IRENA
International Renewable Energy Agency

RD&D FOR RENEWABLE ENERGY TECHNOLOGIES:

COOPERATION IN LATIN AMERICA AND THE CARIBBEAN

About IRENA

The International Renewable Energy Agency (IRENA) is an intergovernmental organisation that supports countries in their transition to a sustainable energy future and serves as the principal platform for international cooperation, a centre of excellence, and a repository of policy, technology, resource and financial knowledge on renewable energy. IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy, in the pursuit of sustainable development, energy access, energy security and low-carbon economic growth and prosperity. www.irena.org

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ABBREVIATIONS

AECID	Agencia Española de Cooperación Internacional para el Desarrollo (Spanish Agency for International Development Cooperation, Spain)
CEDECAP	Centro de Demostración y Capacitación en Tecnologías Apropiadas (Demonstration and Training Center for Appropriate Technologies, Peru)
CODELCO	Corporación Nacional del Cobre (National Copper Corporation, Chile)
CONICET	Consejo Nacional de Investigaciones Científicas y Técnicas (National Council for Scientific and Technical Research, Argentina)
CTCN	Climate Technology Centre and Network
ENTSO-E	European Network of Transmission System Operators for Electricity
GDP	Gross domestic product
GMI	Gabinete Ministerial de la Innovación (Ministerial Cabinet for Innovation, Uruguay)
FAPESP	Fundação de Amparo à Pesquisa do Estado de São Paulo (São Paulo Research Foundation, Brazil)
IGO	Intergovernmental organisation
INEES	International Network on Energy and Environmental Sustainability
IRENA	International Renewable Energy Agency
IITC	IRENA Innovation and Technology Centre
IS	Innovation system
LAC	Latin America and Caribbean
MoU	Memorandum of Understanding
MTI	Multilateral Technology Initiative
NGO	Non-governmental organisation
REGSA	Promoting Renewable Electricity Generation in South America
RET	Renewable energy technology
R&D	Research and development
RD&D	Research, development and demonstration
SME	Small and medium enterprise
SSC	South-south cooperation
SWH	Solar water heater
TEC	Technology Executive Committee
TIS	Technological innovation system
TSO	Transmission system operator
UNFCCC	United Nations Framework Convention on Climate Change

EXECUTIVE SUMMARY

Latin America and the Caribbean (LAC) is a diverse and heterogeneous region in terms of natural and economic resources. Thus, energy challenges vary significantly among the subregions and countries. While some countries in the region experience a fast industrialisation process and seek to follow the trends on expansion and modernisation of their energy infrastructure, others strive to address energy security, access and competitiveness challenges. At the same time, the potential of energy production from hydro, solar and wind resources in the region is enormous. Today, these resources have high potential to overcome the energy challenges in the region and to modify its energy mix towards a more sustainable system.

Innovation is essential for matchmaking between the energy challenges and the technological solutions required to overcome them. Thus, innovation plays a crucial role in further adapting and deploying mature renewable energy technologies (RETs) and developing emerging ones. Technological research, development and demonstration (RD&D) are the basis of innovation and hence, are cornerstone stages to enabling higher penetration of RETs in end-use sectors. However, innovation is not only about technological advancements, but also about their transition towards commercialised solutions. From basic research to commercialisation of breakthroughs, successful innovation requires, in parallel, new forms of financing and enabling policy frameworks.

When it comes to innovation, LAC is not a dormant region. This report presents an inventory of activities focused on spurring innovation and specifically for various RETs. The development of short-term forecast tools for wind generation, hydrokinetic turbines for use with marine currents, smart mini-grids for electrification of isolated and rural communities and biofuel production from microalgae are a few examples of the RD&D activities identified in LAC by the International Renewable Energy Agency (IRENA). Moreover, innovation indicators collected in this report reveal that LAC has significant potential to conduct technological research. Some countries produce more science, in relation to the expenditures invested with this purpose, than leading countries on innovation worldwide. However, the analysis conducted in this report on the RET RD&D momentum in LAC finds that there are wide-ranging opportunities to coordinate these innovation activities and to link the efforts invested in innovation. That is to say, LAC co-invention and cooperative research can contribute to bridge the gaps on RET innovation and diminish the energy challenges in the region.

International and inter-sectorial cooperation is a catalyst of innovation and a powerful tool to develop goal-oriented and streamlined RD&D programmes in the complex landscape of innovation. It does this by bringing together stakeholders, enabling the exchange of experiences and facilitating access to competences, knowledge and funds. Driven by its member countries' mandate, in this report IRENA provides an overview of how to reinforce cooperation in RD&D of RET in LAC. This overview is based on a discussion of the main gaps and areas for improvement of RET innovation in the region. The discussion is supported by surveys and interviews conducted with cooperators, researchers and other innovation stakeholders active in the field of RET and complemented with the observation of RD&D indicators of several LAC countries. The main gaps on innovation to be bridged are mapped in Figure ES 1 and are further discussed in this report.

To close these gaps, policy makers will find in this report an overview of recommendations on how to strengthen cooperative RD&D of RET. These recommendations are also enriched by the discussions held with regional actors and stakeholders of RET innovation. In a nutshell, the recommendations touch upon the following matters:

- **The relevance of having a governance structure to interconnect all innovation related fields and align technical expertise, innovation stakeholders and national plans through, for example, cross-cutting governmental offices.** As an example, the Uruguayan Strategic National Plan of Science, Technology and Innovation illustrates this discussion point.

- **Coordination from national to local jurisdictions to streamline political objectives of provincial and local governments.** Horizontally and vertically, public administration for research, innovation and entrepreneurism can be facilitated through more efficient administrative processes, simpler permit concessions of first implementations or easier access to testing facilities. In this context, the experiences of Brazil through the São Paulo Research Foundation and the Technological Innovation Act are shared in this report.

- **Support to the private sector for the diversification of RET applications and the identification of niches in markets through public-private partnerships, public tenders and programmes specifically addressed to the manufacturing sector.** The international cooperation of local and foreign companies and the collaboration with the Chilean National Copper Corporation to implement the world's largest thermal solar plant to supply process heat to mining operations illustrate this point. The venture of public capital from the Argentinian National Council for Scientific and Technical Research with private capital for RET research is also noted in this report.

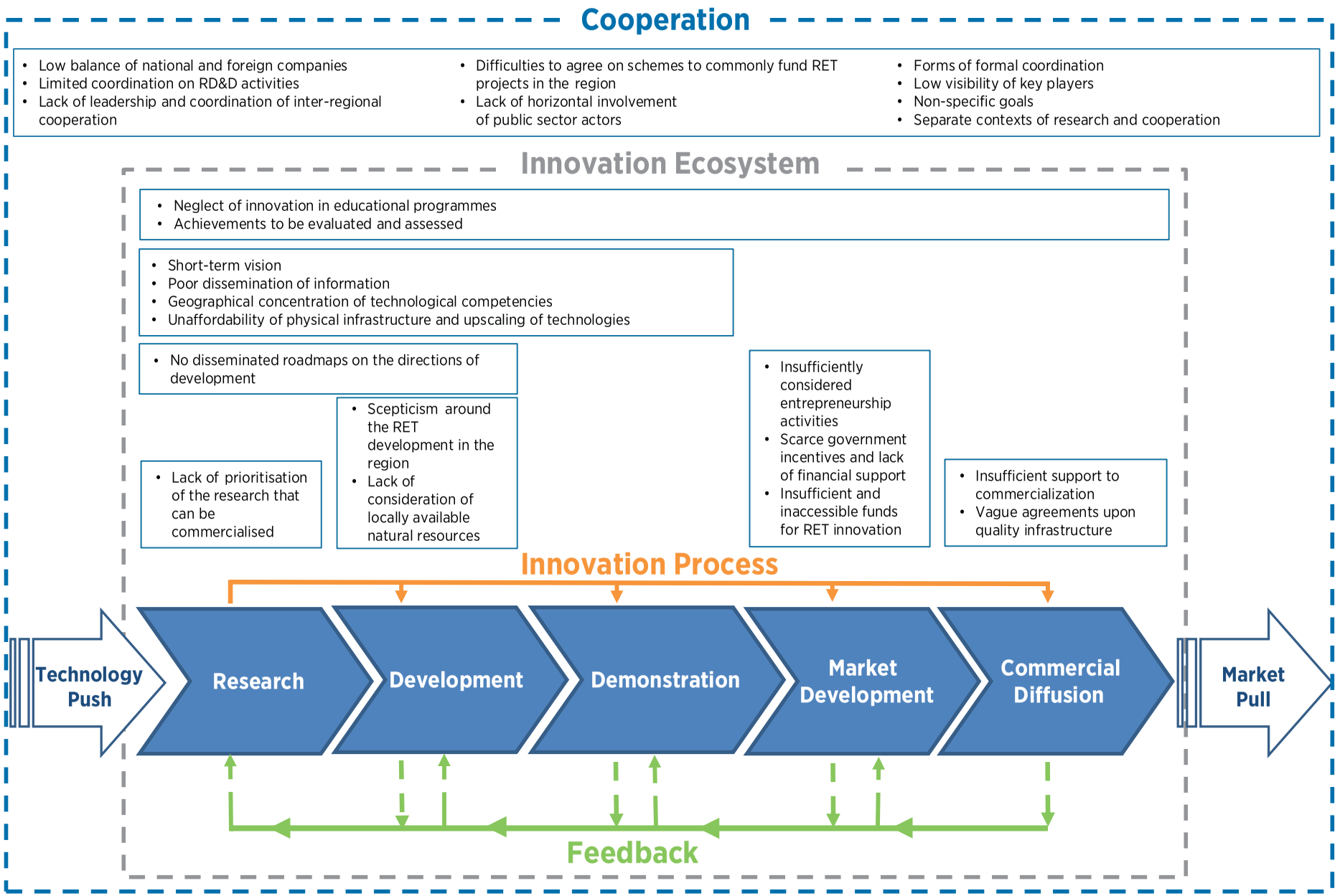
- **The role of local cooperative aid actors in bringing to the attention of policy makers and investors the social needs for innovative technological solutions and promoting in communities the social assimilation of pilots, prototypes and adapted technology prior to its implementation or scale-up.** Given that social responsibility is a trigger for innovation, this report encourages partnerships with these local cooperative aid actors when formulating cooperation schemes. This cooperation is key, for instance, in the programmes promoted by various governments in LAC, the Latin American Energy Organisation (OLADE) and other institutions, to substitute traditional firewood stoves with efficient technologies. Given that this substitution entails not only technological challenges but also financial and cultural concerns, cooperative local actors are key to involve the domestic sector in this transition and adapt the new technology to the local circumstances of areas where this transition is a priority.

- **The exchange of information among researchers, policy makers and main market actors in the region.** The report calls for the dissemination of research activities among technology centres via, for example, newsletters, peer-reviewed journals which focus on RD&D of RET in LAC or international research summits with a clear focus on the LAC context. At a supra-regional level, this report discusses the benefits of creating networks with technology centres abroad to develop and disseminate joint research projects and share resources. An example introduced in this regard is the dialogue and cooperation between the European Union and LAC to constitute the Joint Initiative for Research and Innovation and implement the Latin America, Caribbean and European Union Network on Research and Innovation.

A number of other recommendations and suggestions on practical actions to put in place can be found in this report, briefly illustrated in some cases by endeavours undertaken by cooperators within the region and abroad. The key message of this report gives a boost to the deployment of RET in LAC by reinforcing cooperative RD&D to face the energy challenges and fulfil energy demand in the region.

This report also sets the groundwork to broaden IRENA's practical support to LAC member countries in RET development and deployment. IRENA will do this by acting as a hub for countries to create networks in those technology fields of research that are a priority for their national sustainable development objectives. With these next steps, IRENA seeks to stimulate cooperation along the whole continuum of innovation of RET, from basic research to commercial diffusion.

Figure ES 1: Map of gaps on innovation of RET in LAC.



GLOSSARY OF TERMS

Innovation

Innovation refers to the development and diffusion of new or improved products, processes or services.

Innovation policy

Public intervention to support the generation and diffusion of new products, processes or services (Edler et al., 2013).

Innovation processes

Innovation processes involve the exploration and exploitation of opportunities for new or improved products, processes or services (Smith, 2005).

Innovation system

An innovation system comprises the important economic, social, political, organizational, institutional and other factors that influence the development, diffusion and use of innovations (Edquist, 2005; see also Edquist, 1997). The constituents of the innovation system are all these factors plus the relations amongst them. The components of the innovation system are the organisations and institutions:

- Organisations are formal structures, consciously created with an explicit purpose, and they are made up of players and actors.
- Institutions are the sets of common habits, norms, routines, established practices, rules, or laws that regulate the relations and interactions between individuals, groups and organisations.

Knowledge development and diffusion

Learning processes of relevance for the development of innovations, and the spread of knowledge acquired through these learning processes.

Legitimacy

Legitimacy is a matter of social acceptance and compliance with relevant institutions (Bergek et al., 2008).

Market formation

Market formation takes place with demand-inducing activities which allow new technologies to compete with established technologies.

Open innovation model

The open innovation model emphasises that firms increasingly use external ideas and external paths to market as complements to internal ideas and internal paths to market.

Quality infrastructure

Quality infrastructure refers to quality standardisation, certification, accreditation and metrology (Harmes-Liedtke and Oteiza Di Mateo, 2011).

South-south cooperation

Mutual cooperation aimed at fostering self-sustaining development, involving deepening relations among developing countries while conducting technical and economic cooperation (Japan International Cooperation Agency, JICA, 2014).

Technological innovation systems

Network(s) of agents interacting in a specific economic/industrial area under a particular institutional infrastructure or set of infrastructures and involved in the generation, diffusion, and utilisation of technology (Carlsson and Stankiewicz, 1991).

Technology transfer

Technology transfer is a broad set of processes covering the flows of know-how, experience and equipment amongst different stakeholders such as governments, private sector entities, financial institutions, NGOs and research/education institutions (IPCC, 2000).

1 INTRODUCTION

The potential of energy production from solar, wind, marine, geothermal, biomass and hydropower in the Latin American and Caribbean (LAC) region is enormous. The production from renewable sources would suffice to meet the current demand of the entire region with power (IDB, 2013). What is more, the estimated demand of 3.5 PWh in LAC by 2050 could be fulfilled just by harnessing 4% of the total technical potential of renewables in the region. Currently, hydropower in LAC accounts for 20% of the world's technical hydropower potential (IEA-ETSAP and IRENA, 2015).

The deployment of renewable energy technologies (RETs) varies significantly among the LAC countries. While some countries have a widely developed RET infrastructure and have put in place efficient policies to enable RET deployment, a deployment gap is evident in various countries in the region, some of which are exposed to energy security challenges due to volatile oil and gas prices. Despite the impact of such price volatility on energy security, the LAC region is a net exporter of energy. However, countries with poorly diversified energy portfolios widely expose their economies to fluctuating gas and oil prices. This frequently results in low energy affordability for their citizens and market actors. Energy access is a cause of concern in the LAC region, where 7% of the regional population (31 million people) do not have access to grid-connected electricity (IEA, 2011). Apart from energy access, affordability and security, another factor strongly influencing the deployment of RET is infrastructure reliability (of power plants, transmission lines, etc.). This factor also varies widely within the different subregions.

From an environmental point of view, there is growing global pressure to accelerate the deployment of low carbon technologies in order to decrease pollution and the depletion of natural resources. Despite a relatively low emission intensity compared to developed regions, the ongoing challenge for the LAC countries lies in boosting economic growth while simultaneously avoiding the massive deployment of fossil fuel-based mature technologies.

Innovation has a crucial role to play in the deployment of RET solutions in the LAC region. Encouraging innovation on RET is pertinent to developing new RETs, improving existing ones and providing solutions to particularities of the energy sources, such as intermittency and the need for verification of sustainability. Innovation not only consists of inventing and deploying new technologies, but also includes the development of new forms of financing and enabling policy frameworks. In this paper, innovation refers to the development and diffusion of new and/or improved products, processes or services based on RET (refer to Glossary of Terms).

International cooperation is essential to foster innovation in RET. It is of paramount importance in developing successful and goal-oriented science, technology and innovation programmes and in creating platforms where experiences and best practices in RET innovation are shared and transferred across countries (IRENA, 2013; IRENA, 2015a). Cooperation networks are essential in strengthening cooperation policies to engage different parties and stakeholders to solve key barriers.

Prompted by a request from member countries, the International Renewable Energy Agency (IRENA) has carried out an assessment of the innovation status and possibilities of renewable energy deployment in LAC. This report seeks to reinforce the RET innovation momentum in the LAC region and motivate the international debate on what practical actions can be put in place to spur collaborative efforts in the research, development and demonstration (RD&D) of RET in LAC.

1.1 Objectives and Scope

IRENA aims to foster the transition from conventional to renewable energy systems. To achieve this mandate, IRENA seeks to motivate its member countries to develop and promote solid sustainable energy policy frameworks. This requires, among other factors, the design of efficient innovation policies. Thus, IRENA begins an overview of the RD&D cooperation status in LAC as part of the mandate from member countries. The specific objectives of this report are:

- The identification of RD&D activities, key stakeholders in the field of RET innovation, cooperation opportunities and drivers in the LAC region;
- An analysis of the main gaps in innovation that arise from gaps in the cooperative efforts existing within LAC countries and entities and within other external regions for the deployment of RET;
- The definition of strategies to strengthen intersectorial, local, national, regional and international cooperation.

The two main questions answered in this report are:

- *What are the main challenges to unleashing innovation in RETs that can benefit the national economic and energy objectives in the LAC region?*
- *What recommendations can be given to strengthen cooperation in the LAC region and define strategies to reinforce innovation in RETs?*

The research carried out to achieve the above-described objectives will explore all the technologies independent of their stage of development and their application in the market (solar energy, wind energy, hydropower, bioenergy, ocean energy and geothermal energy).

1.2 Target Readers

This report addresses significant issues across various stakeholder groups, which broadly can be identified as follows:

- Policy makers of the LAC region that strive for further deploying RET in their countries should read this report in order to become aware of the positive impact that reinforcing international and inter-sectorial cooperation has on technological research and innovation;
- Researchers, innovators and entrepreneurs, including academia related professionals and private sector, should read this report to ensure that they have an insight into the benefits of taking part in the cooperation initiatives and motivating collaborations with different sectors and foreign regions;
- Investors, including multilateral and investment banks worldwide, should read this report to understand how the combination of cooperation and innovation leads to fruitful results and provides trust and confidence in making investments.

2 INNOVATION SYSTEMS AND THE ROLE OF RD&D IN THE R.E.T. INNOVATION CHAIN

Innovation refers to novel technology or improved goods, services or alternatives to produce goods and services. Currently, there is good potential to bring emerging RET to a more mature stage of development, which means that there is an urgent need for innovations within this field. Figure 1 highlights that research, development, demonstration, market development and commercial diffusion are all activities of central importance to innovation.

Research efforts are particularly important for breakthroughs. Research and development (R&D) have been defined as "creative work undertaken on a systematic basis in order to increase the stock of knowledge" (OECD, 2002). R&D efforts are necessary (though not sufficient) to the ability to commercialise new technologies. In order to be part of such innovation processes (refer to Glossary of Terms) organisations of all sorts – companies, universities, research institutes, financiers, bridging organisations, policy actors – need to access a variety of resources and acquire a wide set of competencies.

Demonstration activities are targeted at testing developed solutions and upscaling these from prototypes to full-scale models. The market development stage encompasses efforts to introduce the developed and demonstrated technology on the market. Finally, a novel technology can be considered to be commercially diffused when its maturity allows a competitive profitability without specific incentives protecting it (ICCEPT and E4tech Consulting, 2003). However, as Figure 1 depicts, innovation processes are characterised by multiple feedback loops and iterations. Thus, an innovation process should not be considered a strictly linear sequential process according to the stages of research, development, demonstration, market development and commercial diffusion.

Innovation is based on the creation, absorption and transmission of knowledge and, therefore, many actors are often involved. While such learning may take place on the individual level exclusively and involve only a single individual, this is rather the exception than the rule. Instead, in today's often complex and multidisciplinary innovation processes, many individuals and organisations are likely to be engaged in a range of activities related to innovation. The cooperative nature of innovation may, for example, mean that various individuals or groups hold complementary resources – be

Figure 1: Key activities in innovation processes

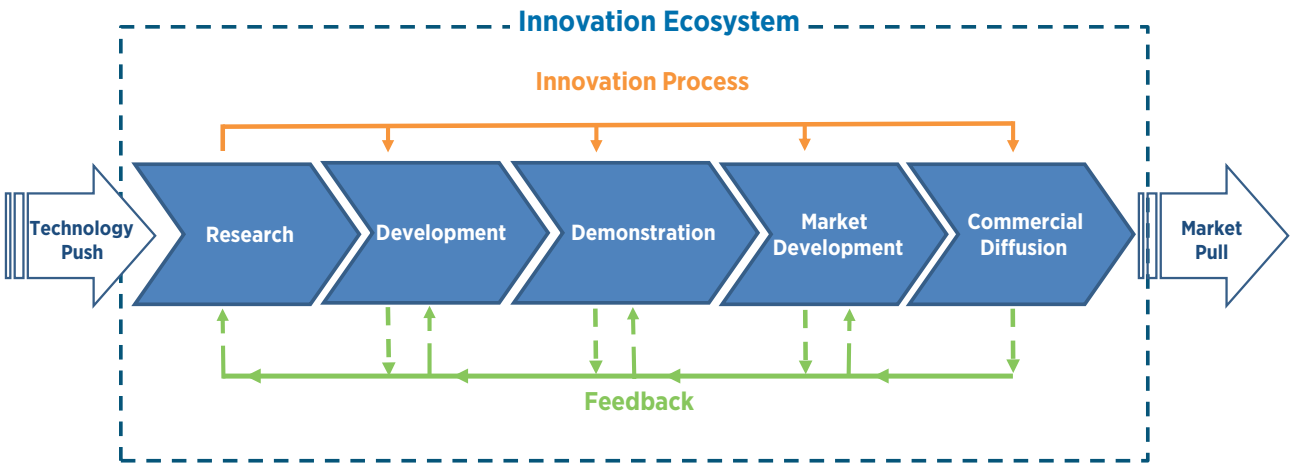
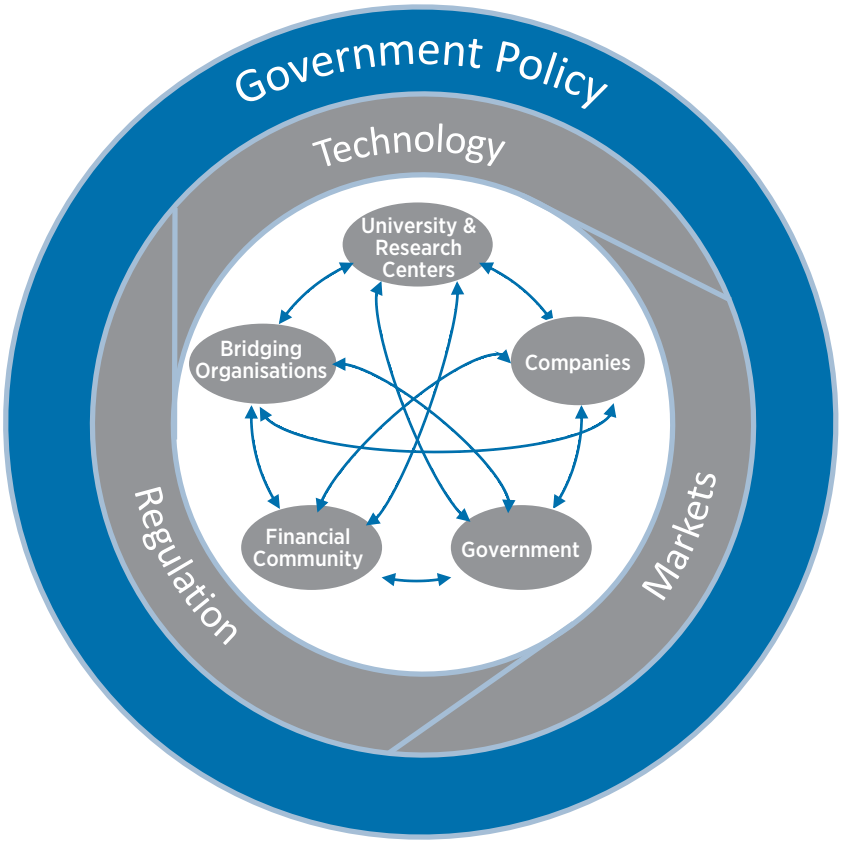


Figure 2: The structural elements of an innovation system



it knowledge, capital, facilities or others – that only in combination can lead to innovation. The partners may be companies, research organisations, financiers or public authorities, among others. Linkages with external actors such as customers, suppliers, competitors, research centres, universities or public authorities provide access to novel ideas, knowledge and technologies, suggestions for product or process improvement, and solutions to technical or organisational problems. In short, the constituents of innovation are a set of components and the relations among these components, which are shaped by laws, rules, norms and routines (North, 1992).

