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Are ready-made technology transfer solutions suitable for developing the renewable energy sector in Sri Lanka?

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Abstract- As per the International Energy Agency, the unprecedented levels of economic growth emerging in the developing nations will make them responsible for future growth in energy demand and greenhouse gas emissions. Based on the International Energy Agency 2009 report, rapidly growing energy demand in developing countries is projected to double by 2030. The development, transfer and use of renewable energy technologies are promising ways towards low-carbon development in these countries. Recognizing the importance of sustainable energy for sustainable development, the origin of transferring sustainable energy technologies in the context of the international climate cooperation and in particular from developed countries to developing countries, lies in the United Nations Framework Convention on Climate Change (UNFCCC).
However, developed nation's homogeneous approaches for all developing countries and their disconnection with developing countries' national enabling factors have resulted with a limited success in promoting them. This paper is a theoretical overview of the current literature, and the paper attempts to answer the research question "Are readymade technology transfer solutions suitable for developing the renewable energy sector in Sri Lanka?" The theoretical overview discusses the current renewable energy sector of the country, followed by theoretical overview of technology transfer process, UNFCCC framework in facilitating the renewable energy technology transfer, and finally the key factors that need to be considered when tailoring the green technology transfer to Sri Lanka

Index Terms— CDM, Renewable Energy, Sri Lanka, Technology Transfer, UNFCCC

INTRODUCTION

Among the primary needs of humanity, access to clean and reliable sources of energy undoubtedly plays a prominent role in economic development and human welfare. Although many of the developing nations were being identified as fastest growing economies, most of these countries are still struggling to combat the issues associated with poverty. The region as a whole is experiencing a vibrant economic growth with a high rate of energy consumption fuelled by population growth, economic development, an energy intensive industrial base and urbanization [1].As per the International Energy Agency, the unprecedented levels of economic growth emerging in the developing nations will make them responsible for future growth in energy demand and greenhouse gas (GHG) emissions [2]. Based on the International Energy Agency 2009 report, rapidly growing energy demand in developing countries is projected to double by 2030 [3].

Catering to the expanding energy services, while tackling the environmental impacts associated with energy use, represents a critical challenge in the 21st century. Recent developments in countries like China and India, where energy production has increased significantly, demonstrate how difficult it is. Carbon emissions from these countries are rising rapidly. Renewable energies have the important potential to provide sustainable solutions in addressing the concerns of both economic developments and environmental challenges. In recent years there has been a significant development of alternative energy technologies, both in terms of performance and cost reduction. Moreover, many developing countries are particularly well positioned when it comes to developing a new generation of energy technologies [4]. Recognizing the importance of sustainable energy for sustainable development, the United Nations General Assembly has designated the year 2012 as the international year of sustainable energy for all [5]. Therefore, renewable energy is emerging as the energy supply solution for the 21st century.

SIGNIFICANCE OF THE STUDY

The origin of transferring sustainable energy technologies in the context of the international climate cooperation and in particular from developed countries to developing countries lies in the United Nations Framework Convention on Climate Change (UNFCCC). Literature reveals that the UNFCCC has attempted to promote technology through several means: an Expert Group on Technology Transfers (EGTT), Technology Needs Assessments (TNA), and two financial mechanisms: the Clean Development Mechanism (CDM) and the Global Environment Facility (GEF) [6]. Out of these different mechanisms, Sri Lanka has adopted the CDM and the mechanism for trading "Certified Emissions Reductions" (CER) and "Removal Units" (RMU).

Apart from UNFCCC attempts, many other international frameworks have also supported developing nations with technology cooperation and transfer in the renewable energy sector. However, although many programs are functioning to strengthen the international cooperation, such programs have failed to attain the expected goals for a rapid global clean energy transformation [3]. Many developing countries are affected by lack of resources, particularly for commercial energies in general and electricity in particular, which occur due primarily to wrong policies and investment decisions and limited access to finances. Therefore, any model dealing with the energy sector of developing countries should be able to capture the relevant features effectively to attain the expected results [7]. On the other hand, developed nations' homogeneous approach for all developing countries and their disconnection with developing countries' national enabling factors were the main reasons behind the limited success of the current attempts [2]. This is further supported by a recent release by UNFCCC where they have specifically emphasized the importance of tailoring activities to meet unique circumstances and needs of the developing countries [3].

