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The technology transfer reality behind Costa Rica's renewable electricity

by

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Abstract

Costa Rica is a developing country that has been the first to produce electricity form 100% renewable sources for 300 days and its representatives advise other countries to "follow Costa Rica's example". The aim of this study is to inspect this phenomenon from the points of factors that contributed to it, the country's national innovation system capabilities, and technology transfer issues. The technology transfer is studied with a special focus on trade in renewable energy technologies to establish its significance for the economy and in the region. The results show that the innovation capabilities, implemented renewable energy policy instruments leave room for improvement. Trade is a significant channel of technology transfer for the sector and for the economy, however, Costa Rica's performance in the area falls behind that of other countries in the region. Overall, in remains unclear if there is an example to be followed by other developing countries in Costa Rica's experience.

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List of Abbreviations

LAC – Latin America and the Caribbean group of countries

UMI – Upper Middle-Income group of countries (World Bank classification)

MFN – Most Favoured Nation

RET – technologies associated with renewable energy generation

GFCF – Gross Fixed Capital Formation

FDI – Foreign Direct Investment

DAC – Development Assistance Committee

ODA – Official Development Assistance

GEF – The Global Environment Facility

WB – the World Bank Group

BP – British Petroleum, plc

BNEF – Bloomberg New Energy Finance

IFC – International Finance Cooperation

HS – harmonized system of goods classification

1 Introduction

The current state of the environment is a result of the past technological choices; similarly, the technological choices of today will determine the state of the environment tomorrow (Karakosta et al., 2010).

The importance to study environmental policy conducted by developing countries and their efforts to reduce emissions comes from the need to disregard the notion of "environmental privilege" (Steinberg, 2001), that only industrialized economies have the means and political will for a sustainability transitions, and that developing countries are "too poor to be green" (Steinberg, 2001, p. 29). Economic development is most rapid in developing economies, however, in order for their development to be sustainable, they must avoid the polluting developments paths of the industrialized economies (Karakosta et al., 2010, Wilkins, 2002). "Climate change is the greatest market failure the world has ever seen" (Stern, 2007). An effective global response to this market failure includes three key elements of policy, among which are pricing of carbon, that can be implemented through tax, trading and regulation; policy to support innovation and the deployment of low-carbon technologies; and action to remove barriers to energy efficiency and to inform, educate and persuade the society about climate change response (Stern, 2007).

As both economic growth and population growth in the traditional scenario of industrialization lead to increased fossil fuel consumption (Popp, 2009), there is a need for an emissions reduction scenario. This scenario depends on two strategies (Holdren, 2006): reducing the carbon intensity of energy use (amount of carbon emissions per unit of energy consumed) which can be achieved through the deployment of cleaner energy sources, such as natural gas and renewable energy sources. The second strategy is reducing the energy intensity (energy use per dollar of GDP) by increasing the energy efficiency. Both strategies require the continuous development and diffusion of new and improved technologies associated with energy use (Popp, 2009). Environmentally-sound technologies (EST), as defined by the UN, include technologies "which protect the environment, are less polluting, use all resources in a more sustainable matter, recycle more of their wastes and products, handle residual wastes in a more acceptable manner that the technologies for which they are substitutes, and are compatible with nationally determined socio-economic, cultural and environmental priorities" (UN, 1993). This rather broad definition provides just an outline of the characteristics that technologies that benefit the environment should possess, and for specific research purposes requires narrowing down. This research will focus on technologies, associated with renewable energy, which also fit the criteria of ESTs.

The country under focus is Costa Rica, as a country with a pronounced environmental policy and a high degree of renewable sources in the economy's energy balance. Over 90% of the country's electricity comes from renewable sources, most of which is hydropower (around 75%). To establish the significance of policy for the sector, the environmental and renewable energy policy initiatives of the developing country will also be taken into consideration. Costa Rica is famous for its long-standing commitment to social welfare issues, having abolished the military in 1948 by the founders of the modern republic, which allowed the country to free up recourses to allocate to the social issues (Steinberg, 2001:50). Since the 1940s the country has been focusing on building social institutions, such as public education and healthcare, the Costa Rican Institute of Electricity (ICE), a state-owned enterprise that provides electricity and telecommunications was also founded during this time; since the 1970s the national awareness of the environment became pronounced, with, among other things, the establishment of the National Institute for Biodiversity.

1.1 Research Problem

Costa Rica has achieved remarkably high shares of renewable energy sources in electricity generation. The country has been prided for being able to last 300 days powered exclusively by renewables, which no country has been able to achieve previously.

In the international climate negotiations and in political statements Costa Rican representatives have made claims of being the pioneers of sustainable development as a developing country, aiming to "set an example" to the world. The president of Costa Rica, Alvarado Quesada, at the World Economic Forum in the winter of 2019, in his speech was making the case for developing countries leading the world in the fight against climate change, claiming that sustainable development is already being accomplished in Costa Rica, and the rest of the world should follow (Stewart, 2019). Quesada claims that once before Costa Rica did the impossible and reversed deforestation – now it is on its way to accomplish the impossible again, by eliminating fossil fuels by 2050.

Without disregarding Costa Rica's achievements in "greening" the economy, the question on which factors made it possible for the country to reach 98% renewable electricity, how green the economy really is, and what exactly is the example that Costa Rica can set to other countries, is called for.

Greening the electricity sector requires technologies for electricity generation and natural resources. This calls for questioning the origin of these technologies in Costa Rica: is its national innovation system strong enough to produce them? If not, what is the role of technology transfer from other countries, and what do the policy-makers implement to facilitate it?

Thus, the research questions of this thesis are the following. Which factors contributed to Costa Rica's achievements in electricity generation from renewable sources? Are the qualities possessed by the national innovation system of Costa Rica sufficient for the successful development or adoption of technologies associated with renewable energy generation within the LAC region and in comparison, to other countries in the region? Which channels of technology transfer are the most significant for the economy and the sector of renewable energy? Are the renewable energy technology imports in Costa Rica significant within the LAC region and in comparison, to other LAC countries? Is it possible for other developing countries to imitate Costa Rica's success?

1.2 Aim and Scope

The complexity and multidimensional nature of the issue of renewable energy generation calls for a multidimensional approach to the sector in Costa Rica. Technologies lie at the heart of electricity generation. Technology transfer issues, in turn, bring about the need to analyse the national innovation system of Costa Rica, as it determines the technology development and knowledge absorption capabilities and capacities of the economy. At the same time, it is important not to disregard the initial factor endowments, possessed by the country, which may determine the resources available to the economy in terms of energy production.

Though Costa Rica's history of institutional changes and efforts in the direction of sustainability date back to the 1970s, the scope of this thesis is limited to the time period of 2001-2018, as before this time, Costa Rica's environmental actions dealt mainly with issues of biodiversity, and climate change mitigation in terms of emissions targets and renewable energy targets appeared on the country's agenda largely in the beginning of the 21st century.

The thesis deals with the national innovation system of Costa Rica, the background information on the country's electricity sector and natural resources, technology transfer through FDI, and licensing. It is expected that the main transfer of technologies associated with renewable energy could be trade, thus the empirical analysis will focus, in particular, on trade in technologies related to four main renewable energy sources for electricity generation: hydro, wind, geothermal, solar.

The aim of the thesis is to identify factors that are beneficial for Costa Rica's high share of renewables in electricity generation and the factors that may hinder the transition to a more sustainable energy sector. The objectives of the thesis are to answer the research questions by inspecting the country's national innovation system in regard to its capacity to absorb technological knowledge; establish the policies undertaken in the country in the renewable energy sector; and assess the flows of technology transfer in the sector in regard to their significance for the economy and in the context of the regional developments.

1.3 Outline of the Thesis

The structure of the thesis is as follows. Section 2 presents a review of previous research on associated topics and the theoretical approach upon which the empirical analysis is based. Section three deals with the data used for the empirical analysis and the sources for the descriptive statistics, establishes data limitations and specifies the method used in this research. The fourth section offers the empirical analysis, including the background information on the energy and electricity sector in Costa Rica, its innovation capabilities, assesses the natural factor endowments possessed by the country, analyses the policies associated with renewable energy and the three main channels of technology transfer, in the trade-related section discussing the imports on technologies associated with renewable energy generation. The final section presents the conclusions drawn from the conducted research and opportunities for further research on the topic.

2 Theory

2.1 Previous Research

The literature strands under review deal with issues related to development and diffusion of sustainable technologies, the effect environmental policy has on the development and adoption of these technologies.

Popp et al. (2010) provide a review of the literature on technological change and the environment, identifying the following strands of literature connected the subject: studies on environmental induced innovation; studies on theoretical and also empirical aspects of innovation and environmental policy instruments; papers on the factors affecting the adoption of environmental technology; studies on the barriers to the adoption of environmental technologies. Studies on environmental induced innovation include those by Lanjouw and Mody (1996), Jaffe and Palmer (1997), Newell et al. (1999) and others. Most of these studies focus on environmental policy (regulatory and market-based) in industrialized economies. The innovation activity induced by policy is measured by patent activity and R&D spending. Research that focuses on the theoretical aspects of innovation and environmental policy instruments began as early as 1978 and 1979 (Magat) and deal with the analysis of command-and-control environmental regulations and market-based instruments and their role in stimulating environmental innovation. Studies on the empirical aspects of innovation and environmental policy instruments, including Newell et al. (1999), Johnstone et al. (2009) and others, also largely focus on data on developed economies. The research that considers the factors that affect the adoption of environmental technologies also focus on developed economies and the environmental technologies under consideration are mostly pollution-control technologies, and do not include energy-related technologies, like energy-efficiency technologies or technologies associated with renewable energy. The papers that study the barriers to the adoption of environmentally friendly technology also analyse data of developed economies and mostly on pollution-control technologies. In this block of literature, the works by Mulder et al. (2003), Nijkamp et al. (2001), Howarth et al. (2000), Anderson and Newell (2004) deal with energy efficiency and energy-saving technologies and identify the following barriers to their adoption: agency, decision-making and inadequate information (Howarth et al., 2000); economic barriers like alternative investment, low energy costs and capital replacement (Nijkamp et al., 2001); complementarities among technologies (Mulder et al., 2003); inadequate information, initial cost and payback years of adoption (Anderson and Newell, 2004).

Pfeiffer and Mulder (2013) also note that few studies have focused on the diffusion of renewable-energy technologies and those that have largely consider developed countries. In their study they focus on the diffusion of non-hydro renewable energy technologies (NHRE) across a large sample of developing countries and find that it accelerates with the implementation of regulatory and economic environmental policy instruments. They also find that higher income per capita and schooling levels, as well as a stable democratic regime play a positive role in the diffusion of these technologies. They find weak support for the positive influence of the Kyoto Protocol and international climate cooperation on the diffusion of NHRE. An important finding is that a large share of hydropower lowers the probability of NHRE being adopted in a country, as well as fossil fuel abundance. In their results they find that NHRE tend to become substitutes for fossil fuel sources of energy, rather than a complementing source.

Despite the fact that most of the studies on environmental technology adoption focus on developed countries, there has been research conducted on environmentally friendly technology adaptation in developing countries. The significance of such research lies in the fact that in developing country settings factors fostering the adoption of environmentally friendly innovations my differ from those is developed countries. Some examples of this type of research include the works by Fisher-Vanden et al. (2006), Blackman and Kildegaard (2010). Blackman and Kildegaard (2010) focus on the adoption of pollution-control technologies in Mexico. They find that in a developing country like Mexico, the firm's human capital and stock of technological information influence clean technology adoption; and that private-sector trade associations and input suppliers are important sources of information about technologies for the business sector. They also find, that in contrast to the results commonly found in developed countries, the firms size and regulatory pressure do not play such a big role in clean technology adoption. Fisher-Vanden et al. (2006) focus on energy-efficiency technology adoption in the business sector in China and find that in contrast to pollution-control technologies, energy-efficiency technologies diffuse even without environmental policy in place, as they offer users the opportunities for cost savings.

Cross-border diffusion of Environmentally-sound technologies is key to addressing environmental problems and is particularly significant for developing countries which are rapidly adding new capacity while the vast majority of ESTs is still developed in OECD-countries (Dechezleprêtre et al., 2011). The research dealing with the diffusion of climate change-related technology was conducted by scholars as Dechezlepretre and Glachant (Dechezlepretre et al. 2011, Glachant & Dechezlepretre 2017, Glachant et al. 2017) and Lanjouw and Mody (1996). The study by Dechezleptretre et al. (2011) is a more comprehensive in terms of patent data and countries covered, and contemporary study than the one by Lanjouw and Mody (1996), though both of them deal with the diffusion of environment-related technologies among countries, including transfers from industrialized economies to developing countries. The diffusion of technologies is analysed by Dechezlepretre et al. (2011) using patent data as an indicator of innovation and technology transfer, which has certain limitations. They focus on market-driven transfers. The limitations concern patents being only one of the possible means of protecting an invention, the fact that an invention is patented does not necessarily imply that the patent will be obtained and used by others and the fact that some inventors may be unwilling to patent their technology due to a number of reasons. Lanjouw and Mody (1996) in their study focused also on the relationship between the stringency of environmental policy and the innovation activity measured in the number of environmentally-related patents granted; and found that increased abatement costs lead to an increase in patent numbers with a time lag. Dechezleptretre et al. (2017) have also studied the cross-border transfer of environmental technologies in regard to particular sector (ex. the automobile industry) and Dechezleptretre and Glachant (2014) analyse the influence of environmental regulation abroad on national innovation on the example of the wind industry. Work on climate-related technology transfer has also been conducted by Popp (2011), who partly bases a more theoretical approach to the issue on the work on Dechezletpretre et al. (2011) and Lanjouw and Mody (1996) to establish policy implications following the need to incentivize the transfer and also the role the Kyoto Protocol Clean Development Mechanism played in facilitating it.

Works by Wilkins (2002) and Karakosta et al. (2010) focus on the importance of low-carbon an environmentally-sound technologies for sustainable development, highlighting the importance of developing countries “leapfrogging” to more sustainable technology usage and renewable energy system employment as opposed to following the polluting paths of industrialization of modern developed economies. These works highlight the complexity of the process of technology transfer to developing countries, especially climate-related technologies and technologies associated with renewable energy.

Environmental innovations and their diffusion from developed countries have been discussed in the work of Beise and Rennings (2005b), which stresses the importance of trade and market conditions for the diffusion of these innovations. However, the paper mainly focuses on the diffusion among industrialised economies.

Technology transfer in general has been studied by authors like Maskus (2004); Hoekman et al. (2005). Maskus (2004) who establish the means of technology transfer: market (trade, FDI, licensing joint ventures, cross-border movement of labour) and non-market (imitation and reverse engineering, employee turnover and published information). Maskus (2004) also establishes that the majority of technology transfers takes place through trade, FDI and licensing, which is used by the above-mentioned authors in their research. The theoretical aspects of technology transfer for renewable energy were studied by Wilkins (2002).

Studies have also been conducted on the trade flows of Climate Change Mitigation Technologies of the European Union by European Institutions (Pasimeni 2017 and Rudyk et al. 2015), however, they paint a global picture of trade in the technologies. Rudyk et al. (2015) also stress that international diffusion of Climate Change Mitigation Technologies is a key objective under international climate negotiations, among which is the United Nations Framework Convention on Climate Change (UNFCCC), that in in its turn, brings about benefits in climate change mitigation across the world as well as leading to such economic benefits and growth and job creation.

