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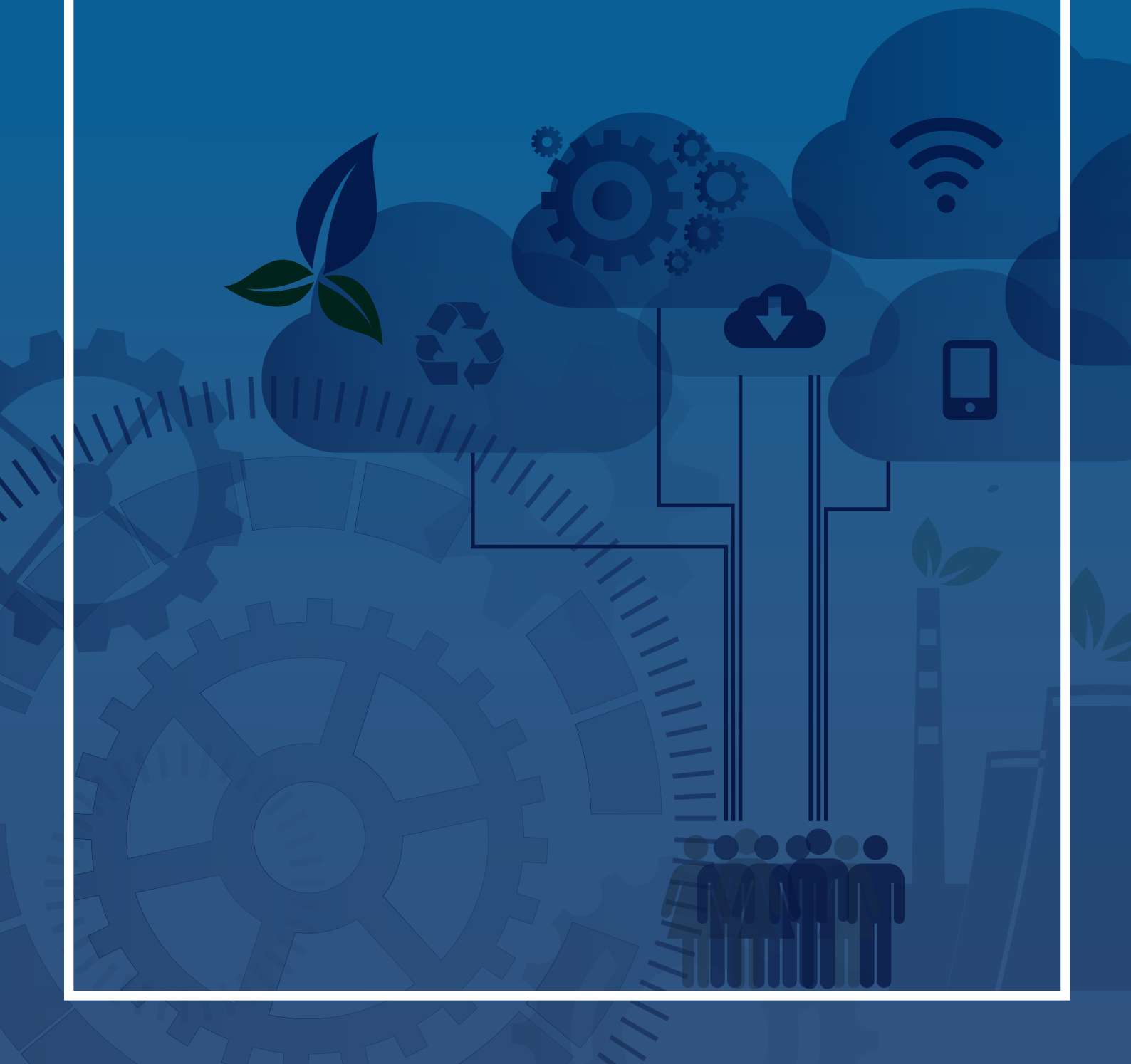
Moving Ahead with Technology for Eco-innovation



ISBN No.: 978-92-807-3688-5

Job No.: DTI/2153/PA

Acknowledgments

The Moving Ahead with Technology for Eco-Innovation guideline has been commissioned by the Economy Division of the United Nations Environment Programme (UN Environment) as part of the UN Environment Eco-innovation project.

Lead authors: Dr Wayne Visser with contributions from Dr. Nicola Dee, Liazzat Rabbiosi, Katie Tuck, Andrea Floudiotis and Karina Boers.
Supervision and coordination at UN Environment, Economy Division: Elisa Tonda, Andrea Floudiotis, Liazzat Rabbiosi, Katie Tuck and Helena Rey.

The working version of the Moving Ahead with Technology for Eco-Innovation guideline was tested during the implementation of the Eco-innovation project by the project teams of SIRIM Berhad in Malaysia, National Cleaner Production Centre in Egypt, Centro Nacional de Producción Más Limpia y Tecnologías Ambientales in Colombia, Council for Scientific and Industrial Research in South Africa as well as CER/ Grupo GEA in Peru. UN Environment is grateful for their committed work in testing and applying the eco-innovation manual's methodology in their respective countries and for their invaluable feedback from this experience.

UN Environment acknowledges the following people that provided comments to the preparatory work for the Moving Ahead with Technology for Eco-Innovation: Jamie O'Haire, Walter Reinhardt, Jonathan Duwyn, Fiona Tokple, Garrette Clark, Hyunju Lee, Hanan El Hadary, Valentijn Bilsen, Jerome Moulin, Anja von der Ropp, Klaus Willnow, Laurence Duyck, Ali Abo Sena, Bharat P Jain, Hung Suck Park, Philip Stevens, Kevin Cilliers, Aida Szilagy, Marcio Torres, Stephanie Nitze, Helena Rey de Assis, Sandra Averous-Monnery, and Pablo Montes Iannini.

Special thanks also go to the participants of the country validation and training workshops in Colombia, Egypt, Malaysia, Peru and South Africa. Too numerous to mention, their inputs and provision of comments have also significantly helped to tailor this supplement to the needs of the end user.

UN Environment gratefully acknowledges the funding support of the European Commission to the Eco-innovation project and related activities.

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FOREWORD

Technology plays a central role in economic growth for both, developed and emerging countries. In fact innovation has a positive effect on job and wealth creation of a nation. Especially for SMEs, developing new or adapting to technology is vital in order to stay competitive. Technology offers diverse opportunities, from more effective production and higher profit margins to a reduction of social and environmental impacts along the value chain. For many, new and innovative technology leads to a better competitiveness on national and international markets. Hence, within the Eco-innovation project a close look on the dynamics of technology development and adaptation was taken.

The successful implementation of new technologies for eco-innovation however is dependent on multiple factors. It requires enabling legal frameworks in the country, human and financial capacities of Small and Medium sized Enterprises (SMEs) and supportive as well as trained business intermediaries (e.g. service providers).

A challenge especially in traditional sectors is to create the necessary open mind set to changes effecting long-standing accustomed production patterns. There is a need for flexibility to adapt to superior production technologies, waste reduction or new energy efficiency measures. Individual firms often lack the incentive, the expertise, and the resources to embark on the path of an innovation front-runner. They have trouble gathering the information they need to identify opportunities. Therefore this report addresses service providers and offers approaches as well as real life case studies on new eco-innovation technologies and how to integrate it into the company. On the basis of real life examples, key elements for a successful shift towards technology are showcased. In a step-by-step approach, methods to support the decision-making process are discussed of whether to develop or transfer technologies for eco-innovation.

Business intermediary organizations such as Resource Efficient and Cleaner Production Network coordinated by UN Environment and United Nations Industrial Development Organization (UNIDO) are important change agents helping enterprises in developing and emerging economies to learn and adapt to sustainable business practices. UN Environment has been nurturing this network as a key.

Despite the willingness to integrate eco-innovation, governmental back up is crucial for technology adaptation and thus sustainable development. Consequently this report discusses what supportive and dynamic role authorities play and how legal frameworks can encourage development towards eco-innovation and in what cases, no frameworks, but a 'hands-off' approach proves to be expedient. As a result, the present report examines the naturally complementary relation of Eco-innovation and technology as well as the resulting role of SMEs, governments and business intermediaries.

Ligia Noronha
Director
Economy Division
UN Environment

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Drip irrigation technology © Shutterstock

Executive Summary

Today, the use of state-of-the-art technology in business is vital for competitiveness within most markets worldwide. The transit of a business towards sustainability with of Eco-innovation is closely connected to the use of adequate innovation. It helps to unlock social, environmental and economic benefits. To generate those, the choice of method to develop, transfer, adapt and disseminate technology according to the present business specifics is essential.

Identifying the right technology for eco-innovation development method is crucial for the success of the business model. This report discusses whether to **develop the technology in-house**, use **open innovation** or decide to outsource to a **strategic partner** to develop the technology for you. These are essential decisions that need to be made early on when implementing a new business model. Developing a technology in-house is a time consuming and costly decision, requiring intense research, additional capacity building for employees, and often a larger investment. However, the returns of a customized technology solution can have tremendous benefits to the core competences of the company. It can create a competitive advantage, which increases the overall competitiveness of the company in the market. In case internal capacities are not fit to develop the technology independently, but sufficient to cooperate with strategic partners on a technology solution together, **open innovation** might be the suitable approach. However, in cases in which the selected technology is not adding value to the core competence of the company and internal know-how as well as financial capabilities do not seem feasible, it might be more economic to outsource the activity to a **strategic partner**.

There are numerous kinds of technology suitable for eco-innovation. The term is not necessarily bound to mechanic innovation within the upstream process of a good or service. It can also refer to innovation in the field of communication, transport and business operations. It can be a system to mobilise money, a technology for recycling or simply a more resource efficient procedure. As a result, innovation often yields savings in time, money, resources, which can positively affect the surrounding society.

Next to the internal factors a number of external factors exist that enable technology for Eco-innovation. The **specific institutional capacity** determined by the strength of the relationship among institutions and stakeholders, including businesses, universities and research institutes, as well as government is crucial for an enabling environment supporting the creation of eco-innovation. Technologies for eco-innovation can only have an impact, if they are **adopted by the market**. Creating demand therefore requires identifying a suitable market with sufficient policy support to foster their initial uptake. The **ability to absorb new technologies** determines the extent to which companies or individuals can create, adapt, or use technologies for eco-innovation**. Intellectual property rights** meaning the ownership of intellectual assets limits the extent to which competitors can free ride on the research and development efforts of others, enabling the owners of the technologies to profit from their innovation and investment**. Access to funding** is a key challenge to the development, adoption, or transfer of technologies for eco-innovation.

These factor highly depend on the existing political framework that can either work as enabler or break in technological transition. Local business intermediaries can function as an important bridge between policy makers and the actual involved SMEs. By doing so they become instrumental in developing and supporting enabling conditions for technologies for eco-innovation.

Preface

The Eco-innovation project has the objective of developing local resources and capacities for eco-innovation in developing and emerging economies. It targets service providers for Resource Efficient and Cleaner Production (RECP)[1] and other business intermediaries, also referred to as RECP service providers in this report, in order for them to provide technical assistance to Small and Medium sized Enterprises (SMEs). Service providers are organisations that function as business and government intermediaries. Service providers have a diverse portfolio of services depending on their specific mandate, skills, competencies and interests, as well as the context in which they operate. Their primary role is to promote environmental sustainability in the business sector.

The project builds on cooperation with national and local governments, making business case for eco-innovation, enhancing policy context (including developing and transferring technology), developing technical expertise and capacity for adoption of eco-innovation (including technologies) and fostering regional and international collaboration. The ultimate goal of the project is to enhance the business sector contribution to the achievement of resource efficiency and to shift towards sustainable consumption and production patterns.[2]

ABOUT THIS REPORT

As part of the Eco-innovation project, this report aims to inform about technological aspects of eco-innovation emphasizing the role of RECP service providers. More specifically, the report:

- Describes on the role of technology within eco-innovation and how it fits in its iterative implementation methodology in an enterprise and its value chain;
- Inform on the role of policy in creating key enabling factors for the successful adaptation and development of technologies for eco-innovation at an enterprise and national level;
- Helps to identify, develop, transfer and adapt technologies for eco-innovation, through market and non-market based methods;

1/ RECP Service Providers are members of the UN Environment and UNIDO joint initiative to create a Resource Efficiency and Cleaner Production Network (RECPnet) composed mostly of National Cleaner Production Centres (NCPCs). They have a function of business intermediaries. They can also include other institutions that have a mandate to promote environmental sustainability in the business sector through service provision, capacity building and technical assistance. For the purpose of the publication, they are named 'RECP Service Providers'.

2/ For more information, see: www.unep.org/ecoinnovationproject

- Focuses on the role of business intermediaries in technology development process for eco-innovation, especially as conveners and partnership builders, along with other stakeholders: SMEs, universities, government, and large companies.

As such, the report is written primarily for RECP service providers or other business intermediaries, such as National Cleaner Production Centres (NCPCs), located in developing countries and emerging economies. They often perform an important function in advising and enabling SMEs in developing, transferring and localizing environmental technologies in their respective countries. This role of NCPCs is explicitly recognized and called for in the Addis Ababa Action Agenda[3]. The report may be also interesting to policy-makers in order to understand the context for technology development and transfer within the framework of the 2030 Agenda for Sustainable Development and the Sustainable Development Goals.