This paper is a theoretical overview of the current literature, and the paper attempts to answer the research question "Are ready-made technology transfer solutions suitable for developing the renewable energy sector in Sri Lanka?" Apart from the introduction and the significance of the study, the paper is structured along six sections. Thus, the 3rd section of this article presents an overview of the current renewable energy sector of the country. While the 4th section discusses the theoretical overview of the TT process, proceeding sections (section 5 and 6) elaborate the UNFCCC framework in facilitating the renewable energy TT and their failure in doing so. Section 7 of this article highlights the key factors that need to be considered when tailoring the green TT to Sri Lanka. Finally, the last section is the conclusion which highlights the importance of local knowledge in making technology choices for the country.

SRI LANKAN POWER SECTOR

After the end of the three-decade civil conflict, the Sri Lankan economy has seen robust annual growth at 6.4% over the course of 2003 to 2012, well above its regional peers [8]. In parallel to the robust economic growth, Sri Lanka has been struggling to meet the rising demand for power. The current statistics show that the country's electricity demand has been growing at an average rate of 5.9% per annum [9]. Experts claim that with the current escalating demand, the demand for electricity will be doubled by 2020 compared with the 2010 figure. More specifically, in 2010 the base load of the country was 9,268 GWh, and the CEB long-term generation expansion plan forecasts the demand to reach 16,937GWh by 2020 [10].

In 1995 Sri Lanka produced 95% of its grid electrical energy needs from conventional hydro power plants. However, expansion of household electricity consumption and the boost in the industrial sector of the country have forced the country to depend on alternative energy resources such as fossil fuels. The total amount of electricity generated during 2012 was 11,878.8 GWh out of which 70.9% was from thermal power plants (both oil and coal), while 23.0% was from major hydro and the balance 6.2% was from Non-Conventional Renewable Energy (NCRE) which comprised small hydro, wind power, biomass and solar [11].

A combination of factors has contributed to the emphasis in recent times on generating electricity through NCRE sources. The growing electricity demand, requirement for several resources or an energy mix, environment concerns, and electrification of rural areas which requires high capital investment, operational costs and the difficulties associated with extending grid connected electricity lines to remote areas are the main reasons behind the government motive in promoting NCRE developments. On the other hand, the attractive tariff imposed on the NCRE power sector attracted a large number of local and foreign investments in the NCRE sector [12]. The present contribution of NCRE in grid electricity generation is only 6.2% from the total generation. Based on the SLSEA, Energy Balance 2012, the following table (Table I) exhibits the installed capacities and generation of NCRE power plants by end 2012.

These statistics show that the small hydro is the dominant NCRE power source, followed by wind, biomass and lastly, solar. Small hydro took the lead in the NCRE power sector due to several reasons. Technologies required to harness hydro resource potential are well developed and are available from many sources, including local manufactures. Secondly, the relatively low capital requirement and attractive tariff structure are the main driving forces for the sector's development [13]. Globally, harnessing wind energy for electricity generation has been one of the fastest growing technologies for the last decade or so and has become well developed and mature [14]. An attractive tariff structure along with the booming market for wind power plant manufacturers were the reasons for the wind power sector's success in Sri Lanka.

Biomass accounts for over 10% of global primary energy supply and is the world's fourth largest source of energy [15]. The bioenergy sector is relatively complex because there are many forms of biomass resources. In the Sri Lankan context, fuel wood and agricultural residues are the most common form of biomass available for electricity generation. In recent times biomass has attracted interest as a primary energy source for electricity generation due to its potential as a low cost, indigenous supply and attractive tariff system. However, inconsistencies in the supply chain mechanism have led biomass to fall behind other NCRE sources. Solar power is a highly abundant energy resource in the Sri Lankan context. However, apart from a few off-grid solar systems and net metering solutions, the country's total grid connected solar powered capacity is only 1.4MW. Technical limitations in the national grid and high initial investments are the main hindrances for the sector's development [10].