The research that has focused on any sustainability-related issues in Costa Rica typically deals with the forest protection and biodiversity sector, in which Costa Rica has showed remarkable results in terms of reforestation, protection of biodiversity through institutional innovations, domestic policies and international cooperation. The studies include works such as Steinberg (2001), who stresses the environmental leadership of Costa Rica and Bolivia, focusing on the fact that it is indeed possibly for developing countries, that are largely thought to be "too poor to be green" to achieve remarkable results in environmental protection. environmental protection; and Pagiola (2008), who focuses on the Payments for Environmental Services program in Costa Rica, that has allowed for the country to reverse deforestation and become a pioneer in biodiversity.

The literature review allowed to establish the complexity of the processes behind the necessary diffusion of sustainable technologies to developing countries. Works of the diffusion of such technologies on the global scale indicate that most of the technologies as still developed in industrialised economies, which highlights the opportunities presented to developing countries in terms of their adoption to achieve the leap-frogging to a more sustainable energy system for a sustainable economic development. The literature review also reveals that although the issues related to the connection between environmental policy and factors affecting the adoption of environmentally friendly technologies have been covered at large in research, the research mostly deals with developed economies. The country under focus in this thesis, however, is a developing country, and, even though, the literature on diffusion of energy-related technologies is not as vast, it allows for the establishment of the factors, that may differ in terms of stimulating the adoption of energy-related technologies, such as the importance of the human capital in the national innovation system, the access to information about clean technologies, trade conditions, market development and associated with it issues. A positive factor was recognised through the studies of previous research, namely the fact that environmental regulation may not be the driving force of the diffusion of energy-related, especially, energy-efficiency, technologies, which is typically driven by market forces. Studies on the adoption of energy-related clean technologies in developing countries also find the factors that may hinder their adoption, such as natural factor endowments constraints, and warn that developing countries also may need to overcome carbon lock-in, or, in the case of Costa Rica, facing the need for the diversification of the electricity mix, hydro lock-in. The strand of literature that deals with sustainability-related issues in Costa Rica mainly focuses on the biodiversity and reforestation areas, which allows for the conclusions regarding the developed civil society awareness and acceptance of environmental issues, however, leaves the opportunity to explore the renewable electricity sector of the economy, which is under focus in this thesis.

2.2 Theoretical Approach

The theoretical framework used to analyse the transfer of renewable energy technologies (RET) to Costa Rica is based on the studies by Hoekman et al. (2005) and Maskus (2004) that concerns technology transfer to developing countries. As this study is focused on the renewable energy sector, the specific characteristics of environmentally-sound technologies have to also be taken into consideration. Specific characteristics of technologies associated with renewable energy which fall under the more broad definition of environmentally-friendly, or environmentally-sound technologies, have been addressed in the studies by Popp et al. (2010), Beise and Rennings (2005a), (2005b), Rennings (2000), (Newell, 2008a), which allows to establish the significance of environmental policy and regulation, as well as the country's policies regarding research and development (R&D) and addressing the national innovation system. To analyse Costa Rica's innovation capabilities and technology absorption capacities, the National Innovation System concept will be used, based on the works by Chaminade et al. (2018)

The significance of international technology transfer (ITT) in general found ground in the fact that both acquisition and diffusion of technology foster productivity growth (Hoekman et al., 2005).

The channels of technology transfer include market and non-market ways of technology exchange (Maskus, 2004). The market channels include trade in goods, foreign direct investment (FDI), licensing, cross-border migration of managerial personnel, joint ventures. The non-market channels include imitation and the departure of employees to competing enterprises. For the purpose of empirical analysis, technology transfer can be defined as trade in technology between OECD-countries and major "emerging" economies private sector and the private sector and/or government enterprises of developing countries (Desgain and Haselip, 2015). The aim in international technology transfer for host countries is to lower the cost of imports of IPR-intensive goods and increase the capacity to absorb and adapt technology (Hoekman et al., 2005).

The rationale for policy intervention in technology transfer lies in the associated market failures. The market failures (Hoekman et al., 2005), that occur in the ITT sector include the asymmetric nature of information, i.e. the fact that technology owners are not able to fully disclose the knowledge associated with their technology in view of preserving the basis for trade, whilst the buyers have trouble assessing the value of the technology prior to the purchase. This increases transaction costs and could hinder the technology flows volumes. Another market failure is the fact that owners of new technology typically tend to have the "upper hand" and hold substantial market power due to the "lead time" and IPR protection, which benefits the innovator, while hindering the welfare of the importer states. A majorly significant market failure deals with externalities associated with uncompensated knowledge spill-overs. This problem is also especially significant when considering environmental innovations or environmentally related technologies. Environmental innovations produce positive spill-overs in both the innovation and diffusion phases (Rennings, 2000), what is unusual about them is that environmental innovations incur lower external costs and benefit the society as a whole more (Beise and Rennings, 2005b), the environmental benefits bearing a public good character. This gives rise to the double-externality problem, where the innovator is incapable of reaping the appropriate profits, which, in turn, reduces incentives for firms to invest in environmental innovations and leads to the need for policy measures to stimulate them (Beise and Rennings, 2005b). An additional market failure deals with the scale of technology adoption and the benefit associated with it in the form of increasing returns through learning-by-using, learning-by-doing, or network externalities (Popp et al., 2010). Apart from the aforementioned knowledge externalities, it is important to consider the environmental externalities that technological change and the subsequent technology transfer bring, which, in turn, call for increased government support for environmentally-friendly R&D (Popp et al., 2010) and adoption of such technologies.

ITT market reveals several market failures which need to be addressed through policy interventions. Addressing them is a complex matter, however, scholars propose a number of targets at which policy action should be aimed (Hoekman et al., 2005) in terms of correcting these failures. First, there is the need to increase access of local buyers of technology to the international knowledge market, and the same time improve the ability of technology owners to signal the true value of their inventions. What is more, policy makers need to focus on lowering the costs of acquiring and absorbing existing technology. Incentives for domestic innovation also need to be stimulated.

Technology transfer in renewable energy also adds to the need of policy action due to the fact that energy systems are subject to inertia and lock-in effects (Unruh, 2000, 2002), which adds to the significance of policy interventions. The alternative energy technology sector is specific in the fact that policy interventions need to aim at tackling both the knowledge spill-over externalities and the environmental externalities (Popp et al., 2010). Studies show, however, that policies addressed at all knowledge spill-overs are more efficient than those focusing exclusively on the alternative energy sector (Schneider and Goulder, 1997).

Environmental policies take two main forms (Popp at al., 2010): the “command-and-control” environmental standards and market-based approaches. Both types of environmental policy can potentially lead to an increase of innovation activity and technological change as firms will be incentivised (or forced) to perform in ways different to the “business-as-usual” model. Market-based instruments can be viewed as mechanisms that encourage behaviour through market signals rather than through explicit directives regarding pollution-control levels or methods (Popp et al. 2010). The regulatory standards, in turn, allow firms less flexibility in pollution-abatement methods and techniques and incur higher costs for the firms in achieving the emissions or other targets (Popp et al., 2010). Newell (2008b) concludes that a successful effort to accelerate and then sustain the rate of development and transfer of GHG mitigation technologies must include a diverse set of markets and institutions beyond those explicitly related to climate and include those from energy, trade, development and intellectual property. Specific policy instruments in the renewable energy sector may include a renewable energy target and laws/programmes by source on the national level; fiscal incentives, such as VAT, import and income tax exemptions, carbon taxes, accelerated depreciation and other fiscal benefits; grid access policies; regulatory policies, such as renewable energy auctions, feed-in-tariffs, energy quotas and certificates and others; financial instruments: currency hedging, direct funding, pre-investment supports, guarantees, etc.; and other special environmental regulations and benefits (IRENA, 2015).

Transfer of technologies associated with clean and/or renewable energy can be and is targeted on several levels, including the global cooperation on climate change and technology transfer, the domestic level of environmental and energy policy as well as domestic R&D policy and at the level of private and state-owned firms. Technology-oriented agreements are aimed at knowledge-sharing and coordination, research, development, and demonstration and could potentially increase the overall efficiency and effectiveness of international climate cooperation and domestic actions targeting climate change (Newell, 2008b). For climate change mitigation international cooperation on technology transfer may not be as significant as it may seem. Coninck et al. (2008) and Barrett (2006) find that agreements on emissions reduction and setting emissions targets are more important for addressing climate change; and technology-oriented climate cooperation is likely to be successful as a complementary measure to emissions-based policies rather than a substitute for them. Domestic actions for emissions mitigation is a crucial feature of a global response to climate change and is what induces long-term innovation (Newell, 2008b).

The barriers for the adoption of environmentally-friendly technologies on a micro-level include inadequacy of information; the fact that up-front costs tend to matter more than longer terms operating expenses (Jaffe and Stavins, 1995); the need for capital replacement; complementarities among technologies. The introduction of renewable energy technologies also involves changes in informal and behavioural norms (Karakosta et al., 2010) which brings the institutional aspect into consideration.

A National Innovation System (NIS) can be defined as an "open, evolving and complex system that encompasses relationships within and between organization, institutions and socio-economic structure which determine the rate and direction of innovation and competence-building emanating from processes of science-based and experience-based learning" (Lundvall et al., 2009, p.7 in Chaminade et al. (2018)). A crucial characteristic of a NIS is its capacity to absorb and utilise the knowledge created abroad (Chaminade et al., 2018). The national innovation system is important for the adoption of renewable energy technology for two main reasons. If the NIS is developed, it is possible to generate the necessary technologies. Is the innovation capacities of a country are not developed enough to generate innovations, which is often the case in developing countries, the innovation system still needs to be a priority for policy action, as the absorptive capacity of a country's NIS is the determinant of successful technology transfer through channels, such as trade, FDI and licensing. The country's able to receive the utmost benefits from technology transfer through trade by being the recipient of knowledge spill-overs, which largely depends on its innovation system, namely its capacity to adopt technologies and absorb knowledge, which, in turn, depends on the human capital, institutions, financial markets (Popp, 2009).

The presented theoretical approach to the issue of renewable energy related technologies to Costa Rica allows for the empirical analysis based on the following points in order to answer the posed research questions. The natural resources that can be found in the country are accounted for in order to establish the potential of using them for electricity production. The national innovation system of Costa Rica is analysed, focusing more on the human capital aspect of it, whether it possesses the capacities to absorb foreign technologies. The environmental and innovation-related policies enacted in Costa Rica are analysed to gauge the efforts the country takes to address the challenges it faces in terms of renewable electricity generation and technology transfer. The channels of technology transfer (TT) assessed are FDI, licensing and trade, with attention paid to ODA, in order to determine the most significant channel of TT and estimate the significance of Costa Rica's position in the LAC region and other countries in the region.

3 Data and method

The method adopted to answer the posed research questions is of qualitative. Empirical data is used to assess the most significant channel of renewable energy technology transfer and to analyse the significance of Costa Rica's imports in relation to the Latin America and the Caribbean region and other countries in the region. Statistical data is also used to illustrate the carbon footprint of Costa Rica, its energy use, ODA, FDI and royalties and license fees flows.

For the empirical data used to assess the actual trade flows from to Costa Rica, the International Trade Centre Trade (ITC) Map will be the main source. The Harmonized system (HS) is a system which registers and monitors international trade flows, comprised in a way that allows for comparison and analysis of trade flows from different countries. The data of trade in products is aggregated in broader groups of goods. Based on the list of Low-Carbon Energy Technologies comprised by Pasimeni (2017) and adapted from other sources (see Appendix A) it is possible to establish the trade through the ITC Trade Map. It is important to note that the classification by Pasimeni is not the only possible way to sort LCETs in groups, however, it is based on patent data and previous research. Pasimeni's list of LCETs are further shortened to better reflect the most relevant technologies for the renewable energy sector of Costa Rica. Thus, the trade flows in technologies, associated with electricity produced from geothermal, hydro, solar and wind power are under focus.

To establish the significance of the trade flows to Costa Rica, they are compared with imports of the same HS codes to Brazil, Chile, Mexico, Uruguay, Ecuador and Paraguay and the Latin America and the Caribbean region. These countries are chosen based on several factor. The countries belong to the region of Latin America and the Caribbean; all of them, except for Chile, belong to the upper middle-income group (according to the World Bank country groups classification); have renewable energy targets (more or less ambitious depending on the country). Chile is the only high-income country in the sample. Out of the countries analyzed, Brazil is the largest economy in the LAC region with 123 GW installed power capacity in 2012, approximately double that of Mexico, the second largest economy in the region., 65% of which is hydroelectricity. Chile has the most diversified electricity mix in the Southern Cone subregion of LAC, including natural gas, hydropower, fuel oil, coal small hydro, wind, biomass;

Uruguay's capacities in wind power and biomass energy allow it to be considered the second "greenest" electricity producer in the region after Paraguay, all of the electricity of which is generated from hydropower (IDB, 2014).

Additional statistics and supporting data for the analysis of the RET imports and analysis of ODA, FDI, NIS, energy sector are obtained from sources, such as the International Energy Agency statistics, OECD Data bank, The World Bank World Development Indicators database, Bloomberg New Energy Finance Climatescope report, BP energy statistics.

3.1 Data limitations

The necessity of assessing the trade in technology associated with generation of geothermal energy for Costa Rica is dictated by the increasing share of geothermal energy in the renewable energy sources mix (see Figure 1). However, as mentioned in Appendix A, the main parts of a geothermal plant are not exclusive to the use in geothermal energy generation and may be used in other industries. Thus, the sector of actual use of the imported goods under the HS codes analysed is difficult to identify.

An additional limitation to the trade in technologies associated with renewable energy is that the trade flow data analysed is in current USD, not accounting for inflation and exchange rate fluctuations. Volumes of the trade flows are unavailable and non-comparable between themselves, and prices for the technologies and equipment traded are also unavailable, which implies that the analysis does not account for technologies' price dynamics.

Trade in and tariffs related to technology associated with geothermal energy is difficult to assess (Steenblik, 2006). The main components of a geothermal plant, besides the electric generator are the steam turbine, heat exchangers, condensers, heat pumps, connecting piping and valves. Apart from the steam turbines (which are also not separately identifies in the HS), other parts have multiple uses and are not exclusive to geothermal energy generation.

Other forms of technology transfer include FDI and licensing. However, the focus of this thesis remains on trade in renewable energy technologies, thus FDI and licensing volumes are analysed only for the purpose of establishing the significance of these channels for the country in general, not specific to renewable energy.

The researcher’s limitations include not being able to use information about Costa Rica’s renewable energy policies from the primary source due to a language barrier. Thus, the information on implemented policies in the sector is obtained from secondary sources.

4 Empirical Analysis

The empirical analysis of the transfer of technologies associated with renewable energy in Costa Rica is conducted within a framework based on the theoretical approach discussed in Section 2.2 of this thesis. It includes an examination of the National Innovation System of Costa Rica and assessment of the country's innovation capabilities, initial factor endowments of the country; the policies associated with environmental action and energy sector. The factual transfer of technologies is evaluated within the three main channels of technology transfer to developing countries: trade in technology associated with renewable energy, foreign direct investment (FDI) and official development assistance (ODA), and licensing, focusing mainly on trade in RET as the main technology transfer channel. Costa Rica's performance is evaluated in the context of the LAC region and compared to selected countries in the region, including Brazil, Ecuador, Chile, Mexico, Paraguay and Uruguay, which have been chosen due to their levels of economic development and performance in the renewable electricity field.