The **regulatory conditions** under which innovation takes place are of central importance. These conditions are specific to the **technology** in focus and the specific **market** in which these products compete (see Figure 2, as well as section 5 of this report). However, governments have a double role in the innovation system: firstly, they formulate policies that set the framework for the innovation system (see Glossary of Terms). This is the case to the extent that governments invest in R&D and, in more recent years the extent to which they make clear prioritisations of certain research areas. Secondly, governments are also active players in the activities in the innovation system, for instance through public procurement or in innovation processes that are concerned with public infrastructure, such as the construction of electricity grids.

Innovation policy (see Glossary of Terms) frameworks vary from country to country based on national and subnational contexts. The capacity to innovate in RETs is the product of many variables that vary widely across national and subnational contexts. Countries across LAC have different innovative capacities as well as different

Technological Innovation System Framework

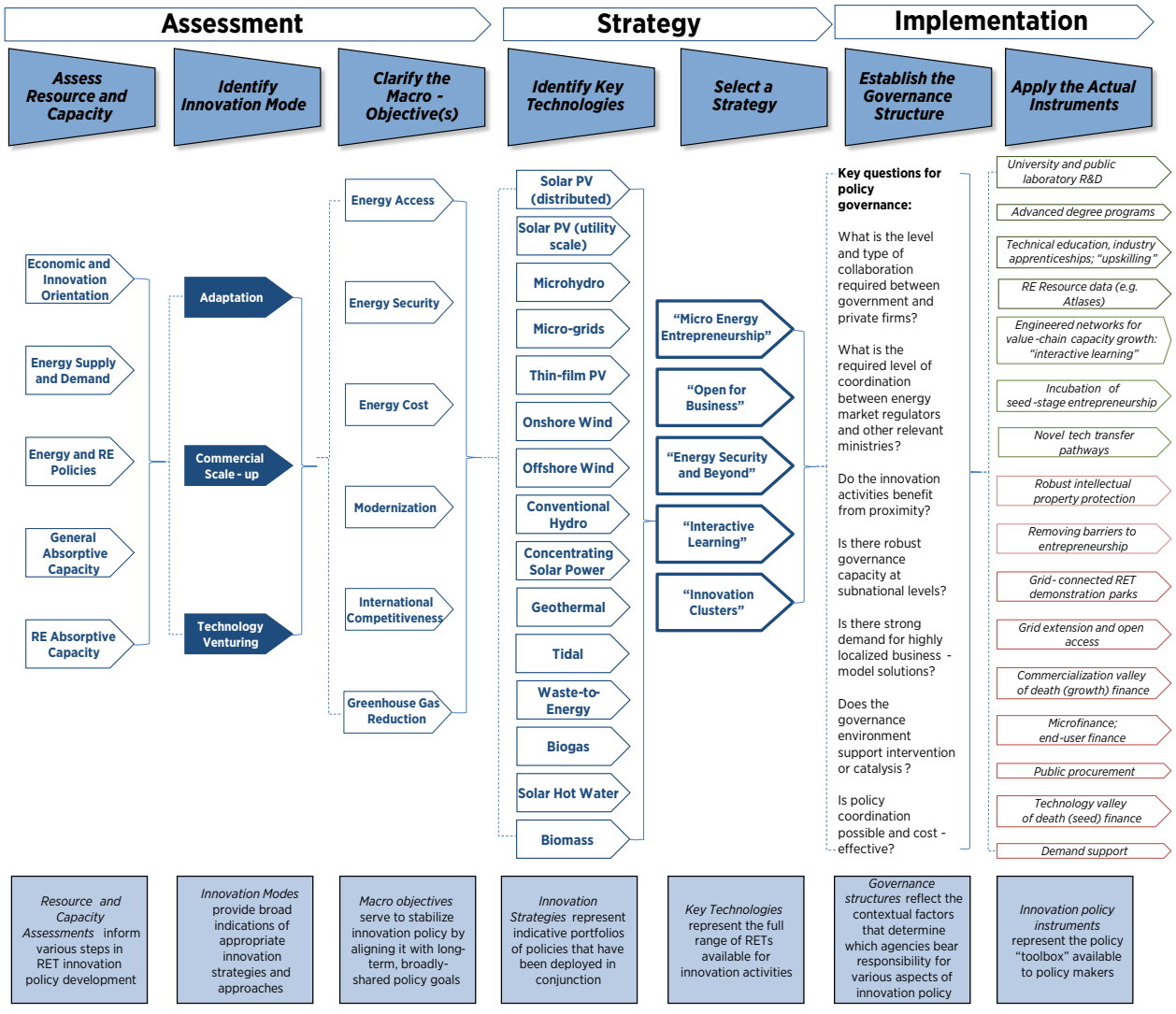
The technological innovation system (TIS) framework (see Glossary of Terms) is today considered a state-of-the-art approach for understanding the development of emerging technologies such as the various forms of RET. Refer to Appendix A for a detailed explanation of TIS.

barriers hindering the progress of technological deployment, but also different strengths with regard to natural resources and institutional conditions. Thus, specific policies and instruments to promote technological innovation need to be customised to bolster the unique capacity development needs in a country, and appropriate for the technologies of interest in the context in which they are applied.

Renewable Energy Technology Innovation Policy

A discussion paper by IRENA (IRENA, 2015a) provides broad guidelines for designing renewable energy technology innovation policy (RETIP), taking as a basis the understanding of the contextual variables that shape the innovation capacities in different countries. The RETIP process articulates a three-stage process covering the entire innovation policy development cycle and consists of: the assessment of existing resources and capacities, the identification of technologies and strategy that are well suited to the particular context, and the selection of appropriate policy instruments and establishment of a governance structure. To sum this up, there is not one innovation policy that suits all the current scenarios that different countries present. Policy makers can find in RETIP a tailored solution for individual countries. Figure 3 illustrates the guide to the RETIP development process systematically. The complete RETIP guidelines are available in the cited discussion paper.

Figure 3: Guide to the RET innovation policy development process



3 COOPERATION IN RD&D

3.1 What is *Cooperation*?

Cooperation refers to "the practice of people or greater entities working in common with commonly agreed-upon goals and possibly methods, instead of working separately in competition" (GIZ, 2013). For cooperation to occur it is essential that all participating actors have: (i) a common goal, (ii) a strategic independence of those involved, and (iii) a behavioural model based on action and reaction.

Cooperation can take place with actors either inside or outside the value chains. Cooperation inside the value chain refers to cooperation between customers and suppliers. Such user-producer relations have been highlighted as central to innovation, as they allow suppliers to learn from each other, agree on product specifications and understand changing customer preferences (Lundvall, 1992). In contrast, cooperation outside the value chain points to institutions such as universities, research institutes, intermediaries and standards setting organisations. Together with users, these institutions are often sources of knowledge for innovators and thus cooperation among these institutions is key to motivating innovation.

3.2 Policies and Mechanisms for Cooperation

The growing importance of innovation necessitates cooperation to develop and access the competencies and knowledge that are needed to speed up the development of RET. Thus, cooperative knowledge creation is a fundamental and increasingly important element in innovation. Such cooperation can take various forms, from temporary projects to long-term contractual partnerships and research joint ventures. Public policies can directly influence cooperation. The availability of public funding for R&D increases the probability of engagement in cooperative projects, particularly in the development stage of the innovation process (Arranz and de Arroyabe, 2008; Rothgang et al., 2011). The impact of such policies is found to be of particular importance in the longer run, beyond the duration of the individual projects that receive funding (Defazio et al., 2009). In this way, policies that stimulate international cooperation are particularly important for building long-term relations across nations and continents.

The success of cooperation policies and long-term relations comes hand-in-hand with a shared responsibility of the parties involved. This means that cooperative actions led by institutions of advanced economies should be designed considering an equivalent win-win situation. The main responsibility to reach such an approach lies with the institutions and governments of developed countries. They should avoid actions in which the technology and knowledge providers from those countries are the only partners to benefit from the cooperation.

Public policies can also indirectly facilitate cooperation by:

(i) Establishing platforms where new actors can have an easier access to networks created by former cooperators and jointly set up research projects with them (Guimerà et al., 2005);

(ii) Improving the level of technical capital of institutions (that is the institution's capability to create new technologies, products and processes), so institutions with low technical capital can become more attractive partners in the eyes of potential collaborators (Stuart, 1998);

(iii) Connecting actors located in the periphery with central institutions of RET innovation located in city regions, so institutions in peripheral areas can have easier and less costly cooperation with the central institutions.

The next box highlights some examples of emerging cooperation schemes that have been applied to spur innovation in different contexts.

Upcoming sections in this report discuss the identified gaps to innovation. Some of the identified gaps are cross-cutting issues affecting the different aspects of innovation, such as human and financial capacity, knowledge development and diffusion, entrepreneurism

Emerging Cooperation Schemes

Public-private partnerships

Public-private partnerships for knowledge infrastructure are a widely used innovation policy instrument. Such programmes involve state funding of R&D projects led by industry, and collaborations between scientists from industry and government. Such partnerships have the potential of developing commercial products and innovation; however, incentives should be structured so funding is not provided to the most commercially promising proposals, which normally would be funded by industry itself (Stiglitz & Wallsten, 1999).

For example, the European Union's Seventh Framework Programme and most recently Horizon 2020 have a strong and increasing focus on stimulating cooperation between public and private actors in research and innovation activities.

Public procurement for innovation

In addition to supply-side initiatives, demand-side initiatives such as public procurement for innovation policies may also stimulate cooperation. Basically, public procurement for innovation implies that government orders a product or system, which does not exist (Borrás and Edquist, 2013). Often, the government will play an active part in the development of such innovations and/or give consortia privilege to individual companies in the selection process.

An example of public procurement for innovation was the Light Corridors project, initiated by the former Swedish National Board for Industrial and Technical Development. "The objectives of the programme were to stimulate the development of energy efficient products, systems and processes, to demonstrate their function, to stimulate market penetration and to commercialise the results in residential and commercial buildings and in industry" (Edquist and Zabala-Iturriagagoitia, 2012). The initiative led to the establishment of new technological standards and the development of new energy efficient lighting solutions.

Urban living labs

A policy type of particular importance for the development of RET is urban living labs, *i.e.* "real-life" experiments that explore the technological, economic, social and cultural aspects of new potential innovations. Cooperation between business, government and users is at the heart of these living labs, which provide room for demonstration of new technologies in real-life settings and possibility for assessment of the upscaling potential.

An illustrative example of an urban living lab is Masdar City. Masdar is a wholly owned subsidiary of the Abu Dhabi Government-owned Mubadala Development Company. "Masdar City serves as an open technology platform that gives partner companies an unmatched opportunity to develop, test and validate their technologies in a large scale, real-world environment – and in particular, with consideration to the region's climate conditions and consumption patterns. It is a community where cutting edge clean-tech R&D, pilot projects, technology testing and construction on some of the world's most sustainable buildings are all ongoing" (Masdar City, 2013).

The Aruba Gateway Vision is another example of an urban living lab. "Aruba's government believes that Aruba is positioned to become a robust gateway between Latin America, the United States and the European Union for commerce, political dialogue and investments. (...) The focal point in this effort is to explore the possibilities for Aruba to become a key player in technology research. The Government has already taken the first steps in this direction in the field of sustainable energy technology. Since Aruba has the best possible climatological circumstances, the government is developing an international research facility that will take advantage of Aruba's abundant wind, water and sun to conduct research and testing of the newest technologies in the field of sustainable energy and to offer courses and conferences for the region. Aruba Gateway Vision and eventually the creation of a Science and Technology Park is to enable, stimulate and manage the flow of knowledge and technology among universities, R&D institutions, companies and markets; the goal is for Aruba to create and grow an environment for innovation-based companies through an incubation, and spin-off processes" (Government of Aruba, 2013).

Implementing Agreements

Also known as Multilateral Technology Initiatives (MTIs), Implementing Agreements are multilateral cooperation structures that the International Energy Agency uses to "enable member and non-member countries, businesses, industries, international organisations and non-government organisations to share research on breakthrough technologies, to fill existing research gaps, to build pilot plants and to carry out deployment or demonstration programmes. In short their work can comprise any technology-related activity that supports energy security, economic growth, environmental protection and engagement worldwide" (IEA, 2013).

Intergovernmental networks and knowledge hubs

Various intergovernmental organisations (IGOs) have established knowledge hubs that act as cooperation platforms and direct developing countries requests. An example is the Technology Mechanism of the United Nations Framework Convention on Climate Change (UNFCCC).

Through the Technology Executive Committee (TEC) for policy guidance, and the Climate Technology Centre and Network (CTCN) for technological implementation, the Technology Mechanism "facilitates enhanced action on technology development and transfer to support action on mitigation and adaption" (UNFCCC, 2014).

and market formation, among others. These aspects are all interconnected and it is precisely in this interconnection where weaknesses in cooperation were identified, as part of the analysis of barriers to innovation. Such weaknesses include ambiguities in formal forms of cooperation; insufficient managerial skills, experience in coordinating cooperation and agreements on funding schemes; and the needs to involve public sectors at horizontal level, coordinate ongoing RD&D activities and harmonize existing innovation policies and frameworks. Further discussions on these points are presented in section 6.

4 CASE STUDIES OF STRATEGIES FOR RD&D COOPERATION ON R.E.T.

This section provides three examples of successful strategies for RET based on cooperative mechanisms that hold inspiring lessons for LAC countries. The examples are:

1. Cluster cooperation: Early wind turbine development in Denmark
2. Technology transfer through licensing: The growing Chinese wind turbine industry
3. Public-private partnerships: Bioethanol for transport in Malawi

Although other examples can be found within the LAC region, these cases illustrate how developed, emerging and developing economies in different continents have succeeded in developing RET by giving central importance to cooperative RD&D efforts.

The cases also highlight the importance of combining a strong performance within knowledge development with other activities in the innovation system, including entrepreneurial experimentation (wind turbines in Denmark), market formation (wind turbines in China) and influence on the direction of research (bioethanol in Malawi).

4.1 Cluster Cooperation: Early Wind Turbine Development in Denmark

The Danish story of wind power is considered to have succeeded in terms of industrial cooperation facilitated through multiple actors, or cluster cooperation. In fact, cooperation is considered to be the single most important factor for cluster formation in the early stages of wind turbine development in Denmark (Garud and Karnøe, 2003). For this reason, the early period of the industrial development of wind turbines holds valuable lessons for the development of RET in LAC, as it highlights how countries can foster and develop small ongoing initiatives benefiting from sharing technological experience across organisations and communities.

At the start of the industrial development of wind turbines, investments in RD&D were particularly important to improve the performance of this, at that time, emerging technology. Given existing market and technological uncertainties, RD&D was organised largely collectively, rather than individually, through the Danish Wind Turbine Test Station. Established in 1978, this station became a centre for formal and informal cooperation between research organisations, wind turbine producers and firms from related industries. The objective of the station was to provide technical support to the wind turbine cluster emerging at that time. After the station's establishment, the government of Denmark approved a law requiring the testing and certification of wind turbines before owners could qualify for public subsidies. Due to this government decision, the station became a relevant source of knowledge and centre for industrial cooperation and exchange of information (Garud and Karnøe, 2003). A second key factor was the strong involvement of farmers and other users in the collaborative technology development of wind turbines. This resulted in simple designs that were both robust and functional, which eventually allowed the upscaling of the technology.

In comparison, in the case of United States, end-users and small consumers were not much involved, but instead a strong technology push came from the government. This resulted in large investments by the government in a technological field in which there was insufficient experience. This led to less successful results than in Denmark, where enterprises were characterised by more collective and experimental development processes and more gradual improvements (Garud and Karnøe, 2003). In the Danish case also large networks of specialised stakeholders within the wind industry were constituted by small and medium enterprises (SMEs) and manufacturers.

Although the budget invested in R&D in Denmark was relatively small, it was allocated effectively among SMEs, which were dedicated to the design and initial stages of development of various sizes of turbines

(Kamp, 2002). Furthermore, the high degree of collaboration and knowledge sharing in the cluster ensured a high impact of the allocated funds. As a result, the Danish wind industry exemplifies how **dynamic clusters can foster innovation by collectively cooperating and competing in a fruitful way.**

Summing up, the case of early Danish wind turbine development points to the central importance of collaborative knowledge development, but also highlights how knowledge development does not necessarily require very large investments. Further, collaborative entrepreneurial experimentation (both in private settings and in the publicly funded test station) and resource mobilisation in the form of skills and human capital from related industries, were crucial assets made available for single firms through the development of the cluster.

4.2 Technology Transfer through Licensing: The Growing Chinese Wind Turbine Industry

Industrial development around wind power in China started in the 1980s and was at that point mainly based on imports of wind turbines from Denmark through government purchases from producers Bonus (later acquired by Siemens) and Vestas. The 1990s and early 2000s saw the establishment of many domestic producers, including current leading companies Goldwind and Sinovel. While the home market continues to be very dominant in the project portfolios of Chinese wind turbine producers, they are now increasingly focusing on foreign markets.

The achievements of the Chinese wind turbine industry are founded on a combination of external and internal collaboration in knowledge development. On the external side, having initially focused on learning from equipment imports, Chinese wind turbine producers engaged in a large number of international cooperation efforts in the early 2000s (Gosens & Lu, 2013). Initially, licence agreements with German and Dutch wind turbine producers, and the collaboration associated with these, were highly relevant for development of the wind turbine industry in China. This was followed by a large number of joint development efforts between Chinese producers and western wind turbine design houses such as Windtec and Vensys. The wind turbine design houses brought sophisticated technologies into this cooperation, while the Chinese producers offered competencies concerned with commercialisation and upscaling of production. This demonstrates that western and emerging market companies may bring complementary competencies into such cooperative relations to mutual benefit. In some cases, such cooperation led to acquisitions of western companies by Chinese wind turbine producers, supported by favourable loans from state-owned development banks.

However, in order to build up sufficient internal capacity and become less dependent on knowledge developed abroad, there has been an increasing focus on domestic wind turbine R&D in China. Considerable in-house R&D efforts have been carried out by all major Chinese wind turbine manufacturers, supported by grants from the Chinese government (Tan, 2010), and recent R&D spending has been increasingly focused on offshore wind turbine developments. Even western companies, such as Vestas, have opened designated R&D centres in China. Consequently, the leading Chinese wind turbine producers are now fully capable of independently developing new wind turbine designs, and the technological lag (the number of years Chinese manufacturers are behind western manufacturers in producing turbines of similar capacity) has been decreasing rapidly over the last decade. Further evidence of the growing technological capacity is the rapidly increasing number of patents granted to Chinese wind turbine producers. This should, however, be interpreted with caution, as the propensity to patent and innovative performance are not necessarily directly correlated (Gosens and Lu, 2013).

In summary, the combination of strong market formation and a persistent focus on knowledge development, both domestically and through cooperation with international partners, has underpinned the growth of the Chinese wind turbine industry. Additionally, resource mobilisation in the form of governmental financial support of acquisitions of foreign technology and companies has also played a central role.

4.3 Public-private Partnerships: Bioethanol for Transport in Malawi

The case of Malawi highlights that developing countries can also build strong technological competencies within

specific niches of renewable energy (Batidzirai and Johnson, 2012). Today, Malawi has become exemplar of bioethanol transportation in Sub-Saharan Africa, and the technical expertise of Malawian bioethanol professionals is in high demand in other African countries. Furthermore, the case points to the leapfrogging potential of developing countries within RET, even though this should be seen in light of the relatively limited level of infrastructural development needed in Malawi to allow for rapid upscaling of the bioethanol technology (Johnson and Silveira, 2013).

Since the early 1980s, Malawi has emerged as a regional leader in the use of bioethanol as a transport fuel. Due to rising oil prices and issues concerning energy security and deforestation (following from the widespread use of wood as a fuel), the focus in Malawi was quickly centred – and subsequently sustained – on bioethanol. Consequently, the use of bioethanol as a transport fuel has grown rapidly and replaced 10-20% of the oil used for transportation purposes. The example of Malawi is instructive as it highlights that oil importing developing countries may actually break away from the dominant use of fossil fuels (Johnson and Silveira, 2013).

Early development and demonstration activities in Malawi centred on experimentation with different blends and modifications of engines in bioethanol production plants. More recent technological development efforts are supported by governmental R&D funds and since 2007 for example, there has been a focus on pilot tests of dual-fuel vehicles. These tests have involved collaboration between the local ethanol industry, the Malawian government and a technical school (Liwimbi, 2007). More recently, attention has been given to introducing bioethanol in fleet transportation (Wambua, 2011). Fleet applications of bioethanol provide room for additional experimentation, which is important for the further expansion of the domestic market for bioethanol. Additional development activities have been put into formulating technical standards based on public-private coordination for bioethanol, which are likely to lead to improved reliability in the home market, facilitate trade in bioethanol and contribute to standard setting processes elsewhere in Africa (Johnson and Silveira, 2013). Importantly, the role of such a close public-private partnership is emphasised for the development and diffusion of ethanol technologies in Malawi, as well as in other African countries (Batidzirai, 2007). Recently, the Malawian government has identified cluster development around bioethanol, bioplastics and sugar as one of three key areas in the National Export Strategy (Phiri, 2014); thus, there continues to be a clear focus on stimulating cooperation around bioethanol production in the country.

In summary, as in the two previous examples, efforts focusing on cooperative knowledge development have been central to the development of bioethanol in the Malawian transportation sector. However, bioethanol enjoyed high legitimacy from the beginning, as an important part of the answer to domestic challenges concerning energy security and deforestation. Ethanol was readily prioritised, with **considerable resources chanelled into public-private cooperation initiatives to develop ethanol technology.**

5 OVERVIEW OF ONGOING COOPERATION INITIATIVES ON RD&D FOR R.E.T. IN L.A.C.

A number of different actors active in the region in RET RD&D were contacted during the development of this study. Contacts included: IGOs and governmental centres, academia, NGOs and private companies. Through this bottom-up approach, a general picture of ongoing projects, programmes and policy frameworks aiming to enhance technological research, innovation frameworks or market areas was conceptualised. The methodology applied in the analysis of these initiatives to gather information on the barriers to innovation and RD&D in LAC is explained in further detail in Appendix B.

From the global picture of innovation momentum in the region, certain initiatives were selected to pursue in-depth information on innovation and cooperation. The initiatives for this study were selected based on compliance with the following criteria: firstly, the initiatives are facilitated by cooperation programmes established by institutions pertaining either to different sectors or to different geographical areas. Therefore, all initiatives are inter-sectorial or international examples of cooperation. At the same time, the initiatives should pursue the common goal of enhancing innovation along the different steps of the innovation chain. Thus, from basic research to commercial diffusion, all initiatives focus on enhancing RET innovation.

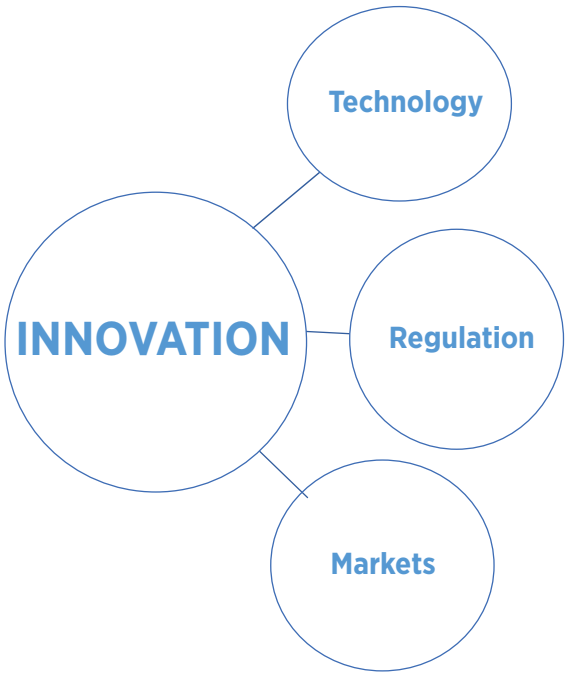
In total, 37 interviews were conducted with innovators, researchers and stakeholders amongst IGOs, governmental offices, private enterprises, NGOs and academia, representing eight initiatives. Together these initiatives entailed cooperation of key partners from 14 countries, mainly in LAC and to a lesser extent in Europe. The participation of governmental bodies and offices in this study is notable and indicates that as well as being the engine of innovation policies and regulations, governments are also catalysts of technological research and markets.

As described in section 2, successful innovations are due not solely to **technological research,** but they also arise from the adoption of **appropriate regulation and policies**. Similarly, **innovative markets** have to be stimulated in order to satisfy the real energy demand and social needs. This means aligning the *technology push* driving forces of innovation with a *market pull*. Thus, the initiatives selected for this study all aim at positively influencing the technological research, the regulation framework or the market arena in which the innovation is hosted. It has to be stressed that technological research, regulation, policies and markets coexist and are interrelated. Thus, support provided in one unavoidably influences the others.