TABLE I: INSTALLED CAPACITIES AND GENERATION OF NCRE POWER PLANTS BY END 2012 [11]

Type of Power Station	Number of Plants	Total Installed Capacity (MW)	Generation in 2012 (GWh)	Share in Generation (%)
Small Hydro	106	227.3	564.7	77.0
Wind	9	73.0	144.5	19.7
Biomass	2	10.5	22.2	3.0
Solar	4	1.4	2.0	0.3
Total	**121**	**312.2**	**733.3**	**100.0**

THEORETICAL FRAMEWORK

In literature the term 'technology transfer' has been defined and measured in many different ways and assessed against a wide range of criteria. Khalil has defined technology transfer as the process that permits the flow of technology from source to the receiver [16]. Despite the different definitions given for transfer of technology, the development and transfer of technologies in the renewable energy sector are incorporated as priorities in both the UNFCCC and its Kyoto Protocol [17]. Though there are quite a few studies that have been conducted on green technologies between developed and developing countries, to date there are no overcharging theories which have emerged as to how TT models can be used between the two parties to transfer said renewable energies effectively [18].

The literature on TT models revealed that some of the early work of Hayami and Ruttan (1971) and Mansfield (1975) provide some of the earliest perceptions on the modes of TT which are applicable even today. Mansfield classified TT into vertical and horizontal TT [19]. The transfer of technology from one country to the next represents horizontal transfer, which may also involve a degree of vertical transfer as well. This is mainly due to the fact that low carbon technologies are currently pre-commercial or supported technologies and undergo development towards commercialization within the new country context [18]. According to Bell, technology is transferred through three types of flows of transferable technology between technology suppliers and technology importers (recipients) as Capital goods and equipment, Skills and know-how for operating and maintaining equipment, and Knowledge and expertise for generating and managing technological change [20]. Ivarsson and Alvstam agreeing with Mansfield have shown that TT can be either internalized or externalized [18].

In some literature the transfer of technology and the technology cooperation were used interchangeably to represent diffusion of technology from source to the receiver. But there is a clear difference between the two terms. While in the year 2000 IPCC defined TT as a broad set of processes covering flows of equipment, know-how and experience between various types of actors, technology collaboration can be defined as a mutual agreement between two countries to attain a common goal [20]. International Technology Collaborations which comprise science and technology development, exchange and diffusion through public-private partnership for technology absorption, capacity building and innovative project financing mechanisms are desirable and mutually beneficial to developed and developing countries [21]. A large number of organizations are implementing clean energy technology cooperation programmes among countries to accelerate technology innovation and deployment and reduce global greenhouse gas emissions. This includes numerous bilateral programmes along with such multilateral initiatives and agencies as the Asia Pacific Partnership on Clean Development and Climate, the Major Economies Forum, the Global Environment Facility and Multilateral Development Agencies, the Clean Development Mechanism, the Climate Technology Initiative, the International Energy Agency, the International Partnership for Energy Efficiency Cooperation, and the newly created International Renewable Energy Agency [3].

The Cleaner Development Mechanism (CDM) which was initiated on 3rd September 2002 under the 'Kyoto Protocol' of UNFCCC is defined as an innovative policy tool development which allows emission-reduction (or emission removal) projects in developing countries to earn certified emission reduction (CER) credits, each equivalent to one tone of CO2' [22]. The recent publications of UNFCCC have revealed that over a third of the registered and proposed CDM projects claim TT benefits, including both knowledge and equipment transfer from sponsor to host countries [17].

TRANSFER OF TECHNOLOGY IN UNFCCC FRAMEWORK

The origin of transferring sustainable energy technologies in the context of the international climate co-operation lies in Article 4.5 of the UNFCCC. Article 4 states that developed country parties and other developed parties included in Annex II to take ''all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and know-how to other Parties, particularly developing country Parties'', and to ''support the development and enhancement of endogenous capacities and technologies of developing country Parties'', and calls on other parties and organizations to assist in facilitating the transfer of such technologies [23].