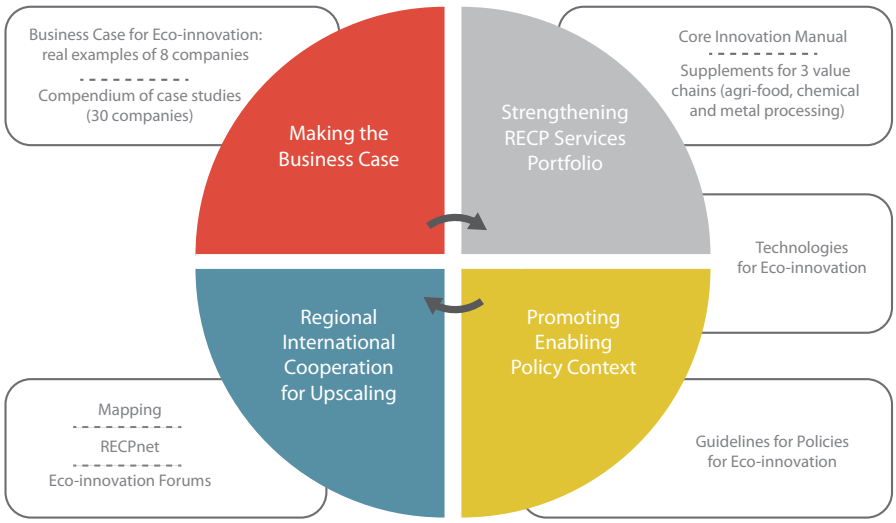
This report complements other publications in UN Environment's eco-innovation series, including:

- ✔ A Business Case for Eco-Innovation publication that clearly demonstrates why eco-innovation makes good business case based on examples of eco-innovative companies from around the world.
- ✔ An ***Eco-I Manual,*** which provides a step-by-step guide to support RECP service providers and other business intermediaries in assisting SMEs to implement eco-innovation.
- ✔ Three ***sector specific supplements for agri-food, chemicals, and metals value chains*** provide technical guidance on how to practically implement the methodological approach of the core Eco-I Manual.
- ✔ Guideline for ***Mainstreaming Sustainable Consumption and Production (SCP) Policies for Eco-Innovation*** that informs policy-makers about necessary policy enabling conditions in the SCP framework, which can provide incentives for eco-innovation. It also informs RECP service providers about proactive ways to contribute to a policy framework that will foster sustainable production and consumption and eco-innovation.

For this report primary and secondary research was conducted from January 2013 to May 2015. This included reviews of academic and practitioner literature (e.g. papers and reports) on eco-innovation, technology development and technology transfer. Primary research was gathered over the course of three months from April to June 2013 and included personal interviews with service providers (typically NCPCs) from Egypt, India, Nicaragua, South Africa, and Vietnam. Also subject experts from Cambridge University, Emagine, Greenwich University and UNIDO as well as case study representatives (besides the service providers) from Ecuador, Nigeria and the UK have been interviewed. In addition, there was written correspondence with case study representatives from South Africa. Lastly, UN Environment and UNIDO held an expert review workshop in May 2014, with representation from a variety of sectors and regions.

3/ United Nations. 2015. Addis Ababa Action Agenda from the Third International Conference on Financing for Development (Addis Ababa, Ethiopia, 13–16 July 2015). Endorsed by the General Assembly in its resolution 69/313 of 27 July 2015. Article 122 speaks of the role of capacity building initiatives such as RECPnet and NCPCs in promoting the development and diffusion of relevant science, technologies and capacity development.

Figure 1: **UN Environment Eco-innovation project components and outputs**



Aquaponics, alternative way for farming © Shuttertock

Introduction to technology and **its role in eco-innovation**

CHAPTER **ONE**

This first chapter introduces eco-innovation as an approach that enables companies to identify new business opportunities and innovation through the lenses of sustainability, and the specific role of technology in this process. It also contextualises technology within eco-innovation, highlights its function, potential and limitations in achieving sustainable and inclusive development.

1.1 INTRODUCING ECO-INNOVATION

Achieving sustainable development on a global scale will require system-level changes from markets and policies, to institutions and behaviours supported by technological breakthroughs and technology diffusion[4]. It is estimated that todays environmental changes are costing companies up to millions of dollars each year in lost revenues. However, it also creates new opportunities to innovate and generate new business value[5]. Most companies now understand the critical need to include sustainability in their business practices to ensure their market viability[6]. Yet, many do not know what this entails, where to start and how to achieve the systemic change that is needed[7].

4/ OECD (2014) Science, Technology and Industry Outlook 2014: UNEP (2014) Decoupling 2: technologies, opportunities and policy options, A report of the Working Group on Decoupling of International Resource Panel

5/ Tsitsiragos, D. 2016. "Climate change is a threat – and an opportunity – for the private sector." World Bank. Accessed online at: **http://www.worldbank.org/en/news/opinion/2016/01/13/climate-change-is-a-threat---and-an-opportunity---for-the-private-sector**

6/ Winston, A. 2015. "The Ambitious Business Goals Aiming to Change the World." Harvard Business Review, February 2015.

7/ Lubin, D.A.; Esty, D.C. "The Sustainability Imperative". Harvard Business

Eco-innovation is an approach for companies to lead their way in sustainability. It is a continuous process of change that requires companies to think strategically and systematically through life cycle (system) thinking[8] about sustainability issues. A life cycle approach considers the whole life cycle activities of products or services, which include the extraction of raw materials from natural resources and the energy generation. Materials and energy are then part of production, packaging, distribution, use, maintenance, and eventually recycling, reuse, recovery or final disposal. To recognize and capture sustainability business opportunities, companies evaluate and prioritize the impacts from environmental, social and economic pressures affecting their businesses, looking beyond the company's boundaries across the value chain. The approach leads to re-thinking a company's business strategy and model to address key sustainability hotspots[9] through innovative solutions developed in collaboration with the value chain partners. It helps to integrate environmental and social issues into the profit making purpose of any business. Sustainability becomes part of the corporate DNA and a source of innovation, in turn fuelling engines of inclusive and sustainable growth[10].

1.2 THE ROLE OF TECHNOLOGIES IN ECO-INNOVATION

Technology is the application of scientific or technical knowledge for practical purposes. It refers not only to physical equipment and tools, but also to the knowledge, techniques and skills that surround its deployment and use.[11] Within this context, technology forms part of a broader infrastructure that supports eco-innovation, which positively effects economic development in developing and emerging countries. Technology thus has

Review, May 2010

8/ Life cycle thinking is a mostly qualitative approach to understand how our choices influence what happens at each of the stages of the life cycle of an industrial activity: from raw material acquisition through manufacture, distribution, product use and disposal. This approach is needed in order for us to balance trade-offs and positively impact the economy, the environment, and society (UNEP, 2004).

9/ Sustainability hotspots are the most significant impacts in the value chain or the life cycle of a product or service system, which can be used to identify impact improvement opportunities and to prioritize impact reduction actions

(UNEP/SETAC, 2014).

10/ Inclusive growth allows opportunities for everyone to participate in the growth process while making sure that benefits are shared. Given that the poor face challenges that impair their conditions and limit their opportunities, to be inclusive, growth should benefit everyone while reducing the disadvantages faced by the poor, both in terms of benefits enjoyed and, especially, in terms of access to opportunities for participation." International Policy Centre for Inclusive Growth. UNDP: http://www.ipc-undp.org/?q=what-inclusive-growth

11/ Rosenberg, N. (1976) Perspectives on Technology. Cambridge: CUP.

Figure 2: **Conceptual model of eco-innovation**

a significant impact on society and the environment. This impact can be inherent in the technology itself, but is also a function of how it is used. Hence, technology application can be for good or ill or sustainable or unsustainable ends. Increasingly, however, eco-innovation as described above has become a pathway to create more sustainable technology. Indeed, technological advances have contributed significantly to decoupling of economic growth from environmental impacts[12] and improving the livelihood of communities (See Box 1 and 2).

Box 1: Drip Irrigation for **decoupling resource use from productivity**[13]

Drip irrigation is sometimes called trickle irrigation and involves dripping water onto the soil at very low rates. The technique reduces water use by 30-70% and increases land productivity by 20-90% depending on the crop. Making this technology more affordable for farmers in developing economies could address a key hotspot of agriculture – an industry that is responsible for 70% of freshwater use globally - and reduce current operational inefficiencies from evaporation, leakage and seepage in open irrigation systems.[14,15]

The Indian State Tamil Nadu Drip Irrigation Project (TNDRIP), a private public partnership between the International Water Management Institute (IWMI), the Tamil Nadu Agriculture University, the Tamil Nadu State Agriculture Department, and Jain Irrigation Systems, provided hands-on technical training to farmers to switch to drip irrigation. Results showed increases in crop yields by up to 40%, and reduction in water use. For example, one banana farmer involved in the study reported cutting daily irrigation duration by half. At the same time, yields nearly doubled.

Box 2: Aquaponics – **The alternative way of farming**

Aquaponics is a system combining aquaculture and hydroponics in a symbiotic environment. Aquaculture refers to raising aquatic animals such as fish in a tank. Hydroponics is a cultivating method of growing plants in waterbeds instead of soil. The water from the fish tank flows through a system, which broken down the fish excretions into nitrates and nitrites. These are nutrients for the plants and therefore no additional fertilizers are necessary. It is a closed system as the water from the fish tank flows through the plants' waterbeds, where it is filtered and transferred back into the fish tank, limiting the need for additional fresh water. An aquaponic system uses approx. 90% less water, requires no soil and eliminates the need for artificial and hazardous fertilizers. In fact, as per yield per area, hydroponic lettuce production is 11 times greater compared to traditional farming.[16] *It is therefore a growing niche market for many developing countries suffering from lack of fertile soil and water.*

A successful example is 'Bustan Aquaponics' farm in Egypt. It was established in 2011 and is the first commercial aquaponics farm in the country, growing a large variety of lettuce, greens, herbs and Nile Tilapia fish. Due to Egypt's hot climate and many pressures on agricultural land, aquaponics prevailed as a sustainable agricultural model. According to the founder Faris Farrag, Bustan's aquaponic system saves 90% of water compared to traditional irrigated farming, growing pesticide-free produce.[17]

Despite this potential, many environmental and social technologies had so far only a limited impact. These technologies are often associated with energy efficiency activities, as these tend to have a clear value proposition: helping organisations to save money on energy bills and recoup the capital cost of installation. They are also usually based on well-established technologies and as a result are rarely disruptive to existing business. Moreover, their use and rate of replacing less sustainable technologies is advancing too slowly, thus making them insufficient to address the full scale of current sustainability challenges. A variety of factors can explain the slow diffusion rate. Characteristics of the country, such as general domestic business environment, research and development capacity, strength of intellectual property rights, foreign

12/ UNEP (2014) Decoupling 2: technologies, opportunities and policy options, A report for the Working Group on Decoupling of International Resource Panel

13/ International Water Management Institute (2013). Success Stories (18). Accessed online at: http://www.iwmi.cgiar.org/Publications/Success_Stories/PDF/2013/Issue_18-Making_a_difference_drop_by_drop.pdf

14/ FAO (1990). Irrigation Water Management: Irrigation Methods.

15/ UNEP (2014) Decoupling 2: technologies, opportunities and policy options, A report fo the Working Group on Decoupling of International Resource Panel

16/ Barbosa, Guilherme Lages, et al. "Comparison of land, water, and energy requirements of lettuce grown using hydroponic vs. conventional agricultural methods." International journal of environmental research and public health 12.6 (2015): 6879-6891.

17/ http://bustanaquaponics.com

direct investment, regulation and cultural attitudes influence the potential of technology influencing societal challenges. These issues are addressed in more detail in Chapter 2 of the report. However, for a technology to be successful and to contribute to sustainability broadly it needs to have a clear purpose and be embedded into strategic and systematic change process, which can be set at a company level and its value chain by an approach such as eco-innovation.

Eco-innovation is a strategic approach to define the technological needs and opportunities of a company. Sometimes a business opportunity begins with a new technology solving a market problem[18]. A company's incentive to invest in technologies will be determined by a variety of factors. Yet, it is mainly driven by the ability to tailor the technological solution to the market needs and ultimately to recover its development costs. In addition, the regulatory and technological trends will also determine the success of a technology in a specific market. Market analysis will help to understand the needs of the market and opportunities therein. Companies can also be proactive in shaping the market demand rather than simply reacting to existing conditions. This often means working with a variety of stakeholders from customers and suppliers to government and civil society.

As demonstrated in Figure 2, technology plays a dual role in eco-innovation, both as a key enabler and outcome of eco-innovation:

- Technology can aid and enable the eco-innovation process in the following ways:
- Support the analysis and collection of new data about markets and sustainability hotspots in order to support the formulation of a new business strategy;
- Make an attractive value proposition in response to an unmet market demand through innovative business models (see Box 3);
- Introduce changes to production through closed loop material flow systems or development of alternative manufacturing processes;
- Enable changes to sourcing and distribution logistics, with the potential to radically improve energy efficiency and traceability of materials across the value chain, through the use of the Internet of Things; and
- Connect consumers with the products or services of a company in innovative ways through sharing schemes and servicing systems.