This qualitative data collection through interviews and questionnaires represents merely a sample of the current cooperation efforts focusing on innovation in LAC. A broader compilation of initiatives was collected in an attempt to map ongoing innovation and categorise the numerous actors taking part. Appendix C shows the map of initiatives, institutions and research centres (IGOs, governmental offices, private enterprises, NGOs and academia) cooperating in the initiatives. Overall, 24 initiatives are compiled. These initiatives entail cooperation of partners from more than 130 institutions in 33 countries. In addition, a brief description of the initiative objective is provided and a link to its website is also offered for further information and details. A categorisation of the innovation system (technology, regulation or markets) in which the initiatives have a larger impact is illustrated in Figure 4.

The list compiled in Appendix C reflects various ongoing endeavours in the region. However, this report does not intend to analyse all initiatives currently developed in LAC. Rather, the sample is analysed to underline that international and inter-sectorial cooperation are central to the individual initiatives through the joint efforts of the actors. Research and innovation centres and cooperators in the region are currently undertaking numerous additional initiatives, projects and programmes, which are not included in the inventory in Appendix C.

Figure 4: Compilation of innovation initiatives according to whether they are oriented to impact mainly on technology, regulation or markets.



- Innovation and Research of Renewable Energy Technologies
- Promoting Renewable Energy Generation in South America (REGSA)
- Low Carbon Communities of the Americas (LCCA): Dominica Wind Project
- Clean Energy ESB
- Proethanol2G
- Research for Development of Low-temperature Geothermal Energy
- Utilization of Coffee Biomass for Production of Biofuel and Generation of Electricity
- Analysis of a Wind Farm Behaviour Operating Under Extreme Wind Conditions
- Y-TEC Marine Energy, Laboratory of Hydrogen and Renewable Energy
  - Renewable Energy in Rural Markets
  - Development of Short-term Forecast Tools for Wind Electricity Generation
  - Solar PV Energy: Technological and Technical Aspects and Perspectives for Development in Uruguay
- Ibero-American Programme of Innovation
- Fostering EU-Caribbean Research and Innovation Networks
- EuropeanUnion - Latin America Joint Initiative for Research and Innovation (JIRI)
- Ibero-AmericanProgrammefor Science, Technology and Development (CYTED)
- IDEAS: Energy Innovation Contest
- Regional Initiative on Innovation for Development of Technologies for Generation of Renewable Energy and Energy Efficiency
- Energy Innovation Center
- Yachai: The City of Knowledge
- Latin American Renewable Energy Journal (LARE)
- Sectorial Fund of Energy

From the cases collected in the inventory, it is observed that technological research projects were the most accessible and numerous in this sample. The research undertaken to create the inventory revealed that governmental centres and academia are the most active sectors in the establishment of cooperation initiatives focused on RET innovation. Naturally, governmental centres and IGOs mainly drive the sample initiatives that focus on promoting policies to promote innovation. When the focus is on promoting technological research, the sample of initiatives collected shows that the most cooperative sectors are mainly governmental centres and offices and academia. When it comes to promoting initiatives to build human capacity and access to infrastructure and financing mechanisms, not only governmental institutions but also NGOs are active cooperators. Although the private sector counts on a significant representation in the inventory, it is not the leader in this category, nor in initiatives compiled on technological research. In addition, a tendency observed from the inventory is that public money and cooperative financial aid fund more initiatives than private capital.

At a technological level, projects related to research on wind technology as well as biomass and bioenergy end products are the technologies most represented in the inventory. In the sample of initiatives collected, hydro and geothermal technologies are the least researched.

The inventory represents intense efforts to research new technologies, enable appropriate frameworks, and support human capacity building and access to infrastructure and funds to develop innovative RET solutions. However, gaps in innovation and research exist. The following section reveals the results of the methodology application and identifies concrete obstacles.

6 IDENTIFIED GAPS AND AREAS FOR IMPROVING THE STATUS OF INNOVATION IN L.A.C.

The analysis of cooperative RD&D activities in the LAC region points to a number of gaps that hinder the development of RET. This analysis is based on the questionnaires and interviews conducted with cooperators, researchers and other innovation stakeholders active in the field of RET in the region. The analysis is also complemented by the observation of RD&D and innovation indicators compiled and evaluated in Appendix D. The following paragraphs in this section describe the findings. A principal observation to be made is that the gaps found in RD&D activities are closely related to challenges in other aspects of the innovation system.

The gaps described in the following paragraphs are not necessarily applicable to all the countries in the LAC region, given the regional heterogeneity in terms of economic development, energy endowment and institutional capacities. However, the identified gaps have been compiled in this section to later design general recommendations to diminish these gaps through cooperation. Policy makers can identify country specific barriers and recommendations through the RETIP guidelines, previously mentioned in section 2 of this report.

6.1 Building Human and Financial Capacity

The analysis identified a number of gaps related to various forms of resources. A key finding of the analysis is that the lack of various forms of competencies does in fact constitute a greater and more fundamental barrier than the lack of financial means. While this does not imply that access to financial means is unproblematic, it was nevertheless emphasised less in the interviews than lack of competencies.

Leadership and Experience in Management and Coordination of Inter-regional Cooperation

A majority of the experts interviewed highlighted insufficient leadership and experience in management and coordination of international and inter-regional RET cooperation as a more marked and prominent barrier than a lack of funds. International, inter-regional and inter-sectorial coordination is tedious due to complex bureaucracy and the long periods required to reach agreements among parties. Cooperation at these levels usually involves many actors, which means a diversity of motivations and interests. Thus, coordinating this cooperation becomes a highly complex task. As cooperative RET innovation projects are becoming more important in LAC, the lack of expert assistance in the management of such innovation centres becomes increasingly problematic. Innovation and research not only require professionals with specialised technical and technological backgrounds, but also managers with leadership experience in RET innovation projects. This includes issues such as allocation of budget, programme design, and management of material and labour resources. Thus, creating technical development infrastructure provides limited returns if it is not managed appropriately.

Agreements on Schemes to Commonly Fund RE Innovation Projects within the Region

Language and intercultural barriers constitute significant challenges for knowledge development in cooperation programmes. Insufficient intercultural understanding can hinder the establishment of strong relationships, trust and risk sharing among cooperators. In some instances, this has led to the failure of initiatives with partners outside the LAC region due to a lack of understanding among parties in the financing schemes of cooperation. Thus, mistrust concerning financial cooperation in RET projects among countries within the LAC region following from differences in the contributions provided by the different countries and the difficulties to agree on schemes for commonly funding projects in a particular country, limits the degree of financial cooperation in the LAC region.

Innovation in Educational Programs

A further central issue concerning the lack of competencies is that innovation generally receives insufficient attention in educational programmes at universities. While many students have interests in innovation, these interests are not stimulated at universities. Providing students with a technological background covering the analysis and design of sustainable energy innovation systems is not always given high priority, and in fact is completely absent in a number of universities. A related issue is that professors at LAC universities have insufficient access to the academic methods, subjects and masters programmes taught at leading universities in the field of innovation. This, however, requires funds to support, for example, stays of LAC professors in leading non-LAC universities – and also highlights the close relation between human and financial resources.

Developing Competencies – The Role of Academic Networks

A type of cooperation intensifying regional efforts towards developing professional and expert competencies is the university consortium. Together with universities from other regions, there are a number of small networks established by LAC universities, which currently carry out promising collaborations and projects to encourage research activities and programmes and to establish a robust foundation for innovation in their curricula. The International Network on Energy and Environmental Sustainability (INEES) and Promoting Renewable Electricity Generation in South America (REGSA) are examples of these networks.

INEES is an international multidisciplinary network of universities in Bangladesh, the Caribbean, Colombia, Ghana and Germany that seeks to develop effective means in university education to support the achievement of environmental sustainability, both in developing and industrialised countries (Universität Flensburg, 2013).

University staff and students of different backgrounds interact in this network. It aims at building up capacities in the field of sustainable energy, strengthening bi- and multilateral partnerships and raising awareness for development problems and intercultural understanding. This network goes one step further than the knowledge transfer from professors to students and also seeks the enhancement of qualifications of university staff in all subjects related to sustainable energy.

This network is currently working to give innovation a more relevant role in its curriculum. It does this by including masters courses on sustainable energy innovation, implementation and entrepreneurship. The University of the West Indies, together with Universität Flensburg and the Deutscher Akademischer Austausch Dienst (German Academic Exchange Service) are making efforts to train professionals who can import knowledge on innovation systems into the Caribbean region.

REGSA is also constituted by universities, in this case from Germany, Brazil, Bolivia and Chile. REGSA “aims at contributing to an increase of the renewable energy share of the electrical power generation in Bolivia, Brazil and Chile” (REGSA, 2014).

Among other objectives, REGSA member universities contribute to develop competencies by raising awareness and supporting the regional dialogue through pilot projects in rural communities. Through this commitment, REGSA “supports the wider application of RE by fostering labour-market oriented research and teaching approaches at Latin American universities in the RE sector” (REGSA, 2014).

Noteworthy analysis of innovation systems and research on sustainable energy are expected because of the efforts put into stimulating the interest of upcoming generations in innovation and guiding the direction of current researchers and innovators. With time, this could turn LAC universities into a principal hub for research in RETs.

Geographical Concentration of Technological Competencies

The issue of geographical concentration of technological competencies within the LAC region is another important issue. Although programmes to develop professional capacities and educate researchers exist at a national level, these are centralised in few locations. Consequently, there is a low level of concrete involvement at the local level. Empowering isolated and rural communities with basic knowledge on issues such as the maintenance and functioning of installed RETs is lacking.

Physical Infrastructure and Upscaling of Technologies

While the lack of human competencies constitutes perhaps the most significant gap, limited financial resources also pose an important barrier. Several interviewees reported that funds granted through cooperative frameworks and governmental institutions in the region are usually insufficient to develop new technologies or carry out innovative initiatives. A number of interviewees from different countries identified the lack of physical infrastructure, *i.e.* research machinery, tools and software, as an important barrier to the development of projects. There is an incipient need to acquire equipment and technology that enables further technological development. In a number of cases, significant investments were made in research projects without providing budgets covering the acquisition of research tools and software such as wind test tunnels, geothermal resources prospection/extraction tools or energy planning and simulation software. As discussed in section 6.4, lack of financial resources in the region may also impede patenting as well as make upscaling of technologies unaffordable. Limited financial resources also make access to expertise unaffordable for many SMEs.

6.2 Strategic Focus for RD&D Efforts

Consideration of Locally Available Natural Resources

Several gaps relate to the direction of research, which is insufficiently clear in a number of cases, thus hampering technological development. A key hurdle is a lack of consideration of locally available natural resources,

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which may provide competitive advantages in technological development within specific fields. Technological development efforts are mainly targeting the adaptation of mature technologies and applied research concerning the most developed RETs. However, less attention is given to basic research and technological development of emerging RETs – such as ocean or geothermal-based technologies – even though some countries have high potentials of these resources. Governments often do not facilitate thorough evaluations of the strengths of countries in harnessing these resources and the opportunities for their exploitation are often lacking. The absence of regulatory and policy frameworks for RET RD&D hampers the exploitation of such resources.

Dissemination of Roadmaps in the Direction of Development

A second important gap is that there are generally no roadmaps or other kinds of information (*e.g.* newslet-

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ters, tracked trends, panels) on the development directions that innovators can follow in order to guide their projects, taking into consideration the global efforts in RET innovation. Currently, some LAC countries are pushing for the establishment of new research centres to stimulate RET research; however, there is a risk that the research done in these centres will remain isolated from the activities taking place in other regions.

Short-term Vision

There is a lack of a shared long-term vision among key stakeholders for many RETs in several countries. As a result there is often insufficient consideration of the long-term character of most technology RD&D within RET, where commercialisation processes may take up to 10-15 years or even longer. This should be taken into account by investors and other stakeholders when evaluating RET RD&D. This issue becomes even more challenging in countries where political situations are subject to rapid changes. Innovators, researchers and entrepreneurs have to deal with the uncertainty concerning the direction of future policy landscapes.

There was a general perception across the interviews that there is no continuity in these policies and therefore no continuous support for individual technologies in the LAC region. Thus, researchers and innovators have to cope with non-existent long-term financing and policies and continuous gaps of uncertainty. This is evident for instance in the case of funding for academic research, where a lack of funds and consistent policy frameworks make it difficult to attract professionals in the field of innovation. Similarly, researchers in academia lack individual incentives for engaging in innovative efforts. This makes it difficult to attract researchers to academia and to incentivise those working in academia to engage in the innovation processes.

Coordination of RD&D Activities

Limited coordination of RD&D activities is a further challenge that follows from the general lack of roadmaps. Exemplifying this, renewable resource maps are a highly prioritised innovation task due to the lack of information available for research centres. A number of institutions are currently working on creating these maps, an activity which consumes significant amounts of resources. In some cases, however, institutions are not aware of similar tasks undertaken by other actors for the same geographical areas, resulting in unnecessary replication.

Separated Contexts of Research and Cooperation

A further gap to cooperative RET development is that public procurement (see section 3.2) tends to be designed in the context of either research or cooperation. However, few tendering processes integrate both research and cooperation with an aim of fostering RD&D cooperation. Thus, the consortiums of institutions applying for these opportunities require a specialised team in cooperation or in research in order to be competitive and considered in public tenders. Although multidisciplinary partnerships in research and cooperation are required to successfully develop and implement new technologies, the tenders frequently dismiss research institutions that present project proposals with cooperation organisations such as NGOs. Similarly, the opposite situation occurs, when calls for proposals are presented in the field of cooperation. Thus, there is a lack of alignment between current public procurement schemes and the general requirements of RD&D projects.

6.3 Visibility and Recognition of Innovation Needs

Visibility of Some Actors and Initiatives

While participation in networks and cooperation programmes generally increases the visibility of participating actors, an important barrier is the absence of visibility of some actors and initiatives to decision makers. This implies that policy makers do not consider some important benefits of RETs. For instance, lack of access to opinion leaders implies that there is little awareness around the relevance of RET as a tool to empower communities. Although energy access and poverty is a priority among policy makers, RETs are not necessarily stimulated according to their potential in the region. Closely related to the previous point is the insufficient recognition of successful RD&D activities. This contributes to the creation of an apathetic atmosphere around innovation, in addition to a lack of diffusion of good practices and successful case studies, as well as difficulties concerning the attraction of further investments.

Community Participation and Bottom-up Initiatives – The Role of NGOs

Various NGOs are carrying out remarkable efforts to involve local governments and civil communities in the decision making process and implementation of RET solutions (ELLA, 2011). In regions such as Cajamarca (Peru), the presence of NGOs is widespread and among other roles, they are acting as recipients for social needs, catalysers of communication with local authorities and enablers of combining research and action into action-research initiatives. Because of these roles, invisible players get a voice and different bottom-up initiatives have existed for longer periods of time than expected.

Some examples of institutions currently working along these lines are CEDECAP (Centro de Demostración y Capacitación en Tecnologías Apropiadas) and Soluciones Practicas. CEDECAP is a training centre with the mission of strengthening "capacities in the use of appropriate technologies to promote sustainable rural development" and spreading "renewable energies as an alternative for development in rural areas" (CEDECAP, 2014). Similarly, Soluciones Practicas is an organization of technical and international cooperation. Its mission lies in using technology to challenge poverty in order to build up the capacity of poor people, improve their access to technical options, and spread awareness of social, economic and institutional systems for technological innovation (Soluciones Practicas, 2013).

Together with universities and other key players, these two institutions work intensively on research of technological solutions to electrify rural areas of the Peruvian Andes, among other regions. In this area, the wind resource has potential to fulfil the energy needs of the communities. In collaboration with different institutions, CEDECAP and Soluciones Practicas have researched wind resource maps in the region, the adaption of low capacity wind generators to the wind velocity conditions at 3,000-4,500 m above sea level, the installation of microgrids in communities, and the assimilation of this technology in the communities. The results obtained from the research and cooperation model have inspired local authorities as well as other institutions in the adoption of measures and definition of projects for the alleviation of energy poverty in the area.

NGOs play a key role in the enhancement of governance and community development approaches. Multi-stakeholder teams and community participation during the planning and development of projects have proved to facilitate the successful implementation of RET solutions.

Horizontal Involvement of Public Sector Actors

A further gap is the general lack of horizontal involvement of public sector actors in RET development. RET research and innovation is linked primarily to energy and education ministries, however, ministries of foreign affairs for example, should also support the topic, focusing on international cooperation. Thus RET research and innovation should be considered not only in energy and education ministries, but also horizontally in other ministries that can support international agreements and dialogue concerning RET RD&D.

Achievements to be Evaluated and Assessed

The creation of legitimacy of RET developed in cooperation projects is hindered by insufficient evaluation of the projects and financial resources for their implementation. Insufficient evaluation of funds and programmes designed to promote research and innovation is widespread. In a number of cases, institutions granted funds were never contacted again to present results, obstacles, challenges, comments or concerns. Consequently there is no learning from experiences and no opportunity to design policies that are more effective. Thorough evalu-

ations of achievements are essential to assess efficiency and effectiveness of measures adopted and grants given and, ultimately, establish legitimacy of such policy tools.

6.4 Knowledge Development and Diffusion

Concerning the development and diffusion of knowledge, a distinction can be made between gaps hindering the technology development in the cooperation programs, and the subsequent diffusion.

Gaps in Technology Development in Cooperation Programmes

Broad and Non-specific Goals

The analysis shows, firstly, that some of the cooperation programmes and frameworks fail because they have very broad and non-specific goals, as well as very general agreements of cooperation and areas of research. Some programmes have neither specific objectives and timelines, nor defined responsibilities or clear methodologies for the cooperation.

Forms of Formal Coordination

Identifying an effective form of formal coordination is an important challenge. In particular, memorandums of understanding (MoU) are often chosen, even though, according to some interviewees, they are not always the most effective form of cooperation. This is especially the case with MoUs involving governmental institutions, where intricate administrative procedures and bureaucratic processes can make such agreements overly rigid. As a result, an MoU can end up as merely a formality, with limited practical value in governing cooperation among institutions. In any case, MoUs are "soft" legal instruments, not intended to embody legal or financial obligations.

Gaps in the Diffusion of Technologies Developed

Support in the Commercialisation Process

A main challenge to the diffusion of technologies developed in the cooperation programmes relates to the duration and scope of some of these. As emphasised in the previous sections of this report, successful diffusion of innovations requires support for the commercialisation process and acceptance of new or transferred technologies in the market (see Glossary of Terms for a definition of *Technology Transfer*). As innovation is an evolving learning process that does not finish with the development of technologies, this requires continuous cooperation. While this highlights the importance of creating durable partnerships and networks, it was observed that the efforts of institutions to diffuse and improve the quality of developed technologies decline once the technologies are developed. In this way, some cooperation programmes are too narrowly focused on developing the technologies, which results in sub-optimal pay-offs from the technologies developed. It is essential to ensure that such initiatives are complemented with activities that create incentives for technology transfer and commercialisation.

Prioritisation of the Research that can be Commercialised

A further challenge to commercialisation identified in a number of interviews is that the basic research carried out in some cooperation projects is difficult to apply to practical solutions. There is a lack of prioritisation of the research that can be commercialised and contribute to satisfying market needs. In many cases, initiatives cannot see their projects translated into tangible prototypes or scaled up technologies, as the projects simply do not consider all the various aspects of the commercialisation process, from basic and applied research to demonstration and market introduction. Thus, there is still a considerable gap to be covered between the knowledge produced by academia and industrial demand, which is important to bridge in the initiation phase of cooperation projects.

This is a particularly important barrier to address in order to complement the current emphasis on technology transfer from developed economies to the region. Although efficient in many cases, some technologies and processes fail when they are transferred from one context to another due to technical, socio-economic and environmental factors. Thus, technology transfer and indigenous technological development are not mechanisms that compete, but rather work together and complement each other.

Dissemination of Information

Poor dissemination of information relating to technological achievements, for example, was identified in various

Enabling Scientific Research and Technological Development – the Brazilian Technological Innovation Act

The Brazilian Act on Technological innovation (Act, No. 10.973/04 of 2 December 2004) established concrete programmes and measures to be adopted for a rapid growth in technological development, especially among SMEs.

The Act covers decisions adopted by the Brazilian government in terms of incentives to encourage public-private partnerships, to raise the participation of academic institutions and research institutions in innovation, and to promote innovation within the private sector. Among other concrete measures, the Law seeks to: i) strengthen cooperation among public research centres and companies; ii) speed up the granting of licences for public institutions; c) negotiate the use of laboratories with SMEs; iv) encourage links among academic institutions and the private sector; v) establish centres of technological innovation to manage different aspects of the created technology, such as property rights; and vi) provide public funds for companies in order to develop scientific research.

The Act has already significantly improved access to knowledge in the country. The success of the Act lies, among other things, in the result of the recognition of the Brazilian scientific and technological context and the definition of specific targets to transform this reality into a solid structure for public research.

In 2010, Brazil's laws were amended to include sustainable development in national public contracts covered by the Act on Public Tenders, No. 8.666/1993, Article 3. Since this amendment, there is a clear and strong boost to "the use of innovations that reduce the pressure on natural resources", such as the use of renewable energy (Bester and Damian, 2012).

Thus, measures of the Technological Innovation Act are applicable for different stakeholders and the main challenges to drive innovation are managed in that direction (WIPO, 2013). **Lessons from this case are the recognition of science and technology as central pillars for economic development and social transformation, and their relevance in the establishment of a legal framework for public-private partnerships in R&D and for access to knowledge and development.**

interviews. Very few institutions have created basic tools to compile such information online, which allows researchers to alert professionals to news concerning technological development. Information is largely decentralised and there is little organisation of information diffusion.

6.5 Promotion of Entrepreneurial Activities

Relevance of Entrepreneurship

One key factor hindering innovation arising from cooperative RET projects is that support to SMEs and entrepreneurship are generally insufficiently considered in the policies of most LAC countries.

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Balance of National and Foreign Companies

While flexibility – which is generally a characteristic of young companies – is currently very important in LAC due to structural changes in the energy mix towards higher participation of RET, concessions for exploitation of renewable energy sources are in some countries often given to foreign companies, partly because of lacking competencies and limited capacity of local companies. It is, however, questionable whether and how this stimulates the development of the local RET sector. Conversely, in other situations, national governmental institutions predominantly carry out exploitation of renewable resources. However, this may lead to a lack of input of professional knowledge from foreign qualified professionals in private industry. Thus, it is rather the exception than the rule that concessions involve both national and foreign companies and allow both access to state-of-the-art knowledge and room for entrepreneurial experimentation. The result is a vicious circle, where the lack of competencies in local companies prevents these competencies from being developed.

6.6 Market Formation for New Technologies

Government Incentives and Financial Support

Market formation is a central gap in the development and diffusion of all RETs, as other studies have also shown. In the LAC region, the manufacturing sector is experiencing difficulties around market formation for specific RETs. Closely connected to the question of legitimacy discussed below, a main issue is the scarcity of government incentives and financial support to allow expansion of RET markets towards critical mass. Even in the case of manufacturing industries that have been very successful in some home markets, further expansion often proves very challenging (see the case below).

Financial incentives for manufacturers, such as the provision of low interest loans, may further serve to

Stimulating Entrepreneurship – the Cases of Corfo and ProChile

Chile is one of the leading countries in supporting the private sector and entrepreneurship in the region. Corfo and ProChile are examples of ongoing initiatives that the Chilean government has put in place to promote and support entrepreneurs and innovators in the private sector.

Corfo is a public sector organisation dedicated to promoting entrepreneurship, innovation and growth in Chile, using tools and instruments compatible with the central framework of a social market economy, and creating the conditions necessary to build a society of opportunity (CORFO, 2013).

Being aware of the difficulties that entrepreneurs face to find niche markets out of Chile and LAC, the government has also set up ProChile. ProChile is "the institution of the Ministry of Foreign Affairs of Chile in charge of promoting exports of products and services. (...) Its economy, support to entrepreneurship, political stability, public security and ideal climatic conditions allow Chile to develop products and services with a unique quality in the region, which added to strict adherence to fair trade practices and sustainability, makes their exports attractive with reliable suppliers and a high level of innovation" (ProChile, 2014).

Chilean experts interviewed considered that these initiatives are actively contributing to stimulating entrepreneurship in the country. However, there is room for potential improvement. Due to the number of new projects and entrepreneurial activities arising from the private sector, the demand for services provided by organisations such as Corfo or ProChile is increasing significantly, and thus there is a need for expanding the offer of such activities.