Accordingly (as mentioned earlier), CDM is one such vehicle (specifically for developing countries like Sri Lanka) to facilitate transfer of technologies between developed and developing countries. Recent studies conducted on CDM tended to concentrate on determining to what extent CDM projects involve transfer. One set of studies analyses transfer claims made in the project design documents (PDD) of CDM projects. A common feature of these studies is that they define TT narrowly [20]. They often do this by implicitly assuming technology as objects that can be moved around. Transfer was considered as simple as the sale or purchase of industrial equipment. This "one shot" relocation of a fully blown technology from one country to another ultimately creates and maintains dependency on the part of the recipient. If transfer is to lead to a more satisfactory outcome, and one which is more in line with the ends of sustainable and equitable development, a much wider approach is required [24].

Although the term 'technology' is commonly used to refer mostly to tangible goods, it is used in academic literature to include intangible elements of organizations' activities as applied knowledge or know-how [25]. This indicates that in broad view the 'ambition' is not only to use technology, but to master and change technology. Bell (2009) and Ockwell et al., (2009) argue that such capabilities are necessary in developing countries for effective reduction of greenhouse gas emissions that will be associated with economic growth over the coming decades [26].

Certain scholars claim that the narrow view of transfer of technology in PDDs can be attributed to the drivers of the Kyoto Protocol. For example, Lema and Lema (2013) argue that though the Kyoto Protocol facilitates transfer of technology between developed and developing countries, TT is not a formal obligation in CDM [26]. However, irrespective of such arguments, we cannot undermine the UNFCCC's accountability in implementing transfer of technology in a broader sense. For example, the Agenda 21 had already identified the most critical dimensions of TT in Chapter 34: "Environmentally sound technologies are not just individual technologies, but a total system which includes know-how, procedures, goods and services, and equipment as well as organizational and managerial procedures. This implies that when discussing transfer of technologies, the human resources development and local capacity-building aspects of technology choices, including gender-relevant aspects, should also be addressed. Environmentally sound technologies should be compatible with nationally determined socio-economic, cultural and environmental priorities" [21].

UNFCCC FAILURE IN TRANSFERRING GREEN TECHNOLOGIES

However, so far the success of the UNFCCC process in promoting green TT has been limited due to several reasons. Firstly, the project-based nature of CDM does not foster large-scale deployment of mitigation technologies or the promotion of innovation in host countries. Secondly, many of the emission reductions achieved by the CDM are not 'additional', which implies that they would have happened anyway and should not be financially supported. Thirdly, several studies of TT in

BRICS CDM projects show that income from carbon credits was rarely the primary reason why the projects were developed, because of the uncertainty of carbon income and the long CDM registration time lags. Finally, CDM projects were concentrated in the largest emerging economies, while African countries and other developing countries have been largely left out [6].

In a different study Pueyo et al., (2012) identify three main gaps of the UNFCCC approach to climate change TT: missing links between international institutions and the national enabling environments that encourage private investment; its non-differentiated approach per (developing) country and technology characteristics; and the unavailability of clear measurements of the volume and effectiveness of TT [27]. As stated, measuring TT is inherently difficult because technology has no measurable physical presence or a well-defined price. Rather, it is embodied in products, intermediate inputs and processes [28]. Thus, among the stated gaps the unavailability of efficient mechanisms for monitoring, reporting and verifying the magnitude and effectiveness of climate change TT in developing countries still remains an unresolved issue in the UNFCCC approach [27].

TAILOR-MADE APPROACH FOR SRI LANKA

To a large extent, the state of the environment today is the result of the technological choices of yesterday. The adverse consequences of rising fossil fuel prices and environment concerns that we face today are the results of past actions that authorities have taken over the last few decades. Similarly, the state of the environment in the future will be determined largely by the technologies we choose today. Literature reveals that the present non-differentiated approach adopted by the country needs to be changed if we are to secure energy sources which are affordable, convenient and sustainable. Thus, the following section of this article attempts to highlight the key factors that need to be considered when tailoring the renewable energy technologies to a Sri Lankan context.