18/ This is sometimes also referred to as technology push and market pull

19/ Azuri Technologies (2014). Accessed online at: http://www.azuri-technologies.com/

Box 3: Technology allowed **Azuri Technologies to seize a new growing market**[19]

Mobile money technology has helped Azuri Technologies to adopt a service system business model and gain the widest reach in Uganda, Ghana, and Ethiopia for its solar powered electricity technologies. The mobile money system enables Azuri to offer a pay-as-you-go business model to its customers to top up their home electricity unit and concurrently pay off the initial cost of the unit. The company's solar powered device (solar-home-system) provides energy to customers from renewable sources. This provides clean, safe renewable power to families at about half the cost of the kerosene it replaces, without the need for any government subsidies or tariffs. Azuri works with a range of partners in the value chain, namely distributors, service agents, installers, and local entrepreneurs to operate and scale up the business offering, thus contributing to social, economic, and environmental improvements in the community.

Technology that results as an outcome of eco-innovation can be sold, and/or used within the company or value chain as part of the continuous innovation process. For example, technology can substitute input materials with innovative components, therefore preventing the need for raw materials or materials with a high environmental impact (see Box 4).[20]

© Azuri Technologies

Box 4: Wear2 creates **innovative new yarn that allows easy re-use or recycling of unused clothing**[20]

Corporate clothing is often discarded due to colour or branding changes or uniform updates. These fabrics are either shredded and used as lower grade materials or just incinerated or landfilled. Wear2's garment disassembly technology was jointly developed by C-Technology and the University of Leeds with the aim to reduce the amount of waste generated by end-of-life corporate clothing. The result is a new yarn, used for items such as labels, logos and back-pockets that can be partially or completely disassembled without damaging the surrounding fabric by using microwave radiation. The combination of innovative adhesives and microwave technology therefore allows garments to be efficiently de-branded and reused. This enables manufacturers to decide at the design phase, which pieces of garment they would like to disassemble in the future by stitching those components with the new yarn.

The technology itself is simple, fast and compatible with conventional garment manufacturing equipment. Energy use to disassemble the garments is negligible, according to the developers. The technology supports the use of new business models, by making it easier for companies to lease corporate clothing rather than sell it, reducing production inputs and waste.

Box 5: Examples of **burden shifting**

Life cycle impact of modern synthetic fabrics[23]

Modern fabrics used in clothing today utilize materials such as nylon and acrylic for their special properties that give durability, water and stain resistance, breathability, and weight reduction among others. Recent research however indicates that these fabrics may deposit microfibers or microplastics through washing. While the technologically advanced synthetic materials used in the clothing may make them more resistant to stains to reduce the amount of times they need to be washed, they seem to cause other unintended negative effects at a later stage in their life cycle by polluting water and contributing to marine eco-system degradation.

Life cycle assessment of renewable energies[24]

Renewable energy technologies can significantly mitigate environmental impacts in terms of the reduction of greenhouse gases emissions, pollution, and dependence on fossil fuel. However, life cycle assessments conducted by the International Resource Panel, indicate that they are associated with trade-offs in terms of land and water use and more demand for certain materials such as iron, cement and copper. This points to the need for the right mix of low-carbon electricity generation technologies as well as policy objectives to potentially reduce pollution and impacts on the environment.

1.3 ADOPTING LIFE CYCLE THINKING AND EMBRACING THE VALUE CHAIN

Not all technologies will necessarily be beneficial. Perceived gains offered by a technological innovation in one space might simply shift the burden to a different part of the chain21 (see Box 5). A life cycle or system perspective implies considering all phases of the product, including the technology's lifespan from extraction of raw materials through material processing, manufacturing, distribution, use, repair and maintenance, to disposal or re-use[22].

Applying life cycle thinking during the identification, transfer and development of technologies within an eco-innovation process enables an informed assessment of trade-offs that a particular business or technological decision entails. Thus, it can help to ensure that net sustainability improvement is created throughout the value chain.

The process also helps a company to realize that many of its sustainability hotspots and potential risks to their business are outside of their boundaries and within their value chains. There are significant economic benefits when

21/ Cambridge University Press (1976) London. Rosenburg. N: Technology and the Environment : an economic exploration in Perspectives on technology

22/ UNEP (2004) Why Take a Life cycle Approach?

23/ Browne, M.A; Crump, P; Niven, S.J; Teuten, E; Tonkin, A; Galloway, T; Thompson, R. (2011). Accumulation of Microplastic on Shorelines Woldwide: Sources and Sinks. Environmental Science & Technology 45 (21), 9175-9179; and UNEP (2016) Marine plastic debris and microplastics – Global lessons and research to inspire action and guide policy change. UNEP, Nairobi.

24/ UNEP (2016) Green Energy Choices: The benefits, risks, and trade-offs of low-carbon technologies for electricity production. Report of the International Resource Panel. E.G.Hertwich, J. Aloisi de Larderel, A. Arvesen, P. Bayer, J. Bergesen, E. Bouman, T. Gibon, G. Heath, C. Peña, P. Purohit, A. Ramirez, S. Suh.

addressing these issues (see Box 6). Finding key partners for collaboration on common challenges often increases the pool of resources and solutions as well as reduces the costs of their development and implementation. Potential partners in the value chain include research institutes, customers, suppliers, financial, and local government institutions. This collaboration can multiply the shared benefits through the value chain that would otherwise not be possible for a single company acting in isolation. Collaboration for technologies for eco-innovation is especially relevant for SMEs, which lack the knowledge or resources to develop new technology. However, they can often benefit from adapting to existing technology or co-developing it through an open collaborative process as explained in Chapter 2 of this report.[25]

Box 6: Surface activation – **Sustainable innovation for used-look jeans[25]**

"Surface activation" offers eco-friendly alternative to controversial "sandblasting". Blue denim jeans are one of the most popular fashion items in the world, as reflected in the production volume of 4 billion garments per year. Another trend in jeans is the 'used look'. To achieve such a worn out appearance into new jeans, a technique called sandblasting is commonly used. It is a machine that shoots compressed air and fine silica onto the fabric for abrasion. The process poses great health hazards to garment workers leading to a high risk of lung cancer. It was officially banned in many producing countries, but due to a lack of technical alternatives, sandblasting remained a common practice is many developing and emerging economies, such as Bangladesh, Egypt, China, Turkey, Brazil and Mexico.

The development of a new technology called surface activation has the potential to replace sandblasting for good. The indigo dyestuff is removed by a combination of drum washing machines and oxidation treatments. Not only is this alternative cheaper and eco-friendlier, it also improves the wash-down process and reduces the concentration of costly and hazardous chemicals.

© Chinese Denim Factories, Inhabitat

25/ https://www.sciencedaily.com

Technology development **and transfer methods**

CHAPTER **TWO**

This chapter explores various methods of technology development and transfer[26] to implement eco-innovation within existing businesses. The methodology intends to be used by service providers supporting SMEs in implementing sustainable innovations into their core business model.

2.1 ASSESSING THE APPROPRIATE METHOD

Many mechanisms exist to develop, transfer, adapt, and disseminate technologies. Linking these to the business strategy and business model will increase the success of technologies for eco-innovation[27]. This underlines the system change approach of eco-innovation that targets all facets of a company and its value chains. Figure 3 illustrates a 6-step approach in assessing the appropriate technology development method.

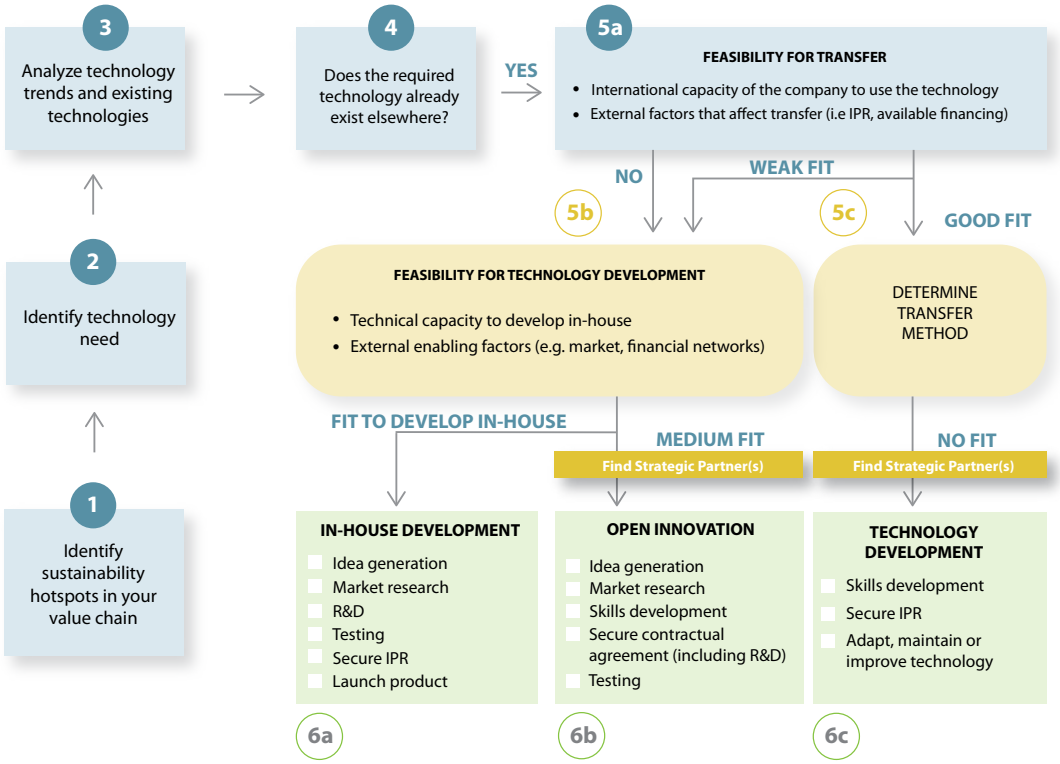
Steps to assess technology development or transfer

Identifying the right technology for eco-innovation development method is crucial for the success of the business model. Whether to develop the technology in-house, use open innovation or decide to outsource to a strategic partner to develop the technology for you, are essential decisions that need to be made in the beginning

26/ Cambridge University Press (2000): Methodological and technological issues in technology transfer: A Special Report of IPCC Working Group III. Published for the Intergovernmental Panel on Climate Change

27/ UNEP (2014)Eco-innovation Manual: Working version for pilot application. 2016; Lopez, F.J.D, and Montalvo, C. (2015). "A comprehensive review of the evolving and cumulative nature of eco-innovation in the chemical industry." Journal of Cleaner Production, Volume 102, 1 September 2015, Pages 30–43.

Figure 3: **Assessing the appropriate technology for eco-innovation development method**



of the organisational change when implementing a new business model.

If the selected technology is not adding value to the core competence of the company and internal know-how and financial capabilities do not meet the technology need, it might be more economic to outsource the activity to a strategic partner. Further, if the internal capabilities to develop the needed technology is weak, but can be built over time, an open innovation might be the right path. Thereafter, the method of technology transfer has to be decided. However, in cases where internal know-how and financial capabilities can carry the technology development and also enhance the core competence of the business, developing the technology in-house is the right strategy.

The 6-step approach can support the decision making process of developing or transferring the chosen technology for eco-innovation.

Step1: Identify sustainability hotspots in your value chain

The first step is to identify the sustainability hotspots within your value chain. These are basically the areas that could be improved in order to be more sustainable, through the use of new or improved technologies. Sustainability can be through resource efficiency, waste reduction, up-cycling waste into new products, or implementing a recycling mechanism within your value chain. Once you have identified, what measures you want to take to design your business more sustainable, you can continue to the next step.

Step 2: Identify the technology need

In the first step you have identified the area of improvement that enhances your business model. During the second step, your aim is to identify what technology is needed in order to implement the changes you have decided during the first step. Also, is it important to understand the outreach of the technology need across the entire value chain, in order not to push sustainability challenges up or down the value chain. It is important to have a holistic understanding how the technology can change your business model to the better.

Step 3: Analyse technology trends and existing technologies

Once you have identified your technology need, the research begins. As developing a new technology is very time consuming and often requires a large upfront investment, it is of outmost importance to have scanned the market carefully if the technology you need

has already been developed or a similar technology is available that can be upgraded or tweaked to fit your need. Here Intellectual Property Rights and local regulations need to be considered. Many databases exist to search for existing technologies and trends. The table below lists some of these and their application.