There are several factors that contribute to the rise of renewable energy capacities and trade in goods associated with renewable energy in the LAC region, to which Costa Rica belongs geographically. The ambitious renewable energy targets set by the countries in the Latin America and the Caribbean region open opportunities for a rapid development of the market for goods and technologies associated with renewable energy. Among other factors that benefit the development of the renewable energy sector are the favourable natural resources, which include hydro resources, significant exposure to sunlight, in many countries geothermal resources. To promote the use of renewable energy countries employs regulatory and fiscal policies (Vossenaar, 2016). Renewable energy capacities have increased significantly in the LAC region, especially noticeably in the wind and solar energy sectors (Vossenaar, 2016).

4.1 Energy in Costa Rica

The contribution of renewable energy sources to the total primary energy supply has displayed a continuous increase in the observed time period (2000-2016) (Figure 1). The electricity sector relies almost entirely on clean energy sources (Desgain & Haselip, 2015) with 98% of the country's electricity coming from renewable energy in 2018 (Rodriguez, 2019).

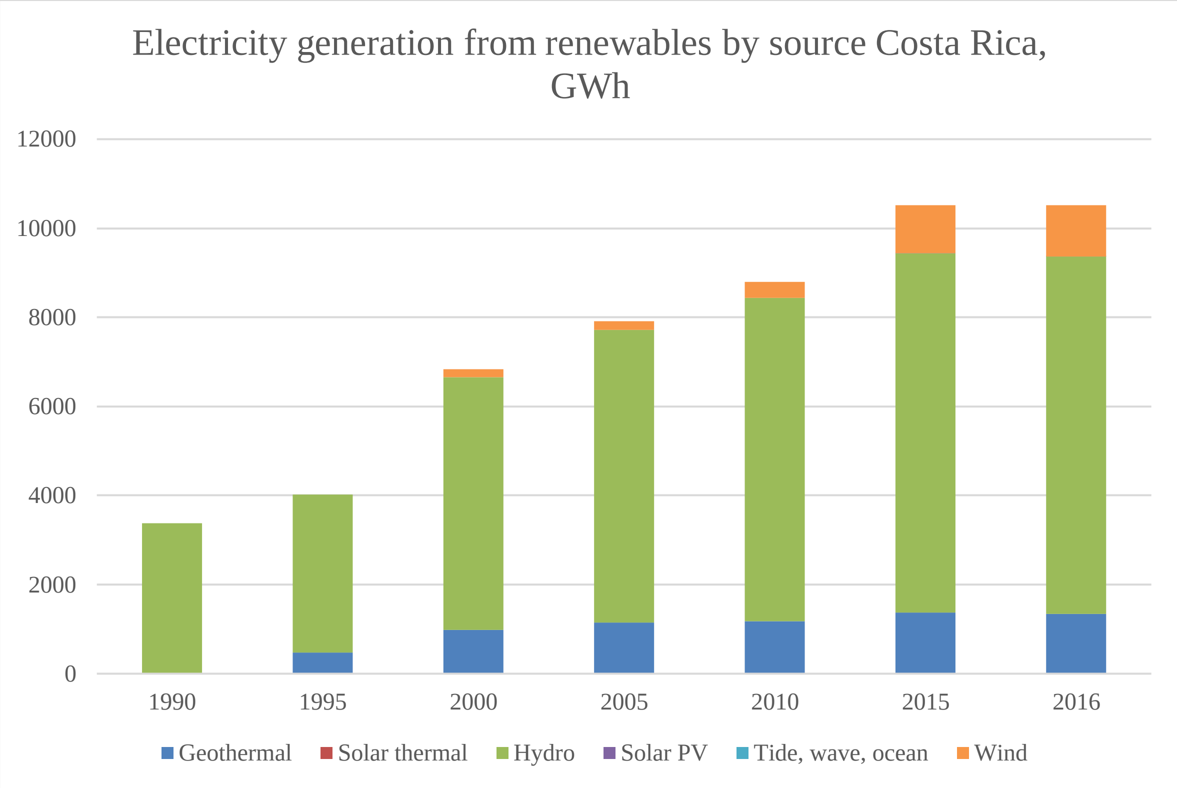


Figure 1 Electricity generation from renewables by source, Costa Rica, 1990-2016
Source: created by the author based on data from (IEA, 2018c)

The main renewable sources of electricity in Costa Rica are hydro, wind, and geothermal energy. As can be seen from Figure 1, the main renewable source of electricity generation in Costa Rica over the observed time period of 1990-2016 has been hydropower. From the year 2000 there has been a continuous increase in the production of electricity from wind power and from the 1990s the use of geothermal energy has seen an increase. There has also been an increase in the use of Solar PV, however, its share is of yet negligible in comparison to other renewable sources, which explains it not being identified in the graph.

Although an extremely large share of total electricity production is already generated from renewable sources, the country faces the need of diversification of its renewables portfolio, not it the least because large hydropower projects are increasingly viewed as unsustainable sources of power generation due to their often serious negative environmental and social externalities (Pfeiffer and Mulder, 2013). An additional reason to diversify, is the issue of electricity supply security, as hydropower is highly seasonally dependent. The demand for electricity is expected to increase (Desgain and Haselip, 2015) in the coming years, which will add to the pressure on the existing system. Desgain and Haselip (2015) also note that the quality of the electricity supply is suboptimal and has deteriorated with frequent blackouts and rationing. Other risks and challenges for the electricity sector, identified by Desgain and Haselip (2015), include market vulnerability due to the increasing share of imported fossil fuels in the primary energy mix; low levels of investment in infrastructure; minimal market competition.

Costa Rica is prided for the high share of renewable energy in the electricity mix; however, it is not the only indicator that needs to be considered in terms of sustainability of an economy. The energy sector constitutes 39% of total GHG emissions with transport accounting for the large majority of it, contributing around 70% (OECD, 2017b), the transport sector accounts for almost half of the total final energy consumption in the country.

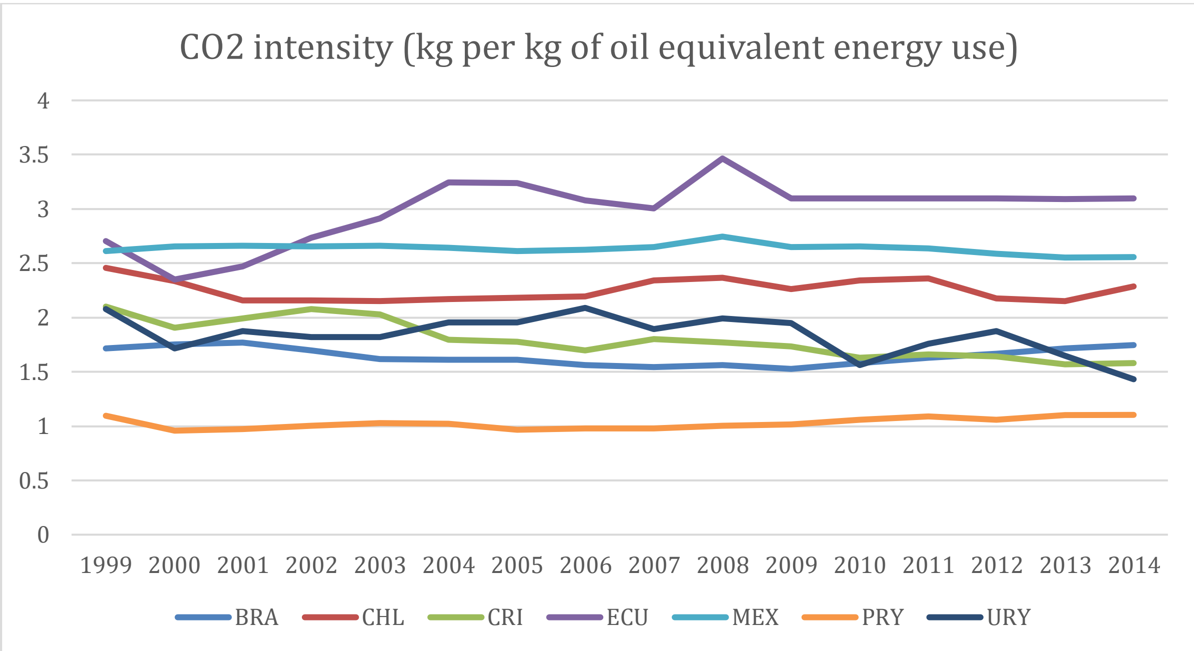


Figure 2 CO2 intensity in selected LAC countries
Source: created by the author based on WB (2019)

CO2 intensity is a measure of emissions per unit of energy used. The CO_2 intensity of Costa Rica's economy has seen a sustained declined in the observed period, from 2,1 to 1,5 kg per kg of oil equivalent, which can typically be explained through the decline in CO_2 emissions and/or decline in energy use. In Costa Rica's case, energy use has seen and increase, and the level of emissions remained at approximately the same level in 1999-2012, meaning that the changes in the energy mix were most likely the driving force of the decline of the carbon intensity. On the regional level, Costa Rica's carbon intensity exceed that of Brazil, a much larger economy, most likely due to the fact that in Brazil renewables account for a bigger share of total final energy consumption (44% against 38% in Costa Rica); and of Paraguay, the vast majority of the energy of which comes from hydropower. It is important not to disregard the total CO_2 emissions, as they have an environmental impact regardless of CO_2 intensity, which, in case of Brazil exceeded that of Costa Rica 240-fold in 2012. Out of all the countries in the sample Cost Rica has the smallest total greenhouse gas emissions (kt of CO_2 equivalent)[1].

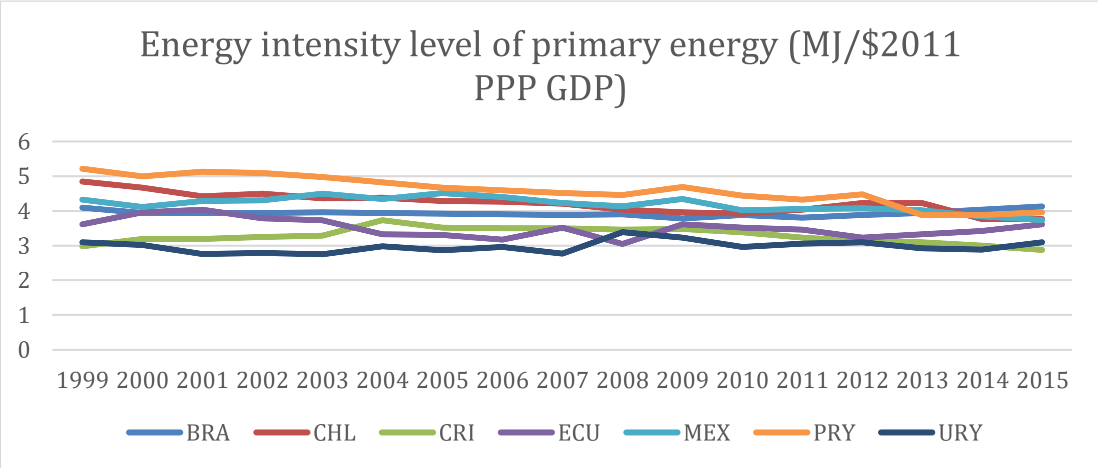


Figure 3 Energy intensity levels of primary energy in selected countries, 1999-2015
Source: created by the author based on WB (2019)

Energy intensity is a measure that communicates how much energy is used per monetary unit of the economic output (Kander et al., 2013). The decline in energy intensity can signify a relative decoupling of energy use and economic growth. In the case of Costa Rica energy intensity has been falling (Figure 3) from 2004 to 2015 ad has decreased by 0,5 units, by 2015 reaching the lowest value among other LAC countries in the sample.

[1] All data is extracted from WB (2019) WDI database

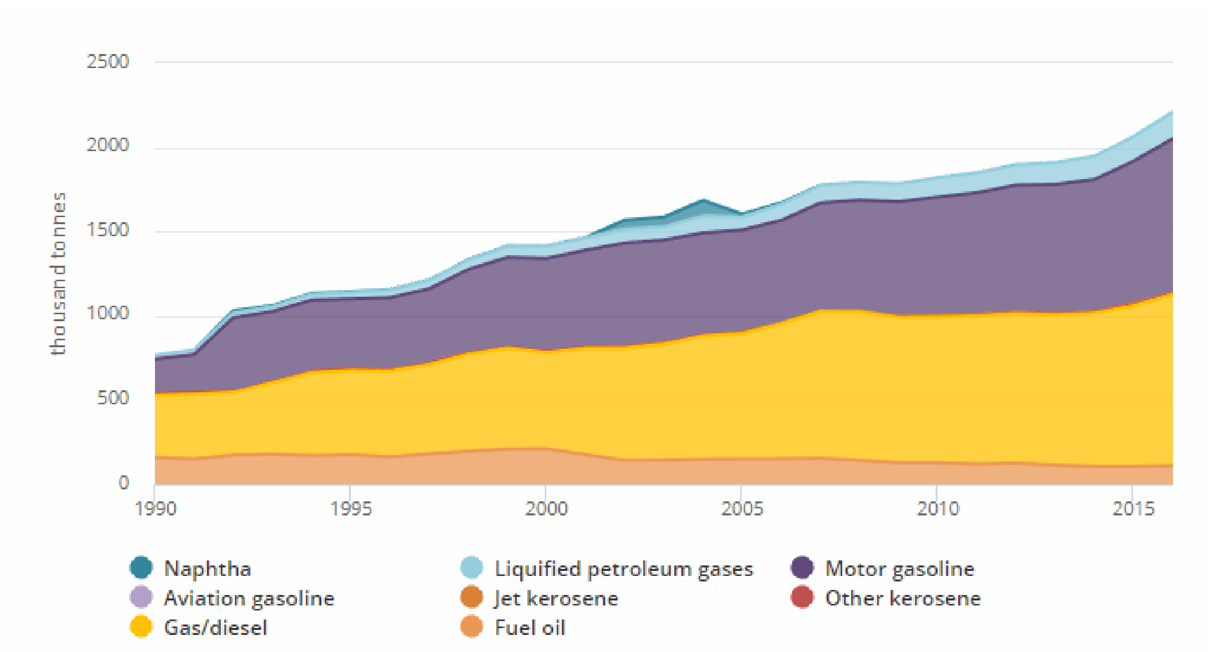


Figure 4 Final consumption of oil and oil products, Costa Rica 1990 - 2016
Source: IEA (2018c)

The transport sector of the Costa Rican economy is still heavily dependent on fossil fuels and accounts for 79% of the country's oil products consumption. Due to the fact, that the country does not have any domestic production of oil or gas, petroleum oils are an imported commodity. Figure 4 shows that the final consumption of oil and oil products in Costa Rica has been increasing over the period 1990-2016 in absolute values.

Despite the rather insignificant volumes of CO2 emissions, the Costa Rican energy sector has room for decarbonization, improving energy efficiency and reducing the currently rising consumption of oil products, mainly in the transport sector.

4.2 Natural resources

Costa Rica has very favourable natural resources for the development of renewable energy, with high hydro, wind, solar, geothermal potential (Griffith-Jones et al., 2017) with no oil or natural gas production (Flavin et al., 2014). Costa Rica's geographic advantage lies in a high per capita concentration of rivers, dams and volcanoes, which, along with favourable levels of rainfall are beneficial for renewable energy production (IHA, 2016).