A. Large and stable demand

The TT can be broadly divided into two categories: inter-firm mechanisms and intra-firm mechanisms [26]. Licensing, technical agreements and cooperation, joint ventures, turnkey projects, and the purchase of capital goods such as machines and equipment are the main mechanisms that fall under the inter-firm approaches, while Foreign Direct Investments (FDI) falls under the intra-firm mechanisms [29]. Apart from this market oriented approach, non-market oriented approaches such as cross-border movement of personnel, meetings, workshops, conferences and other public forums, and open literature (journals, magazines, books and articles) also play a prominent role in transferring technologies to developing countries [22]. Empirical studies about the international climate change mitigation TT have identified trade and FDI as the main mechanisms via which technologies diffuse internationally [2].

Out of these mechanisms the most common TT approach that was used in the Sri Lankan renewable energy sector is the direct purchase of plants and equipment. Considering the fact that Sri Lanka's large and small reserves of hydro power have already been utilized, the authorities have given prominent priority towards wind and solar power sectors. In the current context investors are directly purchasing the components from foreign suppliers and the local value addition remains very low. Further investigations reveal that the concern on large and stable demand was the primary reason for the country to depend on international trade. The private sector, owner of most green technologies and responsible for most TT, is attracted by the scene of a large and stable demand. The success of China, India and Brazil in attracting and deploying foreign technologies and growing domestic renewable energy industries seems to confirm this point. A large market allows technology businesses to build a significant production scale and achieve lower production costs as a result of economies of scale and technological learning curves [30].

B. Capacity to absorb the transferred technology

Countries with significant technological capabilities (such as China & India) would have the ability to absorb the most innovative technologies and develop an endogenous technological base. On the other hand, countries with low capabilities (such as Sri Lanka) would target more mature technologies and would have a stronger dependence on foreign equipment [6]. In the Sri Lankan context, except for small hydro, almost all modern renewable energy technologies are sophisticated and new to the country and technical expertise and facilities for design, manufacture, operation and maintenance are still lacking. Presently there are very few local manufacturers and agents who are involved in renewable energy projects, and the existing maintenance networks are not adequate at all. This lack of expertise and facilities is a major technical barrier for the development of the Sri Lankan renewable energy sector [31].

The literature indicates that to achieve sustainable development, developing countries require assistance with developing human capacity (knowledge, techniques and management skills), developing appropriate institutions and networks, and with acquiring and adapting specific hardware. Thus, TT from developed to developing countries must therefore operate on a broad front covering these ''software'' and ''hardware'' challenges [24].

C. Dependence on foreign sources

In their early critiques of TT, the developing countries focused primarily on reducing what they considered to be the excessive costs of technology transactions and the many restrictive clauses imposed on recipients by the suppliers. Increasingly, focus has shifted from the costs and characteristics of imported technologies to include the factors affecting the creation and maintenance of technological capabilities in the developing countries. However, in most cases, current practices of TT do not allow the recipient enterprises to accumulate such technological capabilities [32].

Globally grid connected solar PV is the fastest growing energy technology with an average annual growth rate of 60% during the five year period from 2005 to 2010 [15]. In parallel to such developments, many international organizations initiated off-grid solar home systems in rural parts of Sri Lanka. However, due to the fast expansion of the national grid, standalone solar home systems in rural villages are going out of use. Yet, the use of solar energy as a supplementary source of electricity generation in commercial buildings and industrial facilities is gaining momentum with the introduction of the net metering facility. In the present context all the hardware pertaining to net-metering solutions are imported from either Europe or from East-Asian countries. Though the Sri Lankan engineers have the skills to do the regular maintenance, very little has been done to absorb the technical skills to produce commercially viable solar cells in the home country.