Box 7: Databases of **potential technologies for eco-innovation**

The **WIPO GREEN database** *is an interactive market place that allows you to search green technology products or post a technology requirement as a need. The database also lists services and intellectual property assets. Anyone with a green technology can apply to add their technology to the database and the searches are open to all.*

The **WIPO GREEN network** *helps facilitate commercial relationships and transactions by connecting green technology providers and seekers, and acts as a gateway to a range of useful services such as experts on Intellectual Property Rights from around the globe. Both the database and network can be used to connect with technology and business intermediaries, or advertise needs.*

Blogs *focused on technology for developing and emerging economies, such as the* **World Bank blog** *can provide useful information on technologies being applied in other markets around the world, which might be transferrable to your country. For example, you might search for relevant tags, such as 'environment', 'climate change', or 'social development' etc.*

Technical patents *are now searchable in online patent databases. Free-to-access databases, such as* **Espacenet**, *which includes over 80 million patents and patent applications, can be used to find solutions to existing problems or to monitor the research and development activities of companies that you are interested in. If the patent office in your country does not have an online patent database, you can always look at patents from relevant companies in other markets to get an understanding of trends and developments that might be useful for companies in your target market.*

- **National government departments for trade and industry, trade and SME associations, and chambers of commerce** *can be interesting sources of data, although their variety and quality will vary significantly from one organization to the next.*

- **Academic and private research centres** *host research groups working on relevant issues that may be relevant to eco-innovation services. Building links with key personnel at those centres can help develop an understanding of the respective interests and competencies, which will facilitate future collaborations.*

Step 4: Does the required technology exist elsewhere?

The result of step three should be an overview of existing technologies in the market and the type of technology trends evolving that could suit your technology need. Step four is the evaluation phase whether your technology need matches an already existing technology in the market or if it requires a new technology to be developed. If the answer is yes, follow to step 5a, if there is no existing technology in the market continue to step 5b.

Step 5a: Feasibility for transfer

Since there is an existing technology available in the market that could solve the technology need, analyse your internal capacities, whether the required know-how to transfer the technology exists within the company. Also, scan external factors that could affect the transfer, such as IPRs or available financing opportunities. If the result to your analysis is that the existing technology is a good fit for your company both in terms of internal capacities and external factors, continue to step 5c. However, if your analysis results in a weak fit, due to lack of internal capacities to transfer the technology and integrating it into your company, continue to step 5b.

Step 5b: Feasibility for technology development

Based on the previous steps, your decisions resulted in either no existing technology solves the technology needs or internal and external factors hinder from

transferring the existing technology to your company. Hence, a feasibility study on how to develop a technology has to be conducted. In this study among others the following questions should be answered 'Does our company have the capacities to develop the technology in-house?', 'Is it economic to develop the technology in-house compared to involving a strategic partner?', or 'Does the effort to develop the technology in-house benefit our core business?'. According to the results of the feasibility study, if the in-house development seems to be the best fit continue to the last step 6a, ***In-house Development***. In case, the feasibility study resulted in in-house development not being the most economic or value added solution, continue to step 6b, ***Open Innovation***.

Step 5c: Determine transfer method

The previous steps have resulted in the decision that there is a suitable technology in the market that is fit to be transferred to your company. Therefore, the method of transfer has to be determined, that supports a smooth and timely integration of the technology. Once the method of transfer is chosen, continue to step 6c.

Step 6a: In-house development

Developing a technology in-house is a time consuming decision, requiring many brainstorming sessions to create a feasible idea on how to develop the technology including intense desk research, investment into R&D, a testing phase, securing IPR and finally launching the product. However, the returns of a customized technology solution can have tremendous benefits to the core competences of the company and create a competitive advantage, increasing the overall competitiveness of the company in the market.

Step 6b: Open innovation

Open innovation is a suitable approach, if internal capacities are not fit to develop the technology independently, but sufficient to cooperate with strategic partners on a technology solution together. Section 2.4.1 explains open innovation in more detail.

Step 6c: Technology transfer

During the technology transfer, the company should develop the needed skill set to integrate the technology that is being transferred, secure the IPR as well as adapt, maintain or improve the technology if necessary.

2.3 ASSESSING THE COMPANY'S CAPACITY TO DEVELOP OR ADOPT TECHNOLOGIES

A number of tools exist that can help assess the technological readiness of a company. This is relevant both in the cases of transfer (i.e. if the company has the relevant capacity to use and maintain the technology), and development (i.e. if the company has the necessary capacity to develop.) A technological audit can be carried out to evaluate the capacity of the company to integrate new technologies, work with technological partners and better define what they need to successfully bring these technologies into the company[28]. Some tools for auditing and planning are listed below:

- The **Technology Audit Survivors Guide**[29]
- The **Guidebook for Developing an Effective Instructional Technology Plan**[30]
- The **Water SDG Toolbox**[31]

Companies with comparable technologies may adapt their business models so they can take advantage of their organizational strengths. For example, a company positioned downstream in a value chain will be more able to introduce a consumer-facing product compared to those situated upstream. In addition, it is essential to understand realistic options for accessing finance and legal protection of ideas, which may impact whether to develop innovations in-house or outsource.

This is also a consideration for whether the company should make its own components or products or buy from a sub-contractor. Outsourcing can increase flexibility and opportunities to learn. However, companies also run a risk of losing knowledge, quality, control, and design for manufacture. Overall, the focus should be on helping to make the most of the business strengths and opportunities, by retaining core competences and outsource activities not related to the core business that could be optimized by external parties.

28/ INNOREGIO (2000): dissemination of innovation and knowledge management techniques by Dr Vassilis Kelessidis Thessaloniki Technology Park

29/ National Center for Technology Planning, 2004. Accessed online at: http://www.nctp.com/survivor_sample.pdf

30/ National Center for Technology Planning, 2004. Accessed online at: http://www.nctp.com/guidebook.cfm

31/ UNWater. 2014. WASH Toolbox. Accessed online at: http://watersdgtoolbox.org/

2.4 TECHNOLOGY DEVELOPMENT

In the eco-innovation process, mapping the full value chain of the company to include all key stakeholders of a product's life cycle is necessary. This enables the company to identify key sustainability hotspots[32] and potential partners that may be affected by the same problem and can help its mitigation through a mutual beneficial common solution. One appropriate mechanism when collaborating with partners for technology development is ***Open Innovation***. The concept of open innovation dates back to the 1960s, but has recently been defined as "a distributed innovation process based on purposively managed knowledge flows across organizational boundaries, using pecuniary and non-pecuniary mechanisms in line with the organization's business model"[33]. The idea behind the concept is for companies to collaborate and exchange their research, using already existing innovation through, for instance, licensing, instead of depending solely on own research.[34]

32/ See UNEP Eco-innovation Manual: Value Chain Pressures Tool and Life cycle stakeholders tool

33/ Chesbrough, H., & Bogers, M. 2014. Explicating open innovation: Clarifying an emerging paradigm for understanding innovation. In H. Chesbrough, W. Vanhaverbeke, & J. West (Eds.), New Frontiers in Open Innovation: 3-28. Oxford: Oxford University Press. Page 17.

34/ Chesbrough, Henry William (2003). "The era of open innovation". MIT Sloan Management Review. 44 (3): 35–41.

The second approach to collaboratively develop technology is ***Open Sourcing.*** It refers to an accessible technology designed to be amended or improved by the user of the technology[35]. In the following section various examples are given of companies using open innovation and sourcing mechanisms to develop their technologies.

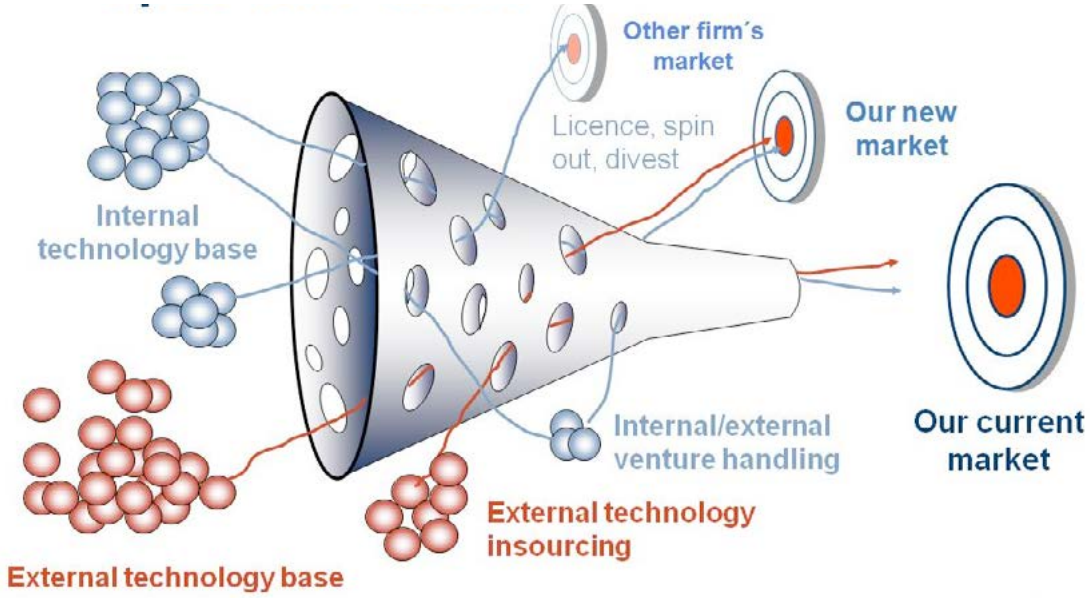
2.4.1 OPEN INNOVATION AND OPEN SOURCING

When there is a medium fit between a firm's core competencies and capabilities and the market opportunities, open innovation can be a good method for developing technologies for eco-innovation. Open innovation and open sourcing have been proven to be effective in their development and dissemination.[36] Open innovation seeks ideas from inside and outside the organisation to advance in the technology aspects of the innovation process. It has therefore two dimensions; (1) the external ideas and technologies that are brought into the company's own innovation process and (2) the un-used and under-utilized ideas and technologies from the company that are incorporated into others' innovation

35/ Open Source. 2017. https://opensource.com/. [ONLINE] Available at: https://opensource.com/resources/what-open-source. [Accessed 9 March 2017].

36/ UNEP Risø Centre (2011) Diffusion of renewable energy technologies: case studies of enabling frameworks in developing countries. Technology Transfer Perspectives Series. Edited by Haselip, J., I. Nygaard, U. Hansen & E. Ackom.

Figure 4: **Open Innovation and Open Sourcing**



Source: Professor Henry Chesebrough UC Berkely: Open innovation: Renewing Growth from Industrial R&D, September 2004

processes[37]. It typically involves some share in risk as well as reward between organizations and external partners. Figure 6 shows how technology can either go into a company's development pipeline or how the company can spin out technology that is not central to its business. The key aspect of the figure is that the boundary of a company (the cone leading to the product development pipeline) is porous and allows ideas and innovations to come in and out[38].

Open innovation fits with inherent features of SMEs as they tend to have more flexibility to innovate while offering a more cost-effective option compared to in-house development. Through this mechanism, expertise can be sought from outside, retaining and building on the company's key competencies. Opportunities for open innovation are growing as firms increasingly value collaborative partnerships. There are an increasing number of platforms giving opportunities for engaging in open innovation.[39,]

Box 8: Example 1 – Open Innovation: **Regional Connect offers a regional innovation platform in Africa**

Regional connect supports Open Innovation by offering organisations opportunities for cooperation and collaboration, ensuring the availability of ideas for developing new and improved products, services and solutions, as well as possibilities for entering new markets. Private organisations, government agencies, and non-profits can publish "Challenges" on the Regional Connect Open Innovation platform. "Challenges" are descriptions of real business needs that require innovative solutions. The Regional Connect platform offers the solution seekers with access to what is believed to be the largest innovation database of solution providers in Africa, managed by the Research Institute for Innovation and Sustainability (RIIS).

Box 9: Example 2 – Open Innovation: **iNNpulsa, Colombia[39]**

iNNpulsa is a government-funded open innovation programme created to support and promote business growth through open innovation. The programme is open to Colombian companies to publish their challenges, sharing them with the general public and other companies in order to co-create solutions. This approach aims to share challenges and ideas to achieve the best results and create a supportive business growth environment in the country. Thus, it is breaking away from the traditional mind set of innovating behind closed doors and facing challenges alone. The programme identifies innovators willing to create collaborative agreements with leading companies to implement solutions and consequently, through collaborative innovation, grow together.

Open innovation has also been facilitated by recent trends that allow a ***democratization of production***. So-called "makers" and "do-it-yourself" spaces provide laboratories, production facilities, and educational opportunities to the public. They are increasingly common, giving access to new technology and tools such as 3D printing, facilitating the development (including testing and prototyping) of new solutions. By democratizing access to these tools, the cost of developing new solutions can be relatively low compared to the investment needed to pursue these methods on an individual basis.[40]

Typically, the open innovation process has four main activities[41]:

1. **Want** = define what we want and how we can innovate	Technology intelligence
2. **Find** = find technologies and partners to work with	
3. **Get** = negotiate the agreement with the external partner	
4. **Manage** = manage the relationship throughout the collaboration	

Engaging in open innovation and collaborative approaches

37/ Chesbrough, H. 2011. "Everything you need to know about open-innovation." Forbes. 21 March 2011.