Renewables account for over 95% of electricity generation in countries where abundant hydropower resources have already been exploited, such as Norway, Paraguay, Uruguay, Ethiopia, Costa Rica and Nepal (IEA, 2018b). More than 30 hydropower plants were built in Costa during the 1990s, however, large share of the hydropower potentials remains untapped (Anderson et al., 2006). The high hydro-power potential and the majoritarian share of hydro-power in the electricity mix lowers the probability of non-hydro renewable energy adoption (Mulder et al., 2003), which is one of the challenges Costa Rica faces.

Taking advantage of the geothermal resources that the country possesses, Costa Rica has continuously increased its geothermal power capacity (see Figure 13). The estimated solar potential (Nandwani, 2006) is 75 000 TWh annually, the electricity consumption in 2016, for comparison, is 9,78 TWh and the total energy consumption in Costa Rica is 19,86TWh. Solar power, remains, however, the most underdeveloped source of electricity generation in the country.

4.3 National innovation system of Costa Rica

Costa Rica's selected scores and rankings in the World Economic Forum Global Competitiveness Report (WEF, 2018) can be used for a general overview of Costa Rica's performance in the innovation sector. Costa Rica overall ranks 55th in 140 countries. It could be noted, that the country's R&D expenditures are low, at 0,6% GDP. Within the country sample of LAC countries, Costa Rica's R&D expenditures is comparable, with only Brazil exceeding 1%. The OECD average, however, is 2,3% in 2018. The quality of research institutions, as evaluated by the WEF, is extremely low: it only receives a 0,0 index and has actually deteriorated compared to the previous estimation. Out of the LAC countries analysed, only the bigger economies as Brazil and Mexico display higher score on this indicator, which is still significantly lower that the best score of 3,88 received by the USA. The same concerns the number of patent applications in Costa Rica, which is 0,95 per million of population and only Ecuador and Paraguay have fewer patent applications within the sample. However, even the highest score of 3,78 patent applications per million of population, reached by Chile, is barely comparable with the best score in the ranking of Japan, with 496,46 patent applications. The total innovation capability score is 40,4/100, and it could be seen that this relatively high score is achieved due to the higher score on trademark applications and diversity of workforce.

The innovativeness of the economy can be characterized by business activity indicators, such as the rate of start-ups, productivity growth, which are below OECD average. A small share of companies invests in R&D (0,2% of sales among manufacturing firms) (OECD, 2017a). Costa Rica only provides support to enterprises' investment in R&D though innovation funds and loan guarantees, whereas no indirect R&D support scheme through, for example, fiscal incentives, is currently in place (OECD, 2017a).

Costa Rica has a history of being a well-functioning democracy since the 1940s and one of the most politically stable countries in the LAC region. WEF (2018) also evaluates the quality of institutions and ranks Costa Rica 44 out of 140 countries. Relative to innovation and technology adoption, the following indicators may be significant: property rights, intellectual property rights, social capital, efficiency of legal framework in settling dispute. Costa Rica has relatively strong property rights and intellectual property rights, gaining 5/7 and 4,8/7 respectively; the efficiency of the legal framework, however, is modest, with the score of 3,8 out of 7; the social capital has room for improvement, scoring only 55,7 out of 100.

Even though, Costa Rica's R&D expenditures are comparable with those of the countries in the LAC region of similar economic development, it could be said, that the country underinvests in R&D, if compared to developed country average and the country's needs. The Costa Rican economy is not yet led by innovation and is in the transitional phase towards this goal, which, among others is reflected in the National Development Plan (Monge-González, 2016). Monge-González and Tacsir (2014) find that R&D and innovation fall short if the country's needs. The current share of R&D expenditure to GDP is around 0,6%, whereas, considering the social rate of return on R&D and GDP per capita, the optimal level of expenditure should be around 2,3% of GDP (Monge-González, 2016).

Higher education institutions and research institutions are key agents in a national innovation system. The higher education in Costa Rica is dominated by five public universities (Monge-González, 2016): the Universidad Estatal a Distancia, the Universidad Nacional de Costa Rica, the Instituto Tecnológico de Costa Rica, the Universidad de Costa Rica, and the Universidad Técnica Nacional, while the number of private universities is increasing continuously. A successful national innovation system is characterised by strong linkages between all actors in the system. Costa Rica does not display strong linkages between actors of the NIS. In Costa Rica the linkages between local and foreign companies are weak (Monge-González and Tacsir, 2014). WEF (2018) estimates the university-business collaboration in R&D at 3,7 out of 7, the score obtained from the World economic Forum Executives Survey, conducted with representatives of the business sector. The fact that business does not consider the linkages with research institutions strong, allows for the conclusion that this mechanism has room for improvement.

Human capital is the most valuable asset in a national innovation system, as the knowledge absorption capacity of an economy heavily depends on it, which is why it is necessary to assess the primary and tertiary education levels, gender equality and employment indicators. In terms of human capital, it can be noted, that Costa Rica has a high literacy rate of 97.4% (Monge-González, 2016). The public expenditure on education as a share of GDP at 8% is also among the highest values in the LAC region and comparable to that of OECD countries. The quality of education is, however, an issue for Costa Rica, as it scores lower than comparable economies on PISA assessments, however it does show comparable results when it comes to management schools (Monge-González, 2016). In 2017 28% of people aged 25-34 and 19% of 55-64 year-olds have received tertiary education, which places Costa Rica quite low compared to other world economies and well below the OECD average (OECD, 2019b). Costa Rica is also at a disadvantage in terms of human capital for knowledge absorption in terms of the percentage of graduates from tertiary programs in engineering, manufacturing and construction, which is low for the whole population, but especially for females. Gender inequality can be considered an issue present in Costa Rica, female labour force participation rate being 45,3% against that of 73,9% within the male part of the population; with women represented by a smaller share in parliament and in employment in non-agricultural sectors of the economy; the female share of graduates of technical tertiary education programmes being only 6,9%; the female to male unemployment ratio being 1,59, the share of female employment in managerial positions being 36,6; the UN Gender Inequality Index (GII) score for Costa Rica is 0,3, ranking the country 64 out of 160 countries (UNDP, 2018).

Societal norms and beliefs play an important role in a country's transition to a different technological system. Whereas, the civil society takes a more than favourable view towards environmental protection issues, which has been displayed in the past with the rise of environmental movements, Costa Rica lacks a "culture of innovation", where society rewards entrepreneurial and innovative efforts of individuals (Monge-González, 2016), which reflects in the low numbers of researchers per capita in the country.

The patent application activity carried out in Costa Rica is low regardless of the benchmark: the country does not perform well in this regard when compared either to countries of similar socio-economic characteristics or compared to the world standards. Costa Rica only provides support to enterprises' investment in R&D though innovation funds and loan guarantees, whereas no indirect R&D support scheme through, for example, fiscal incentives, is currently in place (OECD, 2017a).

4.4 Policies associated with the renewable energy sector

In the context of a relatively underdeveloped national innovation system and the high technological intensity of the renewable energy sector, it is important to consider both policies that are directly aimed at the renewable energy sector, but also those that are associated with innovation and R&D support.

It is important to not disregard the fact that Costa Rica has emerged as a leader in biodiversity policy in the 1970s-1990s (Steinberg, 2001) and can be considered an exemplary case in forest conservation, having achieved actual reforestation in the face of deforestation, now hosting 4 per cent of the world's biodiversity (Chaminade et al., 2018). This fact has become the result of a combined effort of domestic activity in terms of institutional innovations for sustainability and foreign influence in the forms of financial and policy aid (Steinberg, 2001, Chaminade et al., 2018). A continuous and significant role was also played by the civil society, with late 1980s and 1990s showing a formation of hundreds of environmental organizations, which initiated environmental activities, showing an interest in affecting local policy (Steinberg, 2001). Costa Rica was also among the first recipients of the Global Environment Facility (GEF) funds received in support for INBio (the National Institute for Biodiversity), established in 1989. Among the institutional innovations (Chaminade et al., 2018) introduced by the government of Costa Rica for the conservation of bioresources, was the Payments for Ecosystem Services, introduced in 1996, financed by the motor vehicle tax and subsidizing farmers; carbon bonds, in the 1990s (debt-for-nature swaps) to trade carbon sequestration and reforestation with Norway and the Netherlands in exchange for payments or reduction of external debts; and bio-prospective contracts with big pharma companies through INBio, allowing companies to extract plants for medical components.

2008 became the year when Costa Rica pronounced its aim to become the first carbon-neutral economy by 2021, the government focusing their attention on the transfer of low-carbon technology to the energy sector (Desgain and Haselip, 2015). In 2019 the country introduced an economy-wide plan to produce zero net emissions by 2050, producing no more GHG emissions that can be offset by the country's extensive forests (Rodriguez, 2019). National renewable energy targets include 28,2% of primary energy supply to come from renewable sources by 2020s and 97% of electricity to be produced from renewable energy sources by 2018 IRENA (2015). It is important to note that in the 2011 National Climate Strategy, the commitment to achieve carbon neutrality by 2021 allows Costa Rica to sequester its carbon emissions though the country's extensive forests. VII National Energy Plan 2015-2030 defines energy efficiency and electricity generation as priorities for action along 7 axes: improving energy efficiency; optimal distributed electricity generation; sustainability of the electricity grid; sustainable electricity generation development; more environmentally friendly vehicle fleet; sustainable public transport, cleaner fuels.

In 1997 Costa Rica introduced carbon pricing through a tax on fossil fuels (OECD, 2016), the revenue from which funds the Payment for Ecosystem Services. In 2012 the Domestic Voluntary Carbon Market was introduced, a system which allow carbon credits to be generated and exchanged among companies and individuals. Among additional abatement measures introduced since is the creation of certificates of carbon neutrality for companies and sectoral mitigation programmes (Nationally Appropriate Mitigation Actions – NAMAs) (OECD, 2016: 44).

Costa Rica does not have a renewable energy law, however, it has resource-specific laws in practice, including a geothermal law, biomass and biofuel laws (IRENA, 2015). The country does not, however, have programs or laws that consider solar heating or solar power, or wind power. To stimulate the use of renewable energy sources there exists a financial, regulatory and policy framework, with includes tax exemptions on the import of renewable energy materials and equipment (Steinberg, 2001).

Among regulatory instruments, auctions, held by the government for signing a contract for either capacity or energy with the bidder based on the price, are among the most popular instrument in the region of Latin America, and are also used in Costa Rica (IRENA, 2015), though not as widely as in other LAC countries. Costa Rica is among the countries with net metering and self-supply policies, that allow consumers to generate electricity an inject surplus generation into the grid. In 2016 Costa Rica approved new legislature that allows individuals and companies to produce solar energy and sell up to 49% of the excess to the grid (ITA, 2018). Direct financial support available in Costa Rica is limited, and available for energy projects under 20 MW (IRENA, 2015). 2012 saw the first renewable power tender held in Costa Rica, the ICE opening a bidding proves to contract up to 140 MW or wind and small hydro capacity, open for projects up to 20MW each. 28 projects were presented and 6 were chosen: 5 in wind and one in small hydro (BNEF, 2018a).

Feed-in-tariffs, a successful instrument worldwide, has not been widely used in the region, and as of 2015, Costa Rica did not have any in place, but was considering one for large-scale solar PV (IRENA, 2015). Among other largely practised policy instruments that Costa Rica does not implement are certificate systems for renewable or clean energy, nor grid access policies (IRENA, 2015). The fiscal incentives in place are limited and include only import exemptions for import of equipment and solar water heaters (IRENA, 2015, Desgain and Haselip, 2015) and do not include income tax exemptions, accelerated depreciation, tax rebate or others (IDB, 2014).

Renewable energy is a clean source of energy, however, its generation may imply environmental consequences, other that carbon emissions, for example, in the cases of large hydropower plants or geothermal energy plants. Costa Rica does not have an extensive system of environmental impact assessment regulations with regard to renewable energy projects, however, there is legislation in place in regard to geothermal energy sources development in protected areas.

The electricity generation and supply in Costa Rica is organized as follows. The state-owned Costa Rican Institute of Electricity (ICE) together with the National Company of Power and Light (CNFL) control the electricity generation and distribution of electricity. The ICE also operates the National Electric system, controlling electricity transition. The existing private companies that own small hydro-electric installations and wind turbines are required to sell the generated electricity to the ICE with then transmits it to distributors. The centralized electricity system does not allow for market competition, which may hinder the future developments in the sector.

The country has been actively engaged in international cooperation on climate change: among its partners has been the Netherlands' Government via the Institute for Environmental Studies and the Coastal Zone Management Centre, as part of the project: Climate Changes Studies in Costa Rica (UNDP, n.d.). Costa Rica is also partnering with other countries and multilateral organizations in such spheres of achieving the Sustainable Development Goals, as sustainable tourism, ocean conservation (UN, n.d.).

The policy framework of the renewable energy sector in Costa Rica is continuously evolving, though, not entirely comprehensive as of yet, and many market-based and regulatory policy instruments, that have been widely acknowledged as efficient and implemented in the world and in the region, are not currently in place. The innovation policy framework, that can be considered complementary and vital for the successful technology adoption and future technology generation is also flawed and does not provide incentives for businesses to invest in R&D and to innovate.

4.5 Technology transfer channels

4.5.1 ODA

Official Development Assistance can play a significant role for the development of developing economies and their technology adaptation. Typically, ODA is an important source of investments in the less-developed countries, so bilateral and multilateral assistance has a significant role to play also in climate change mitigation efforts in these countries (Newell, 2008a). To establish if that it is also the case in Costa Rica, the shares of ODA in GNI and gross capital formation are analysed. As can be seen from Figure 5, the levels of ODA as percentage of gross capital formation (GCF) in Costa Rica are comparable to those of both Upper Middle-Income countries and Latin America and the Caribbean (LAC) countries, to which Costa Rica belongs in terms of income and geographical location. It can be noticed also, that while ODA as share of GCF has been falling in Upper Middle-Income countries since 2005, the same cannot be said either for Costa Rica, where there is general upward trend, or LAC countries in general, where the value has remained around 1%. To assess the role of ODA for the economy as a whole, the Official Development Aid (ODA) as a share of Gross National Income (GNI) may be a useful indicator. As can be seen from Figure 6, the values of the indicator in Costa Rica are also comparable to those in LAC and UMI countries and the same trends occur as in the ODA as a share of Gross Capital Formation.