A Strong National Industry – Solar Water Heaters in Barbados

The solar water heaters (SWH) case in Barbados is an interesting example. Barbados counts on a solid solar water heating market and around 40-50% of the buildings in the country are equipped with locally manufactured SWHs. Government incentives and purchases have strongly contributed to deploying this technology and securing its financial sustainability. This governmental support, together with short payback periods and little financial risk to consumers, are the two main reasons for the success of SWHs. Another reason for this successful technological deployment and market formation is the innovative character of the entrepreneurs, who also had the technical expertise (Husbands, 2012)

There is high potential for market expansion of solar thermal technologies in new applications such as in the food-processing industry, cooling or desalination through solar collectors. However, the manufacturing industry has not diversified these applications to develop the whole industry. Low interest loans or other financial incentives may assist manufacturers in diversifying and growing the SWH industry (UNEP, 2013). In addition, more qualified labour, such as innovators or researchers, would be required in the private sector for manufacturers to diversify their operations into such different and novel applications of the technology.

Barbados has become a leading country in the SWH industry. Key fiscal incentives, purchase programmes and critical expertise to develop marketable products have enabled a strong national industry. This industry has enormous potential to expand towards innovative applications of SWH technology and diffusion to other small island states. This makes Barbados' manufacturing sector a key player in the promotion and deployment of SWHs in the upcoming years.

assist the diversification and growth of industries such as the SWH industry.

Innovative RET Developed in the Region

A second barrier towards market expansion is that most LAC countries are not technology exporters and it is difficult for companies to access funds for market expansion, as banks and financial institutions tend to mistrust technology created in the region. Insufficient political action was observed to diminish the scepticism of financing institutions towards innovative RET developed in LAC. Thus, it is difficult for LAC technology innovators to scale-up operations and access foreign markets.

Agreements on Quality Infrastructure

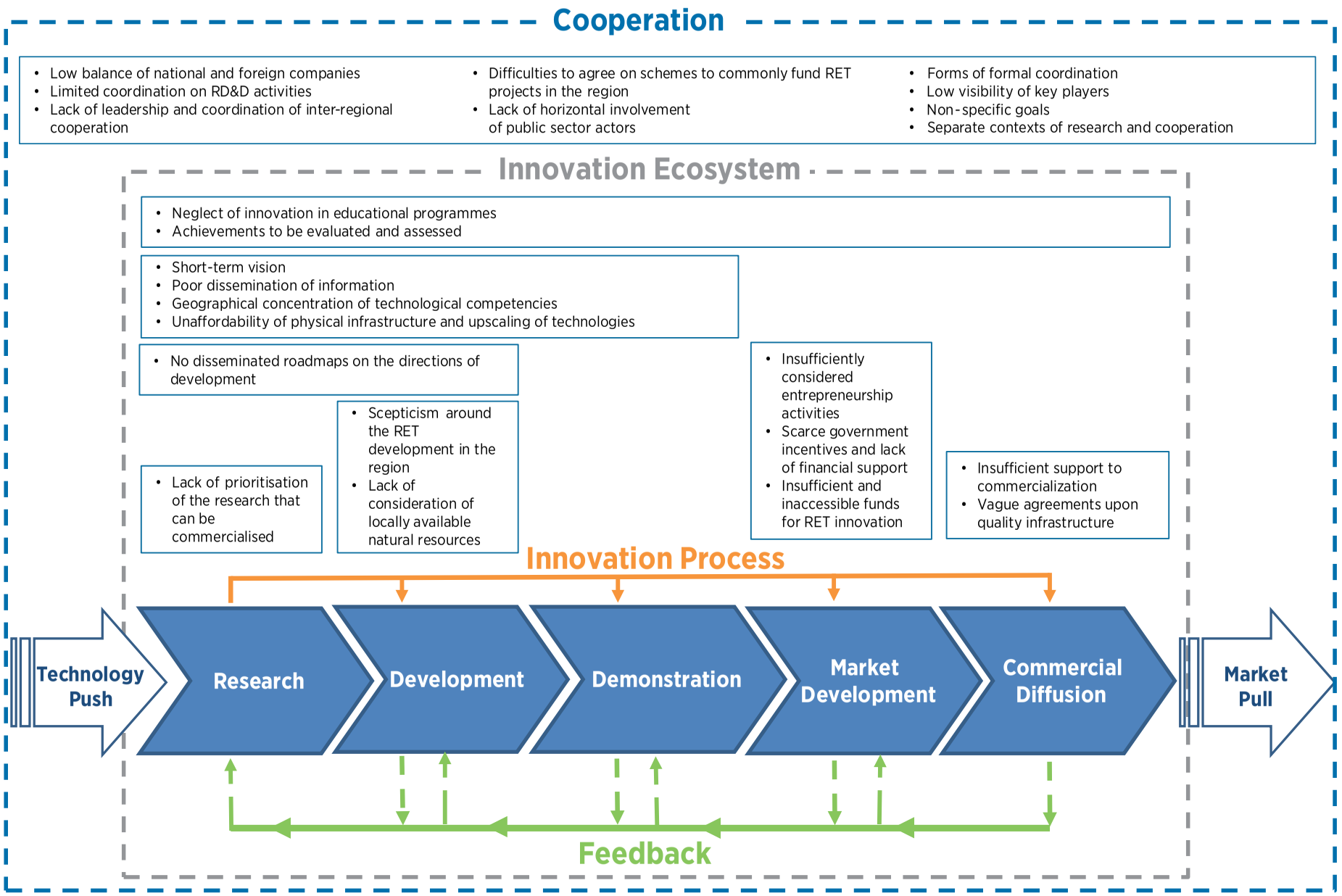
The lack of commonly agreed upon quality standards and certification reinforces the hesitation of financial institutions towards funding expansions of LAC developed technologies (refer to Glossary of Terms for a definition of *quality infrastructure*). The result is that RET manufacturers usually have to take upon themselves the financial and technological risk of market failure. As a result, entrepreneurial and innovative efforts in the manufacturing sector are significantly slowed down. This issue is further aggravated by the lack of long-term vision and policies (see section 6.2).

Funds for RET innovations

Finally, the lack of sufficient entities in the LAC region that finance innovative projects within the field of RET further constrains market formation. Bureaucracy and the rigidity of administrative legal processes to access the insufficient funds available also contribute to limiting the potential for market expansion of the already few technologies developed in LAC.

The gaps found above affect the innovation ecosystem at different stages or relate to the cooperation as a whole. The following map of gaps, illustrated in Figure 5, groups the gaps discussed in this section according to the stage of innovation in which they have highest impact and the gaps found in cooperation.

Figure 5: Map of gaps in innovation stages, innovation ecosystem and cooperation.



7 CLOSING THE GAPS: RECOMMENDATIONS TO REINFORCE INTERNATIONAL AND CROSS-SECTORIAL COOPERATION

This report presents a number of recommendations aimed at improving the status of cooperative efforts existing in the LAC region to promote innovation in RET and suggests some actions to implement these recommendations. Table 1 provides an overview of these recommendations and actions, which are described in detail in the subsequent paragraphs.

These recommendations are addressed to LAC institutions, innovation stakeholders, cooperation agencies and the private sector. Given that every partner has a shared responsibility in cooperation, the following paragraphs are also targeted to cooperators and governments of other regions, especially actors of developed countries and advanced economies seeking cooperation with LAC.

This report does not provide solutions to country-specific problems. However, the suggestions recommend cooperation areas for further exploration on how countries can steer their resources and institutional capacity towards more efficient innovation frameworks.

7.1 Practical Actions with National Scope

The following recommendations suggest actions to close the gaps on RD&D by implementing cooperation amongst actors in the countries and taking a holistic approach to horizontal, vertical and administrative governance.

Link RD&D with other innovation related policy fields

Key barriers identified by the stakeholders interviewed related to entrepreneurism, qualified human resources, efficient mobilisation of financial resources and dissemination of knowledge and expertise (see Appendix A). It

Uruguay's Strategic National Plan of Science, Technology and Innovation

The Uruguayan Strategic National Plan of Science, Technology and Innovation (in Spanish, Plan Estratégico Nacional de Ciencia, Tecnología e Innovación) of 2008 covers three main action areas. First, the design of an institutional Ministerial Cabinet for Innovation (Gabinete Ministerial de la Innovación, GMI) and an office for its operation, the National Agency of Research and Innovation (Agencia Nacional de Investigación e Innovación, ANII). Ministries of cross-cutting innovation related topics including Agriculture, Industry, Energy, Mines, Economy and Finance, Education and Culture constitute the GMI.

The second area of action consisted of reforming legislation concerning public budgeting for innovation, providing incremental financial support to the private sector, strengthening cooperation with the European Union and negotiating loans from multilateral development banks.

Finally, the third action area consisted of the definition of a political strategy based on the identification of priority sectors for innovation. Some of these sectors comprised energy alternatives, environment and natural resources. In this regard, the Strategic National Plan of Science, Technology and Innovation analysed the current energy matrix, resources and demand of Uruguay to make studies for future development according to the main national challenges and the existing capacities in the country. The plan suggests concrete objectives and instruments for RET deployment, as well as opportunities for the country to modify its energy matrix based on the deployment of RET (Brechner et al., 2007).

is essential that the gaps in these areas are addressed when planning national and regional RD&D programmes.

Effective innovation systems require coordinated efforts in the public sector for national plans and objectives aimed at providing clear direction for the future development of RET. This includes facilitating market development for RETs, building required competencies in companies and universities, stimulating entrepreneurship and efficiently mobilising available resources.

Consequently, ministries and national institutions should jointly execute national roadmaps for RET innovation. For example, a cross-cutting governmental body could be instituted to coordinate the main ministerial areas that are related to innovation such as education, environment, economics, transport and agriculture. Such a body would also coordinate ministries with private efforts put on innovation and human resources. A horizontal governance structure in this body would ensure that interests from all aspects related to innovation and the ministries involved are taken into consideration when developing innovation policies and defining RD&D programmes. Thus, national objectives in terms of innovation could be discussed and agreed upon by all parties to ensure that RD&D does not remain an isolated topic in national policy frameworks.

Align national and local governments

As identified in this report, the fact that some LAC countries depend on relevant RET national policy frameworks is an optimistic indicator of the awareness among leading decision makers. However, there is a need to ensure vertical coordination within governments by aligning the whole hierarchy of jurisdictions from federal to local regulatory bodies. By transmitting such awareness through the entire political chain, greater consistency can be achieved in the actions taken in terms of RET RD&D activities. The political leadership and objectives of provincial and city governments can be streamlined, as local authorities are still crucial to the facilitation of these types of activities (*e.g.* in permit concessions for pilot plants, etc.)

Successful implementation requires institutional capacity as much as coordination, and this is stressed when innovative solutions and technologies are implemented. Frequently, implementation in innovation means that successful experiences are not collected and as a result, best practices in implementation are lacking. In such cases, coordination of the different roles and alignment of objectives becomes crucial, both horizontally and vertically.

The vertical dimension of the coordination challenge of innovation policy efforts lies in establishing and coordinating appropriate roles and responsibilities at various levels of government, for example, local, national and supra-national policy bodies (IRENA, 2015a).

Facilitate administration for RD&D

Interviewees highlighted that technological development was significantly slowed due to issues pertaining to administration. In particular, obtaining permits, certificates or other related documentation is currently a lengthy process in cooperative technological development projects. This can lead to discouragement and hinders technological development.

For this reason it is necessary to facilitate clear and simple administrative processes for RET research in order to improve efficiency in processes such as obtaining

São Paulo Research Foundation

The São Paulo Research Foundation (Fundação de Amparo à Pesquisa do Estado de São Paulo, FAPESP), started operations in 1962 and is funded by the State of São Paulo through a levy of 1% of all state tax revenues. In 2012, FAPESP had a budget of US$500m and several thousand staff. FAPESP organises several major projects that reach vertically into federal ministries and horizontally into academia and private industry (IRENA, 2015a).

Table 1: Recommendations aimed at improving the status of cooperative efforts existing in the LAC region to promote innovation in RET and suggested actions to implement the recommendations.

Scope	Recommendation	Practical Action
National	**1. Link RD&D with other innovation related policy fields**	• Ministries and national institutions should jointly execute national roadmaps for RET innovation. • Institute a crosscutting governmental body to coordinate the main ministerial areas related to innovation.
	2. Align national and local governments	• Encourage vertical coordination of innovation policy efforts by establishing and coordinating appropriate roles and responsibilities at various levels of government, for example local and national.
	3. Facilitate administration for RD&D	• Facilitate clear and simple administrative processes for RET research to improve efficiency in processes such as obtaining permits for pilot plant implementations, access to public testing facilities and laboratories or public procurement. • Create sub-offices of qualified administrative services and train them to be specialised in RD&D to expedite and improve the administrative requirements in order to connect government, academia, the private sector, banks, NGOs and IGOs.
	4. Focus RD&D efforts on national macro-objectives	• Elaborate national roadmaps for future RD&D and innovation of RET, building on the needs for RET solutions of each country to guide national research centres, entrepreneurs and the private sector.
	5. Develop skilled management to lead effective cooperation	• Carry out in-house training with experienced managers in innovation. • Elaborate business cases and best practices of RD&D planning. • Define goal-oriented plans and programmes for young and emerging technology centres. • Establish key performance indicators, especially in the managerial layers of innovation initiatives. • Train professionals in intercultural management to establish strong relationships and enhance trust among cooperators. • Participate in extra-regional knowledge exchange programmes and multiply LAC manager experiences in recognised technology centres abroad.
	6. Offer incentives to reward research in RET	• Consider using remuneration as an incentive in the academic environment. • Contribute financially to RD&D and support in assuming new commercialisation methods for the private sector. • Conduct workshops to exchange experiences with other regions or within the private sector on sponsoring and incentivising RD&D. • Explore options for financial cooperation from bilateral aid and public financial cooperation from multilateral organisations. • Emphasize recognition awards.

Scope	Recommendation	Practical Action
National	**7. Identify niche opportunities for innovative RET applications with engagement of the private sector**	• Encourage public-private partnerships to stimulate investments in introduction of RET into novel niches in the market. • Catalyse public procurement to expand the portfolio of RET applications. • Subsidise industry for research of RET adaption to new uses in the industry sector. • Organise programmes to get the national RET manufacturing sector closer to other country and regional experiences.
	8. Involve less visible beneficiaries and consider social needs requiring innovative solutions	• Collaborate with local cooperative aid actors (cooperative aid institutions, think tanks, NGOs and non-profits) and involve them in cooperation schemes (*e.g.* public tenders).
Regional	**9. Intensify regional information exchange for RD&D**	• Create a communication channel to allow research centres to share information and be informed of others' research activities and needs for cooperation (*e.g.* newsletters, open databases or peer reviewed journals).
	10. Streamline technology centres and reinforce networks to encourage cooperation	• Integrate a LAC region-wide network that is responsible for coordinating the activities of technology centres, disseminating financing opportunities and engaging with actors at a supra-regional level. • Encourage dialogue through international research summits.
Supra-regional	**11. Diversify the funding portfolio for RD&D**	• Broaden the spectrum of funding alternatives by exploring new geographical areas and new actors. • Identify potential investors from new regions. • Promote the formation of start-ups and spin-offs by attracting venture capital. • Reinforce financial resource mobilisation through trust funds within the region.
	12. Define a methodology to implement south-south cooperation (SSC)	• Adopt joint agreements on methodologies for SSC and create concrete frameworks for SSC implementation (*e.g.* through Implementing Agreements (see Section 3.2) adapted to SSC instead of triangular cooperation).

Spanish Agency for International Development Cooperation

The Spanish Agency for International Development Cooperation (Agencia Española de Cooperación Internacional para el Desarrollo, AECID) seeks to support the development of institutional capacities of Ibero-American countries, through the 'Iberoamerican Program for Specialized Technical Training'. This programme is dedicated to train human resources of public institutions or developing functions of public interest, reinforce the public administration and promote good practices in public service delivery. The objective of this programme is to create efficient and sustainable national structures within the public sector administration. Through this programme, human resources are able to participate in courses on administration and management in scientific, technical, cultural and educational fields.

As an example, one of the fields in which this training was applied is urban wastewater treatment. In this course, the objectives were the exchange of experiences and analyses of national legislations in this field to build the human resources capacities of public institutions. The results expected were a more adequate training of these human resources to understand the selection and design of wastewater treatments and thereby facilitate their implementation with regard to all the administration to be processed on the public institution side.

Due to its innovativeness and complexity, RD&D is still an intricate matter and public administration requires, in some cases, assistance to deal with all processes related to it. If some RET is not a conventional technology, this tendency is more stressed when applying RD&D to the technology. Thus, similar training on RD&D could be helpful to ease all processes managed in public administration, from basic research to demonstration of first technological pilots, by familiarizing human resources in these institutions with the concepts they deal with daily (AECID, 2014a).

permits for pilot plant implementations, access to public testing facilities and laboratories or public procurements (see section 3.2). For instance, creating sub-offices of qualified administrative services and training them to be specialised in RD&D matters could improve the pace of technological development and contribute to expanding the network of varying institutions that share interests in undertaking RD&D within RETs. Such specific sub-offices could expedite and improve the administrative requirements in order to connect government, academia, the private sector, banks, NGOs and IGOs.

Focus RD&D efforts on national macro-objectives

In order to make reasonable use of policy frameworks, action plans are required at a national level. Policy makers are called to go further in setting an appropriate context for effective RET research activities and to design programmes implementing specific regulations, considering investment opportunities and enabling the necessary changes.

Once the needs for RET solutions are identified, national roadmaps for future deployment of RET should be elaborated, building on the appropriate expertise of professionals within the fields of energy, sustainability, innovation and economic development. These roadmaps would need to serve national research centres, entrepreneurs and the private sector in order to present a clear perspective not only of what is needed, but also of the socio-economic impact arising from the solutions put in place (*e.g.* jobs created or impact on GDP among others).

In this way, national strategies can be carried out depending on their fit with the national RET roadmaps. In turn, this will reflect the competencies and natural resources available in the given territory. Given that the boom for RET deployment is yet to occur in most LAC

REmap 2030

IRENA's Renewable Energy Roadmap (REmap 2030) provides pathways for doubling the share of RE in the global energy mix between 2010 and 2030. The first edition of the comprehensive policy and technology roadmap was based on analysis of the national plans of 26 countries . From the LAC region, the initial analysis included Brazil, Ecuador and Mexico, which represent approximately 60% of the region's total final energy demand (IRENA, 2014). In addition, REmap provides insights into the current situation of RE markets in the power, district heat and end-use (industry, buildings, transport) sectors, national policy proposals to improve the existing policy framework, as well as the socio-economic benefits of doubling the RE share. REmap also suggests opportunities for international cooperation of governments and notions to go beyond the doubling.

The second edition of REmap includes a total of 40 countries representing 80% of the total global energy demand. The largest number of new countries that were added to REmap are from LAC. They include Argentina, Colombia, Dominican Republic and Uruguay, raising the region's coverage to about 75% (IRENA, 2015b).

countries, there is presently an opportunity to develop strategies that efficiently deploy further RET in the region.

The RET roadmaps should also ensure that allocated RD&D funds provide long-term job opportunities and lasting economic development. Therefore, the prioritisation of funds for RET RD&D must be based on objective evaluations that consider the territorial context, the integration of the industry and its alignment with academia from the project initiation. In other words, such roadmaps should prioritise the type of projects that make use of existing financial means, taking into account the contribution of various options to local economic growth and sustainability criteria. In turn, these priorities translate into better living standards of individuals and financial sustainability of communities.

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Develop skilled management to lead effective cooperation

In addition to developing technical knowledge, improving innovation managerial capacities is highly important in leading RD&D planning. The analysis carried

ENTSO-E R&D Plan

The European Network of Transmission System Operators for Electricity (ENTSO-E) defined a R&D plan in 2010. This plan does not just define priority research fields in line with the European Union Strategic Energy Technology plans, but also ensures cross-functional coordination over all transmission system operator (TSO) topics of research and defines TSOs' R&D projects covering system design and operation, as well as optimisation and market facilitation. If needed, ENTSO-E will promote common R&D actions and participate in pan-European R&D initiatives. ENTSO-E takes into account the vision of the EU energy policy targets and it takes on the cross-functional role of coordination within the TSOs' business: electricity markets, transmission grid development, asset implementation and management (ENTSO-E, 2010).

out in this report shows that a lack of various forms of competencies in the LAC region is sometimes a central barrier to profiting from RD&D efforts. This occurs especially within the field of RET, given that some of these technologies are currently the focus of large scale deployment plans in various sub-regions of LAC, as well as in other regions of the world. Hence, experience in maturing RD&D managerial skills is still lacking in the field of RET. For example, the cases analysed highlight that actors are generally very motivated to cooperate with partners in other countries and regions. However, in practice, cooperation is sometimes a difficult process due to insufficient intercultural management and coordination competencies.

It is thus necessary for governments to support their innovation project managers to enhance their experience in RD&D management by enabling LAC manager experiences in technology centres with proven and successful RD&D planning and/or carrying out in-house training with experienced managers in this field. Some other actions that could be taken in this regard include the elaboration of business cases and best practices of RD&D planning, definition of goal-oriented plans and programmes for young and emerging technology centres, and the establishment of key performance indicators, especially in the managerial layers of innovation initiatives.

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Training professionals in intercultural management is important to establish strong relationships and enhance trust among cooperators. RD&D management training allows local excellence in the leadership and coordination of innovation planning. Such training could be intensified, for example, by increasing the participation of LAC researchers and managers of RD&D plans in extra-regional knowledge exchange programmes. Exchange programmes would allow these professionals to import managerial skills into the numerous young institutions

Training Future RD&D Professionals

Several higher education institutions are aware of the relevance of training future professionals on how RD&D activities and programmes can be optimally organised or how experts can professionally evolve from research technical positions to innovation managerial ones. Other institutions offer training on specific RD&D related policies on, for example, commercialisation or intellectual property rights. Complementing these, there are institutions that reflect the importance of training and specialising technical professionals in international and development cooperation by providing grants for sharing international experiences and increased cooperation.

Many of these institutions have already included in their curriculum courses, frequently led by multidisciplinary professionals, the opportunity to teach experts to identify how RD&D activities can be incorporated into wider innovation processes and frameworks and to align them with business and cooperation strategies. The competititve advantage of these courses is that RD&D managers get a holistic approach to innovation, which encompasses not only technical research, but also the key topics (*e.g.* technology clusters, entrepreneurship, technology-based business creation, fund management, etc.).

Apart from a number of private universities, such institutions include, for example, the American Society of Mechanical Engineers (ASME, 2014), the Organisation of American States (OAS, 2014) and AECID (BOE, 2014).

of the LAC region, which are now only beginning to practice RD&D of RET.

Governments can support national institutions in their countries by identifying academic and non-academic partners outside the region, who may assist in the further development of technical as well as managerial competencies in the LAC region. This would allow LAC researchers and innovation managers to familiarise themselves with other successful RD&D planning and organisational techniques. This should not be understood as a replication exercise of RD&D programming, but as an exchange of best practices on how to efficiently lead innovation programmes.

Offer incentives to reward research in RET

The investigation done on the academic environment revealed that a lack of incentives to undertake innovation inhibited researchers from executing further and more developed research activities. Evidently, there is a need to create conducive incentive structures to allow academia and private sector actors to commit to RET innovation.

This report found that within the LAC some universities did provide incentives to professors and staff who, in addition to teaching, were obliged to allocate a minimum number of hours to conducting research and subsequently presenting the results. Such a system is proven to yield more innovative results and further encourages professionals engaged in this task. This is attributed not only to the bonus in remuneration, but also to the recognition of research as a curricular activity. When using remuneration as an incentive, remuneration should be based on criteria according to the economic, social and environmental benefits that the findings add to technological development, and not just on the number of publications that individual researchers or teams reach. Proportional compensation should also be considered for award according to the quality of findings to ensure that the most competitive research is rewarded, thus encouraging better research quality.

This analysis also found that frequently no regulations exist in the national education normative that encourage the adoption of such remuneration systems in a national context. Thus, suggestions similar to those in the preceding paragraphs could be recommended at a national level.

When looking at the case of the private sector, this investigation found that governments could motivate this sector to undertake or intensify innovation activities in the field of RET by financially contributing to this research and development and supporting the private sector to assume new commercialisation methods. The effect of this would be significant as governments can diminish the high risk that research and innovation entails for the private sector, particularly for SMEs.

In LAC, cases do exist where the government has put in place obligations for the private sector to commit to innovation (see section 6.4 on 'Enabling Scientific Research and Technological Development – the Brazilian Technological Innovation Act'). However, the probability for such cases to succeed largely depends on the specific national context and therefore cannot be extrapolated or recommended to all countries in the region.

