 rupees per KWh in Rajasthan).

Taking in to account the availability of renewable energy sources in each of the states, the 2003 Electricity Act required that each state in India to should fix its own minimum percentage for purchase of renewable energy. Consequently, most states have established mandatory renewable energy shares. One of the more aggressive Renewable Portfolio Standards for wind is found in Tamil Nadu, where the standard is set at 10% between 2008 and 2009, increasing to 13% between 2009 and 2010 and to 14% between 2010 and 2011[6]. Apart from the stated state policy moves, India has taken some direct steps to inspire local wind turbine manufacturing sector. The manipulation of customs duties in favor of importing wind turbine components over importing complete machines is one such instance [20].

3.6. Industry Structure and Key Players in India

In terms of numbers India has few wind turbine manufacturers. However, in terms of capacity and global presence, Indian wind power sector rise against many developed nations. Indian company Suzlon is one such example. Though Suzlon coined in India, the company now sells turbines throughout the world [21]. Similar to Chinese wind power sector, India primarily imported wind turbines through international trade [11]. However, the government policy acts such as higher customs duties for imported components encouraged FDIs and local manufacturing. Thus by year 2005 the share of imported wind turbines significantly reduced in the presence of wind components industry [19]. Apart from FDIs, joint ventures that immerged in 1987 with Danish firms Vestas and NEG Micon is again a crucial milestone in wind power industry. Thus by 1997, while globally leading firms, including Vestas, Games and Enercon have made FDIs in India, companies such as Enercon entered the India market through joint venture agreements [11].

The licensing agreements between international wind power producers (such as Vensys, Norwin, Lagerway and Nordex) and smaller Indian wind turbine firms such as BHEL, Global Wind Power, Reegen Powertech, and Siwa can also be seen in early 2000s. The Indian flagship firm Suzlon also followed a route of technology licensing not only for wind turbine systems but also for key components such as blades and gearboxes from the mid-1990s through the early 2000s [22]. As the company (Suzlon) progressed, the company developed local technology through R&D in India and abroad [23].

IV. A PLAUSIBLE TECHNOLOGY TRANSFER AND COOPERATION MECHANISM FOR SRI LANKA

As evident in previous studies, Sri Lankan renewable energy sector primarily depends on the international trade [3]. However, examples driven by China and India, as well as the wide publications in technology transfer in the domain of renewable energy sector state that the focus need not merely be on the purchase of plant and equipment [24]. Ramanathan (2000) shows that in today's international business setting, depending on the attributes of the technology, its intended use, the motivation of the transferee and transferor, a wide range of technology transfer modalities are available. The next section of the study examines some of the popular models of technology transfer that have been developed over the years to help transferees and transferors of technology understand the technology transfer process better [25].

4.1. The Bar-Zakay Model

Bar-Zakay (1971) developed a rather comprehensive technology transfer model based on a project management approach. As illustrated in Fig.1, the model demonstrates the technology transfer process in the Search, Adaptation, Implementation, and Maintenance stages. The model comprises with the activities, milestones, and decision points in each of these stages. The upper half of the figure delineates the activities and requirements of the transferor (referred to as the “donor” by Bar-Zakay) and the lower half that of the transferee or the “recipient” [26].

Bar-Zakay model has several plus points, which makes it a very strong approach in many technologies transfer projects throughout the world. Specifically, the milestones and decision points enable both the transferor and transferee to correct their mistakes, or even to terminate the project at any point in time [24].

On the other hand, the Bar-Zakay model also has certain limitations. As Jagoda (2006) points out that, “The model has limited relevance today since many of the activities, terms, and ideas expressed reflected the setting of the late 1960s to early 1970s, when buyers of technology were mainly passive recipients who depended greatly on aid programs for the purchase of technology. It was also an era when government controls were instrumental in determining the rate, direction, and scope of technology flows” [27].