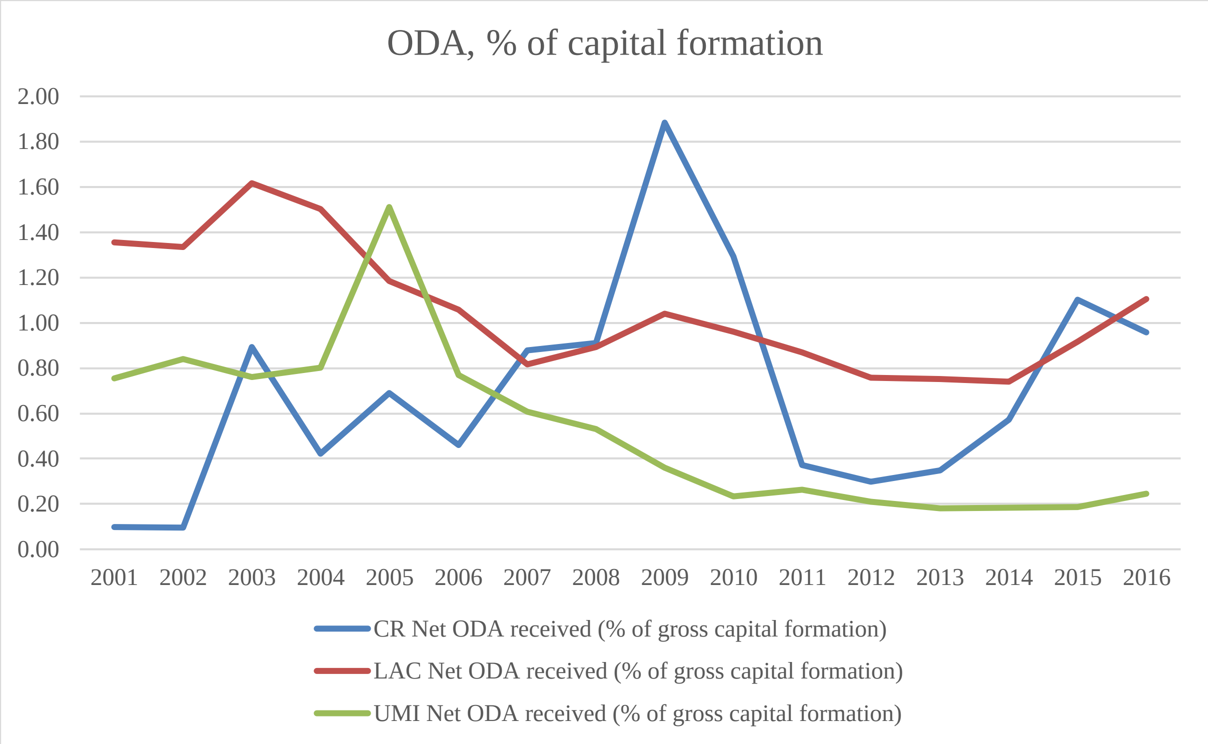


Figure 5 ODA as a share of Gross Capital Formation, Costa Rica, Upper Middle-Income and Latin America and the Caribbean countries

Source: created by the author based on WB (2019)

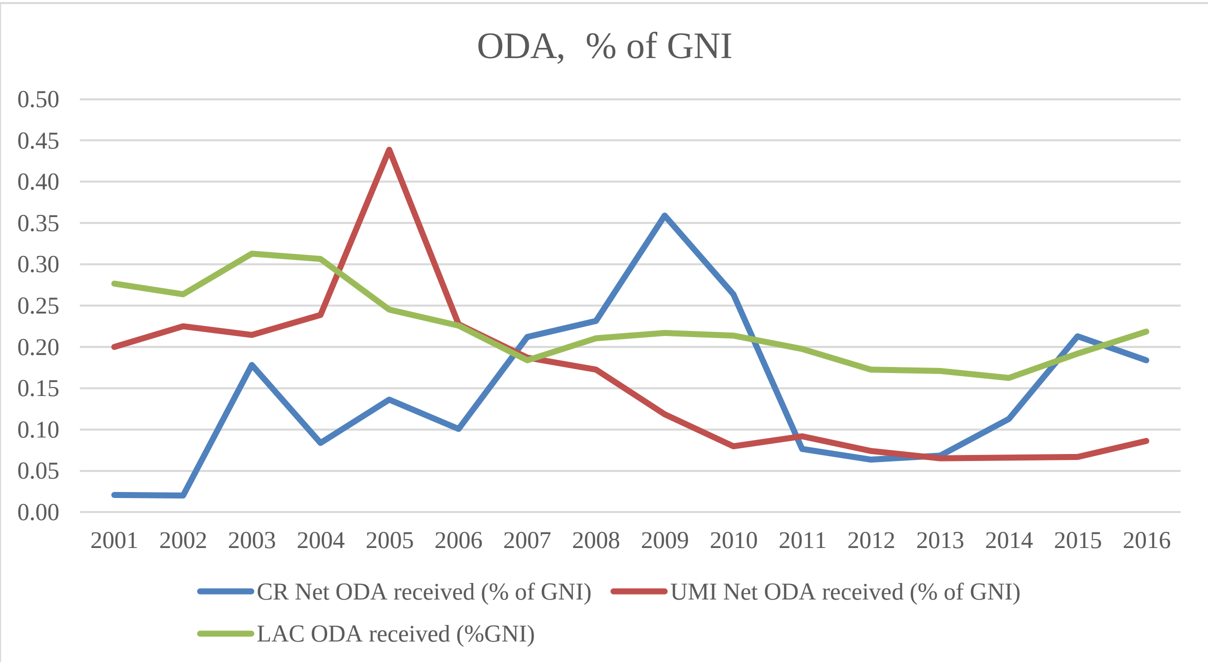


Figure 6 ODA as a share of GNI: Costa Rica, Upper Middle-Income and Latin America and the Caribbean countries

Source: created by the author based on WB (2019)

The most significant partners in terms of development finance donation can be distinguished by the volumes of financial flows. Biggest partners in DAC countries are the Netherlands, USA, Switzerland, Germany, Japan. Among the multilateral institutional donors, the Reginal Development Banks are the most significant in terms of the flow volumes to Costa Rica (OECD, 2019a).

The Bilateral ODA commitments by purpose show that in 2014 and 2017 the commitments for the energy sector within the Economic Infrastructure and Services category reached up to 77,8% and 86,3% of total bilateral ODA commitments respectfully, reaching up to 160,7 and 231,7 USD million (OECD, 2019a). Of the most recent projects, the Reventazon hydropower plant has been a joint initiative of IFC, USA and ICE (the Costa Rican Institute of Electricity) with the total cost of the project being 1,2 Billion USD and a generation capacity of 1,400 GWh each year, which is around 10% of Costa Rica's total electricity generation (Landy, 2015).

4.5.2 FDI

Over the period 2010-2017, Costa Rica attracted 1,9 billion USD in clean energy, with over a third of it aimed at small hydro plants (0,7 billion), 0,6 billion in geothermal and 0,5 billion in wind, peaking in 2014, when almost 0,6 billion USD was provided to these three types of technologies, but later seeing a twofold decrease in 2016 and 2017 (BNEF, 2018) .

Openness to foreign direct investment and the inflow of FDI has been one of the key determinants of economic growth in Costa Rica in the past decades (Monge-González, 2016, OECD, 2017a) and led to the diversification of the economy and the increase of the share of high value-added products in the exports.

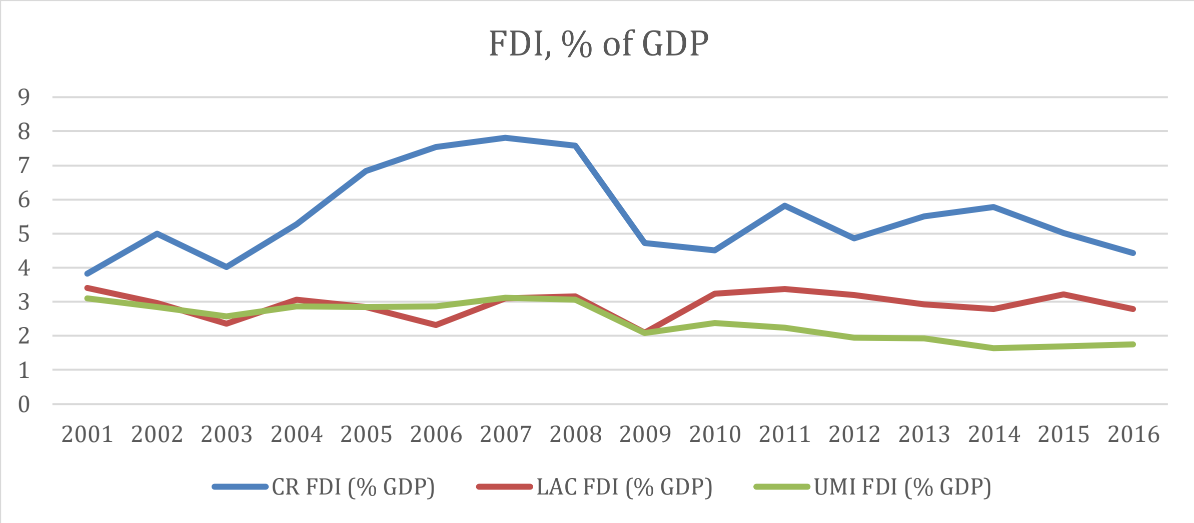


Figure 7 FDI as a share of GDP: Costa Rica, Upper Middle-Income and Latin America and the Caribbean countries

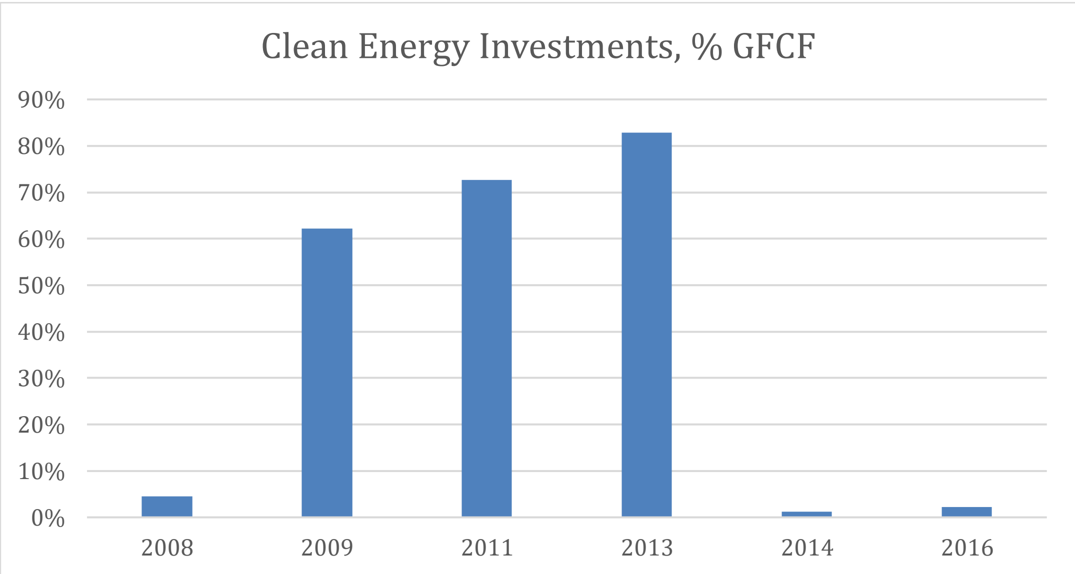
Source: created by the author based on WB (2019)

The FDI inflow data (Figure 7) show that FDI as a share of GDP in Costa Rica is well above the average figures for the countries of Latin America and the Caribbean, as well as significantly higher than that of other upper middle-income countries. FDI (% GDP) stays over 4% in the observed time period, reaching up to 7,8% in the years before the financial crisis, illustrating that Costa Rica is an attractive destination for foreign direct investment.

While the share of FDI is relatively high, it is important to consider the state of the innovation system, which, as seen above, displays weaknesses that can hinder the country's abilities to absorb the imported knowledge. The lack of the capacity to for technological innovation and limited technological competences, key for developing high-tech industries in any sector, handicap Costa Rican firms in terms of linking with MNEs and embedding FDI into the local economy (OECD, 2017a). The government policies have started to be directed at selectively targeting knowledge-intensive sectors in FDI attraction, which led to an increase of the number of high-tech projects with an increase of FDI to them (OECD, 2017a).

Bloomberg's data on disclosed asset finance deals for renewable projects (2018b) provides information on cross-border investments in the years 2008-2017, which can provide an insight on Costa Rica's place in the selected sample of LAC countries, the sources, magnitude and sectoral receipts of international finance. It is not indicated, however, whether the financial deals bear development assistance or commercial investment characteristics, so it is possible they cannot be defined as FDI. However, the data can be used to gauge the magnitude of financial flows to the renewable energy sector in Costa Rica. Over the time period Costa Rica's renewable energy sector attracted 1,4 billion USD, falling behind Brazil (19,17 billion), Mexico (10,11 billion), Chile (8,79 billion), Uruguay (3,03 billion) and outperforming only Ecuador (0,14 billion) in the sample of counties .The only country to invest in Biomass & Waste in Costa Rica was United States in 2016 (7,2 million USD), as well as in solar energy: 8,6 million in 2017; geothermal power attracted over 627 million USD from Honduras, Japan, Luxembourg over 2009-2014; almost 300 million USD were invested into Small Hydro power with funds originating from Belgium, Italy, and Netherlands; wind power is the second renewable energy source after geothermal in attracting foreign funds, having a cumulative 457 million USD invested over 2008-2016, the funds originating from Austria, France, Germany, Guatemala, Honduras, Netherlands, Spain and the US. In terms of significance for the country's economy, this data probably is not enough to establish a trend, as the disclosed deals are available for only several years (Table 1). It could be seen, however, that this flow lacks consistency and it the most recent years (2014, 2016) remained at 1-2% of GFCF, despite the very significant values in 2013 of 83%. All the above could indicate that Costa Rica is not attracting significant foreign investment in the renewable energy sector, especially in those of biomass and waste and solar energy, while the development of geothermal and wind power is regarded as most promising by foreign investors.

Table 1 Clean Energy Investments, % of GFCF



Source: calculated by the author based on BNEF (2018b) and WB (2019)

4.5.3 Licensing

Table 2 Royalties and licence fees

Royalties and license fees	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Percentage of total trade in services	5,13	3,71	3,78	5,40	2,90	3,30	4,60	3,57	3,34	4,04
Percentage of GFCF	2	1	1	2	1	1	1	1	1	1
Share of GDP	0,004	0,003	0,003	0,004	0,002	0,002	0,002	0,002	0,001	0,002
US Dollars at current prices and current exchange rates in millions	63,87	51,36	56,88	87,48	52,69	62,21	64,62	63,59	59,46	82,17

Source: author’s calculations based on UNCTAD (2014)

Costa Rica’s payments in royalties and license fees are not very high, as can be seen from Table 2. Costa Rica also does not show equally levelled performance in this regard in comparison to other countries either from the region, or from the world (Monge-González, 2016). As a share of the total output of the economy, the royalties and license fees are almost negligible, not reaching even 0,5 percent and moreover, falling over the observed time period. The same applies if compared to gross fixed capital formation values, where license fees and royalty payments constitute around 1%.

International technology acquisition through licensing is less important for the economy of Costa Rica compared to its peers from emerging economies, and the companies show a lesser propensity to engage in technology licensing than countries from the LAC region, such as Chile, Mexico or Panama (OECD, 2017a), which makes it a less important technology transfer channel.

4.5.4 Trade

The imports of technologies associated with renewable energy are analysed by four main categories of renewable energy sources, that represent the largest share in the electricity mix of Costa Rica: geothermal, hydro, wind, and solar. Among RET in use today, wind power is the most widely deployed in the world, the cost of which has fallen steadily since its first introduction in 1980s (IDB, 2014). Wind power is typically deployed in larger scales for cost-efficiency reasons. Solar power is the renewable energy source that has experienced the most rapid technological advances, including cumulative advances and module efficient that have also led to cost reductions (IDB, 2014). Solar PV can be used at any scale, from individually powered light bulbs to large production facilities (IDB, 2014). Hydropower is a mature technology that is widely deployed in developing countries (IDB, 2014) also on various scales. The history of geothermal electricity use dates back to the 1970s and is deployed in locations with geothermally heated water near the Earth's surface (IDB, 2014), the scarcity of which limits it spread, but they can be found in LAC, and Costa Rica in particular.