Furthermore, because the needs and financial resources of the different emerging economies in LAC vary, financial measures cannot be applied in every context due to other existing needs of higher priority. In such instances, options for financial cooperation from countries' bilateral aid committed to education and research can be further explored. A matter of bilateral discussion with the donor country could involve the reimbursement of funds when benefits are generated from the technological development, adaption or the new business methods applied. Financial support to incentivise innovation can also be sought from public cooperation and from multilateral institutions.

When rewarding innovation and financial cooperation is not an option (because of lack of resources, critical priorities of a different nature to RET research or a lack of public and private financial cooperation), an alternative is to emphasise recognition awards. Especially when a group of institutions or states well reputed in the field gives recognition awards, such recognition opens paths to researchers in new areas and different institutions or countries. This can stimulate researchers to increase their activities and performance in innovation.

Identify niche opportunities for innovative RET application with engagement of the private sector

In light of regulation changes, it is strongly recommended to conduct collaborative research activities

with a flexible approach. Investing in the introduction of a technology into novel niches in the market can be a way to adapt to a landscape of continuous modification in regulation.

Further, seeking new applications of the technology can also facilitate the commercialisation of RET. Often, the exploration of such niches requires an exchange of ideas between actors from different industrial backgrounds. Thus, a strong collaboration with academia, upstream and downstream partners, among others, is required to identify such opportunities.

For RET manufacturing, there is a high potential to find new niches in hybrid technologies (*e.g.* conventional thermoelectrical processes with solar thermal technology) and upgraded materials (*e.g.* absorbers and adsorbers of solar irradiation for large buildings or concentrator materials for solar thermal technologies). Private firms and research centres are encouraged to boost the collaboration among specialised actors to initiate basic research and further develop these technological fields as well as others of high potential. Such collaboration is essential to fulfil the potential that hybrid technologies, upgraded materials and other breakthroughs may bring to the RET industry.

Y-TEC – A Public-private Partnership

Y-TEC is a firm founded in 2012 as a result of the partnership between the National Council for Scientific and Technical Research of Argentina, CONICET (Consejo Nacional de Investigaciones Científicas y Técnicas) and YPF, with the venture of public and private capital. Y-TEC focuses its operations on innovation and development to provide technological solutions to the energy industry. On one hand, CONICET provides Y-TEC with a qualified labour force in the field of energy research and science. CONICET also contributes by making available its infrastructure of technological institutes across the country. On the other hand, YPF's former management team of technological operations are currently members of Y-TEC executive board. Technological equipment and research staff of YPF's Applied Technology Centre, CTA (Centro de Tecnología Aplicada) is at the disposition of Y-TEC.

One of Y-TEC's objectives is to provide technological solutions to the industry and to SMEs in order to optimise their production processes. To achieve this, Y-TEC carries out research, development and innovation projects in different energy domains, of which RET is one. Y-TEC's organisational structure enables the investment of efforts in the research of niche opportunities in clean technology markets, such as lithium batteries for electrical mobility, upgraded anticorrosive materials for marine technologies and advanced redox flow batteries for large-scale energy storage (Y-TEC, 2014).

Novel RET Applications in Mining

Heat for industrial applications is a niche opportunity to diversify the portfolio of solar energy technology uses. For example, process heat is intensively required in the mining industry. Conventional methods of process heat production rely on diesel fuel typically burnt as heat supply. Solar process heat has the potential to substitute diesel fuel used in this process, while at the same time substantially diminishing the release of CO_2 into the atmosphere. When the business models put in place to finance the plants are sensitive, solar process heat plants can reduce the cost of mining operations (MiningPress, 2014). Thus, innovation is required in the business model, but also in the solar technology that can operate in the mining industry.

Often, mining operations are developed in desert surroundings, under harsh weather conditions that expose technology to swirling winds, dust, hail, heat, extreme temperature variations, earthquakes and lack of water resources. This means that innovation is required to upgrade solar technologies to absorb diffused and direct radiation, recycle panels worn down due to dust and corrosive environments and reach a robust installation that can resist strong winds, earthquakes and weather inclemency. Maintenance also has to be considered, for example in order to develop cleaning methods requiring minimum amounts of water. Apart from these challenges, mines are usually located far from cities, a fact that complicates logistics. Furthermore, any procedures require strict security and safety standards.

In 2011, the Chilean National Copper Corporation, (CODELCO, Corporación Nacional del Cobre), which is the main copper producer of the world (Sunmark and Energia Llaima, 2014) and controls around 10% of the world reserves, called for proposals in a public tender to develop the Pampa Elvira Solar project. This project consisted of the world's largest thermal solar plant to supply solar process heat to mining operations. A Chilean-Danish consortium of private companies, (Energia Llaima and Sunmark with participation of 55% and 45%, respectively) realised the project by developing simple, robust and proven technology that best fit the mining conditions – a fixed structure, high and proven resistance, cost-effective and a long lasting technology.

The feasibility and success of the project is based not only around the technological innovation, but also on the novel business model adopted to finance the plant. Purchase and sale of heat is at a fixed tariff, which allows CODELCO to plan the cost of energy in the long term and avoid fuel price fluctuations. In addition, CODELCO pays only for the energy used in the process. The heat supplier runs ownership, design, construction, operation, maintenance, and Pampa Elvira Solar takes care of the operation and risks. The thermal power purchase agreement is based on a minimum monthly amount of solar energy delivered. The plant counts on heaters for back-up.

This is an example that illustrates one of the various niche opportunities for RET, and industry and private sector can benefit by further exploring such niches. As the case illustrates, stimulating innovation in business models and RET applications is essential to attain such results.

Collaborative efforts are currently underway in national centres and firms for some of the areas mentioned. At a national level, governments are called on to reinforce such efforts by motivating and supporting research within the manufacturing sector through cooperation schemes such as public-private partnerships or public procurement (see section 3.2).

This analysis also perceived reluctance among the private sector to explore new uses of RET, probably due to the novel nature of these technologies and the high risk of applying them in new sectors. Cases and models exist that diminish such risk and there is room for LAC innovators to find applications and partners of interest in the region.

Involve less visible beneficiaries and consider social needs requiring innovative solutions

The community in which the pilot or prototype is hosted plays a key role in perpetuating the use of the technological solution, including both maintenance and scale-up. Thus to foster community acceptance and assimilation of technological solutions, relevance should be given to the user's needs for innovation as well as the actors that bridge the divide between technocrats, project developers and users. Such actors tend to be cooperative aid institutions, think tanks, NGOs and non-profits that should be more involved in cooperation schemes (*e.g.* public procurement). It is recommended to collaborate with these local actors as they possess the knowledge of the community's technological needs and can thus assist technocrats and developers not only to define, implement and test innovative solutions, but also to enable their assimilation.

Local actors can also provide significant experience that can be key in spreading awareness of RET benefits, training communities in using and maintaining technologies, as well as mediating between technology developers, local authorities and the community.

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As mentioned in the preceding paragraphs, local actors could be involved in the planning, implementation and

Argentinian Association for Electrical and Alternative Vehicles

The Asociación Argentina de Vehículos Eléctricos y Alternativos (Argentinian Association for Electrical and Alternative Vehicles) is a not-for-profit association constituted in 2012 by scientists, technologists, professionals and supporters of electrical vehicles in Argentina. The statutes of this association include a social objective covering the promotion of development, as well as the social and market adoption of sustainable transportation or mobility service alternatives to fossil fuel based vehicles. This association seeks this promotion by facilitating the interaction of stakeholders, reinforcing synergies among the main actors and carrying out strategies to establish a legal, economic, technological and ethical framework to fulfil its objectives.

Keeping a social perspective in the coexistence of this network is essential to make electric vehicles adoptable by users and closer to societies. This also applies to other technologies whose level of readiness is high enough to be deployed, but needs to overcome the second 'valley of death', *i.e.* the step between demonstration and market penetration. Appropriation of technologies by users is key to enable their commercialisation. Thus, associations, networks and information hubs play a key role in spreading the benefits of adopting these technologies. This is of special importance for locked-in technologies, such as electrical vehicles. Despite their technological maturity for certain uses, the possibilities of electrical vehicles to escape the lock-in of liquid fuel-based cars are still limited (IRENA, 2014).

In addition to more generous R&D investments in electrical vehicles to address key technical challenges (*e.g.* more limited range and lower maximum speeds than conventional cars, lack of infrastructure), increasing the awareness of consumers of a more environmentally friendly means of transport is key to accelerating the commercialisation of this technology. Associations of stakeholders, think tanks and not-for-profit organisations are relevant agents to spread awareness to users and consumers and keep the social perspective and benefits of adopting this innovative technology (AAVEA, 2014).

assimilation of pilot projects by giving them more visibility in cooperation schemes, such as public procurement (see section 3.2). Public procurement catalyses the implementation of pilot projects and the scale-up of prototypes. Thus, regulatory authorities and granting institutions need to modify their evaluation criteria of proposals received in response to public tenders and other grants given for cooperation schemes. These adjustments should reflect the importance of partnerships in technological solutions achieved with local cooperative aid actors, especially when the implementation of novel technologies and scale-up of prototypes depends largely on the acceptance of or training of communities and end users.

Rural Electrification in LAC

About 10 million people in LAC use biomass for cooking and a large group of countries depend largely on the burning of firewood and charcoal to meet the energy needs of the residential sector (OLADE, 2014). This practice has resulted in severe environmental and health problems that concern some subregions in LAC. Various governments and regional organisations in LAC have already launched programmes to apply pilot projects, which introduce efficient technologies that can be adapted to local circumstances. Besides being a technological issue, substituting traditional firewood stoves also entails financial and cultural challenges.

Financially, governments must develop incentive schemes to encourage the residential sector to substitute conventional stoves for equipment that is more efficient or tender projects to implement other technological solutions when possible, such as district heating. In such cases, public procurement could speed up the transition towards a more efficient use of biomass, but it is possible that there is still a reluctance to accept alternatives to traditional cooking stoves. Culturally, these stoves are used for environmental conditioning, water heating, industry and primarily cooking. Thus, the substitution of the stoves is interlinked with gastronomy; and hence, with the cultural heritage of some communities (OLADE, 2010). OLADE pointed out the necessity of approaching this issue by engaging diverse civil society actors and governmental institutions, so that improved living conditions of poor families are ensured. Therefore, cooperative aid institutions will be helpful to spread awareness of the needs of the domestic sector to be part of this transition.

Mini-grids are another technology being quickly spread in rural areas of many regions. Isolated areas of the Andean region, for example, present a suitable profile to integrate this solution and various organisations have worked and currently continue working on rural electrification. Due to the cost effectiveness of smart mini- and microgrids in certain contexts, the application of this innovative technology in isolated communities is becoming more widespread, where the population needs to be trained on how to use such infrastructure and sometimes, how to maintain it themselves. Again, capacity building is key for these technologies to be successful and scaled-up, and frequently NGOs or aid organisations can carry out this task. Public tenders for rural electrification will be more successful when these organisations are visible and considered in consortia with the technology developers.

7.2 Practical Actions with Regional Scope

The following recommendations suggest actions to close the gaps on RD&D at a regional level by joining efforts amongst countries through exchange of information and networking.

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Intensify regional information exchange for RD&D

The interviews and questionnaires revealed that several issues identified could be addressed by closing the gap in communication in RD&D efforts currently underway. For instance, in the last decade recent changes in the national energy matrixes of countries in LAC have resulted in the proliferation of RET specialised technology centres. In many cases, these centres are simultaneously researching the same technological solutions, given that similar geographical areas present analogous energy challenges. If these centres exchanged information this could lead to a more cost-effective and time efficient evolution of technologies in terms of development, adaption or commercialisation. Similarly, duplication of research topics could also be avoided in this way.

There is evidently a need for such technology centres to create a communication channel to allow them to be informed of the research activities conducted in the different centres from other countries as well as their needs for cooperation. This communication can be enabled, for example, via a newsletter or a peer-reviewed journal that focuses on the RD&D endeavours carried out within the field of RET in the LAC region. These channels have a strong potential to disseminate the professional dedication to this technological field of many experts in the region, attract a skilled labour force and investments and make information more easily and efficiently accessible.

Streamline technology centres and reinforce networks to encourage cooperation

There is a need to create networks to improve coordination between relevant actors in the region. Networks and knowledge hubs (see Section 3.2) can catalyse RD&D by enabling actors to share knowledge, information and resources. Such networks can also increase the visibility of actors and RET RD&D initiatives towards policy makers, and thereby enhance the legitimacy of these activities.

Multiple interviewees underlined the necessity of integrating a LAC region-wide network that is responsible for coordinating the activities of technology centres across the region, disseminating financing opportunities and engaging with actors at a supra-regional level. Some of the functions of such a region-wide network could include enabling an open database on ongoing RD&D projects and actors dedicated to RET within LAC or from abroad, and facilitating the identification of future potential partners. In addition, such a database

Latin American Renewable Energy Journal

LARE, the Latin American Renewable Energy Journal, is a pioneer communication channel to provide experts with a platform for dissemination of research findings about renewable energy, locally and internationally. LARE aims at accelerating the use and integration of RET in all energy applications (buildings, transportation, electricity generation, and industrial applications) by mobilising knowledge through interdisciplinary and peer-review articles, which will be published in English with abstracts in Spanish and Portuguese. The journal relies on an editorial board of internationally recognised experts from institutions such as York University and the Advanced Energy Centre at the MaRS Discovery District in Canada, and the Universidade de São Paulo, Brazil, among others (Etcheverry, J., personal communication, 1 July 2014).

Latin America, Caribbean and European Union Network on Research and Innovation

The Latin America, Caribbean and European Union Network on Research and Innovation, ALCUE NET, has the objective of establishing a bi-regional platform by bringing together the main stakeholders involved in research, innovation, funding and implementation within the private and public sectors as well as civil society. ALCUE NET supports dialogue on policy on innovation, science and technology between LAC and the European Union by implementing the Joint Initiative for Research and Innovation (EU-LAC JIRI). In order to attain such implementation, ALCUE NET contributes to the definition of and support for strategic agendas for R&D and innovation between 2013 and 2017 in four specific areas, among which energy, and specifically renewable energy, is included. The network also fosters cooperation and ensures the effectiveness of the instruments put in place to enable such cooperation (ALCUE NET, 2014).

could maintain updated information on financial opportunities for RET RD&D, as well as the latest news in this field.

Another alternative to promoting networking among technology centres is an international research summit where LAC researchers and other stakeholders in RET innovation processes such as financing institutions, entrepreneurs and policy makers disseminate their initiatives and reinforce the dialogue. This would allow professionals and experts within the various RET fields to inform each other of recent discoveries and new opportunities.

7.3 Practical Actions with Supra-regional Scope

The following recommendations suggest actions to close the gaps on RD&D at a supra-regional level by intensifying technical and financial cooperation with other regions.

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Diversify the funding portfolio for RD&D

The analysis of RET cooperation projects revealed that the financial resources invested in RD&D in LAC are insufficient. Furthermore, this lack of financial sustainability for cooperation systems has become a central barrier to innovation. This exposes a need to broaden the spectrum of funding alternatives by exploring new geographical areas as well as new actors through innovative mechanisms. The following are recommendations in this regard.

Bilateral financial aid at a supra-regional level:

Cooperative funds injected into the region, mostly from Europe and North America, are significant for RET development and research activities. However, with the economic growth of LAC in the last few years, new investment opportunities with new actors and geographical areas have arisen.

Research for this report has found few instances of collaboration involving other regions. Governmental institutions, research centres and NGOs in the LAC region need to identify potential investors and contributors where the cooperation with LAC has not been traditionally intensive, for example with the Middle East region. This could contribute to reinforcing dialogue with new investors, and simultaneously help to slow down the financial dependency on the usual partner countries. This recommendation also addresses investors from other regions that have not typically cooperated closely with LAC. For them, the current lack of synergies with LAC is an opportunity to initiate or expand their investment portfolio in other areas.

Venture capital:

Start-up businesses are highly important to bringing discoveries to the commercialisation phase. However, it is well known that start-ups have a high risk associated with their operations, and thus venture capital is key to developing and commercialising new technologies or business models. Venture capital opens a wide range of possibilities in the field of RET. Cooperation among the private sector is required to design industrial programmes and business schemes that can attract angel investors and other suppliers of venture capital.

Governments can also play a role in supporting start-up businesses in the identification of angel investors and the attraction of venture capital. For example, governments can allocate public funds to advance research projects in which high investment costs and risks make it difficult for private companies and entrepreneurs to take on. Documented experiences have shown that the technological achievements reached spur investments from the private sector and angel investors. This enables awardees of the funds and developers of the projects to start businesses and spin-off companies.

It has been observed that projects awarded with public funds tend to have higher probabilities of technological success and thus of return of investment in the long term – but are not necessarily the most innovative. Thus, the challenge remains in finding the balance between the innovative character of projects funded and the probability of achieving technological findings.

Trust funds:

Section 6.1 discussed the need to reinforce communication and trust for technical and financial cooperation between countries within LAC. The reluctance of countries to mobilise financial resources from one country to another can be mitigated through the formation of trust funds to develop technological solutions of common interest for a sub-region or for various countries. Grantors can contribute to technological developments and scale-up of projects of shared interest among two or more countries in LAC, while ensuring that the trustee institution will guarantee that the funds are utilised for the selected projects.

Trust funds can enable the technological development of projects in the demonstration phase, which end-users otherwise might not be able to afford. These technological solutions typically have a social character with a low return on investment, for example electrification in isolated areas or lighting of rural communities. Depending on the context of the project, investing in scaling-up such solutions could be unprofitable for the private sector. Therefore, trust funds can bring together the resources of countries with the same difficulties. Trustees in this case should ensure that the solutions are applied in all grantor countries.

Advanced Research Projects Agency-Energy

The Advanced Research Projects Agency-Energy (ARPA-E) was officially authorised in 2007 by the Congress of United States of America to credit scientific and technological innovations through advanced research projects of transformational energy technology. US$400 million was allocated to ARPA-E in 2009, which has served to fund 360 projects of this nature. Some of these projects already point at early indicators of success such as, for example, a near-isothermal compressed air energy storage system. Such projects have already attracted millions of dollars of private capital and enabled the project developers to constitute spin-off and start-up businesses while further engaging with the private sector to continue the technological development of the breakthroughs (ARPA-E, 2014).

Define a methodology to implement south-south cooperation (SSC)

SSC (see Glossary of Terms) represents a valuable instrument for cooperation among developing economies with different income levels[1], enabling experiences, knowledge and solutions from countries that have successfully overcome the same challenges to be exchanged. In most cases, this means that the experiences, knowledge and solutions received are more

1 The World Bank classifies countries per income level in low-income economies, lower-middle-income economies, upper-middle-income economies and high-middle income economies (World Bank, 2014).

easily applicable and adaptable to the context of lower-income economies (AECID, 2014b). Typically, the objectives of this cooperation are not only based on the exchange of experiences, knowledge, solutions and best practices, but also on technology and human and economic resources (RACI, 2012).

Particularly for middle-income economies, SSC provides a more adequate tool than traditional financial and technical cooperation to horizontally cooperate with lower-income economies. This bilateral cooperation also allows middle-income economies an active role in cooperation given their position: not eligible to receive development aid, but also not considered to be advanced economies.

SSC is of special interest for LAC given that it is a very diverse and heterogeneous continent in terms of technological development and innovation. In this context, SSC is a helpful tool given that it takes advantage of the synergy and multiple points in common among countries in the region, such as history or language and sometimes, similar challenges to be overcome. In this case, exchanging the solutions and innovations that foster technological progress in some countries eases the approach to challenges in others. Considering that technological innovation and solutions cannot be extrapolated from country to country, SSC can provide guidance to receiver countries in the optimisation of their specific resources to attain similar results. An example of a concrete framework for development of an SSC project could be the adaption of Implementing Agreements (see section 3.2) to the specific conditions of the SSC.

Middle-income economies in LAC are strongly recommended to carry out SSC also with other regions. For example, some of these countries have a vast experience and innovation background in RET that can be of interest for multiple countries in Africa, such as hydropower or bioenergy. Thus, through this type of bilateral aid many more initiatives of RET adaption in the African context could be established. This would contribute to assisting African partners in designing their own path towards technological solutions to meet energy challenges by having an outlook of lessons learnt along the same path in LAC. In regions like Sub-Saharan Africa where 585 million people lack access to electricity (IEA, 2011), SSC in RET RD&D can significantly contribute to accelerating technological progress or innovation in funding mechanisms to mobilise the required resources for such progress.

According to the Ibero-American General Secretariat (Secretaría Nacional Iberoamericana, SEGIB), 90% of the SSC projects in LAC in 2012 were executed by Brazil, Mexico, Argentina, Chile and Colombia (with significant differences among these providers) (SEGIB, 2014). The sectorial analysis of bilateral horizontal SSC revealed that institutional strengthening is one of the most relevant needs among the main recipients (Ecuador, El Salvador, Bolivia, Paraguay and Guatemala). Energy related SSC is included in this category. Given the evident needs from LAC countries in cooperating in this field, it is strongly recommended to increase the participation of RET in the bilateral horizontal SSC carried out in the region.

Despite all the advantages, SSC also presents drawbacks, mainly due to the lack of common methodologies to ease the joint management of projects and to national interests, which should be aligned for both state parties taking part in the cooperation. Thus, it is highly recommended to establish a pre-defined framework for SSC before its implementation.

Strengthening SSC within countries in LAC, as well as with other regions is a burgeoning need. It is recommended that countries act to adopt joint agreement methodologies to create concrete frameworks for the development of SSC. Practically, a supra-regional entity could coordinate this cooperation and the drafting of a mandate, vision, objectives and rules of participation. This entity should ensure that the interests of all countries involved are reflected in the framework, resulting in, for example, Implementing Agreements (see Section 3.2) for SSC adapted to SSC instead of triangular cooperation.

The above areas for reinforcement of the efforts invested on RD&D and innovation seek to address the main gaps found in the innovation landscape of LAC. These areas are illustrated in Figure 6. Cooperation links and harmonises these efforts and therefore multiplies the impact in specific or multiple phases across the innovation ecosystem. The actions/measures described above are further illustrated in Figure 7, according to the main phase in which they have the potential to positively influence the innovation ecosystem.

Argentine South-South and Triangular Cooperation Fund

Argentina has carried out joint technical cooperation projects over a period of 20 years through the Argentine South-South and Triangular Cooperation Fund, FO-AR (Fondo Argentino de Cooperación Sur-Sur y Triangular). This fund implements mechanisms of association, collaboration and mutual support in three main areas: administration and governance, human rights and sustainable development (FO-AR, 2014). FO-AR's main objectives are the establishment of partnerships, strengthening of mechanisms to promote exchange of knowledge, technologies and best practices, and development of tools to streamline technical assistance and optimise human and financial resources.

The means to attain these objectives are mainly the assistance of Argentine experts in foreign institutions, the training of foreign experts in Argentine institutions and the organisation of seminars. FO-AR currently funds SSC projects with other countries in South and Central America and the Caribbean, as well as Asia, Oceania and Africa. In the latter region, for example, FO-AR has begun an SSC with Botswana to strengthen SMEs, transfer knowledge in the specific industrial field of leather, and encourage entrepreneurial actions in these fields and in the capacities of local public officials. In addition to SSC, FO-AR also participates in projects of Triangular Cooperation with several partners, United Nations divisions and high-income countries, such as Japan.

To conclude, many of the above recommendations could significantly improve the status of cooperative efforts existing in the region to promote innovation in RET. Although these recommendations do not require major financial investments, they are key to complementing existing initiatives in RD&D. Coordinating RD&D with policy efforts aimed at facilitating market development for RETs, building required competencies in companies and universities, increasing the legitimacy of RETs, stimulating entrepreneurship within the field of RETs, and providing a clear direction for the future development of these technologies, will not only yield higher productivity in RD&D but also substantially improve the impact of research in society.

Figure 6: Map of areas for potential improvement to reinforce cooperation and close the gaps in the innovation ecosystem of LAC.