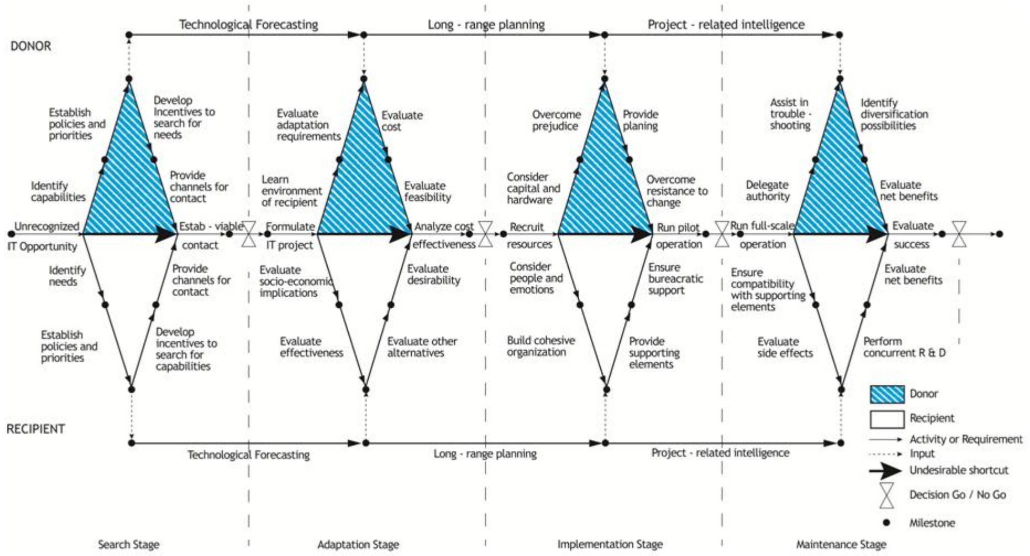


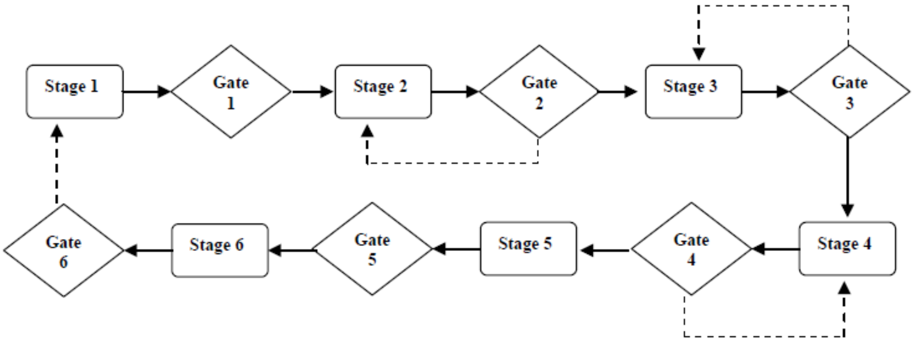
Figure 1. The Bar-Zarkay model

4.2. Stage Gate Model for International Technology Transfer

The stage-gate approach was originally developed by Cooper (2001) for managing the new product development process. It has, within its operational framework, the ability to study a process in terms of activities, milestones, and decision-point sequences [28]. This stage-gate structure was adopted by Jagoda and Ramanathan (2009) for developing a systematic approach for planning and managing international technology transfer [29].

The stage-gate model (as shown in Fig.2) of international technology transfer essentially delineates the international technology transfer process into a set of predetermined stages and gates. The stages are made up of prescribed tasks with cross-functional and simultaneous activities. The gate or controlling point is at the entrance to each gate. Based on the information generated at each stage, in-depth and critical analysis is carried out at the gate that follows the stage. Based on the evaluation, a decision may be taken to go forward, kill the project, put it on hold, or recycle it. It is envisaged that through this approach, proactive measures could be taken to avoid or minimize problems thereby enhancing the chances of successful international technology transfer [29].

The stage-gate model which is a very elaborate and realistic model supposed to take care from conception to conclusion is of much use in developing countries. The model focuses on Core Value Determinants (CVD) and selection of partner and technology. The CVD is based on customer value creation which is again based on quality, cost, convenience, delivery and flexibility, but significantly the model does not take care of the fundamentals like goal, strategy, business plan of transferor and transferee or their strength or weakness in the life cycle model. On the other hand, the model does not emphasize much on measurement of effectiveness and creating spirit of innovation [30].



Stage 1: Opportunity spotting and identifying value enhancing technologies
Gate 1: Confirming identified technologies
Stage 2: Focused technology search
Gate 2: Project confirmation
Stage 3: Negotiation
Gate 3: Finalising and approving agreement
Stage 4: Preparing a ITT project implementation plan
Gate 4: Approving implementation plan
Stage 5: Implementing technology transfer
Gate 5: Implementation audit
Stage 6: Technology transfer impact assessment
Gate 6: Developing guidelines for post-technology transfer activities

Figure 2. Stage-Gate Model for international technology transfer

4.3. Technology Transfer Model to Foster the Renewable Energy Sector of Sri Lanka

The two examples pertaining to the development of wind power sector in China and India indicates that the countries that were not part of the group of early wind turbine innovators have used "technology leapfrogs" to foster the development of their own domestic large wind turbine manufacturing companies. A common strategy has been to obtain a technology transfer from a company that has already developed advanced wind turbine technology. This can be done through international trade, licensing agreement, joint ventures or through collaborative research and development [15].