Figure 8 Imports of goods as a share of GDP, Costa Rica

Source: created by the author based on WB (2019)

The significance of trade for Costa Rica's economy can be determined from the share of imports in the economy's GDP. It can be seen (Figure 8) that over the observed period this indicator remained over 25%, even despite its decline in the recent years. The share of imports in the GDP is significantly higher than that of FDI and licensing, which may indicate that in relation to technologies related to renewable energy it may also be the most significant transfer channel. In relation to all categories of good, Costa Rica displays a relatively high share of capital goods imports in the total imports, with the value being around 30% in the period 2002-2013.

Table 3 Share of Capital Goods Imports in Total Imports, 2002-2013

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Costa Rica	34,6	36,1	31,9	35,0	34,3	28,5	28,1	25,5	27,7	29,3	29,4	28,8

Source: adapted by the author from Monge-González (2016)

Costa Rica can be considered an open economy in terms of foreign trade: the average tariff duties in 2018 constituted 3,67% on all goods and the share of imports in GDP amounted to 32,8% (WEF, 2018). The trend for openness is furthered in the renewable energy technology sector, where Costa Rica has even lower average MFN tariffs on the imports on technologies, associated with renewable energy, the simple mean of which in 2016 amounted for 1,94% for the observed HS-codes. Costa Rica also displays good performance in terms of market access for foreign RET in comparison to other countries in the region, which can be seen in Figure 9: out of all economies under analysis Costa Rica shows the lowest tariff rates. The highest tariff barriers to RET imports in Costa Rica can be noticed in relation to technologies, associated with geothermal energy, which amounted to 5,24%, which is still lower than that of the other countries. For technologies that are related to Solar PV and hydropower, the average MFN tariff is 0 in Costa Rica, which could indicate the significance of the sectors being recognized by policy-makers, and could also aid the imports of Solar PV technologies and consequently increase the share of solar energy in the electricity mix; hydropower remains of strategic importance for electricity production in the country and due to continuous increase in capacities and lack of domestic production of necessary technologies, the 0 tariff rates could prove beneficial.

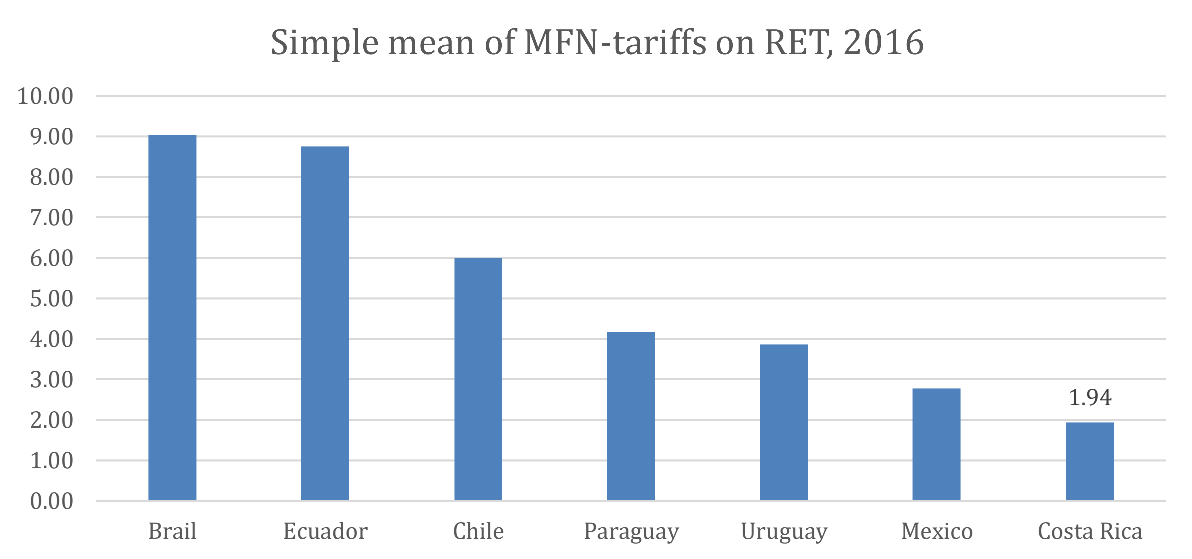


Figure 9 Simple mean of MFN tariff rates on renewable energy technologies in Brazil, Ecuador, Chile, Paraguay, Uruguay, Mexico. Costa Rica in 2016

Source: author's calculations based on WTO (n.d.)

As a share of gross fixed capital formation, the imports of the selected HS-codes are not very significant. However, this indicator can be used to assess the dynamics of the importance of those technologies. For Costa Rica the value if the indicator peaked in 2014, which could be explained through the increases in the imports of hydro power, solar and wind power technologies in the same year, however, in general the values are not very high, nor they are in the other countries in the sample, where it typically does not exceed 1%, except for the case of Uruguay, where in the most recent years it passed 4,5%. The insignificance of the share of renewable energy technology imports in GFCF can also be explained by the selection of HS-codes analyzed, as it includes only 14 positions. It is, however, on approximately the same level as ODA flows and licensing payments.

Table 4 Share of RET imports in GFCF, 2001-2016

	Costa Rica	Brazil	Chile	Ecuador	Mexico	Paraguay	Uruguay
2001	0.65%	0.11%	0.27%	1.71%	0.33%	0.40%	0.62%
2002	0.55%	0.12%	0.41%	1.09%	0.35%	0.23%	0.50%
2003	0.81%	0.16%	0.46%	1.03%	0.38%	0.21%	0.35%
2004	0.42%	0.10%	0.23%	1.30%	0.35%	0.13%	0.49%
2005	0.39%	0.09%	0.24%	1.14%	0.39%	0.52%	0.50%
2006	0.37%	0.11%	0.33%	0.99%	0.44%	0.27%	0.35%
2007	0.42%	0.12%	0.35%	1.06%	0.38%	0.29%	0.52%
2008	0.99%	0.14%	0.47%	0.89%	0.41%	0.40%	0.38%
2009	0.36%	0.18%	1.04%	0.62%	0.54%	0.35%	0.39%
2010	0.48%	0.17%	0.63%	0.74%	0.67%	0.26%	0.55%

2011	1.02%	0.17%	0.35%	0.65 %	0.70%	0.26%	0.38%
2012	0.52%	0.24%	0.32%	0.59%	0.74%	1.04%	0.34%
2013	0.62%	0.22%	0.94%	0.64%	0.81%	0.27%	1.28%
2014	1.24%	0.15%	0.91%	0.64%	1.00%	0.27%	2.38%
2015	0.77%	0.13%	0.95%	0.75%	1.04%	0.29%	4.77%
2016	0.82%	0.12%	1.09%	0.65%	1.08%	0.64%	4.57%

Source: author's calculations based on ITC (2018)

The combined imports of observed renewable energy technologies to Costa Rica fall behind most selected countries in volumes, for the exception of Paraguay. The share of imports has not exceeded 2% in the observed time period (Table 5). Which allows to make a conclusion that in the region Costa Rica is not the most significant importer of RET in the region. The share, however, varies across different types of technologies.

Table 5 Shares of combined imports of RET in selected countries of LAC imports

	Costa Rica	Paraguay	Ecuador	Brazil	Mexico	Chile	Uruguay
2001	1.8%	0.5%	7.2%	10.1%	44.2%	3.7%	1.6%
2002	1.8%	0.3%	6.5%	10.6%	52.8%	6.1%	0.8%
2003	2.4%	0.3%	5.6%	12.8%	47.7%	6.5%	0.5%
2004	1.4%	0.2%	8.4%	10.0%	50.8%	4.2%	0.9%
2005	1.1%	0.8%	6.8%	9.8%	48.7%	4.6%	1.0%
2006	0.9%	0.4%	5.3%	11.8%	50.7%	5.6%	0.7%
2007	1.3%	0.5%	5.7%	14.8%	44.6%	6.4%	1.1%
2008	2.4%	0.6%	4.1%	15.2%	35.6%	7.2%	0.8%
2009	0.7%	0.5%	2.8%	18.5%	33.9%	12.7%	0.7%
2010	0.9%	0.4%	3.4%	21.3%	41.4%	8.0%	1.1%
2011	2.0%	0.4%	3.1%	20.9%	43.2%	4.7%	0.8%
2012	0.9%	1.2%	2.6%	22.6%	37.4%	4.0%	0.7%
2013	1.0%	0.3%	2.8%	18.9%	36.8%	10.9%	2.7%
2014	2.0%	0.4%	2.9%	12.0%	45.2%	9.2%	4.8%
2015	1.3%	0.3%	3.3%	6.7%	45.3%	9.1%	8.3%
2016	1.4%	0.7%	2.7%	5.5%	44.9%	10.6%	7.7%

Source: author's calculation based on ITC (2018)

Hydroelectric power remains the dominant source of renewable electricity production in Costa Rica, although its share in the electricity generated from renewable electricity sources has been declining steadily since 2009 with the increase in the generation from other renewables.

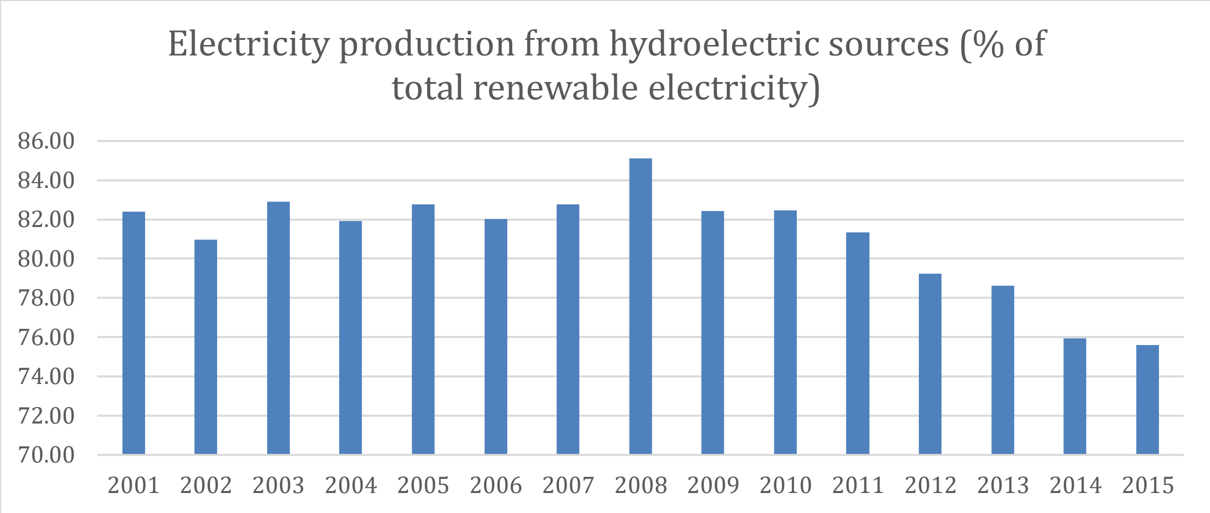


Figure 10 Electricity production from hydroelectric sources, % of total renewable electricity production, Costa Rica, 2001-2016

Source: author's calculations based on WB (2019)

Technologies associated with hydropower saw a sharp increase in imports before 2016, this concerns especially hydraulic turbines and water wheels of a power exceeding 10 thousand kW. This increase falls within the overall trend of a rise in imports of technologies related to hydropower, however, possibly, can be connected to the new hydropower stations, that came inline in 2016: Bijagua (17 MW), Reventazon (305,5 MW). The latter project was worth 1,2 billion USD and was one of the largest hydropower projects in Central America and one of the largest public infrastructure projects (IHA, 2016). The project is also notable in terms of its lack of negative environmental impact regarding protecting biodiversity.

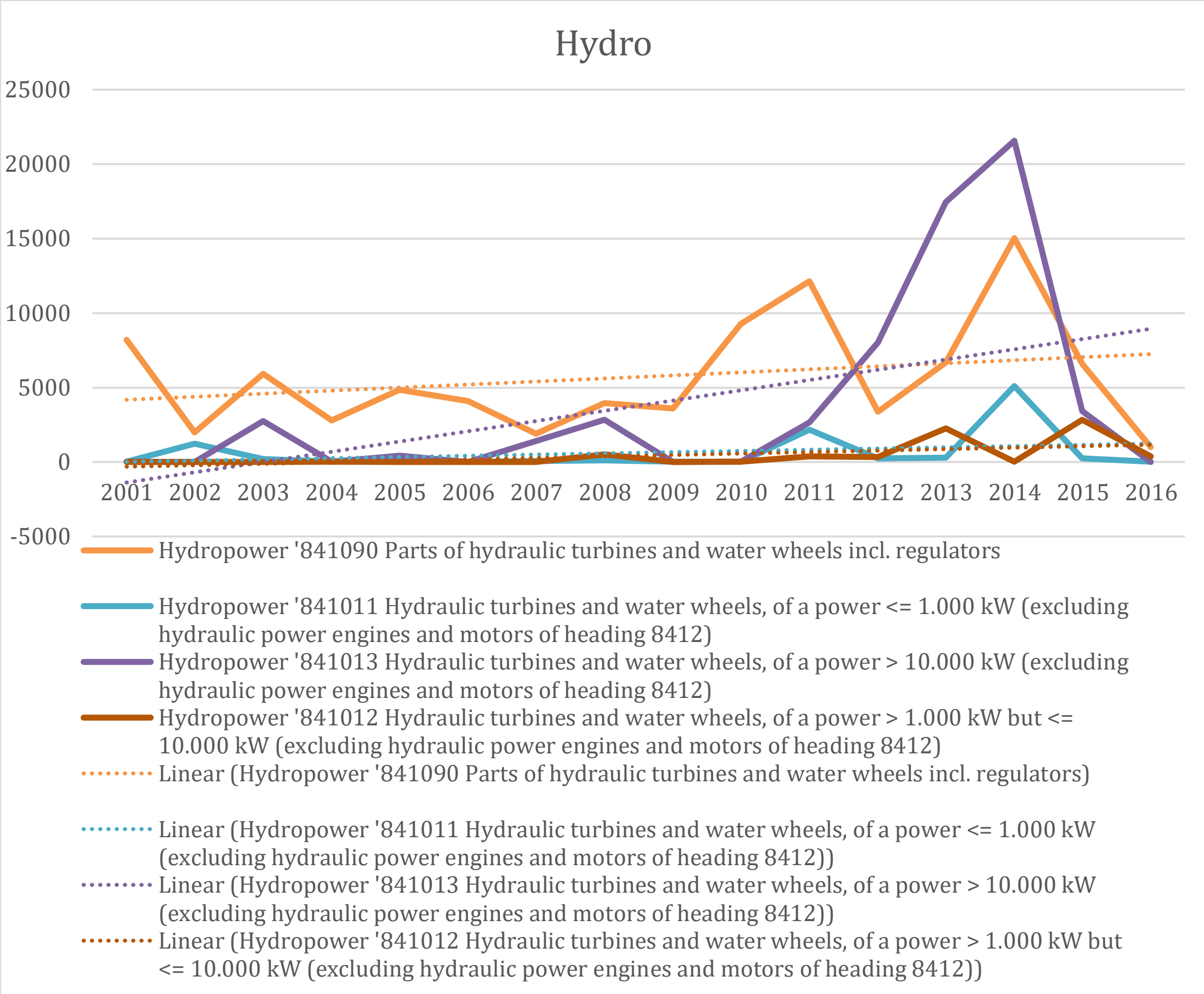


Figure 11 Imports of technologies associated with hydroelectricity production, Costa Rica, 2001-2016

Source: author's calculation based on ITC (2018)

The share of Costa Rica's imports of hydroelectricity associated technologies (HET) in the total LAC HET imports is considerable and is outperforming that of the UMI countries of the sample, such as Ecuador, Paraguay and Uruguay, and on the most recent years also the larger economies, except for Chile. Its dynamics follow the dynamics of the imports (ex. sharp decline in 2016).