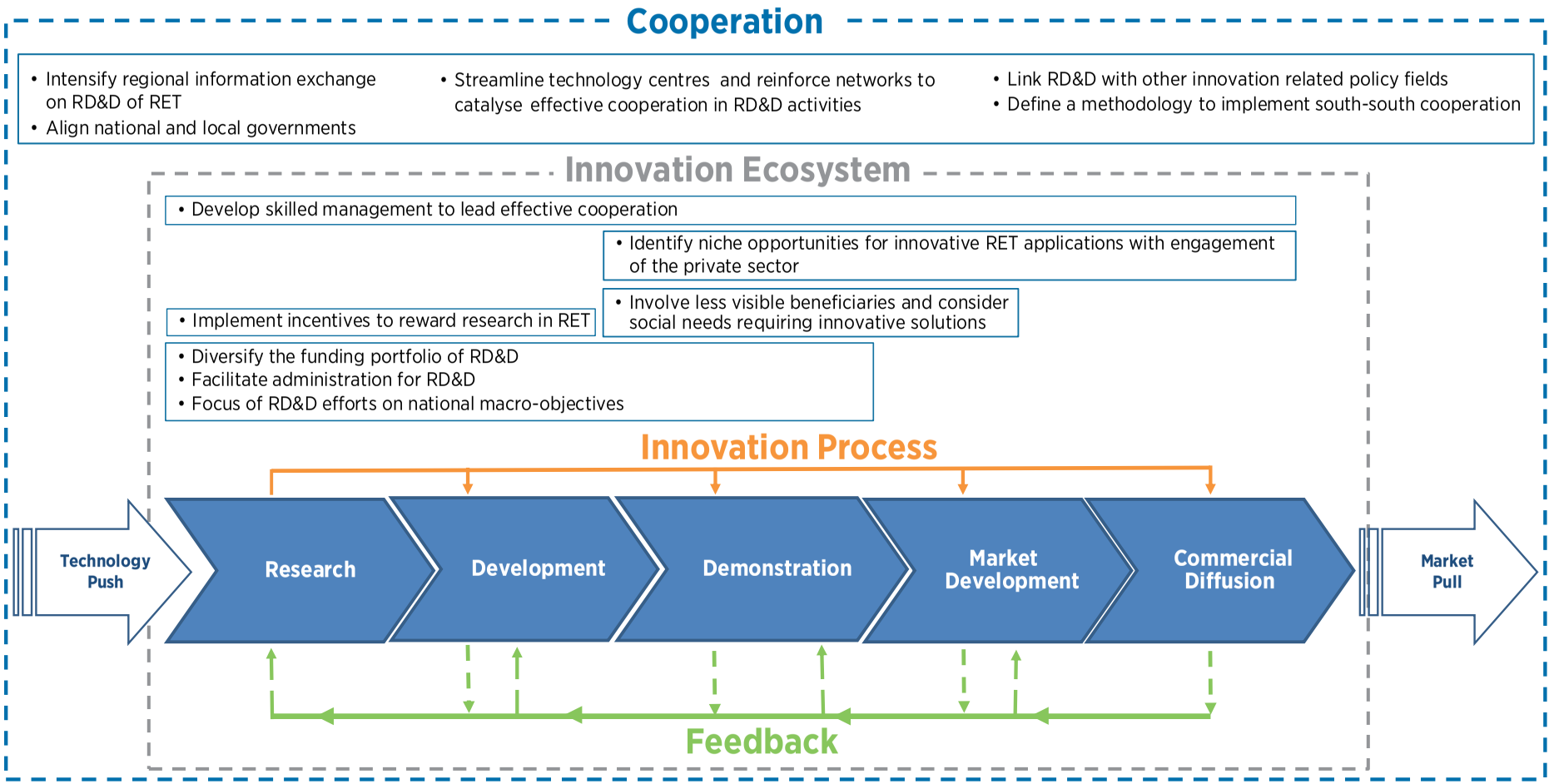
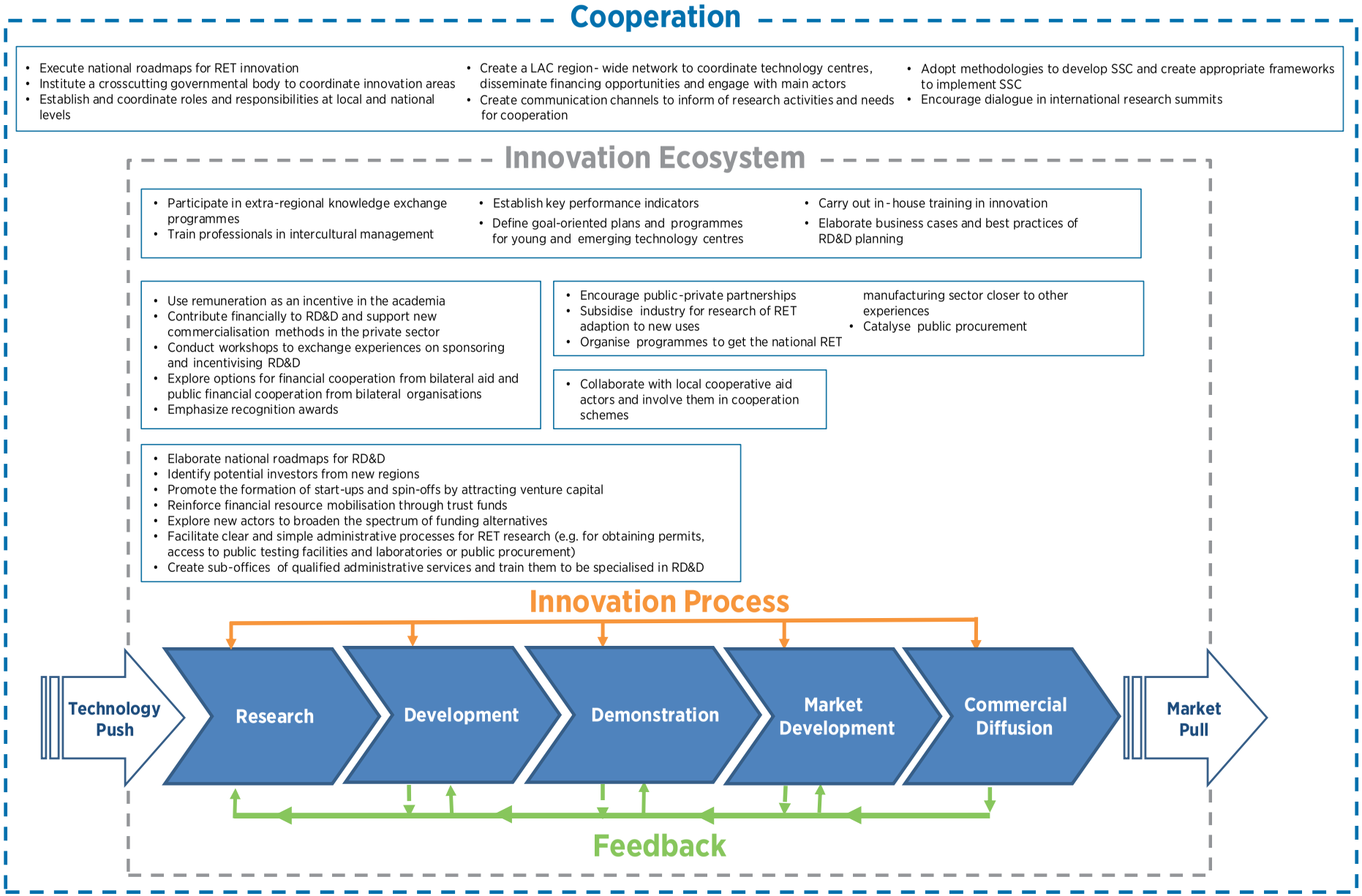


Figure 7: Map of practical measures to reinforce cooperation and close the gaps in the innovation ecosystem of LAC.



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APPENDIX A:

Understanding Innovation: Technological Innovation Systems

Uses of the Term 'Innovation System'

It is important to note that the term 'innovation system' (IS) has come to mean different things for different actors. There are different views on what exactly the 'innovation' focus means. In the original definitions of innovation systems the authors were in agreement that the general purpose of an IS is to develop, diffuse and utilise innovations, that is new products (goods as well as services) and processes (Carlsson and Stankiewicz, 1991, 1995; Galli and Teubal, 1997). The term innovation has always been used to mean a new solution (goods, services and processes) aimed at a group of users, implying that before the new solution has been adopted it is merely an invention, not an innovation. While the different perspectives of the IS literature (regional, national, sectoral, technological) concur in this respect, empirical studies have tended to focus mainly on the development of knowledge relevant for innovation, and more specifically on research and development issues. No doubt these are important aspects of understanding innovation processes, but they are only one part of the analysis. Equally important is the role of the companies, users and financiers in deploying breakthroughs through, for example, new business models, and the role of policy in supporting their adoption by users through, for example, new regulations.

Further, when used in a practical policy context, the term IS sometimes has different interpretations. An example of this is when regional actors see the IS as the 'support system' of for example technology transfer offices, bridging organisations and such actors that aim to help universities commercialise technology, or help (above all) small companies to grow. Another example is when an organisation or initiative aiming to spur the growth of a specific region sees itself not only as a part of the innovation system but in fact, as the innovation system.

The technological innovation systems (TIS) framework (refer to Glossary of Terms) is today considered a state-of-the-art approach for understanding the development of emerging technologies such as the various forms of RETs. It originates from the innovation system framework outlined above but focuses explicitly on innovation in relation to technological fields. This approach has proven very helpful to understand how to stimulate the development of RET (*e.g.* Negro et al., 2008). To do it, key functions in the IS are categorised. These functions consider the central processes that are needed for innovation systems to successfully develop and diffuse new technologies. While there is no comprehensive or complete list of such functions, the following six are arguably of central importance (Hekkert et al., 2007).

Function 1: Knowledge Development and Diffusion

This function is at the core of any development process around RETs. Naturally, RD&D processes are crucial inputs to knowledge development, hence, the focus of this IRENA report.

To quote Lundvall (1992) *"The most fundamental resource in the modern economy and, accordingly, the most important process is learning."* A narrow understanding of an innovation system primarily incorporates scientific and technological knowledge. However, while scientific research, technology and process development within RET are indeed important to generate new knowledge, there are definitely various other kinds of relevant knowledge types, such as market, design and logistics. Thus, the function of 'knowledge development and diffusion' (refer to Glossary of Terms) includes all types of knowledge necessary for innovation in any specific innovation system.

Clearly, with this broad definition of knowledge development, it can come about in a multitude of ways. Naturally, R&D activities of all kinds – be they in companies,

universities or elsewhere – contribute to the creation of new knowledge. One important source of knowledge development is also the interaction between producers and customers taking place in joint development projects, for example between wind turbine producers and developers of wind parks. Indeed, perhaps less discussed in the IS literature but often of significance are the learning processes taking place when products are placed in the open market, such as industry fairs, and met with the reactions of potential customers and media.

According to the open innovation model (refer to Glossary of Terms), those actors that know how to make use of external ideas and knowledge can be successful innovators (Chesbrough, 2003; Laursen and Salter, 2004). Companies that are too internally focused fail to see important opportunities outside their current business or the potential of combining internal knowledge with external knowledge, hence the need for stressing the importance of cooperative initiatives around technological development in renewable energy.

While most organisations are involved in knowledge creation and diffusion, this IRENA report does not focus on the organisations' own RD&D processes, but rather on those carried out in cooperation initiatives. While this function of development and diffusion of knowledge is crucial to the development of RET, other functions are also of importance. These are briefly described below.

Function 2: Market Formation for New Technologies

For any IS to flourish there must be a market that is interested in the innovations produced. This market is likely to be global in character, even though some aspect of it may have national or even regional traits. Swift market formation (refer to Glossary of Terms) is, therefore, often essential to the creation of any new national or regional industry. One may say that there are three distinct phases through which market formation evolves. In 'nursing markets', at a very early phase, a lot of emphasis often lies on user-producer interaction with a small number of early adopters through which learning and improvement takes place. As a result of this, the performance of the new product, process or service makes it ready to increase for a greater number of actors to be involved as users (and thus as providers of feedback) in 'bridging markets'. Finally in 'mass markets' the development potential of the product, process or service has reached saturation and only minor changes in the design can be expected.

In particular, market formation has great relevance for the emergence of new technologies such as forms of renewable energy production. Innovations that build on existing products or processes are likely to be relatively easily accepted, while markets for completely new technologies (*e.g.* wave power or offshore wind) often need to be formed. One form of cooperation which can assist in the creation of new markets is for companies to bundle resources in order to reach attractive global markets which would have remained unattainable for the single company.

Function 3: Human and Financial Capacity

This function refers to the allocation and mobilisation of resources required for organisations to innovate. Such resources can include competence, human capital or financial capital. While most of such resources are secured through the organisation's own strategic moves, the innovation system itself must be well equipped to provide access to the variety of resources. Thereby, organisations may feel the need to engage in collective action, for example to secure human and financial capital. As an example, with regard to mobilising financial capital, thriving innovation systems are often better equipped to attract investments from outside the region.

Function 4: Strategic Focus for RD&D Efforts

The function called 'guidance of search' represents a process of selection to arrive at specific foci for investment. It involves on the one hand the factors that make organisations choose to be part of the industry and the system. In the words of Bergek et al (2008): *"If a TIS is to develop, a whole range of firms and other organisations have to choose to enter it. There must then be sufficient incentives and/or pressures for the organisations to be induced to do so."* On the other hand, the function includes the factors that 'direct' or 'lead' organisations to move in a certain direction. For example, before any specific technology is developed in a company, it first has to be decided which questions and problems are to be addressed and what technological choices to take. Likewise, in entering a new geographical market, deciding on investing in new production facilities requires choices to be made, and the company is not alone in these choices but is

influenced by a set of factors. The same goes for, for example, a university's choice of core profile areas, which may be influenced by the regional industrial needs, governmental allocation of funding or access to researchers. Whatever the situation, the organisation may be 'guided' by a number of factors, including regulatory demands, policy incentives, where venture capitalists place their investments, what the competitors do, what customers demand, social responsibility, the public debate, etc. Some of these factors are relevant independent of location, and some are specific to the nation or region.

Function 5: Promotion of Entrepreneurial Activities

In a dynamic development process, fraught with uncertainties, variety creation is vital. It is through many 'experiments' that alternatives and opportunities are tested, validated and sometimes proven to be long-lived, and at other times discarded. Such variety creation relates to scientific and technological alternatives, but likewise to organisational solutions, market choices, etc. As Bergek et al. (2008) put it, an innovation system *"without vibrant experimentation will stagnate"*. The lack of entrepreneurial experimentation may lead to lock-in to a too narrow set of solutions. Experimentation comes about in many ways: through the sheer existence of many actors trying out different solutions, through brave financiers investing in uncertain applications, or by individuals able to build on diverse sources of knowledge to find new solutions. Variety creation presupposes a milieu where 'failure' is accepted, and where actors keep testing and trying. Entrepreneurship is one important part of such variety creation, in the form of exploring and exploiting new business opportunities.

While entrepreneurship is often associated with the role of the single entrepreneur and new business start-ups, a process perspective to entrepreneurship allows for a broader conceptualisation also opening up for companies diversifying their business for innovative developments . A classic example within RET is Vestas, the leading Danish producer of wind turbines, which initially produced agricultural machinery.

Function 6: Visibility and Recognition of Innovation Needs

Creation of legitimacy (refer to Glossary of Terms) for emerging technologies constitutes an essential dimension of innovation, given that breakthroughs are only meaningful when they are needed by users. Thus, legitimacy and acceptability of innovated technologies is a commitment with users. Although innovation is meaningful when it is addressed to fulfil needs of users, legitimacy is often a neglected dimension of innovation. Bergek et al. (2008) state: *"Legitimacy is a matter of social acceptance and compliance with relevant institutions: the new technology and its proponents need to be considered appropriate and desirable by relevant actors in order for resources to be mobilised, for demand to form and for actors … to acquire political strength."*. To accomplish legitimacy, actors may adhere to dominating rules, standards and accepted behaviour, or by various strategies manipulate these or create new ones. This attention to legitimacy has proven to be very useful in the light of emerging RETs that compete with traditional technologies. For example, Nygaard (2008) has demonstrated the prominence of this dimension for fuel cell and hydrogen technologies, where cooperation between companies and organisations was crucial in establishing legitimacy for the technologies.

Relevance of the TIS framework to RETs

It is argued that technology-specific policies are required to stimulate the transition towards a sustainable society. In this respect, the TIS framework is highly relevant to analyse the areas for specific RETs where intervention is required. Thus, a key contribution of the TIS framework is that it makes a tool for identifying system weaknesses available to policy makers (Jacobsson and Bergek, 2011).

For RET technologies at an early developmental stage (*e.g.* hydrogen for transportation) analyses of the TIS functions will often point to various key weaknesses. In such cases, public policies will have to target improvement within the various structural elements simultaneously, based on a thorough analysis of the individual innovation system's functions. For more mature RET technologies (*e.g.* onshore wind energy) the TIS framework can be used to fine-tune policies and ensure that they develop with the requirements of important actors within the field.

APPENDIX B:

Methodology for Data Collection and Analysis of Gaps in Cooperative RD&D

The methodology described in this appendix is designed to collect data about cooperative RD&D initiatives (programmes, projects, activities, etc.) and to allow a swift identification of the main gaps in cooperation to be bridged for these initiatives. The methodology draws on a series of interviews and questionnaires conducted with key players in the field for qualitative data collection and gap identification. Subsequently, this data is analysed in section 6 according to the TIS framework explained in appendix A. This methodology is based on a review of scientific literature on this field (GTZ, 2010; ICCEPT and E4tech Consulting, 2003). The outline of this methodology is provided in the paragraphs that follow.

Step 1 – Identification of the objective for innovation

This step consists of determining the objective of innovation in the specific initiative that is studied.

Step 2 – Analysis of key players and stakeholders

This second step identifies and categorises the key players and stakeholders in the initiatives. A classification of the players is done based on five main categories: IGOs, governmental organisations, NGOs, private enterprises and academia. The financial power and expertise as well as political position are analysed to identify the key players.

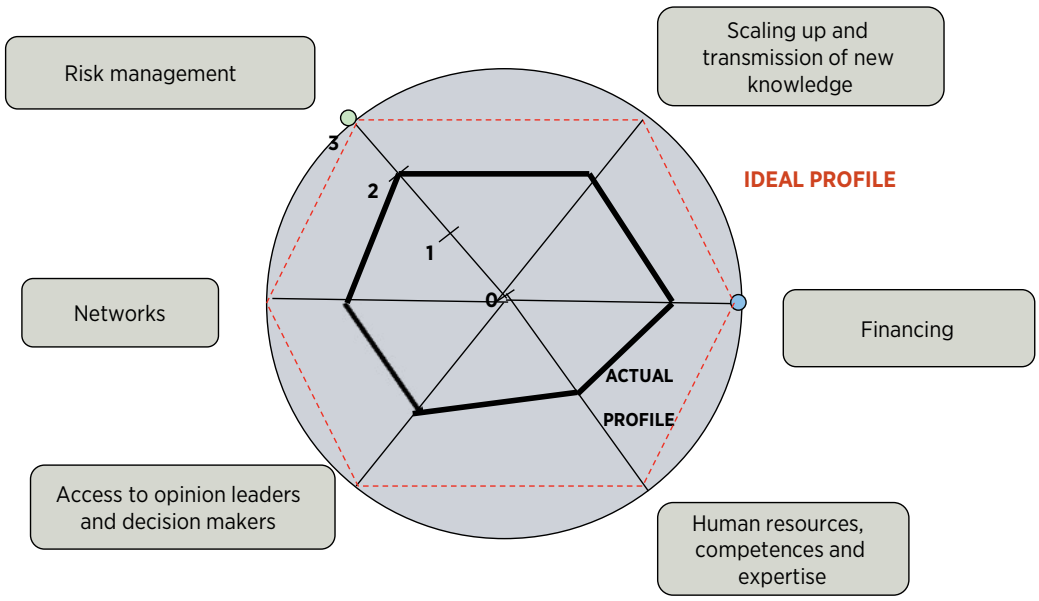
Step 3 – Identification of drivers

A third step follows by identifying the key drivers for cooperation. In this study, driver refers to different motivations for parties to cooperate.

Step 4 – Collection of information of innovation functions and cooperative aspects

In this step, key players are interviewed and asked to fill in surveys[2]. For an organised collection of data, the

Figure 8: Performance profile of the cooperation system



Source: Adapted from GTZ, 2010.

2 For further information about the surveys and questionnaires, please contact IRENA Secretariat: secretariat@irena.org

information collected in interviews and questionnaires is categorised depending on whether it relates to: (i) scaling up and transmission of new knowledge, (ii) financing, (iii) human resources, competencies and expertise, (iv) access to opinion leaders and decision makers, (v) networks, or (vi) risk management.

In addition, by answering closed yes/no questions in the surveys, the key players quantify how cooperation contributes to the reinforcement of each category of information. By quantifying through closed yes/no questions, the methodology ensures that the responses to the answers are equally understood by all the interviewees.

The responses provided by key players are depicted in the operative profile of cooperation represented in Figure 8. By showing the differences from the real profile with the optimal one, this step of the methodology reveals the relevance of the different barriers to innovation.

Step 5 – Analysis of barriers

The next step in the methodology analyses the empirical findings acquired from the key actors through the analytical TIS framework (see section 6).

The analytical TIS framework complements this methodology by, firstly, relating these empirical findings to previous literature carried out on drivers and barriers to cooperative RD&D initiatives of RET and, thus, provides wider validity to these findings. Secondly, the TIS framework helps to identify connections between the different drivers and barriers.

Step 6 – Recommendations and reinforcement of incentives

The next step of the methodology offers policy makers recommendations that seek to reinforce cooperation and overcome the detected barriers (see section 7).

Step 7 – Tracking the progress of cooperation

An additional round of interviews is conducted to assess the success of the cooperation and the fulfilment of innovation objectives. These interviews take place after a determined time, which depends on each initiative analysed, and discuss whether: (i) the objectives or drivers have changed; (ii) there are new key players or key players that are no longer taking an important role in the cooperation arena and the reasons for these changes; (iii) the quantification and identification of key factors have evolved and how it affected the profile of the cooperation system; (iv) the barriers must be reanalysed; and (v) new recommendations are required.

Depending on the results obtained from tracking the changes, the methodology will be applied again to reinforce long-term relationships and cooperation.