Fig. 3 illustrates a plausible technology transfer approach for Sri Lanka. The states mechanism was drawn under the assumption that the country will strengthen its technological capabilities over time. As illustrated in Fig.3, the model proposes to use technology transfer mechanisms to enhance the technological capabilities in the renewable energy sector. Presently, Sri Lanka's commercial scale renewable energy power development depends on the international trade. The model proposes to use international trade to acquire primary technologies, so that the engineers will be able to learn the operation and maintenance of the technology through experience. The model then proposes licensing agreements from suitable technology transferors. Such licensing agreements will give the local engineers the freedom to adopt the renewable energy technologies to suit local conditions (such as wind speed, humidity factors, and climatic conditions in wind power sector). Strengthening through the proposed technology transfer methods and enhanced technological capabilities Sri Lankan renewable energy sector should be brave enough to go for joint ventures. Through such mechanisms the country should next move to designing stage of the renewable energy power plants. Such efforts will not only enhance the hardware skills but also will develop the software skills of the local producers. The proposed gradual step by step approach will finally encourage the local renewable energy industry to innovate and to manufacture improved technologies, with which the country might even be in a position to export to international markets.

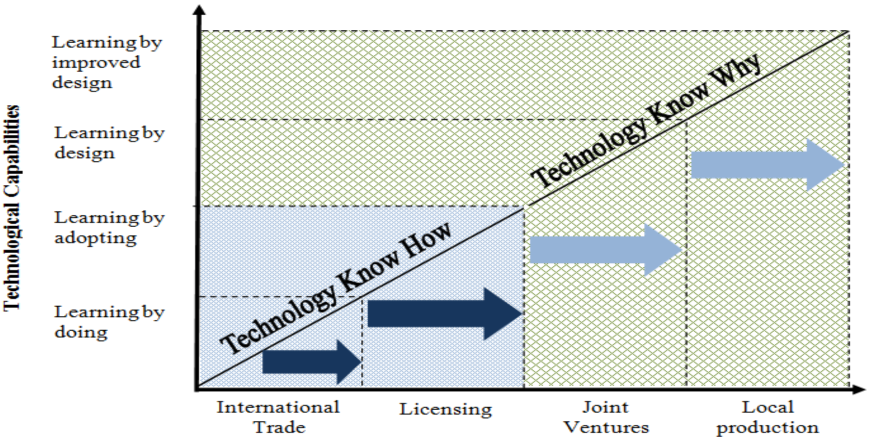


Figure 3. Framework to develop technological capabilities via technology transfer

4.4. Recommendations in Fostering Technology Transfer and Cooperation in the Renewable Energy Sector of Sri Lanka

The examples drawn in the previous section reveal that the international technology transfer is viewed as a timely solution to promote the deployment of advanced technologies across borders among the global communities. Even though India and China are key places to explore these interactions, they certainly do not represent the entire diversity of the developing world, and there are distinct differences among countries that make the lessons learned in these cases potentially difficult to apply elsewhere. An important distinction is that the technology transfer models used in China and India may not be easily replicable in less developed countries with less indigenous technical capacity within their borders. Thus Sri Lanka as a developing nation has to look into policy reforms and should gradually acquire technological capabilities in order to follow the proposed technology transfer mechanism.

4.5. Enhancing Renewable Energy Technological Capabilities of Sri Lanka

4.5.1. Gradual Steps in Technological Capacity Building

Although the deployment of technological goods is what matters to address an issue such as climate change, the transfer of technological capabilities is indeed the key to developing countries obtaining a share of the green business pie. The acquisition of technological capabilities is a gradual process and will require a number of steps. Technology capacity building begins with learning by doing followed by learning by adapting, aiming at augmenting productivity through efficient utilization and adaptation of technologies at the shop floor. Next comes learning by design and learning by improved design, aiming at replicating processes and designs for better understanding and further improvement of given technologies [31].

Thus developing technological capabilities in Sri Lanka is a long term process. Thus the technological capability development is a gradual process and will require continuous progression of steps. Lessons can also be learned from small hydro power sector of the country. The sector initiated with direct transfer of technology of capital goods such as hydro turbines. Later country managed to enhance the national capability to manufacture its own turbines (e.g. VS Hydro). Today it is in a position to export such technologies and expertise to other part of the word.