Table 6 Countries' share of technologies associated with hydroelectricity production in LAC imports of said technologies, 2001-2016

	Costa Rica	Paraguay	Ecuador	Brazil	Mexico	Chile	Uruguay
2001	7,2%	0,03%	0,9%	1,3%	1,8%	2,0%	0,02%
2002	4,3%	0,00%	4,2%	11,1%	9,4%	20,5%	0,00%
2003	7,6%	0,04%	1,5%	6,8%	8,5%	2,4%	0,01%
2004	7,5%	0,01%	10,0%	8,5%	15,2%	5,1%	0,03%
2005	7,7%	0,01%	0,8%	7,2%	20,6%	3,5%	0,02%
2006	5,0%	0,00%	1,6%	3,9%	17,1%	21,7%	0,02%

2007	5,2%	0,01%	6,6%	0,7%	21,8%	14,7%	0,00%
2008	5,3%	0,01%	9,3%	0,3%	9,2%	7,1%	0,01%
2009	2,1%	0,02%	3,8%	4,0%	2,4%	15,2%	0,01%
2010	4,2%	0,01%	4,7%	2,3%	2,4%	16,1%	0,01%
2011	5,0%	0,11%	1,0%	3,5%	3,5%	5,1%	0,00%
2012	3,3%	3,44%	3,0%	2,5%	1,6%	6,3%	0,01%
2013	10,5%	0,16%	6,5%	8,2%	2,8%	5,1%	0,01%
2014	12,7%	0,03%	11,1%	0,3%	2,0%	9,5%	0,00%
2015	5,3%	0,00%	15,3%	0,1%	1,4%	10,1%	0,00%
2016	0,7%	0,02%	24,4%	0,1%	3,2%	15,3%	0,01%

Source: author's calculation based on ITC (2018)

The trend for import of technologies associated with the generation of geothermal energy, has seen a continuous increase over the observed time period of 2001-2016 (Figure 12). This also corresponds with the increase of the share of geothermal energy in the electricity generation mix (Figure 1). The total installed geothermal capacity has increased fourfold over the period 1995-2017 (Figure 13). The average annual growth rate over this period has been 13%, and in the most recent period, 2006-2016, the annual growth rate in capacities constituted 2,3%.

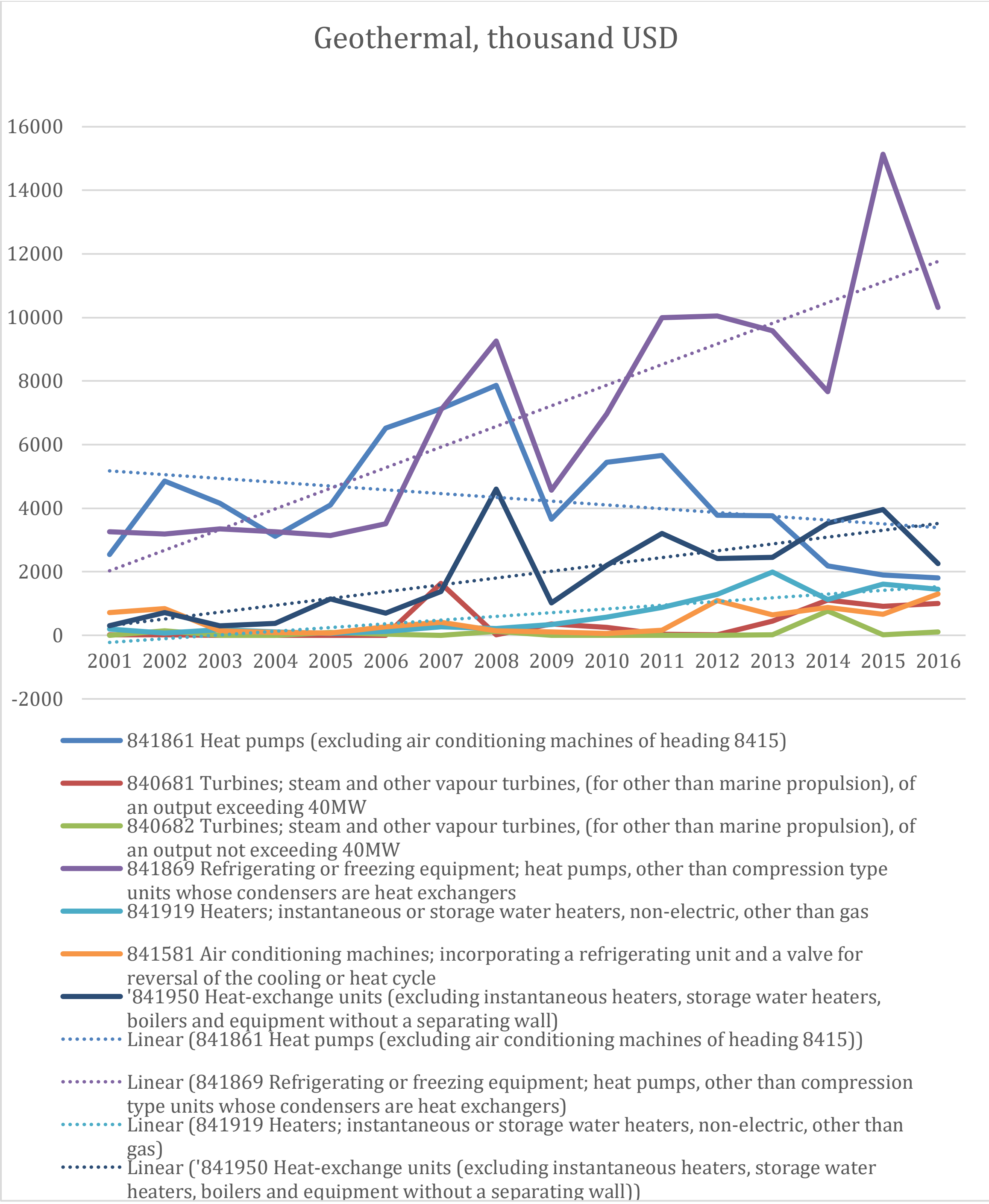


Figure 12 Imports of technologies associated with geothermal electricity production, Costa Rica, 2001-2016

Source: author's calculation based on ITC (2018)

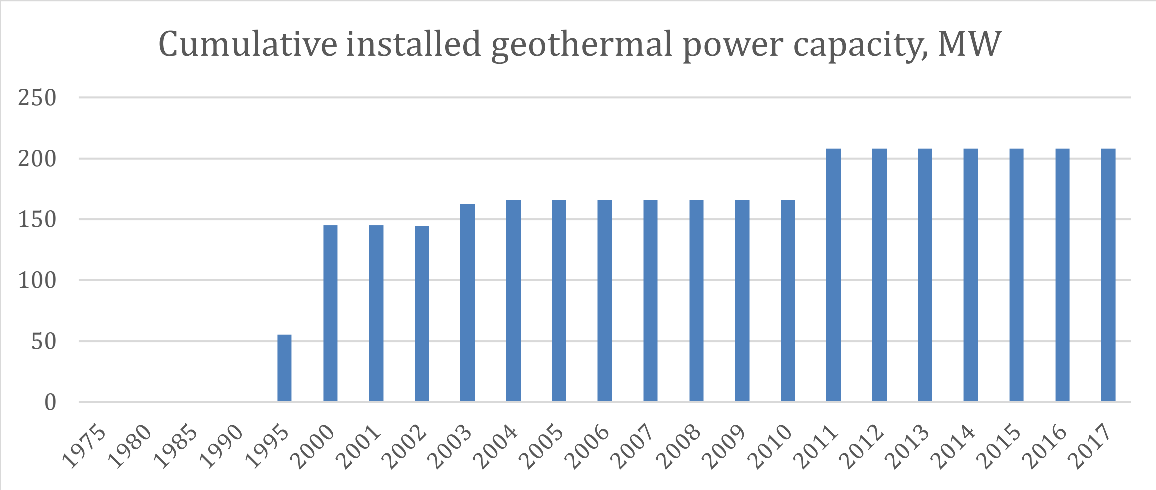


Figure 13 Cumulative installed geothermal power capacity, Costa Rica, 1975-2017

Source: author's calculations based on BP (2018)

Table 7 Countries' share of technologies associated with geothermal electricity production in LAC imports of said technologies, 2001-2016

	Costa Rica	Paraguay	Ecuador	Brazil	Mexico	Chile	Uruguay
2001	1,2%	0,5%	2,4%	18,3%	34,9%	5,6%	2,9%
2002	1,9%	0,4%	1,5%	18,2%	43,7%	7,3%	1,5%
2003	1,4%	0,2%	1,2%	23,1%	40,1%	11,5%	0,8%
2004	1,2%	0,3%	1,4%	17,3%	42,6%	6,9%	0,9%
2005	1,1%	0,3%	1,3%	17,1%	40,8%	7,7%	1,0%
2006	1,2%	0,4%	1,2%	15,8%	42,8%	8,0%	0,8%
2007	1,6%	0,5%	1,4%	22,3%	36,0%	9,4%	1,2%
2008	1,4%	0,6%	0,9%	19,0%	29,2%	10,5%	1,1%
2009	0,7%	0,4%	0,9%	21,5%	22,7%	15,6%	1,4%
2010	1,0%	0,6%	1,3%	30,2%	22,0%	13,2%	1,2%
2011	1,4%	0,7%	1,4%	25,6%	25,6%	6,1%	2,0%
2012	0,8%	0,7%	1,2%	37,6%	20,7%	4,6%	1,0%
2013	0,9%	0,5%	1,8%	30,3%	19,0%	5,8%	0,8%
2014	0,9%	0,5%	2,1%	21,1%	26,7%	8,5%	1,0%
2015	1,4%	0,9%	2,3%	15,3%	34,7%	9,2%	1,1%
2016	1,1%	2,4%	1,8%	16,5%	32,9%	9,2%	0,9%

Source: author's calculation based on ITC (2018)

Costa Rica's combined imports of technologies related to geothermal energy production as a share of those of LAC are not very significant and largely fall short of that of the larger economies, such as Brazil, Mexico and Chile and is more on the same level as Uruguay. This speaks for the relative insignificance of the imports of geothermal technology imports in Costa

Rica, as geothermal is not even among the main renewable energy sources in Uruguay (IEA, 2018a).

Wind power is the second most important sources of power in Costa Rica, accounting for 11,5% of the country's electricity mix (Djunisic, 2019). The country has quadrupled its wind power production in the years 2008-2016 (Alvarado, 2018). The imports of technologies associated with wind power generation have also increased in the years 2008-201(Figure 14). There are currently 18 operating wind plants, the majority of which are private or run by rural cooperatives. By the beginning of 2019 the country's wind capacity reached 407,77MW, which includes the newly inaugurated 60,11GW power plant, opened in January, 2019 (Djunisic, 2019).

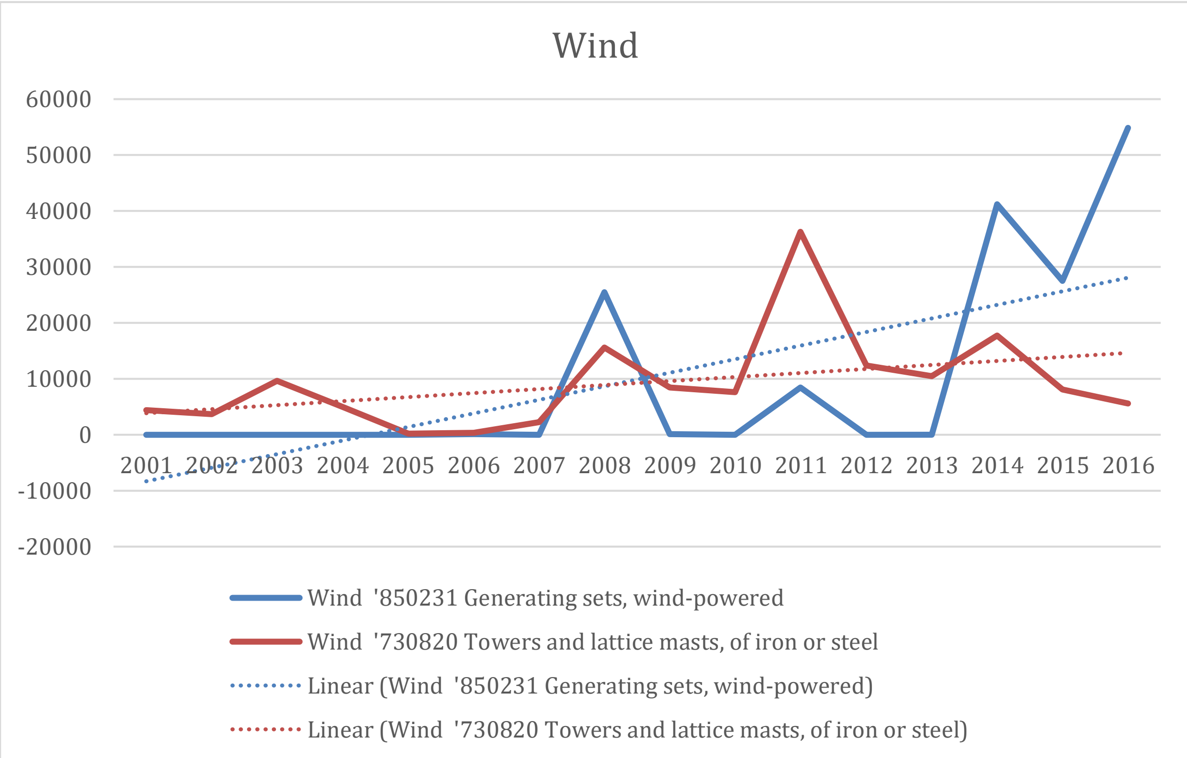


Figure 14 Imports of technologies associated with wind power electricity production, Costa Rica, 2001-2016

Source: author's calculation based on ITC (2018)

The cumulative wind turbine capacity of Costa Rica has seen a continuous rise since the late 1990s (Figure 15) and has increased sixteen-fold in twenty years and five-fold in 5 years up to 2017. The annual growth rate in capacity in 2006-16 amounted for 16,6%, which is significantly higher than that of geothermal power capacity and quite significant.