38/ Gotro, J. (2010). Keys to Innovation; Utilize Open Innovation. November 23, 2010. Accessed at: **http://polymerinnovationblog.com/keys-to-innovation-utilize-open-innovation/**

39/ http://oiregionalconnect.com/

40/ Barjarin, T. (2014, May 19). Why the Maker Movement is Important to America's Future. Retrieved July 8, 2014, from Time Magazine: **http://time.com/104210/maker-faire-makermovement/**; Gershenfeld, N. (2005). FAB: The Coming Revolution on Your Desktop--From Personal Computers to Personal Fabrication. New York, NY: Basic Books;

41/ Mortara, L. (2010) 'Getting help with open innovation', a report by the Centre for Technology Management, University of Cambridge Institute for Manufacturing

requires an on-going gathering of 'intelligence' on technologies for eco-innovation (Table 1).

An open innovation process can be managed internally by a firm, but requires an investment in building the necessary capabilities in-house. This is only worth doing if open innovation will be used on a regular basis. The alternative is to use business intermediaries as brokers of open innovation. This has the advantage of drawing on the business intermediaries' capabilities and contacts. As an intermediary, it is important to be clear what these capabilities and networks are and why they may be of value to the client firm. These networks are important for a variety of stakeholders (technology firms, business intermediaries, government, investors etc.), enabling parties with different interests to come together.

The process of open innovation may raise various Intellectual Property Rights concerns, which can be handled through a practice known as 'open sourcing'. It is a collaborative mode of production, testing and distribution, often involving volunteers and where patents and related research are shared publicly through platforms like Eco-Patent Commons (Box 15). IPR is handled by using licenses, either General Public License or Creative Commons License[43]. An example is Cesar Harada, who open sourced a highly flexible boat that he designed to help soak up large tracts of oil following the BP Gulf of Mexico spill. One way of stimulating progress on ***open innovation*** has been through the creation of prizes to seek solutions to particular problems for which the sufficient market demand does not necessarily exist, such as those detailed in Box 17 below.

Box 10: Example 1 – Open Sourcing: **Eco-Patent Commons** [44]

In 2008, the World Business Council for Sustainable Development (WBCSD) launched the Eco-Patent Commons[45], a new technology-sharing initiative, in 2008. It encourages companies to donate patents for inventions, which, while not essential to their own business development, provide "environmental benefits." These are published on a searchable website, and made available for use by anyone free of charge. Companies only need to pledge one patent to join the Commons. Among the first patents to be donated were a recyclable protective packaging material for electronic components from IBM, and mobile phones recycled into calculators and personal digital assistants from Nokia. In another example, Xerox has pledged patents that cover a process that cuts the time it takes to remove toxic waste from soil and water from years to months, as well as a patent that covers technology that makes magnetic refrigeration less harmful to the environment.

42/ Kerr, C.I.V., L. Mortara, R. Phaal and D.R. Probert (2006). A conceptual model for technology intelligence. International Journal of Technology Intelligence and Planning 1, 73-93

43/ Licensing refers to an agreement whereby an owner of a technological intellectual property (the licensor) allows another party (the licensee) to use, modify, and/or resell that property in exchange for a compensation (consideration). The legal ownership of the Intellectual Poperty remains with the licensor.

44/ World Intellectual Property Organisation. 2009. WIPO Magazine, April 2009 Edition No.2. "Patent Pools". Accessed online at: http://www.wipo.int/export/sites/www/wipo_magazine/en/pdf/2009/wipo_pub_121_2009_02.pdf

45/ http://www.wbcsd.org/work-program/capacity-building/eco-patent-commons.aspx

Table 1: **Gathering 'intelligence' on technologies for eco-innovation**[42]

	Internal sources	External sources
Need still undefined	Trawl – Making explicit the intelligence information already in-house which is not yet formalised	Scan – Keeping abreast of technology developments that could impact on the business
Need defined	Mine – Extracting explicit intelligence information from an internal repository	Target – Monitoring the development of new technologies identified as relevant for the future

Box 11: Example 2 – Open Sourcing: **Cesar Harada**[46]

Protei's flexible sailing boat was developed by Cesar Harada in response to the need to clean up large tracts of oil in the ocean, following the BP Gulf of Mexico oil spill in 2010. The sailboat's design has been steadily refined through Protei's open source hardware approach, whereby everyone is free to use, modify, and distribute its product design and use. In return, the only requirement is that users credit Protei with the idea and share their own improvements with the community. This approach has resulted in rapid prototyping of the technology's iterations across the world through the growing network of its users who build on and share their progress. The underlying philosophy of the organisation is to flip the traditional business priorities upside down, putting environment at the top and profit at the bottom. This places value on a company's long-term sustainability while also facilitating faster development of technologies for sustainability.

Box 12: Example 3 – Open Innovation: **Prize competitions**

X-Prize is a foundation with a mission to bring about radical breakthroughs for the benefits of humanity, thereby inspiring the formation of new industries and the revitalization of markets. The prize mechanism enables teams from all over the world to compete for a financial reward for solving a specific challenge. For example, the Progressive Automotive X Prize (USD 10 million) inspired a new generation of super fuel-efficient vehicles.

Ashoka Change-makers is an enabling platform for a network of worldwide social entrepreneurs aiming to allow everyone to become a change-maker. Their platform hosts numerous open innovation competitions typically aimed at solving problems in sustainable development. This is done through joint partnerships with companies such as Unilever and the Lego Foundation.

2.4.2 IN-HOUSE DEVELOPMENT

If the decision has been made to develop technologies in-house, eco-innovation would be more successful in tandem with the organizational changes required to support the process[47]. Firms tend to do poorly when they try to innovate within the same structure and apply the same management processes that are used for day-to-day activities. Hence, it often helps to form a separate innovation team, which operates outside of the normal organisational hierarchy.

Numerous methods have been used for in-house technology development. Commonly used is process-oriented techniques based on total quality management and continuous improvement processes, which are the basis for ISO 9000, lean manufacturing and six sigma methods. Six Sigma, for example, which was developed by Motorola in 1986 and later adopted by others like General Electric, creates a special infrastructure of people within the organisation (Champions, Black Belts, Green Belts, Yellow Belts, etc.) who are experts in these methods. While it does result in performance improvements, these methods are often used to improve existing technologies, rather than developing something new.

Another approach for in-house technology development is the Stage Gates method, which is effectively a planned experiment (see Box 13). Each phase can be built into the roadmap for eco-innovation including a gate with a go/no go/hold/re-try decision point. This is determined by checking high level deliverables from the previous phase against a set of success criteria like strategic fit, product and competitive advantage, market attractiveness, technical feasibility, synergies or core competencies, financial risk or reward. A detailed explanation of the 6 phases and their activities are given in the "Eco-I Manual – Eco- innovation implementation process".

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Box 13: The 6 Phases of **Eco-Innovation**

Phase 1 – Prepare
Identify the right market for the eco-innovation technologies. Pre-work designed to discover and uncover business opportunities and generate new ideas.

Phase 2 – Set Strategy
Get ready for the preliminary assessment. Quick and inexpensive preliminary investigation and scoping of the project – largely desk research.

Phase 3 – Set Business Model
Understand in more detail the performance of the company through in-depth assessment. Detailed investigation involving primary research – both market and technical – leading to a business model, including product and project definition, project justification, and the proposed plan for development.

Phase 4 – Build Roadmap
The actual detailed design and development of the new product and the design of the operations or production process required for eventual full-scale production. The main activities are building a roadmap, in which to define and prioritize the requirement of the new project.

Phase 5 – Implement
Create a project plan and get it approved. Tests or trials in the marketplace, lab, and plant to verify and validate the proposed new product, brand/ marketing plan and production/operations.

Phase 6 – Review
Commercialization – beginning of full-scale operations or production, marketing, and selling. Review the performance of the operations and evaluate the project.

Whenever proposing a staged process for technology development it is important to recognise that being innovative means being creative in a commercially applicable setting. Therefore, while a method like eco-innovation can be useful when companies are looking for a procedure for technological innovation, this can also inhibit the creative process. Hence, firms using this approach for technologies for eco-innovation must also remain open to unforeseen opportunities and unexpected findings. A key part of the process is continuous learning and challenging previously held assumptions. Business intermediaries can play a valuable role in stimulating this creativity and experimentation.

As mentioned in Chapter 1, if the company wishes to commercialize the technology, it is important to select an appropriate target market, otherwise it will lack impact and therefore the ability to contribute to sustainability. An alternative approach to learning about the market is the 'lean start-up', based on the principle of early trial and rapid adaptation (see Box 14). During this trial and adaptation process, business intermediaries can be helpful in assisting companies to test prototypes with their customers and other stakeholders, in order to gain input and feedback on their proposed solutions.

Box 14: Lean **Startup**[48]

The Lean Startup movement draws on the lean manufacturing method pioneered by Toyota and can be applied to innovative ventures whether in existing or new firms. The essential ideas are:

Customer development not product development – Get out of the office and talk to people who will use your product. Don't build things until you know what people want it and why.

Build, measure, learn – When you build a product, include ways to get feedback from actual use so you can improve your offering.

Pivot – If it's not working, try a new approach and start again.

Participatory design can be also a way to overcome potential entry barriers for a new technical solution. This means involving potential stakeholders while the innovation is still being developed, thereby anticipating objections as they emerge and prior to full-scale production (see Box 15). Where technologies for eco-innovation are being transferred from one country to another, this can be critical to ensure the adoption of the technologies beyond the early pioneers. Where eco-innovation requires behavioural change, education of stakeholders will also be essential.[48]

48/ http://theleanstartup.com/

Box 15: Viridian Solar – **An example of participatory design**[49]

Viridian Solar is a UK company that was set up to redesign solar thermal panels, initially for the UK market. Their ideal future customers were property developers with new housing developments. However the construction industry was known to be conservative, especially regarding new technologies.

The founders of Viridian decided to form a consortium of their future potential customers. These customers all committed to offer feedback as Viridian redesigned the solar thermal panels. Initially, Viridian anticipated this interactive design and feedback process would take 6 months, but it took more than twice as long. However, the consortium provided valuable input, including the need to design for ease of installation so that construction workers would not require specialized training or significant additional time to install the panels. Once the product was launched, Viridian was able to rapidly deploy their product to customers in the consortium, as consortium members had already had their concerns addressed.

2.5 TECHNOLOGY TRANSFER

When the fit between a firm's core competencies and the market opportunities for development of a unique technology are weak, technology transfer is usually the most appropriate method for the adoption of technologies for eco-innovation. Several ways exist to classify technology transfer methods. For example, the OECD distinguishes between embodied technology transfer, that comes through import of equipment into a country and disembodied technology transfer, which refers to the flow of know-how or experience.[50] This can also be referred to as formal or informal channels of transfer.

Another way is to categorize technology transfer into market or non-market methods (Table 2), of which market channels are usually the most significant. Some transfers occur between willing partners in voluntary transactions, but many take place through non-market transactions or spill overs.[51]

49/ Viridian Solar. 2017. http://www.viridiansolar.co.uk. [ONLINE] Available at: http://www.viridiansolar.co.uk/index.html. [Accessed 9 March 2017].

50/ OECD (2009) Policies for the Development and Transfer of Eco-Innovations: Lessons from the Literature. Prepared by David Popp, OECD Environment Working Papers, No. 10, OECD Publishing.

51/ Hoekman, B. & B.S. Javorcik (2006) Global Integration and Technology Transfer. Palgrave MacMillan, London; UNEP Risø Centre (2012) Overcoming Barriers to the Transfer and Diffusion of Climate Technologies. Guidebook prepared by Boldt, J., I. Nygaard, U. E. Hansen & S. Trærup.