4.5.2. Technological Know-How and Know-Why

Literature reveals that the classification of technology capabilities can also be further narrowed to “know-how” and “know-why”. Know-how is acquired initially through assimilation of imported technologies, followed by quality controlling, plant and production practices, slight modifications to equipment and tooling, troubleshooting, the use of different raw materials and so on. Know-why is the next stage of technological development, which involves the understanding of the nature of the process and product technologies leading to the development of new improved designs. Applied research and frontier R&D leading to major innovations follow this stage [32].

Generally, technology know-how is expected to bring about rapid and immediate productivity growth in developing countries like Sri Lanka. Know-why, on the other hand, is absolutely necessary to create and strengthen the technological foundation of these countries. Without going through this phase of know-why oriented technological learning, developing countries can never aspire to reach the global technology frontier to catch up with the levels of technological advancement of developed countries in the long run. However, there may not be any immediate pay-off of know-why oriented technological effort in terms of immediate productivity gains in the short and medium terms [33].

4.5.3. Lessons from Chinese Solar PV Industry

The large-scale deployment of PV generation capacity, and consequently the existence of a mass market for PV modules, is a very recent phenomenon. Until the late nineties, PV systems have been installed almost exclusively off of the grid, for marginal uses (communication devices, satellites, remote habitations) for which PV electricity was competitive compared to other available off-grid electricity sources. In early days the fast deployment of on-grid PV systems has been entirely driven by limited number of industrialized countries such as Germany, Japan, Spain, and the US. However, the picture changed dramatically and today China is the world leader in cell production and module assembling [34].

In 2009, China had attracted about one third of the global FDI flows in the PV industry. Economic literature shows that the investment by a multinational firm in a productive asset such as factory in a foreign country also induces a transfer of knowledge, since the technology is operated directly in the recipient country. Besides the importing of equipment goods, the purchase of manufacturing equipment usually involves the transfer of complementary know-how through training sessions of engineers and technicians operating the production line. This in turn progressively enables PV manufacturers to adapt their production chain to local conditions.

The circulation of a skilled workforce has been another key factor aiding the emergence of the Chinese PV industry. Chinese PV companies have benefited strongly from the arrival of highly skilled executives, who brought capital, professional networks, and technology acquired in foreign companies or universities to China. For instance, the founder and CEO of Suntech, the China's largest PV Company, had been studying at the University of New South Wales in Australia, and then worked for the Australian company Pacific Solar. In addition, four out of the six members of the Suntech Board studied or worked either in the US or in the UK.

4.5.4. Developing Renewable Energy Technological Capabilities in Sri Lanka

The Chinese lessons in solar PV industry provide Sri Lanka a good example to enhance our technological capabilities in the renewable energy sector. The given example show that Chinese producers have acquired the technologies and skills necessary to produce PV products through two main channels: the purchasing of manufacturing equipment in a competitive international market and the recruitment of skilled executives from the Chinese diaspora who built pioneer PV firms.

V. DISCUSSION & CONCLUSION

The current technological capability in the renewable energy sector of Sri Lanka has a vast room to improve. The Sri Lankan diaspora may be one such initiative that can be used to strengthen its technological capabilities to accept and sustain the upcoming new technologies in the renewable energy sector. On the other hand, mere know-how that flows from foreign suppliers may not bring informal tacit knowledge, which we might only be able to absorb via experts who have the competencies and practical knowledge.

However, as stated earlier since China and India do not represent the entire diversity of the developing world, we should not apply their models of transferring green technologies and capabilities directly in the Sri Lankan context. Rather we should identify our own competencies and should use the foreign sources to overcome our technological capability gap.

Supportive policies for renewable energy technologies will help to bridge the gap between low carbon solutions and their commercial viability. Technology policy is commonly divided into market-pull and technology-push policies. Technology push policies are those influencing the supply of new knowledge, increasing the absorptive capacity of the recipient country and hence reducing the cost of TT. The most common examples of technology push measures are government sponsored R&D, tax credits for companies to invest in R&D, support for education and training, infrastructure development and funding demonstration projects [35]. Market pull policies influence the demand of technologies expecting cost reductions through a variety of learning processes as the installed capacity increases [36]. Common examples of market pull policies in the field of climate change include: carbon markets, tax credits and rebates for low-carbon consumption, energy efficiency standards, feed-in tariffs, renewable energy portfolios and taxes on competing technologies, intellectual property protection, and government procurement or technology mandates [35]. Both market-pull and technology-push are complementary and a mix of them is necessary for technological development. Experience in China, India and Latin American countries such as Chile and Brazil has shown that in addition to a large demand, successful TT responded to governments' strong signals and incentives favoring renewable energy technologies [22].

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