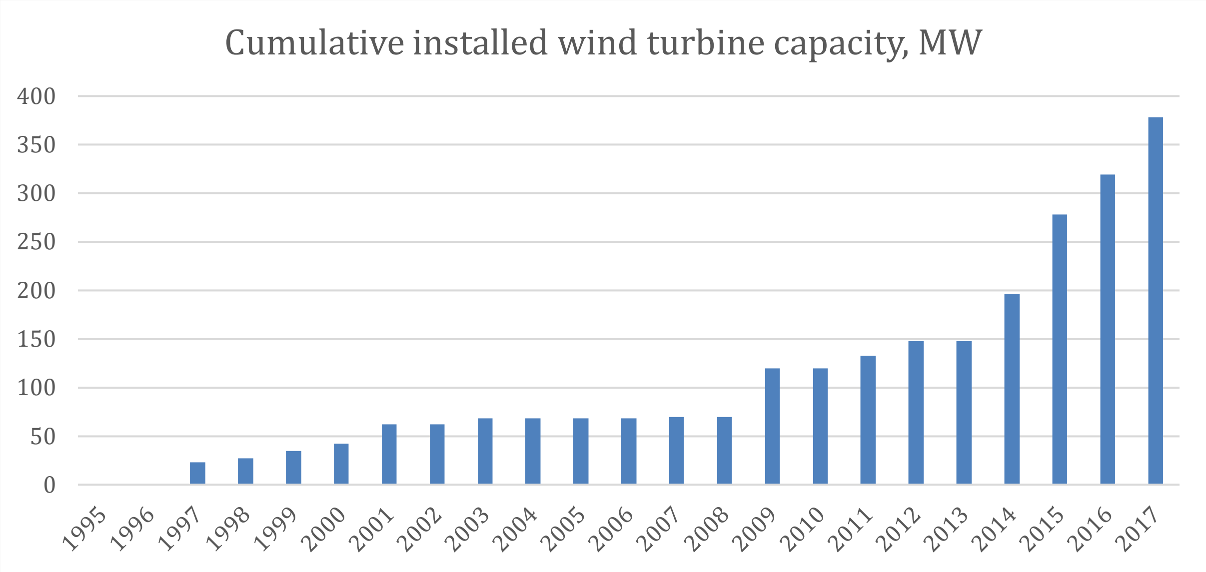


Figure 15 Cumulative installed wind power capacity, Costa Rica, 1995-2017

Source: author's calculations based on BP (2018)

Costa Rica's share of imports of RET associated with wind power is bigger than that of other technologies, however, it still falls short of most countries in the selected sample, especially in the most recent years, when compared to Brazil, Mexico, Chile and Uruguay. Brazil's share of imports fell, but most likely due to its adding domestic production enough to become an exporter (Vossenaar, 2016).

Table 8 Countries' share of technologies associated with geothermal electricity production in LAC imports of said technologies, 2001-2016

	Costa Rica	Paraguay	Ecuador	Brazil	Mexico	Chile	Uruguay
2001	5,0%	2,5%	0,1%	3,4%	30,2%	5,1%	0,5%
2002	6,1%	0,7%	4,0%	3,0%	34,5%	9,0%	1,2%
2003	12,7%	2,0%	0,1%	5,6%	30,5%	2,6%	0,2%
2004	6,6%	0,9%	0,4%	5,7%	26,0%	1,8%	5,4%
2005	0,2%	7,0%	5,5%	4,6%	15,2%	1,8%	5,1%
2006	0,2%	1,3%	1,3%	26,4%	38,0%	1,5%	2,2%
2007	1,0%	1,9%	3,6%	19,0%	11,0%	3,3%	4,2%
2008	7,4%	1,6%	0,5%	26,1%	15,9%	4,7%	0,9%
2009	1,0%	1,1%	0,2%	31,9%	23,5%	17,2%	0,3%
2010	1,0%	0,7%	0,3%	37,7%	38,0%	4,8%	2,8%
2011	4,0%	0,6%	0,1%	45,1%	31,6%	7,0%	0,4%
2012	1,1%	3,5%	0,9%	32,0%	30,5%	5,8%	1,4%
2013	0,7%	0,5%	0,8%	27,7%	19,1%	22,9%	8,9%
2014	3,4%	0,6%	0,6%	19,7%	33,6%	14,8%	15,9%
2015	2,4%	0,2%	3,6%	10,1%	28,2%	8,9%	32,3%

2016	3,6%	0,1%	1,2%	2,8%	33,0%	25,2%	26,4%

Source: author's calculation based on ITC (2018)

Electricity generated from solar PV reached only 3GWh in 2016, which makes this power source the most underdeveloped in Costa Rica's renewable electricity mix yet. There is no significant local production of solar energy related technologies (ITA, 2018), most of which are imported. As of 2018, solar energy accounted for only 0,01% of the electricity mix, and the projections of the Costa Rican Ministry of Environment and Energy (MINAE) expect this share to rise to 1,3% by 2030, which gives an incentive to increase the capacities.

The imports of technologies associated with solar electricity generation have increased the pace since 2010 and the trend has seen continuous increase, peaking in 2012 within the observed time period. The share of Costa Rica's imports of solar renewable energy technologies in the LAC imports are negligible and have reached only 0,24% in 2016, which is still higher than that of Paraguay and Uruguay.

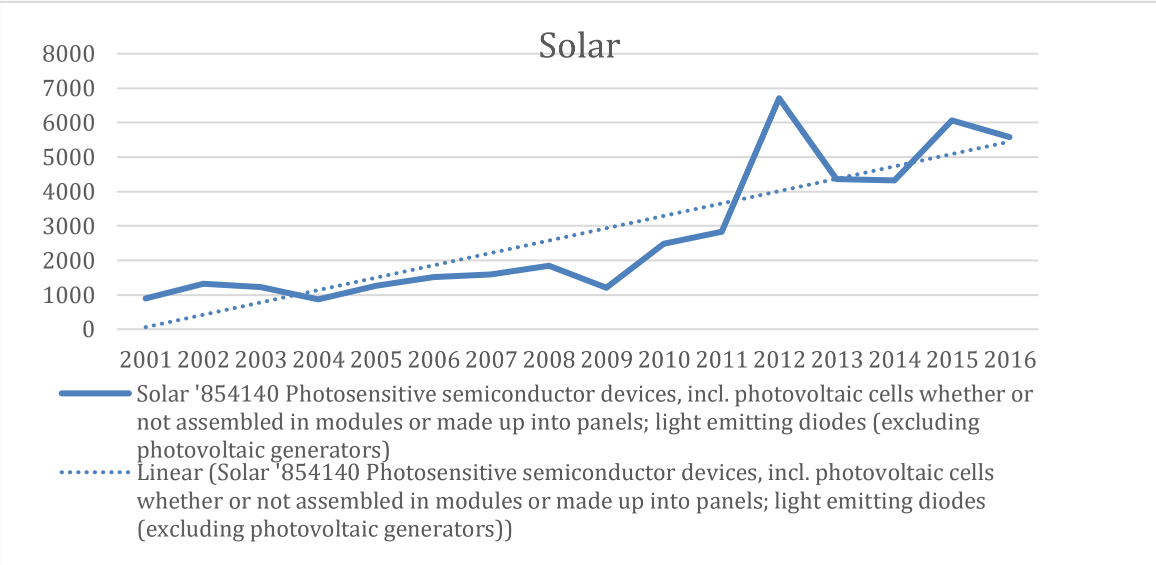


Figure 16 Imports of technologies associated with solar PV electricity production, Costa Rica, 2001-2016

Source: author's calculation based on ITC (2018)

Of the three main technology transfer channels, that include FDI, licensing and trade, and specific to developing countries, official development assistance, the significance of licensing for transfer of RET in Costa Rica is very low, as licensing is not a widespread practice in business in general. FDI in general has been an important factor in terms of fostering economic growth in the country, however, the author has not been able to obtain comprehensive data on

FDI in the renewable energy, thus, conclusion on the importance of this channel for the sector are difficult to draw, however, the volume of FDI inflow to the economy is considerable. It could be speculated from the discovered weaknesses of the national innovation that the country may have trouble with absorbing the knowledge from this channel. Regarding trade, which has been analysed in more detail in regard to renewable energy technology, it could be said that the imports of just 14 positions is of the same value compared to GFCF, as ODA and licensing. The analysis of imports revealed relatively low levels of imports of solar PV, especially if compared to other countries in the sample, which corresponds with the low share of this power source in the electricity generation. Wind power related RET are the ones with the largest USD values of imports among the four sources, reaching up to 60 million, and the share in the LAC total for wind is also the largest. Geothermal technologies are second to wind in the recent years, which corresponds with the trend for increasing the share of these two sources in the electricity generation Geothermal technologies are followed by hydro, which, as previously mentioned, remains the most important source of electricity generation, and the its installed capacities are still increasing.

5 Conclusion

The aim of the thesis is to identify factors that are beneficial for Costa Rica’s high share of renewables in electricity generation and the factors that may hinder the transition to a more sustainable energy sector. The objectives of the thesis are to answer the research questions by inspecting the country’s national innovation system in regard to its capacity to absorb technological knowledge; establish the policies undertaken in the country in the renewable energy sector; and assess the flows of technology transfer in the sector in regard to their significance for the economy and in the context of the regional developments.

Costa Rica has ambitious renewable energy targets, including zero net emissions target. The identified factors, that may contribute to the reaching of these targets are favourable natural resources, including large hydro, geothermal, wind and solar potential of the country. The absence of fossil fuel resources partially allows Costa Rica to escape a carbon lock-in in terms of electricity generation. The openness of the economy to foreign trade, its history of attracting foreign direct investments can also be considered among the beneficial factors. Additional factors include stable democratic institutions, active cooperation in global climate negotiations and the awareness and acceptance of environmental issues by the civil society.

The national innovation capabilities in Costa Rica are limited. The National Innovation System is still under development, with Costa Rica remaining behind more developed economies in the region on various factors. The stable democratic regime and functioning institutions, however, inspire hope that political action can be taken to improve the innovation capabilities, the research potential, linkages between research institutions and the business sector, the human capital in terms of the quality of education and gender equality to further the country’s capacity to absorb and create knowledge. To answer the research question, it could be said that based on the increasing capacities in renewable energy sources and imports of renewable energy technologies, the NIS of Costa Rica is able to absorb these technologies and successfully implement them, resulting in an increase of renewable electricity generation. However, it is not sufficient at this point to achieve that depending only on domestic capacities.

The policy actions taken and aimed at the renewable energy sector include those on a national level, some fiscal incentives, regulations and financial stimuli. They is, however, a number policy instruments used and recognized as efficient worldwide and in the LAC region, that have not been introduced in Costa Rica, and the country falls behind on stimulating innovation and providing incentives for local and foreign actors in terms of further development of the sector. Taking into consideration the limitations of the researcher in terms of the use of Costa Rica's policy documents, it was possible to analyse policymaking in the country from secondary sources, which may have affected this conclusion.

The main renewable energy sources for electricity in Costa Rica include hydroelectricity, geothermal power, wind and solar PV. The large deployment of hydro power on the one hand ensures the clean electricity, however, on the other hand, brings the threat of hydro lock-in and the challenge to diversify the electricity mix, as hydroelectricity is threatened by climate change, is weather dependent and is of limited reliability. In the most recent years, Costa Rica has increased its cumulative capacities in geothermal and wind power sources, however, solar energy remains underdeveloped, though, not without positive prospects.

The limited local production of renewable energy technologies and the above-mentioned weakness of the innovation capabilities bring about the need for technology adoption from abroad, as mostly innovations in the sector still takes place in developed countries and the technologies are available. It has been identified that trade is likely to be a more significant channel of technology transfer to Costa Rica, in comparison to foreign direct investment and licensing. The imports of renewable energy technologies are significant for the economy of Costa Rica and show an upward trend. In comparison to the LAC region and the selected economies, Costa Rica generally falls behind in terms of the magnitude of the flows.

Overall, it can be said that it remains unclear if Costa Rica can serve as an example to other developing countries in terms of achieving a high share of renewables in electricity generation. For countries with similar natural resources, it is possible to deduce the solution of taking advantage of exploiting their hydro and geothermal resources. In terms of policymaking and introducing market-based and regulatory instruments that incentivise the use of renewable energy sources, countries other than Costa Rica probably have been more successful. The challenges that the country faces in the energy sector, where there is room for decarbonization and reduction of fossil fuel consumption, despite the insignificant total volumes of emissions are also present and the country has not shown any substantial improvements.

This thesis can imply that though renewable electricity production is a priority for all countries, there are also other issues that need to be taken into consideration, such as improvements in the efficiency of the energy sector, national innovation system performance, human capital. Costa Rica deserves praise for its clean energy production, but it may be challenging to deduce a “recipe” for a transition to a greener electricity mix.

Further research on the topic is necessary and may deal with a broader country sample that would allow for a quantitative analysis of the factors that may lead to increased sustainability of the energy sector to assess the significance of the NIS, policies and transfer channels for this goal.

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Appendix A

Low-Carbon Energy Technologies and their codes in the HS classification

Technology	HS code	HS code description
Hydropower	841011	Hydraulic Turbines, Water Wheels, of a Power Not Exceeding, 1,000kw
	841012	Hydraulic Turbines and Water Wheels, Power 1,000-10,000kw
	841013	Hydraulic Turbines, Water Wheels, of a Power Exceeding 10,000kw
	841090	Parts of Hydraulic Turbines and Water Wheels, Including Regulators
Solar PV	854140	Diodes, transistors and similar semiconductor devices; photosensitive semiconductor devices, including photovoltaic cells whether or not assembled in modules or made up into panels; light-emitting diodes; mounted piezoelectric crystals
Wind	730820	Towers and lattice masts, of Iron or Steel
	850231	Generating Sets, Electric, Wind-powered
	850300	Parts suitable for use solely or principally with the machines heading 8501 or 8502
	841381	Pumps for liquids, whether or not fitted with a measuring device; other pumps (Wind turbine pump)
	841290	Engine and motor parts (Wind turbine blades and hubs)

Geothermal	840681	Turbines; steam and other vapour turbines, (for other than marine propulsion), of an output exceeding 40MW
	840682	Turbines; steam and other vapour turbines, (for other than marine propulsion), of an output not exceeding 40MW
	841869	Refrigerating or freezing equipment; heat pumps, other than compression type units whose condensers are heat exchangers
	841861	Refrigerating or freezing equipment; compression type units whose condensers are heat exchangers
	841919	Heaters; instantaneous or storage water heaters, non-electric, other than gas
	841581	Air conditioning machines; incorporating a refrigerating unit and a valve for reversal of the cooling or heat cycle
	841950	Heat exchange units; not used for domestic purposes

Source: adapted by the author from Pasimeni (2017); Steenblik (2006), APEC (2012)

Appendix B

Definitions of the main concepts used, taken from IEA (2015):

Energy products included under the title "renewable" include: hydroelectricity, geothermal, solar photovoltaic, solar thermal, tide, wave, ocean, wind, solid bio- fuels, biogases, liquid biofuels and renewable municipal waste.

Hydroelectricity

Hydroelectricity refers to potential and kinetic energy of water converted into electricity in hydroelectric plants.

Geothermal

Energy available as heat emitted from within the earth's crust, usually in the form of hot water or steam. It is used for electricity generation, heat production for sale to third parties or directly as heat in its prima- ry form.

Solar energy

Solar radiation exploited for electricity generation and hot water production. Passive solar energy for direct heating, cooling or lighting of dwellings or other buildings is not included.

• Solar photovoltaic: This is solar radiation exploit ed for electricity generation by photovoltaic cells.

Wind

Kinetic energy of wind exploited for electricity generation by wind turbines.

Electricity generated shows the total number of GWh generated by thermal power plants separated into electricity plants and CHP plants, as well as production by hydroelectricity (excluding pumped storage production), geothermal, etc