APPENDIX C:

Inventory of Institutions and Initiatives Aimed at Fostering Market or Technological Innovation in Latin America and the Caribbean

Table 2: List of institutions

Identified Key Players in the Inventory			Territories
1	CONACYT	National Council for Science and Technology	Mexico
2	MINCYT	National Ministry of Science, Technology and Productive Innovation	Argentina
3	MINEC	Ministry of Economy	El Salvador
4	SENACYT	National Secretariat for Science, Technology, and Innovation	Panama
5	CONACYT	National Council for Science and Technology	Paraguay
6	ANII	National Research and Innovation Agency	Uruguay
7	CONCYTEC	National Council for Science, Technology and Technological Innovation	Peru
8	FONTAR	Argentine Technological Fund	Argentina
9	ADI	Innovation Agency	Portugal
10	CONICYT	Nicaraguan Council for Science and Technology	Nicaragua
11	CDTI	Centre for Industrial Technology Development	Spain
12	FINEP	Study and Projects Financing Agency	Brazil
13	VcyT	Vice-Ministry for Science and Technology	Bolivia
14	APRE	Agency for the Promotion of European Research	
15	MENON		
16	UAB	Autonomous University of Barcelona	Spain
17	UWI	University of West Indies	Multiple
18	UAG	University of Antilles Guyane	Multiple
19	UNIBE	Iberoamerican University	Dominican Republic
20	UNA	University of the Netherlands Antilles	Curaçao
21	CIRAD	International Cooperation Center of Agricultural Research for Development	France
22	RVO	Netherlands Enterprise Agency	Netherlands
23	CARICOM	Caribbean Community	Multiple
24	ITCR	Technological Institute of Costa Rica	Costa Rica
25	MINEDU	Ministry of Education	Bolivia
26	CNPq	National Council for Scientific and Technological Development	Brazil
27	CONICYT	National Commission for Scientific and Technological Research	Chile
28	MIEM	Ministry of Industry, Energy and Mines	Uruguay
29	MINECO	Ministry of Economy and Competitiveness	Spain
30	CEA	Atomic Energy and Alternative Energy Commission	France
31	EC	European Commission	Multiple

Identified Key Players in the Inventory			Territories
32	RedCLARA	Latin American Cooperation of Advanced Networks	
33	Colciencias	Department of Science, Technology and Innovation	Colombia
34	MICIT	Ministry of Science and Technology	Costa Rica
35	CITMA	Ministry of Science, Technology and Environment	Cuba
36	SENESCYT	National Secretariat for Higher Education, Science, Technology and Innovation	Ecuador
37	CONACYT	National Council for Science and Technology	El Salvador
38	AECID	Spanish Agency for International Development Cooperation	Spain
39	CONCYT	National Council for Science and Technology	Guatemala
40	SEPLAN	Technical Secretariat of Planning and External Cooperation	Honduras
41	INTN	National Institute of Technology, Standardization and Metrology	Paraguay
42	FCT	Foundation for Science and Technology	Portugal
43	MESCyT	Ministry of Higher Education, Science and Technology	Dominican Republic
44	DICYT	Department of Innovation, Science and Technology for Development	Uruguay
45	MCTI	Ministry of People's Power for Science, Technology and Intermediate Industries	Venezuela
46	MINCEX	Ministry of Trade and Foreign Investment	Cuba
47	IDB	Inter-American Development Bank	Multiple
48	CEPAL	United Nations Economic Commission for Latin America and the Caribbean	Multiple
49	CAB	Andrés Bello Convention	Multiple
50	OEI	Organisation of Ibero-American States	Multiple
51	UNESCO	United Nations Educational, Scientific and Cultural Organization	Multiple
52	OAS	Organization of American States	Multiple
53	IAEA	International Atomic Energy Agency	Multiple
54	GBIF	Global Biodiversity Information Facility	Multiple
55	CAF	Development Bank of Latin America	Multiple
56	KPK	Partnership Korea Fund for Technology Knowledge and Innovation	South Korea
57	NDF	Nordic Development Fund	Multiple
58	MIF	Multilateral Investment Fund	Multiple
59	GDF Suez		
60	DOE	United States Department of Energy	United States
61	JICA	Japan International Cooperation Agency	Japan
62	MKE	Ministry of Knowledge Economy of Korea	South Korea
63	ECPA	Energy and Climate Partnership of the Americas	Multiple
64	INER	National Institute of Energy Efficiency and Renewable Energy	Ecuador
65	INIAP	National Institute of Agricultural Research	Ecuador
66	INIGEMM	National Institute of Geological, Mining and Metallurgical Research	Ecuador
67	INPC	National Institute of Cultural Heritage	Ecuador
68	INAMHI	National Meteorology and Hydrology Institute	Ecuador

Identified Key Players in the Inventory			Territories
69	INAE	Ecuadorian Institute of the Antartic	Ecuador
70	INBIO	National Biodiversity Institute	Ecuador
71	INSPI	National Institute of Public Health and Research	Ecuador
72	IEE	Ecuadorian Space Institute	Ecuador
73	IGM	Military Geographic Institute	Ecuador
74	IIE	Electrical Research Institute	Mexico
75	UNT	National University of Tucumán	Argentina
76	MaRS	Advanced Energy Centre at the MaRS Discovery District	Canada
77	UT	Tarapacá University	Chile
78	YU	York University	Canada
79	USP	University of São Paulo	Brazil
80	UAM	Autonomous University	Mexico
81	ITC	Canary Islands Technology Institute	Spain
82	EGADE	EGADE Business School at Instituto Tecnológico de Monte-rrey	Mexico
83	HAW	Hamburg University of Applied Sciences	Germany
84	Uchile	University of Chile	Chile
85	UCB	Bolivian Catholic University	Bolivia
86	UNISUL	University of Southern Santa Catarina	Brazil
87	DTU	Technical University of Denmark	Denmark
88	ULUND	Lund University	Sweden
89	UGENT	Ghent University	Belgium
90	EPFL	Federal Institute of Technology of Lausanne	Switzerland
91	UFRJ	Rio de Janeiro Federal University	Brazil
92	UFPE	Pernambuco Federal University	Brazil
93	UFSC	Federal University of Santa Catarina	Brazil
94	UFMG	Federal University of Minas Gerais	Brazil
95	FURB	Blumenau Regional University	Brazil
96	IVIG	International Virtual Institute of Global Change	Brazil
97	LNEG	National Laboratory of Energy and Geology	Portugal
98	CIEMAT	Energy, Environmental and Technological Research Center	Spain
99	INT	National Technology Institute	Brazil
100	Inbicon		
101	Fraunhofer		
102	GreenValue		
103	Holm Christensen Biosystemer ApS		
104	BIOMM		
105	KL Energy		
106	GCD	Government of the Commonwealth of Dominica	Dominica
107	USDA	United States Department of Agriculture	United States
108	Cenicafe	National Coffee Research Centre	Colombia
109	UCV	Pontifical Catholic University of Valparaiso	Chile
110	Clean Energy S.A.		
111	SES	Senior Experts Service	Germany

Identified Key Players in the Inventory			Territories
112	Iceland GeoSurvey		Iceland
113	CIRCE	Information Centre and Business Creation Network	Spain
114	SP	Soluciones Prácticas	
115	CEDECAP	Demonstration and Training Center for Appropriate Technologies	Peru
116	UNI	National Engineering University	Peru
117	UPC	Polytechnic University of Catalonia	Spain
118	UPRG	Pedro Ruiz Gallo National University	Peru
119	DGIS	Directorate General for International Cooperation	Netherlands
120	CONICET	National Council for Scientific and Technical Research	Argentina
121	YPF		
122	UTNRSC	National Technological University, Santa Cruz Regional Faculty	Argentina
123	INVAP		
124	UdelaR	University of the Republic	Uruguay
125	UTE	National Administration of Power Stations and Electric Transmissions	Uruguay
126	ADME	Electricity Market Management	Uruguay
127	URSEA	Energy and Water Services Regulatory Agency	Uruguay
128	ANCAP	Fuels, Alcohol and Portland National Administration	Uruguay
129	SE	National Secretariat of Energy	Argentina
130	SAyDS	Secretariat of Environment and Sustainable Development	Argentina
131	STN	National Secretariat of Tourisms	Argentina
132	ME	Ministry of Education	Argentina
133	WB	World Bank	Multiple

Table 3: List of initiatives

No.	Initiative	Key Players (O = observer, C = upon consultation, W = from website, T = translated from website, A = adapted from website)					Link
		NGO	Academia	Governmental Centre	IGO	Private Sector	
Promoting Regulation: Innovation Top-down Approach Programmes and Agreements amongst Regulatory Bodies							
1	Programa Iberoamericano de Innovacion [Ibero-American Program of Innovation (T)]			1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13			http://segib.org/es/node/8269
2	EUCARINET: Fostering EU-Caribbean Research and Innovation Networks	14, 15	16, 17, 18, 19, 20	21, 22	23		http://www.eucarinet.eu/
3	European Union – Latin America Joint Initiative for Research and Innovation (JIRI) – Priority Area: Energy (Working Group on Renewable Energy)		24	1, 2, 25, 26, 27, 10, 7, 28, 29, 30	31		http://ec.europa.eu/research/iscp/index.cfm?lg=en&pg=latin-americ-carib-4
4	CYTED: Ibero-American Programme for Science, Technology and Development	32 (o)		2, 13, 26, 27, 33, 34, 35, 36, 37, 38, 29, 39, 40, 1, 10, 4, 41, 7, 42, 43, 44, 45, 46, 11, 6	47 (o), 48 (o), 49 (o), 50 (o), 51 (o), 52 (o), 53 (o), 54 (o)		http://www.cyted.org/?lang=en
Supporting the Market: Initiatives to Build Human Capacity and Access to Infrastructure and Financing Mechanisms (Calls for Proposals and Funding Schemes)							
5	Regional Initiative on Innovation for Development of Technologies for Generation of Renewable Energy and Energy Efficiency (w: http://www.caf.com/en/currently/news/2012/03/regional-initiative-to-develop-innovative-technologies-in-renewable-energy-sector)				55	Researchers and innovation institutions of LAC (T, A)	http://eventos.caf.com/patentes/iniciativa-regional
6	IDEAS: Energy Innovation Contest			56	47, 57, 58	59	http://www.iadb.org/en/topics/energy/ideas/ideas,3808.html
7	Energy Innovation Center			60, 61, 62	63, 47		http://www.ecpamericas.org/Initiatives/default.aspx?id=27
8	Yachay: The City of Knowledge (T)			64, 65, 66, 67, 68, 69, 70, 71, 72, 73 (w: http://www.yachay.gob.ec/institutos-de-investigacion-y-desarrollo/)			http://www.yachay.gob.ec/

No.	Initiative	Key Players (O = observer, C = upon consultation, W = from website, T = translated from website, A = adapted from website)					Link
		NGO	Academia	Governmental Centre	IGO	Private Sector	
9	Latin American Renewable Energy Journal (LARE)	74, 75, 76, 77, 78, 79, 80, 81, 82					The goal of the LARE Journal is to advance knowledge about renewable energy locally and internationally to help accelerate the use and integration of RE in all energy applications (...). The LARE Journal will provide a platform for experts and practitioners to disseminate research findings through incisive articles based on an interdisciplinary peer-reviewed approach focused on knowledge mobilization. All articles will be published in English and will include abstracts in Portuguese, Spanish and English English (Etcheverry, J., personal communication, 1 July 2014).
10	Fondo Sectorial de Energía [Sectorial Fund of Energy (T, A)]	Research institutions	Research institutions	6, research institutions		Research institutions	http://www.anii.org.uy/web/node/75
Researching on Technology: Bottom-up Approach Technical Projects							
11	REGSA: Promoting Renewable Energy Generation in South America		83, 84, 85, 86				http://www.regsa-project.eu/en.html
12	Proethanol 2G		87, 88, 89, 90, 91, 92, 93, 94, 95, 96	97, 98, 99		100, 101, 102, 103 , 104, 105	http://www.proethanol2g.org/
13	Low Carbon Communities of the Americas (LCCA): Dominica Wind Project			60, 106	63		http://www.ecpamericas.org/Initiatives/default.aspx?id=33
14	Utilization of Coffee Biomass for Production of Biofuel and Generation of Electricity			107, 108	63, 52		http://www.ecpamericas.org/Initiatives/default.aspx?id=82
15	Clean Energy ESB		109	97		110, 101	http://clean-energy.cl/en/
16	Research for Development of Low-temperature Geothermal Energy (T, A)			64, 111, 112 (w: http://www.iner.gob.ec/relacionamiento-interinstitucional/)			http://www.iner.gob.ec/proyectos/#inicio5
17	Analysis of a Wind Farm Behaviour Operating Under Extreme Wind Conditions (T, A)			64, 113, 111 (w: http://www.iner.gob.ec/relacionamiento-interinstitucional/)			http://www.iner.gob.ec/proyectos/#inicio5

No.	Initiative	Key Players (O = observer, C = upon consultation, W = from website, T = translated from website, A = adapted from website)					Link
		NGO	Academia	Governmental Centre	IGO	Private Sector	
18	Innovación e Investigación en Tecnologías de Energías Renovables (IITER) [Innovation and Research of Renewable Energy Technologies (T)]	114 , 115 (C)	116 (C), 117, 118 (C)	119 (w)			http://www.solucionespracticas.org.pe/innovacion-e-investigacion-en-tecnologias-de-energias-renovables-iiter_
19	Y-TEC Laboratorio de Hidrogeno y Energías Renovables [Y-TEC Laboratory of Hydrogen and Renewable Energy (T, A)]			120		121	http://www.conicet.gov.ar/wp-content/uploads/2014/04/Folleto_Y-TEC.pdf
20	Y-TEC Energías del Mar [Y-TEC Marine Energy: Data Collection of the Marine Resource and Material Corrosion Research (A, T)]		122	120		121	http://www.conicet.gov.ar/wp-content/uploads/2014/04/Folleto_Y-TEC.pdf
21	Y-TEC Energías del Mar [Y-TEC Marine Energy: Development of Hydrokinetic Turbines for Electricity Generation (A, T)]			120		121, 123	http://www.conicet.gov.ar/wp-content/uploads/2014/04/Folleto_Y-TEC.pdf
22	Energía Solar Fotovoltaica: Aspectos Tecnológicos, Técnicos y Pespectivas de Desarrollo en Uruguay [Solar PV Energy: Technological and Technical Aspects and Perspectives for Development in Uruguay (T)]		124	6, 125, 126, 127			http://iie.fing.edu.uy/investigacion/grupos/esfv/
23	Desarrollo de Herramientas de Predicción de Corta y muy Corta Duración de la Generación De Energía Eléctrica de Origen Eólico [Development of Short-term Forecast Tools for Wind Electricity Generation (T)]		124	6, 128, 125, 28			http://www.fing.edu.uy/cluster/eolica/
24	Proyecto de Energías Renovables en Mercados Rurales [Renewable Energy in Rural Markets Project (T)]			129, 130, 131, 132, provincial institutions	133	Concessionaires	https://www.se.gob.ar/permer/

APPENDIX D:

RD&D in LAC with a Global Perspective

The aim of this section is to provide an overview of RD&D indicators in Latin America, in comparison to developed economies, and highlight those aspects that are closely linked to the discussions about obstacles hindering research and recommendations to bolster the innovation landscape through cooperative efforts.

The overview relies on aggregated data for all sectors, given the scant regional data and statistics of RET RD&D indicators, not only on renewable energy but for all economic sectors[3]. Providing further explanations of the results shown in the statistics presented falls outside the scope of this study.

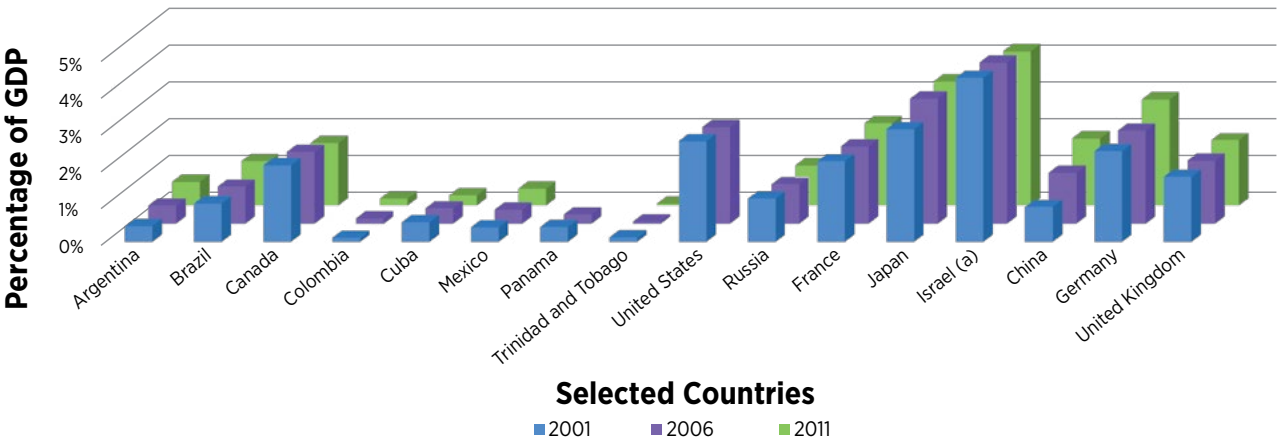
Financial Resources Indicators

National priorities depend on the status of national economies and thus, expenditures on R&D are adjusted to public budgets and country macro-objectives. Despite LAC countries have lower R&D investment levels in contrast to other regions, Figure 9 shows that there are some efforts to increase the relevance that R&D has on national budgets. In 2011, Brazil became the first Latin American country to invest more than 1% of GDP in R&D.

It is nevertheless worth noting that R&D expenditures have increased considerably from 2001 to 2011 in most countries in the region (contrary to most developed countries), with few exceptions. Countries such as Argentina and Mexico have experienced significant growth rates.

Figure 10 shows the sectors carrying out R&D. It is evident that there are large differences across the region, with higher education institutions responsible for almost all R&D in some countries, such as Guatemala, while government and private non-profit organisations carry out more than 90% of R&D in other countries, such as Panama. Compared to both developed countries (*e.g.* United States, Canada, Germany, United Kingdom, France and Israel) and emerging economies in other regions such as China and Russia, the share of R&D performed by the business sector is relatively low in LAC. Uruguay and Chile are the countries where the business sector accounts for the largest share of R&D with 15-20%. Thus, government and higher educational institutions perform most of the R&D in LAC. This figure reveals an evident need to design appropriate incentives which attract business enterprises and the private sector to invest in research in LAC.

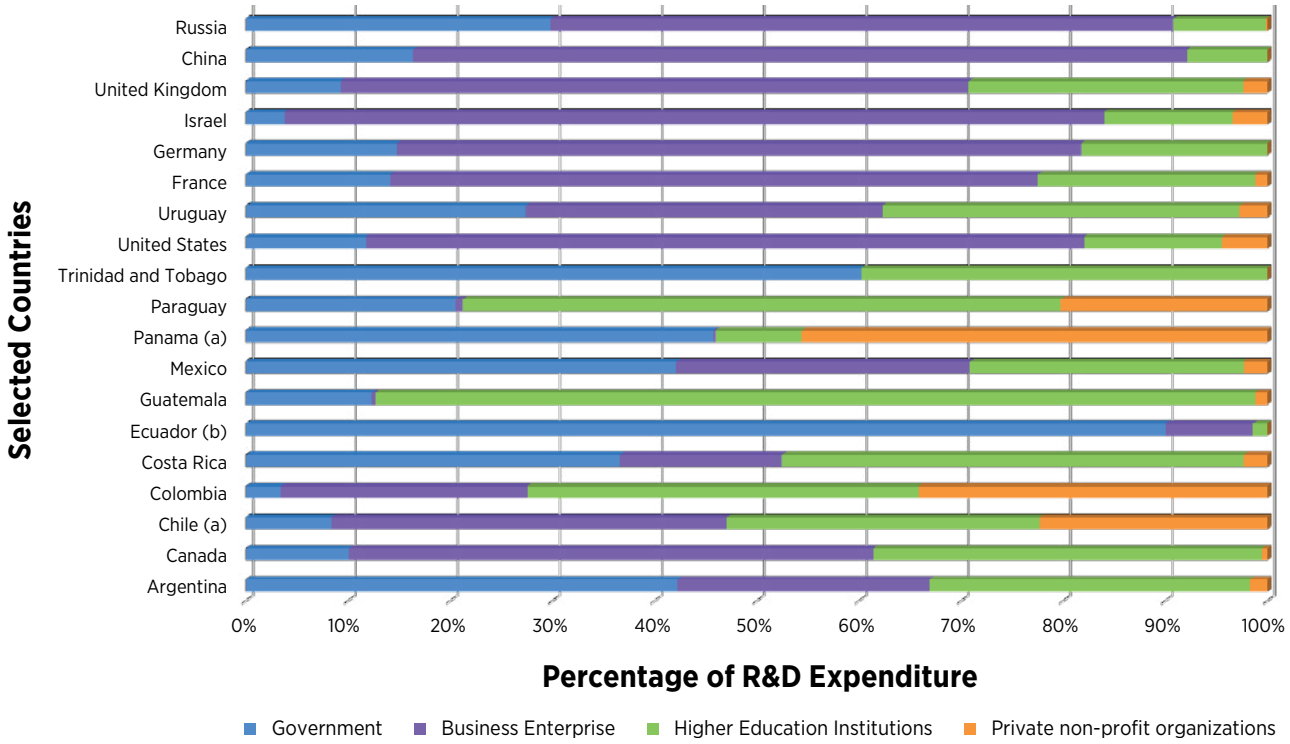
Figure 9: R&D expenditure as a percentage of GDP in 2001, 2006 and 2011.



(a) Defence excluded (all or mostly)
Source: Data from RICYT (2013) and OECD (2013).
Note: Blank data points indicate that information is not available.

3 The figures on this appendix present data from different countries depending on the availability of data on the selected years of analysis.

Figure 10: Share of R&D expenditure by performance sector in 2011 (or last year with available data).

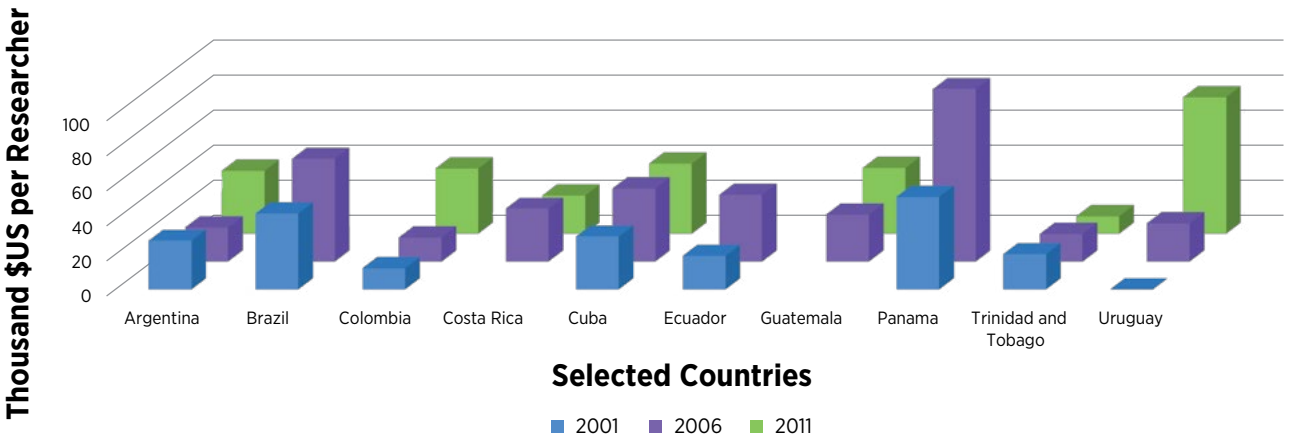


(a) 2010 (b) 2008
Source: Data from RICYT (2013) and OECD (2013).

Examining the R&D expenditures per researcher in the LAC region (Figure 11), it is seen that there are significant differences between the countries. Panama and Uruguay have by far the highest expenditure levels in the region with respectively US$105,000 and US$75,000 per researcher. Generally, there is an increasing trend in the R&D expenditures per researcher, however, a few exceptions (Costa Rica and Trinidad and Tobago) can also be found. In the case of Costa Rica, there has been increasing investments in R&D (thus indicating an increasing number of researchers), while R&D expenditures in Trinidad and Tobago have been decreasing (Figure 11).

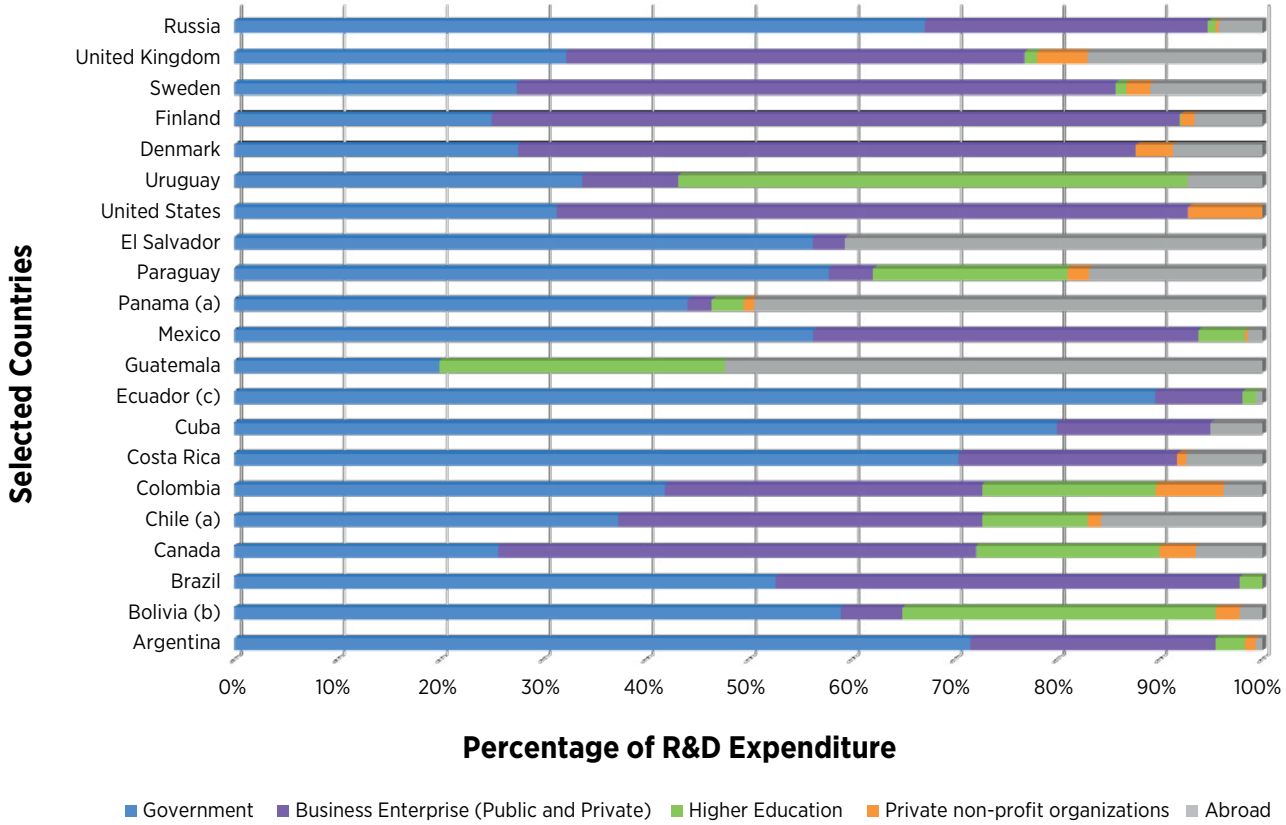
Concerning sources of R&D funds, Figure 12 highlights that a smaller share of funds comes from the business sector in Latin America than in the North American and

Figure 11: R&D expenditure per researcher in 2001, 2006 and 2011.



Source: Data from RICYT (2013).
Note: Blank data points indicate that information is not available.
Note: The number of researchers is based on the headcount method of data collection.