The local counterparts who engaged in developing pilot scale solar cells are not able to produce to the required specifications and standards of quality, reliability, durability, and cost. Raw materials, parts, and components have to be imported continuously to maintain the proper functioning of the imported technology. These required imports can become a drain on scarce foreign currency [29].

D. Inappropriate supply chain mechanisms

The assimilation and linking the initially acquired technology into the wider structure of the economy through forward and backward linkages to other areas of production is a key concern specifically in the biomass sector of Sri Lanka. In Sri Lanka, biomass, mainly fuel wood, still provides nearly 50% of the primary energy, which is predominantly catered for a wide variety of thermal energy applications in domestic and commercial sectors. At the most sophisticated end of the end use spectrum lies the steam generation and gasification applications, presently used in many major industries. Steam generated in boilers is used to produce electricity, completing a full cycle of elevating a primary form of energy to a very refined and versatile energy form which is electricity.

Sri Lankan engineers claim that the technology behind biomass power plants is not that complex and they claim that the country already has the capacity to manufacture certain components. But the real issue lies with the supply chain mechanisms behind the sector. Biomass requires a lot of preliminary steps to be followed (growing, harvesting, chopping, drying and feeding) in order to get it going and generate electricity. In the Sri Lankan context the lack of consistent supply chain mechanisms that support continuous generation of electricity via biomass is the major concern. Thus, if we are to develop the biomass-based electricity generation sector of the country, TT should penetrate the backward and forward integrations behind the core technology acquired.

E. Need for technology adoption

Pertaining to the above issue, one of the key factors which the current TT in the renewable energy sector faces is the challenges in adopting the imported technology. The adaptation is necessary because of physical or climatic factors. Adaptation in some cases may require relatively sophisticated inputs of skills or information, drawing on the experience of other local firms. It has been found in various empirical studies in Latin America, Africa, and newly industrializing countries that the primary source of technological change within firms has arisen not from formal R&D activities but from an accretion of these relatively minor troubleshooting efforts to adapt equipment and procedures to local conditions [32].

Classic examples could be found in the current wind power developments sector of the country. Globally, wind energy for electricity generation has been one of the fastest growing technologies for the last decade or so and has become well developed and mature [14]. Similarly, the Sri Lankan government has also given a prominent priority to the wind power sector of the country and large scale developments are taking place in the North western, southern, and central part of the country. However, presently all the components in the wind power turbines are imported to the country from India, Europe, and from China. Most of these technologies were developed adhering to the environmental conditions of the transferor's country. Thus, already the local investors claim that some of such imported components face technical issues (such as plant factor and unexpected breakdowns) due to the salt level of the sea breeze (specifically in the north western part of Sri Lanka).

F. North-to-South vs. South-to-South technology transfer

The breadth of the adoption which is required in a transferred technology also depends on the source and the receiver of the technology. The IPCC framework usually applies to renewable energy technologies transferred from North-to-South. But as Brewer (2007) points out, it neglects the fact that some developing countries have climate-friendly technologies which could be transferred from South to North and also from South to South [24]. Today, developing countries in Asia, South America and Africa are among the world leaders in the production of a wide range of climate-friendly technologies [25]. Again, specific examples could be found in the world wind power CDM projects. Literature reveals that out of the top six suppliers to wind power CDM projects, two are Chinese and one is Indian. The other three are developed country global market leaders [26]. This picture shows a relatively strong representation of developing countries in current green TT.

CONCLUSION

The ready-made TT solutions that are widely available in the Sri Lankan renewable energy sector have proven their long-term un-sustainability. The concept of TT goes beyond mere transmission of equipment or even embodied knowledge. Effective TT also involves the transfer of tactical knowledge capabilities that cannot be subjected to market-like exchange. Thus, there is a clear difference between technology trade and broad transfer of technology.

Unless Sri Lanka has the proper knowledge to make informed choices among technological options, there is a risk that the efforts to promote international TT may become overwhelmingly supplier driven and geared more towards transferring available technologies rather than technologies required by the country.

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