Figure 5: **:Growth of licensing payments: 1990-2006**

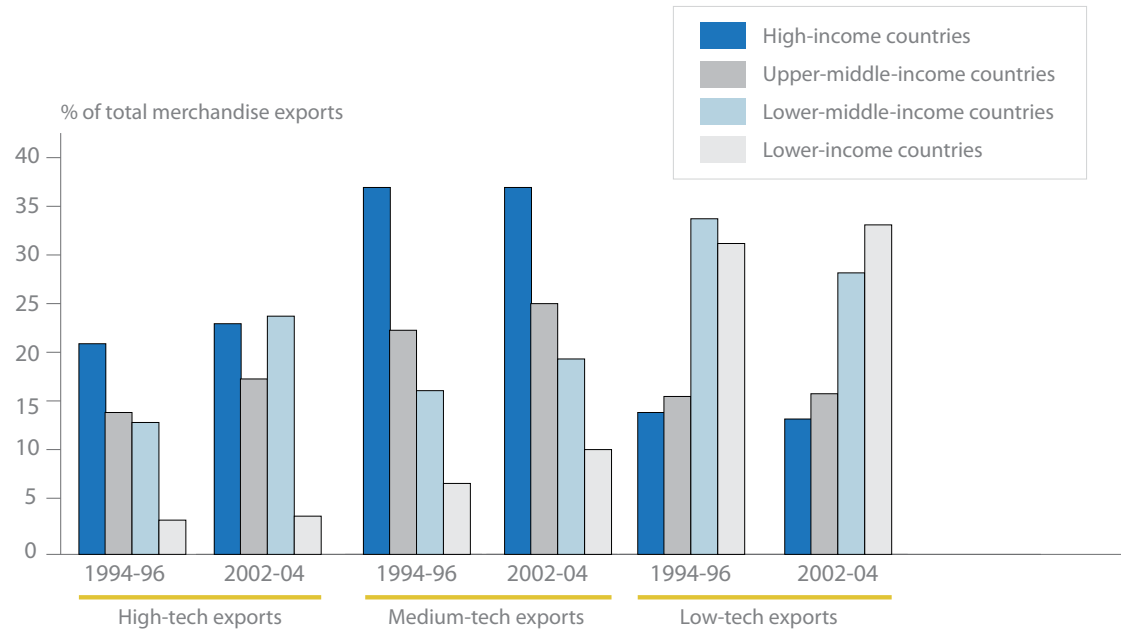

Table 2: **Methods of market and non-market based eco-innovation technology transfer**[51]

Method	Description	Example
Market based mechanisms		
International Trade	Technology is embodied in the goods being traded	Importing hybrid-electric vehicles or fuel cells
Foreign Direct Investment	A multinational invests in a local plant, facility or subsidiary	Investment in a new wind energy plant in a developing country
Licensing or sub-contracting	Technology is licensed to a local firm for use in their market	LanzaTech's solid waste to biofuel technology has been licensed to India
Joint-venture	Organisations join contractually to share profits and losses	A carbon software developer joins with a green certification firm
Fee-for-service	A technical consultancy addresses a specific technological challenge	Sagentia developed the M-PESA mobile payments solution for Vodafone.
Franchise	Technology is linked to a central brand and marketing system	Ecowash Mobile offers franchises for its waterless car wash concept
Carbon Finance	Low carbon solutions are given preferential finance or carbon credits	Carbon Clear is a carbon offsetting company based in the UK.
Non-market based mechanisms		
Concession	Exclusive operational use is granted for public-owned assets	A fertiliser company is allowed to operate part of an effluent facility
Spin outs	Transfer of knowledge from a parent organisation to the spinout	A solar firm in one country spins out a company to focus on other markets.
Development aid	Development agencies and charities sponsor technologies	An international organization donates metals recycling technology
Collaborative research	Universities collaborate on R&D with commercial partners	3D printing technology is being brought to market this way.
Deployment of staff	Scientific and technical personnel can be exchanged or recruited	Green chemistry experts are recruited by strategic industries

Many middle-income emerging economies tend to adapt to tested and verified technologies developed elsewhere. This is mainly due to the fact that no R&D investment and trial phases are incurred and an economic benefit through imitation can be achieved[52]. Licensing is a key source of technology transfer for these countries. Currently, low-income countries are associated with low-tech exports, in contrast to the high-tech exports of developed countries (see Figure 5)[53]. High-tech innovation – state-of-the-art and cutting-edge technology – is not absent from low-income countries, but tends to be concentrated in higher education institutions or multinational corporations. Consequently, emerging and developing economies are more likely to be involved in technology transfer than technology development.

52/ Naudé, Wim, Adam Szirmai, and Micheline Goedhuys. Innovation and entrepreneurship in developing countries. UNU, 2011.

53/ World Bank (2008), Global Economic Prospects: Technology Diffusion in the Developing World, Washington, DC.

Whichever form of technology transfer a company chooses, it will have to weigh up the cost of that choice, such as the growth potential and marketability of a licensed product/process[54]. As discussed in chapter 1, the absorptive capacity of the company will also determine the efficacy of the transferred technology. Companies should therefore perform an effective assessment and evaluation prior to transferring technology.

2.5.1 MARKET-BASED METHODS

Among the market-based methods, research shows that the bulk of technology transfer is in the form of international trade, foreign direct investment and licensing[55]. Foreign Direct Investment is seen as potentially one of the most important and the cheapest channel of direct technology transfer as well as of indirect knowledge spill overs to host countries. As such depending on the level of human capital and absorptive capacity in the host country, FDI can have a positive impact on economic growth[56]. Licensing fees, especially those paid by low and middle income economies, are also a popular method, having increased from USD 7.2 billion in 2000 to USD 58.4 billion in 2014[57] While these methods of market-based transfers are often between developed and emerging economies, they are increasingly also occurring between emerging economies (see Box 16).

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54/ UNCTAD (2014). "Transfer of Technology and Knowledge Sharing For Development: Science, Technology and Innovation Issues for Developing Countries." New York and Geneva.

55/ ICSTD & UNCTAD (2004) Encouraging International Technology Transfer. ICSTD/UNCTAD Issue Paper, No. 7, UNCTAD-ICSTD Project on IPRs and Sustainable Development. Prepared by K.E. Maskus.

56/ Borensztein, E., J. De Gregorio & J.W. Lee (1998) How Does Foreign Direct Investment Affect Economic Growth? Journal of International Economics, 45: 115-135.

57/ World Bank (2016). World Bank Data accessed online at http://data.worldbank.org/

58/ World Economic Forum (2013a) Achieving the New Vision for Agriculture: New Models for Action. A report by WEF's New Vision for Agriculture initiative in collaboration with McKinsey & Co.

59/ SS-GATE (2010) 2010 SS-GATE Convention held in Shanghai. Report of the South-South Global Assets and Technology Exchange (SS-GATE).

Box 16: LanzaTech & Jiangsu Redbud Textile Technology – **South-South technology transfer**

LanzaTech *has been running a 100,000-gallon demonstration plant in China producing ethanol from carbon monoxide emitted by a steel plant. Two additional plants, each capable of producing 30 million gallons of ethanol, were planned in China and LanzaTech's technology has been licensed to India for the conversion of solid waste into biofuel. In this case, the process was innovated to align with a circular economy or closed loop design objectives.*[58]

Jiangsu Redbud Textile Technology *entered into a technology transfer agreement to promote jute fibre green technology in China and Benin. The company has developed and tested new varieties of jute, which are well adapted to wastelands, saline ground, low-lying wetlands and drought conditions. A collaborative platform, SS-GATE, introduced this technology into Africa, building a 'green jute industrial park' to strengthen technical cooperation. The product was innovated to fit environmental conditions, and the institution created a collaborative space for innovation.*[59]

2.5.2 NON MARKET-BASED METHODS

Non-market based methods of technology transfer can include the gleaning of information from reverse engineering products, analysing patent applications, attending trade shows and conferences, reviewing published literature (e.g. technical journals) and taking advantage of 'spill over' effects by engaging former employees of technology companies.[60]

A popular non-market based method, especially in emerging and developing economies, is international collaborative research, as illustrated in the case of biomass gasifier technology in India and Nigeria (see Box 17)

60/ IDEA Consult, VITO, DTI, REC & Ecorys-UK (2012) The Development and Diffusion of Environmental Technologies: Technology Transfer, Knowledge Flows and International Cooperation. Report for the European Commission.

61/ IDEA Consult, VITO, DTI, REC & Ecorys-UK (2012) The Development and Diffusion of Environmental Technologies: Technology Transfer, Knowledge Flows and International Cooperation. Report for the European Commission.

62/ Based on interviews conducted with the intermediary, TERI, by the author. See Annex A for further details.

63/ http://cava.nri.org/. Interviews with Richard Coles & Christopher Thorpe, Emagine, Ben Bennett, University of Greenwich, and Kolawole Adebayo from C:AVA in Nigeria.

Box 17: International collaborative research – **Examples from India and Nigeria**

Indian Biomass Gasifier - The transfer of a two-stage biomass gasifier technology to rural India involved collaboration between The Energy and Resources Institute, the Technical University of Denmark and Sorena Sa[61]. Long-term financial support came from the Swiss Agency for Development and Cooperation (SDC) and the Government of India through a subsidy scheme. Capacity building and training of the manufacturer, local service delivery agents, operators and village level institutions were crucial to ensure the project's success. Equally, the experience of international partners like the Technical University of Denmark on similar projects was essential.[62]

The Cassava: Adding Value for Africa Project (C:AVA) – C:AVA has developed value chains for high quality cassava flour in Ghana, Tanzania, Uganda, Nigeria and Malawi to improve the livelihoods and incomes of at least 90,000 smallholder households as direct beneficiaries including women and disadvantaged groups. C:AVA is led by the Natural Resources Institute of the University of Greenwich, working with a variety of local partners in each of these countries. In the case of Nigeria, C:AVA's partners are the Federal University of Agriculture Abeokuta, FUNAAB and the Bill and Melinda Gates Foundation. Benefits realised include an improved flour to fuel ratio from 3.3 kg/l to 60.7 kg/l.[63]

One common thread through all of these methods for the development and transfer of technologies for eco-innovation is that they tend to be iterative in nature, i.e. the technological solution and transfer approach are usually the result of experimentation and several rounds of improvement. Technology adoption within the eco-innovation process must be open to continual modification to be successful under local conditions. A good example of this is a rice husk gasification project in Vietnam (see Box 18).[64]

Box 18: SPIN **rice husk gasification project in Vietnam**[64]

A Sustainable Product Innovation Project (SPIN) in Vietnam introduced biomass gasification technology using rice husks and other locally available crop residues as a feedstock for domestic stoves and SME applications. The gasifier stove has gone through several iterations of improvement to improve on the usability, quality, efficiency, and cost effectiveness of both production and use. The result has been 11 household and 7 industrial versions of the product. While no one version has proven to meet all requirements of all users, the best model for various contexts has been developed and is now in the process of being commercialized.

2.6 THE INTELLECTUAL PROPERTY RIGHTS (IPR) PROCESS

For any of the aforementioned methods or technologies for eco-innovation it will be necessary to establish how to manage the Intellectual Property Rights (IPR). In the case of technology transfer through market methods, the IPR is traditionally negotiated with the developer/licensor. In the case of collaborative development of technology, the ownership of IPR would still need to be agreed with the other partners and usually forms part of the partnership contract. In the case of in-house development, depending on how the technology is to be used, the protection of the Intellectual Property may be necessary to recover upfront investment for the technology development. As mentioned in box 7 in chapter 2, the WIPO Green website has a roster of experts that can provide support services on Intellectual Property Rights[65].

2.7 FINANCING FOR TECHNOLOGIES FOR ECO-INNOVATION

Funding is a key enabler to technologies for eco-innovation, as firms often face high upfront investment. A number of opportunities exist for potential financing. These include new approaches to financing sustainable development, especially with SMEs, including impact or mission-driven investments, corporate social responsibility (CSR) investments by corporations, community development venture capital funds, and

64/ Based on interviews conducted with the Vietnamese NCPC by the author. See Annex A for further details.

65/ https://webaccess.wipo.int/green/

special lenders[66] (e.g. responsible investment funds, green funds, ethical investment indexes). A few examples are the Triodos Bank with its global Sustainable Pioneer Fund, the Brazilian Stock Exchange (Bovespa) Sustainability Index and Japan's ODA loans to India targeting environmental and climate change resilient projects.

The Climate Technology Initiative's Private Financing Advisory Network (PFAN) provides pro bono support to technology development in the clean energy sector and links developers with investors. PFAN[67] operates similar to a start-up incubator, as they identify 'promising' projects at an early stage and provides mentoring for development of a business plan, investment pitch, and growth strategy, significantly enhancing the possibility of financial closure.

Equity finance[68], such as venture capital, used to be dominated by investments in developed countries, but new funds are increasingly targeting emerging and developing economies. An example is Jacana Partners, a pan-African private equity firm founded by UK entrepreneurs who invest in African SMEs. Other firms, such as U.S. Gray Ghost Ventures invest heavily in Indian entrepreneurs. Venture capital specifically targets high-risk entrepreneurial ventures with the potential for high growth and significant financial rewards. Other than the traditional investments, new fintechs, peer-to-peer lending as well as crowdfunding platforms (e.g. Kickstarter), increasingly invest in new, innovative and sustainable business ideas (see Box 19).

Box 19: The phenomenon of **crowd funding**[69]

Crowd funding has emerged as a new financing model. Instead of relying on wealthy individuals and institutional investors making large financial commitments, it seeks small financial commitments from a large number of people i.e. the crowd. There are three general models – reward based, debt based and equity based. These platforms are typically more suited to new ventures, but increasingly support a range of initiatives. As an example, SunFunder (www.sunfunder.com) is dedicated to using the power of the crowd to fund solar installations for the 1.3 billion people who live without electricity. Other crowd funding platforms include www.kickstarter.com and www.indiegogo.com, which are open to anyone who can get online. Thundafund has recently begun operations in South Africa. Some North American and European crowdfunding platforms are servicing specific regions or industries where crowdfunding platforms are not yet active.

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66/ Versetti, A. (2015). Presentation at Global Network Conference on Resource Efficient and Cleaner Production, Thursday, 15 October 2015, Davos, Switzerland. World Resources Forum.

67/ http://www.cti-pfan.net/about

68/ Equity finance is essentially the sale of a stake in a company to raise funds to put into the company.

69/ http://allafrica.com/stories/201408050278.html

CHAPTER **THREE**

Challenges and Policy Responses for **Technologies for Eco-innovation**

This chapter gives an overview of the different factors important in setting a more favourable context for technologies for eco-innovation. The chapter is intended for policy-makers, RECP service providers, and other business intermediaries working with companies and government agencies to develop, transfer, or adopt technologies for eco-innovation.