Figure 12: Share of R&D expenditure by source of funds in 2011 (or last year with available data).



(a) 2010 (b) 2009 (c) 2008
Source: Data from RICYT (2013) and OECD (2013).

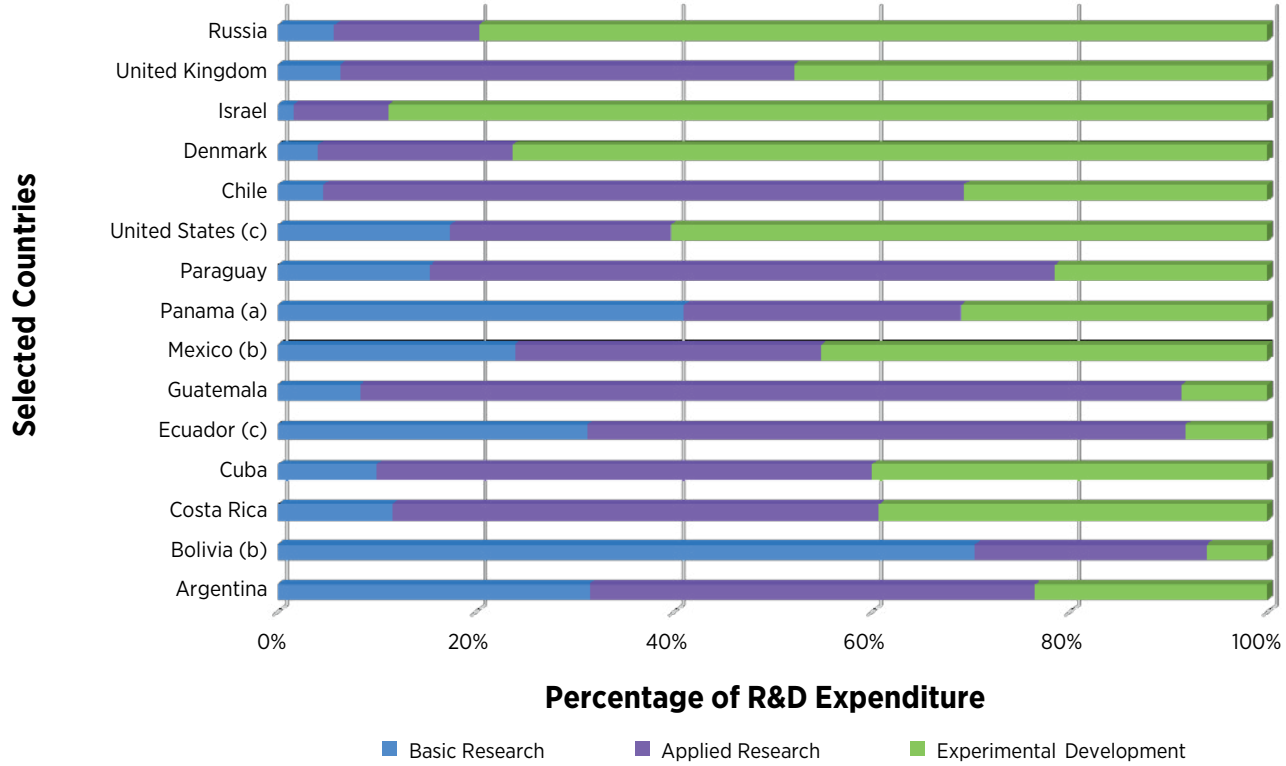
Nordic countries. Conversely, government-sponsored R&D is of high importance in the LAC region. However, in a few countries, particularly Brazil, Mexico, Chile and Colombia, the business sector contributes a considerable share of total R&D expenditures. In some cases, the high involvement of the business sector in R&D is partly explained by government mandates for large state-owned companies to invest a considerable share of turnover in R&D. Noteworthy also are the significant differences between the roles played by foreign sources of R&D investments: while negligible in countries such as Brazil and Argentina, these account for 40-55% in Guatemala, Panama and El Salvador.

In terms of distribution of R&D funds over different types of activities (Figure 13) there are significant differences between the LAC countries. Bolivia is the only country where basic research makes up more than 40% of R&D expenditure, even though Argentina, Ecuador and Panama also invest a large part of their funds in this activity. The LAC countries generally invest a large part of their funds in applied research, most notably Guatemala with more than 80% of all R&D funds going into this area. None of the selected LAC countries invests as large a share in experimental development as the developed countries included in Figure 13. However, Mexico, Cuba and Costa Rica all use more than 40% of R&D funds on this type of activity. However, in comparison, almost 90% of all Israeli R&D funds are used for experimental development.

Human Resources Indicators

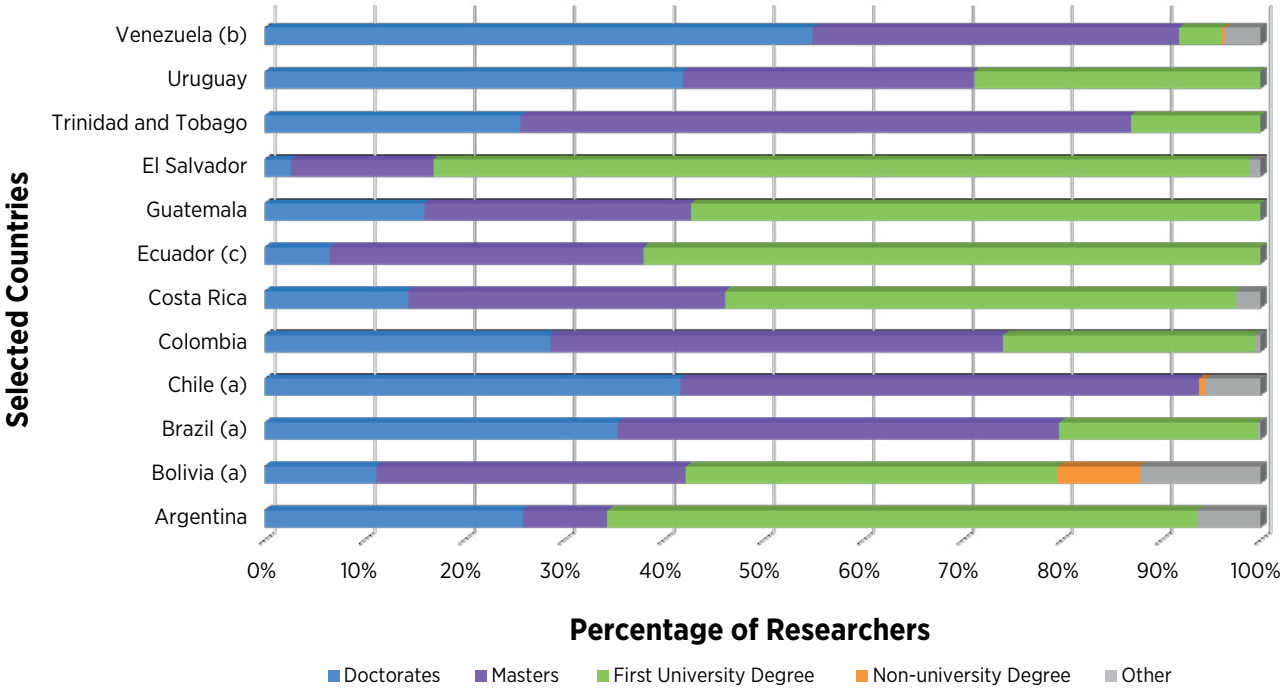
In terms of the qualification level of researchers, Figure 14 highlights that there are significant differences between the countries in the region. While more than half of all Venezuelan researchers have PhDs and 90% have at least a master's degree, and a considerable share of researchers in Uruguay, Chile and Brazil have PhDs, far fewer researchers in other LAC countries hold either masters or PhDs. Highly qualified researchers are essential for the adaption, improvement or creation of technologies. Discussions in sections 6 and 7 highlight

Figure 13: Share of R&D expenditure by type of activity in 2011 (or last year with available data).



(a) 2010 (b) 2009 (c) 2008
Source: Data from RICYT (2013) and OECD (2013).

Figure 14: Share of researchers by highest qualification level in 2011 (or last year with available data).



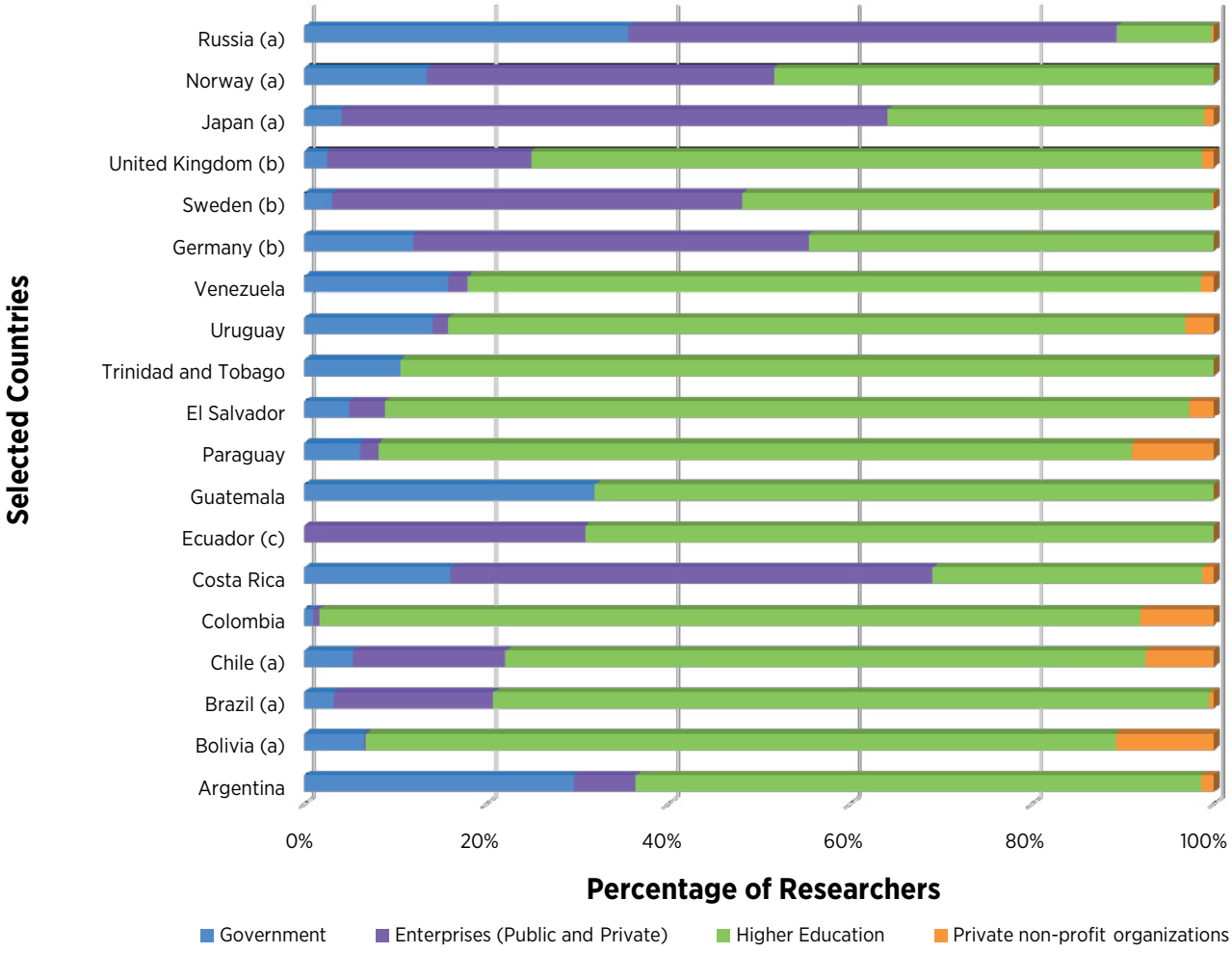
(a) 2010 (b) 2009 (c) 2008
Source: Data from RICYT (2013).
Note: The number of researchers is based on the headcount method of data collection.

the consequences of a lack of this professional profile at a country level and actions to increase the number of masters and PhD researchers.

Figure 15 gives an overview of the sectorial employment of researchers in the LAC countries. In all countries, the majority of researchers are employed in higher education institutions. Further, in Argentina and Guatemala, around 25% of researchers are governmental employees, while Ecuador has a large share of researchers (approximately 25%) employed in public and private enterprises. With the exceptions of Costa Rica and Ecuador, LAC countries in general present a low number of researchers in business enterprise. The need for the private sector to commit to research is not just a financial matter, but it is also closely linked to the human resources invested on research. In comparison, the European countries included in Figure 15 (Germany, Norway and Sweden) as well as Russia and Japan, have large shares of researchers working in enterprises and, in the cases of Russia and UK, in the government and higher education institutions respectively.

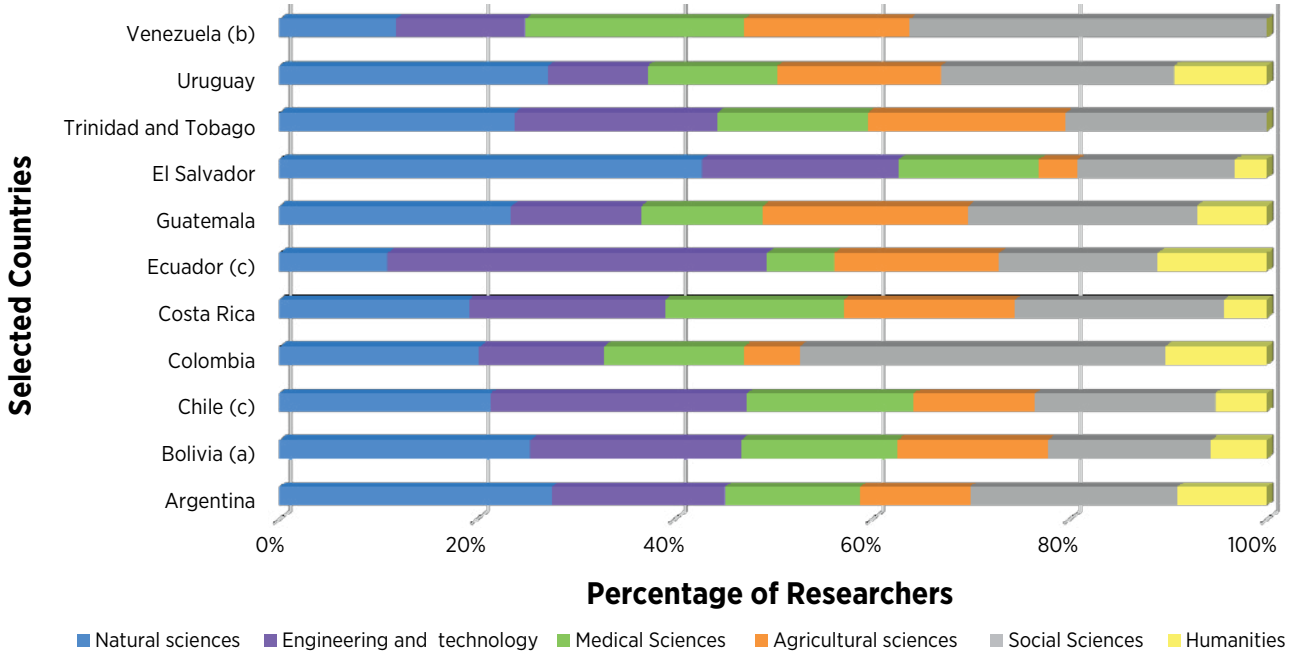
The distribution of researchers over different scientific fields is provided in Figure 16. The share of researchers working in the natural sciences is largest in El Salvador with more than 40%, while Ecuador has the largest share of researchers in engineering, also around 40%. In general, the combined share of researchers in natural science and engineering make up 30-45% in most

Figure 15: Share of researchers by employment sector in 2011 (or last year with available data).



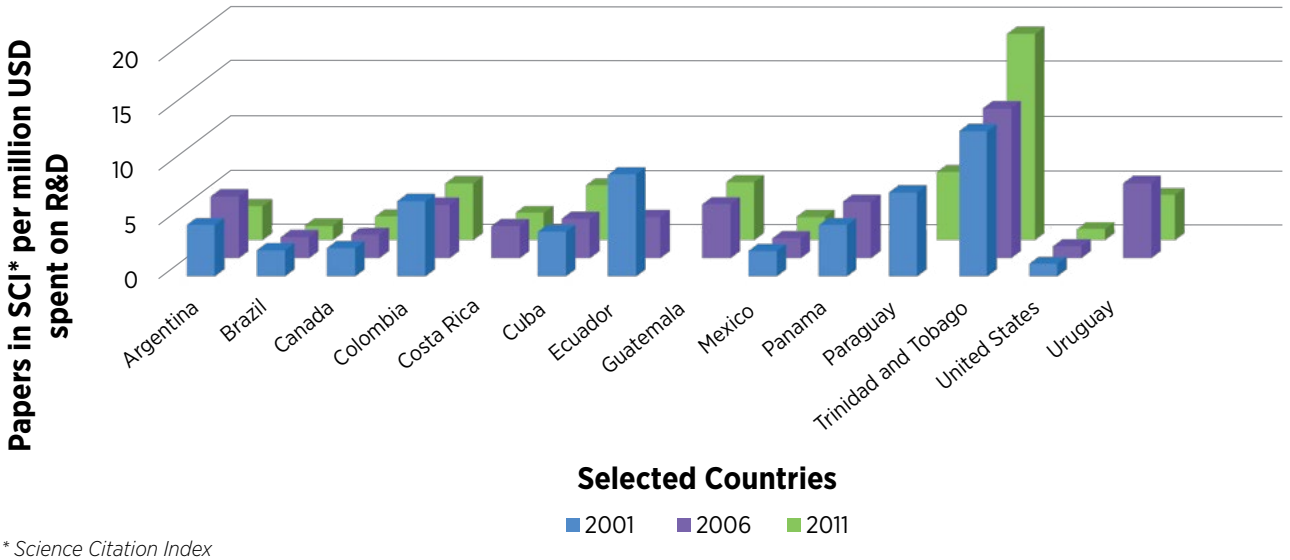
(a) 2010 (b) 2009 (c) 2008
Source: Data from RICYT (2013) and OECD (2013).
Note: The number of researchers is based on the headcount method of data collection.

Figure 16: Share of researchers by field of science in 2011 (or last year with available data).



(a) 2010 (b) 2009 (c) 2008
Source: Data from RICYT (2013).
Note: The number of researchers is based on the headcount method of data collection.

Figure 17: Output of papers compared to R&D expenditure in 2001, 2006 and 2011.



** Science Citation Index*
Source: Data from RICYT (2013).
Note: Blank data points indicate that information is not available.

countries, with Venezuela as the country with the lowest share (20-25%) and El Salvador with the highest share (60%).

Patents and Publications Indicators

Finally, Figure 17 provides the production of scientific papers relative to investments in R&D. The figure highlights that countries in the LAC region publish a high number of papers in comparison to Canada and the United States. While a main reason might be the focus in LAC countries to invest in basic and applied research rather than experimental development (see Figure 13), it still shows that investments in R&D in Latin America is leading to published academic work. There is no clear trend in whether the number of scientific papers relative to investments in R&D is increasing or decreasing in the region. Despite the previous indicators, there is here a positive indication of science and knowledge proliferation in some LAC countries. Such proliferation, in relation to the financial investments, is competitive with developed economies and should encourage policy makers to reflect on the priority given to research and scientific activities.

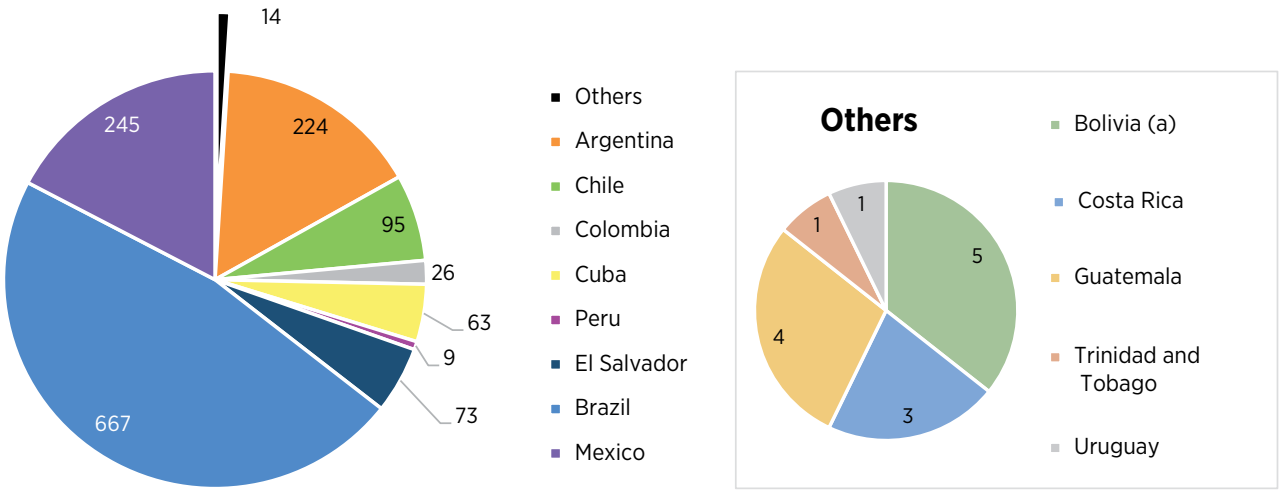
Figure 18 illustrates the number of patents granted to residents, which is an important indicator of the inventive capacity of the local population. While Brazil, Mexico and Argentina make up the clear majority of patents granted, countries such as Cuba and particularly El Salvador also have a considerable number, taking into account their population sizes.

In terms of patents granted to non-residents, the importance of the Mexican market to North American companies is clearly reflected in the statistics. Further, non-residents have also been granted a considerable number of patents in Brazil, Argentina and Chile (Figure 19).

Andean Development Corporation

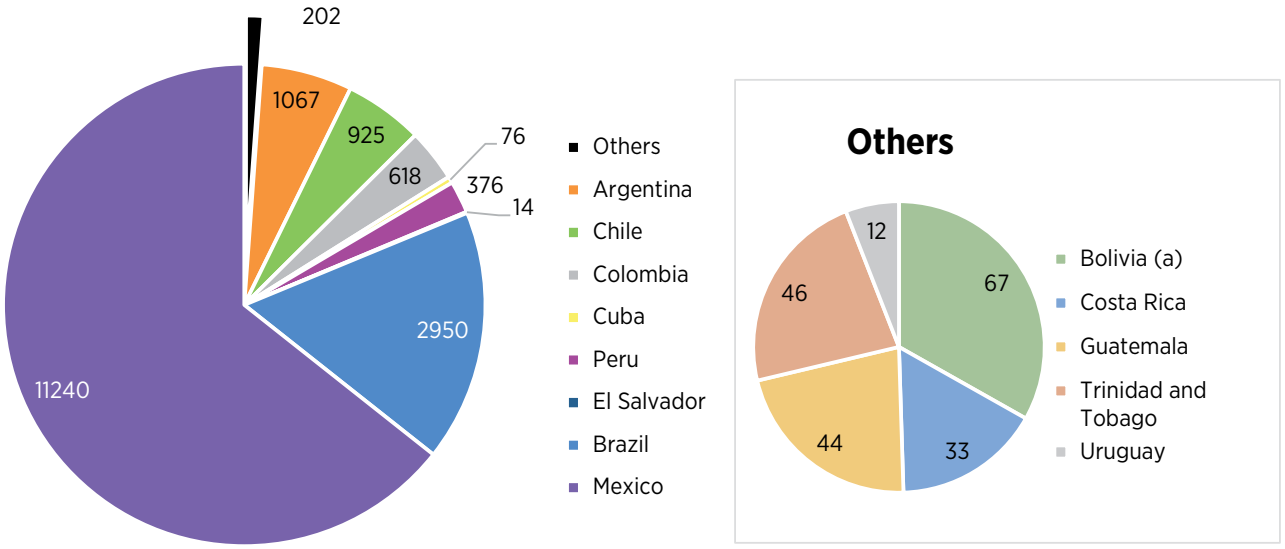
The Andean Development Corporation (Corporación Andina de Fomento) has acknowledged the significance of patent information as one of the indicators of technological innovation. This gave rise to **Technological Patents for Development,** an initiative seeking to provide innovators and inventors with enabling mechanisms to conceptualise and patent their inventions (CAF, 2014). The corporation's data bank also provides indicators about patents in specific fields, such as energy technology. The data bank includes information about exports of high-tech by geographical regions.

Figure 18: Patents granted to residents in 2011 (or last year with available data).



(a) 2010
Source: Data from RICYT (2013).

Figure 19: Patents granted to non-residents in 2011 (or last year with available data).



(a) 2010
Source: Data from RICYT (2013).

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