Five commonly encountered challenges, summarised in table 3.1, can either inhibit or enable the development, transfer, or adoption of technologies for eco-innovation. Some challenges are specific to technologies, value chain or industry, such as the remoteness of infrastructure and high upfront costs to renewables. Other challenges are more country specific and relate to administrative, regulatory, market and socio-cultural conditions.[70]

70/ IEA (2011) Deploying Renewables in Southeast Asia: Trends and potentials. Report for the International Energy Agency by Samantha Ölz and Milou Beerepoot.

Table 3: **Challenges and their impact on TECHNOLOGIES FOR ECO-INNOVATIONs**

	Challenges	Impact on technologies for eco-innovation
3.1	Institutional capacity	Determines how well enabling factors can be created or function individually and as a whole
3.2	Market demand	Determines the level of investment in, and development of, technologies for eco-innovation according to local market signals
3.3	Absorptive capacity	Determines to what extent companies and individuals can create, learn, adapt, or use technologies for eco-innovation
3.4	Intellectual property rights	Determines whether the development of technologies for eco-innovation is incentivized or hindered
3.5	Access to funding	Determines the ability to invest in technologies for eco-innovation or scale up

Policy measures can help to overcome these factors by positively influencing social practice, consumption patterns, production systems, sustainable and competitive business strategies and business model innovation[71]. A full review of the role of policy in technologies for eco-innovation is further elaborated in the report ***"Mainstreaming Sustainable Production and Consumption Policies for Eco-innovation"***. However, the following sub-section of this chapter looks at commonly encountered challenges specific for technologies for eco-innovation[72]. It is important to acknowledge that each of the key factors and their responses cannot be understood or dealt with in isolation. They are often linked to the technological gaps and therefore need to create the right context for technologies for eco-innovation.

3.1 STRENGTHENING INSTITUTIONAL CAPACITY

Innovation and technology development arise from a complex set of relationships among institutions and actors, including businesses, universities and research institutes, and government[73]. This system is different in each country and influenced by the national policy and institutional context. Governments can play an important role in creating a system that supports these various relationships. This encompasses what is often referred to as "institutional capacity"[74] and its strength or weakness in a country as a key factor in the development, transfer, and adoption of technology in a given context.

When institutional capacity is weak, the development of technologies for eco-innovation can be hampered by, for example, cumbersome administrative and transactional inefficiencies that add prohibitive costs in terms of time and resources, especially for SMEs[75]. In addition, a lack of integration and coordination between various government departments, functions, and policy initiatives may result in even well intentioned instruments being misaligned and ineffective.

71/ IDEA Consult, VITO, DTI, REC & Ecorys-UK (2012) The Development and Diffusion of Environmental Technologies: Technology Transfer, Knowledge Flows and International Cooperation. Report for the European Commission; OECD (2009) Policies for the Development and Transfer of Eco-Innovations: Lessons from the Literature. Prepared by David Popp, OECD Environment Working Papers, No. 10, OECD Publishing; OECD (2010) Environmental Policy Design Characteristics And Technological Innovation: Evidence From Patent Data. Environment Working Paper No. 16 by Johnstone, N., I. Haščič & M. Kalamova; OECD (2010d) Working Party On Global And Structural Policies, Climate Policy And Technological Innovation And Transfer: An Overview Of Trends And Recent Empirical Results. Report for the Environment Directorate, Environment Policy Committee; UNEP & EC (2012) Global Outlook on Sustainable Consumption and Production Policies: Taking action together; UNEP Risø Centre (2011) Diffusion of renewable energy technologies: case studies of enabling frameworks in emerging economies. Technology Transfer Perspectives Series. Edited by Haselip, J., I. Nygaard, U. Hansen & E. Ackom; Miedzinski et al (2013). Assessing Environmental Impacts of Research and Innovation Policy. Study for the European Commission, Directorate-General for Research and Innovation, Brussels.

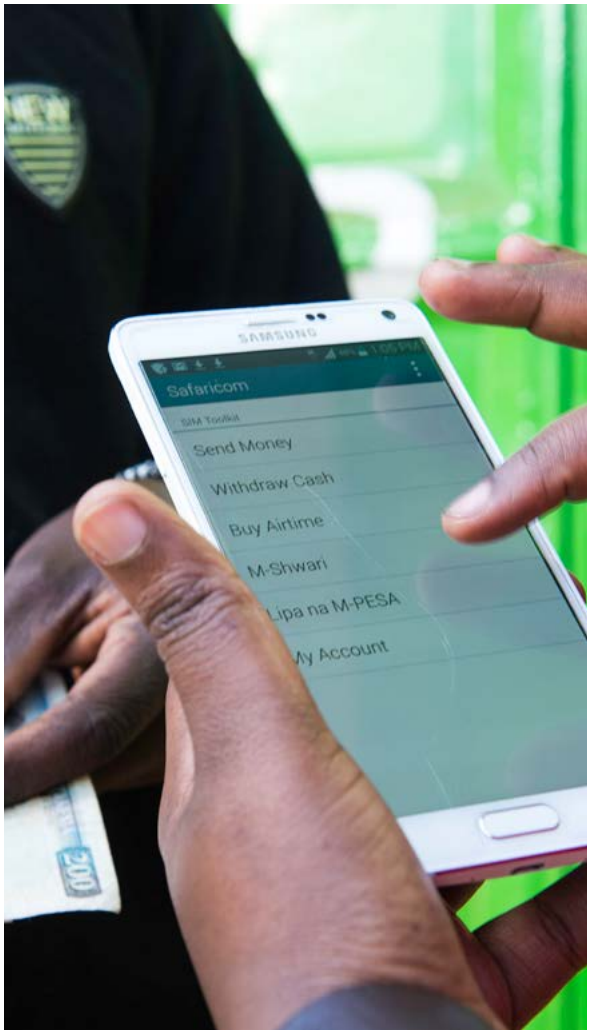
72/ More detailed information on the role of policy in eco-innovation is available in the UNEP publication, 'Sustainable Consumption and Production Policy for Eco-Innovation: Guidelines for policy-makers and RECP Service Providers'. Examples of the role of business intermediaries in the policy process, and this is summarised in Chapter 4.

73/ OECD (1997). National Innovation Systems. Organisation for Economic Co-Operation and Development. Paris.

74/ Institutional Capacity is understood to encompass, on the one hand, the functions that institutions should have the competence to perform, and, on the other, the resources (human, technical and financial) and structures they need to that end (Bhagavan, and Virgin, 2004).

75/ Confirmed by Barahona, C. (2013) Interview conducted by Wayne Visser on 23 April 2013 with Mr Barahona from the Nicaragua Cleaner Production Centre; also, European Commission & Eco-innovation Laboratory (2012) Eco-innovation practices and business opportunities for European SMEs on emerging markets in Asia, Latin America and Africa.

Interestingly, in some cases light regulations or a lack thereof, and weaker elements of institutional capacity, can also foster a quicker pace of technological innovations. In some African countries, innovators need to follow less stringent regulations as an opportunity to test new technological solutions[76]. In the early stages of new or disruptive technologies, heavier regulations can be slow to recognise their value, and thus be overly bureaucratic and inadvertently constrain their development[77]. Also, due to the lack of established infrastructure, technologies and a supportive regime can remove barriers, which hinder the creation and easier adoption of new disruptive innovations (see Box 20). Recognizing these conditions is also part of institutional capacity to foster the right environment for new technologies and highlights the need for a tailored approach to setting the context in each country.[78]



© M-Pesa Safaricom Kenya, Philip Mostert

76/ The Economist (2015). "The pioneering continent: Innovation is increasingly local." April 25th, 2015 edition.

77/ Cowen, T. (2011). **Can I See Your License, Registration and C.P.U.?.** New York Times.

78/ World Bank. 2016. World Development Report 2016: Digital Dividends. Washington, DC: World Bank. (page 32 and 257)

Box 20: M-Pesa **success rests with 'hands-off' approach by the regulators** [78]

M-Pesa, a mobile money transfer system, launched by the company Safaricom in 2007 in Kenya, has given financial inclusion to more people. Powered by mobile communication technologies, the system allows users to transfer money to others and make payments through around 80,000 agents by using basic mobile phone. Cash can thus be sent from one place to another quickly and safely. By 2016, more than 19 million Kenyans were using it, and now about half of Kenya's gross national product (GNP) flows through it.

According to the latest World Development Report (World Bank, 2016), the initial success of the M-Pesa system was a 'hands-off' approach by the Kenyan authorities. They allowed it to proceed as an experiment, thus avoiding typical opposition from banks and red-tape from financial regulators. This allowed Safaricom to maintain a dominant position in the market and to recover the high upfront costs of developing the system. However in 2014, Kenya's Competition Authority changed the rules and opened the system to an alternative mobile operator, which reduced the transaction cost of money transfers and increased the accessibility for more customers.

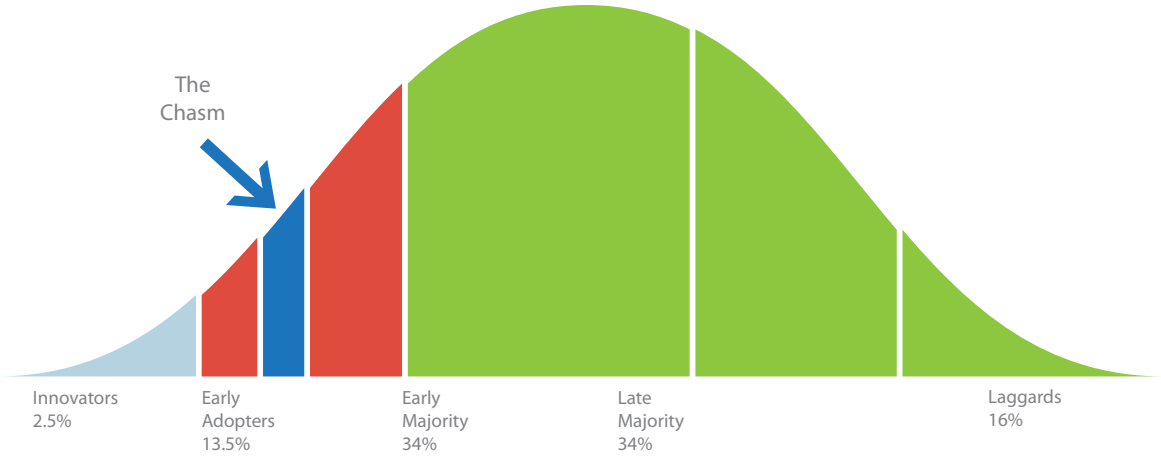
3.2 CREATING MARKET DEMAND

Technologies for eco-innovation can only have an impact, if the market adopts them. Creating demand therefore requires identifying a suitable market with sufficient policy support to foster their initial uptake. Technological innovations, particularly those requiring some change in behaviour, tend to appeal to consumers who see themselves as pioneers and are called 'innovators' or 'early adopters'[79]. Unfortunately, this group of adopters is a minority in the market (Figure 6). The mainstream market prefers to adopt new innovative technologies once they are 'proven' and endorsed by others in the mainstream market, which often means that a chasm emerges between the early adopters and the widespread diffusion in the mainstream market.[80]

79/ Moore, G. A. and R. McKenna (1999). Crossing the Chiasm: Marketing and Selling High Technology Products to Mainstream Customers, Capstone Publishers Ltd.

80/ Rogers, E. M. (1983). Diffusion of innovations (3rd ed.). New York: Free Press

Figure 6: **The adoption curve and crossing the chasm**[81]



Hence, adapting to existing technologies often results in a faster rate of acceptance compared to new and innovation.

To overcome this initial barrier, a number of policy options exist. One of them is that technological innovation can be demonstrated and endorsed by a credible organization (see Box 21).[81] [82]

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Box 21: ETV Programme – **The importance of verification**[82]

Government-driven verification programmes such as the ones listed below aim to generate independent and credible information about new environmental technologies. They do this by verifying that performance claims by technology developers and vendors are accurate, complete, fair and based on reliable test results. Countries such as Denmark, US, Canada, China, Japan, Korea and the Philippines were the first ones, which initiated the ETV programmes as part of policy support to technology diffusion. The EU also runs an ETV programme and subsidies the costs of SMEs' to make the participation more affordable. One of the guiding principles of the ETV is 'verified once, accepted everywhere'. Once the results of the environmental technology screening process become publicly available, they can contribute to scaling technologies developed for commercialization under the eco-innovation process. ETV programmes are available in a number of countries: USA, Canada, European Union (e.g. AIRTV, EURODEMO, PROMOTE, TestNet, NOWATECH), the Philippines, and Japan.

Ensuring adequate market demand[83] is one of the key challenges for the uptake and dissemination of eco-

81/ Moore, G. A. and R. McKenna (1999). Crossing the Chiasm: Marketing and Selling High Technology Products to Mainstream Customers, Capstone Publishers Ltd.

82/ Advance ETV (2012). Advance ETV – Supporting the European Environmental Technologies Verification (ETV) approach and international cooperation on ETV.

83/ Barahone, Cesar (2013) Interview conducted by Wayne Visser on 23 April 2013 with Mr Barahone from the Nicaragua Cleaner Production Centre; European Commission & Eco-innovation Laboratory (2012) Eco-innovation practices and business opportunities for European SMEs on emerging markets in Asia, Latin America and Africa. Presentation by Asel Doranova, 16 April 2012; OECD (2011) Invention and Transfer of Environmental Technologies. OECD Studies on Environmental Innovation, OECD Publishing

innovation solution. Policies can help to correct price signals by targeting negative externalities of existing technologies (e.g. through taxes or permits), thus helping to stimulate demand for sustainable alternatives for a wider market penetration. This generally takes place by either creating an incentive to favour the creation of technologies for eco-innovation and lower their cost of development through subsidies, discounts and supportive financial instruments, or by directly limiting the extent of externalities that manufacturers can produce (e.g. carbon emissions reduction targets). Governments can also create and steer the market demand for sustainable technologies through proactive and enabling public procurement policies

Social and cultural barriers can potentially affect the market demand. The transfer of new technologies, especially from abroad, can create suspicion in local communities if they have had previous negative experiences with foreign investment, cultural conflicts with customs and norms, or are inappropriate technologies that were seen as misguided, resulted in job losses or created other unintended social consequences. Any organisation pursuing technologies for eco-innovation needs to first earn the respect and trust of key stakeholders[84]. Sometimes, new environmental technologies are seen as a challenge to cultural traditions, such as cooking practices, resource collection methods or other communal activities. Technologies for eco-innovation can also face barriers such as language, the perceived role of women in society, or lack of support for entrepreneurs.[85]

3.3 BOOSTING ABSORPTIVE CAPACITY

The development or transfer of technologies for eco-innovation is not limited primarily by their availability, or even the applicability, but rather by the absorptive capacity of companies and the broader country context in which they are applied. The ability to absorb new technologies determines the extent to which companies or individuals can create, adapt, or use technologies for eco-innovation. Absorptive capacity is partly determined by a country's technological maturity, which is dependent on its historical path of development. In some cases, new technological advances may only be possible due to earlier technological progress, thus creating further conditions and opportunities for innovation.

The ability to scale-up the development and diffusion of technology also depends on its adaptation to the local social, regulatory, economic, environmental, and market conditions, especially in the case of transfer from another country. These local conditions are key to closing the gap of technical achievement between countries and their ability to pursue a sustainable path of development.

The World Bank Group measures for 'technical achievement' across three areas: (1) scientific innovation and invention, (2) the diffusion of old technologies, e.g. electrical networks, transport systems, fixed line telephones, and (3) the diffusion of new technologies (e.g. Internet, mobile phones, computers)[86]. Together, these three factors compose the technological achievement index displayed in Figure 7. The index shows that although technical advancement has been increasing rapidly in emerging economies, the gap compared to developed countries remains large, especially for international trade of goods and services with enhanced environmental features[8788].

More recent figures[89] using similar criteria suggest that although this process of narrowing the gap has begun, advancements by low- and middle-income countries are not outpacing those of high income and the world average. The challenge and opportunity for developing economies therefore is to close this gap while creating sustainable and inclusive economic progress. In fact, innovation through the lenses of sustainability can be a significant driver for technological development.

Within companies, absorptive capacity relates to ***the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial end***s[90]. This takes place through various channels, and

84/ IDEA Consult, VITO, DTI, REC & Ecorys-UK (2012) The Development and Diffusion of Environmental Technologies: Technology Transfer, Knowledge Flows and International Cooperation. Report for the European Commission; Nguyen, Hong Long (2013) Interview conducted by Wayne Visser on 23 April 2013 with Mr Nguyen from the Vietnam Cleaner Production Centre.

85/ European Commission & Eco-innovation Laboratory (2012) Eco-innovation practices and business opportunities for European SMEs on emerging markets in Asia, Latin America and Africa. Presentation by Asel Doranova, 16 April 2012; IDEA Consult, VITO, DTI, REC & Ecorys-UK (2012) The Development and Diffusion of Environmental Technologies: Technology Transfer, Knowledge Flows and International Cooperation. Report for the European Commission; Teece, D.J. (1977) Technology transfer by multinational firms: The resource cost of transferring technological know-how. The Economic Journal 87(346): 242-261.

86/ World Bank (2008), Global Economic Prospects: Technology Diffusion in the Developing World, Washington, DC.

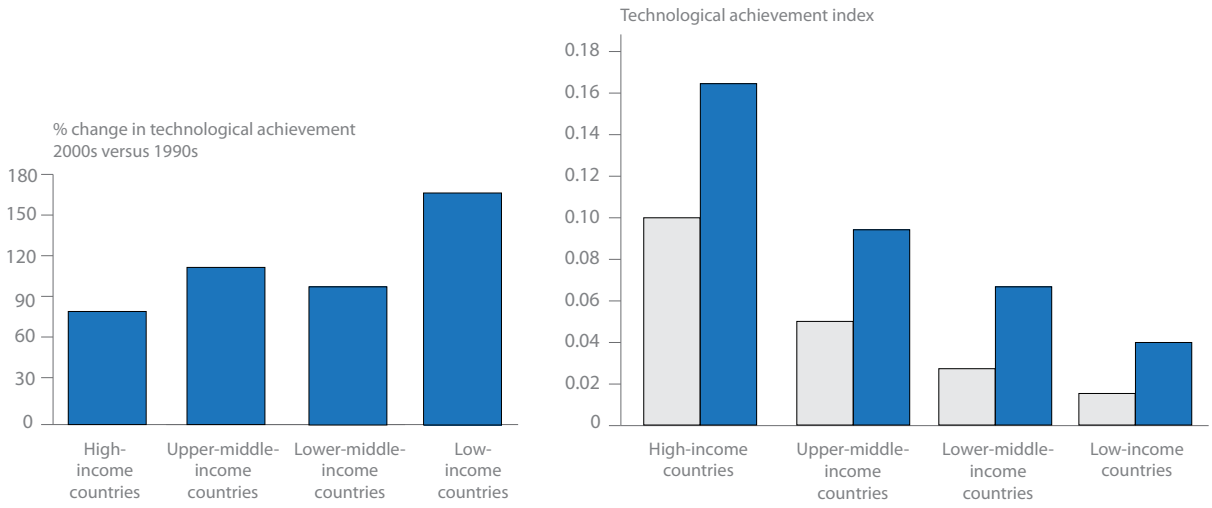
87/ European Commission & Eco-innovation Observatory (2012) Eco-innovation practices and business opportunities for European SMEs on emerging markets in Asia, Latin America and Africa. Presentation by Asel Doranova, 16 April 2012.

88/ Adapted from World Bank (2008), Global Economic Prospects: Technology Diffusion in the Developing World, Washington, DC.

89/ Global Innovation Index Data (2014). Accessed online at: https://www.globalinnovationindex.org/content.aspx?page=GII-Home and World Bank Data (2015). Accessed online at: www.data.worldbank.org. Note: Indicators used include High-technology exports (% of manufactured exports); Patent applications, residents; Research and development expenditure (% of GDP); Charges for the use of intellectual property, payments (BoP, current US$)

90/ Cohen, W.M. & Levinthal, D.A. (1990). "Absorptive Capacity: A New Perspective on Learning and Innovation," ASQ, 35 128-152.

Figure 7: **Rapid progress in developing countries...but the gap remains large**[88]



a company's human capital, or work force, is the most important channel for technology absorption. This is simply because all technology related activities, such as development, transfer and adaptation are conducted by people, and knowledge can only be absorbed and applied by people[91]. Therefore, technologies may need new specialized know-how and skills, which in turn require investment into education and training to overcome gaps in technical literacy. Such investment can be directly delivered by companies or built through institutional investment in educational facilities (see Box 22).[92]

© Victoria Chávez (Government of Ecuador)

91/ World Bank (2011). Fostering Technology Absorption in Southern African Enterprises. Washington, D.C.

92/ Interview conducted with Mr Barahona from the Nicaragua Cleaner Production Centre; Mr Cilliers and Mr McKuur from the South African Cleaner Production Centre; European Commission & Eco-innovation Laboratory (2012) Eco-innovation practices and business opportunities for European SMEs on emerging markets in Asia, Latin America and Africa. Presentation by Asel Doranova, 16 April 2012; IDEA Consult, VITO, DTI, REC & Ecorys-UK (2012) The Development and Diffusion of Environmental Technologies: Technology Transfer, Knowledge Flows and International Cooperation. Report for the European Commission.

Box 22: Investing in technological literacy – **The example of Adelca in Ecuador**

By investing in new technology that allows Ecuadorian steel company Adelca to use 100% recycled steel as a raw material, the firm is saving USD 12 million on the 20,000 tons of steel they produce every month. Each ton of recycled steel also saves 1.5 tons of iron ore, 0.5 tons of coal, 40% of the water used in production, 75% of the energy needed to make steel from raw materials and 1.28 tons of solid waste, while reducing air emissions by 86% and water pollution by 76%. Since Adelca's demand for scrap metals is greater than the supply – and recycled scrap costs less than imported billets – the company has invested in building up its network of recyclers, including paying for and delivering training, donating metal cutting equipment, offering loans and paying the best price for the scrap metals provided. Today, Adelca's recyclers network generates around 4,000 jobs (direct and indirect), with income exceeding USD 1 million a month.

The absorptive capacity of individuals within the company can be influenced by their prior learning, either academic, professional experience, or a combination of the two; their incentive to generate new ideas and build on existing company knowledge; and their ability to use this to contribute towards the company strategy as a

whole. People are therefore key to enabling technology development and diffusion. This need for technological literacy, knowledge, and skills at the company and country level is a clear call to invest in education and technical training. Thus, national policies through Science, Technology and Innovation frameworks play an essential role in the development of technologies for eco-innovation[93].

One important policy instrument in Science, Technology and Innovation frameworks used to bridge the links between academia and business is the creation and operation of business incubators. Business incubation is an emerging trend that according to the UK Business Incubation Initiative 'provides a highly flexible combination of business development processes, infrastructure and people, designed to nurture and grow new and small businesses by supporting them through early stages of development and change'[94]. This type of mechanism is particularly relevant to support eco-innovation, which would typically benefit from a set of various expertise and skills and set up for synergies and idea generation.

Increasingly, countries are introducing incubation facilities and accelerator programmes to convene such stakeholders and let innovations emerge naturally, rather than focusing on choosing specific 'winners'. For developing countries it allows to capture emerging talents and innovation ideas from the grassroots level for the purpose of developing locally adapted technological solutions. Incubation centres can be run by both private and public organisations. However those focusing on new technologies will typically require government policy support at the local or national level to overcome some of the market failures, lack of legal frameworks as well as market entry and diffusion barriers. Bridging the gap between incubation or other support programmes and policy interventions is important to ensure the proper development and integration of technologies and other innovations.
Box 23 gives an example of the Southern Africa Innovation Support programme[95].

Box 23: Southern Africa **Innovation Support programme**

The Southern Africa Innovation Support programme, funded by the Finnish Ministry of Foreign Affairs, seeks to guide innovation in Southern Africa through multi-stakeholder partnerships in Botswana, Mozambique, Namibia and Zambia. It aims to help establish the local facilities needed to support innovation in these countries in the form of technology and entrepreneurship incubation, collaboration and ecosystem environment between individuals, institutions and networks. The aim is to create positive impact on economic and social development in the region through innovation.

While the participation of the government in coordination and running the facilities is minimal, they have an important role in supporting its objectives, facilitating the function and building relevant policies to support innovation process and uptake. The programme has been actively engaging with national government to identify and develop or improve innovation strategies.

To boost absorptive capacity, policy interventions can also target learning opportunities through trade channels and FDI spillovers[96]. In emerging economies like South Africa, 80% of firms have reported that acquisition of new technology is the primary channel to absorb technology[97]. Suppliers of technologies can pass on 'soft' forms of technologies in the form of know-how by installing and servicing equipment, and often training company staff in these techniques. Government policy support in this area can focus on various fields, such financial incentives to make acquisition more affordable, dissemination of information and matchmaking between the needs and available solutions, creating infrastructure such as technical laboratories, and technical competence through consultancies and other business intermediaries.

3.4 PUTTING INTELLECTUAL PROPERTY RIGHTS TO WORK

Intellectual property rights (IPRs) are exclusive rights on intellectual creations in fields related to technology (patents), business (trademarks), arts (copyright), all of which have different legal requirements for obtaining and

93/ For example: nterview conducted with Mr Barahona from the Nicaragua Cleaner Production Centre; with Mr Cilliers and Mr McKuur from the South African Cleaner Production Centre; also, IDEA Consult, VITO, DTI, REC & Ecorys-UK (2012) The Development and Diffusion of Environmental Technologies: Technology Transfer, Knowledge Flows and International Cooperation. Report for the European Commission.

94/ The UKBI (UK Business Incubation) definition states that: –Incubation is a unique and highly flexible combination of business development processes, infrastructure and people, designed to nurture and grow new and small businesses by supporting them through early stages of development and change.

95/ Southern Africa Innovation Support programme (2015). Website accessible at: http://www.saisprogramme.com

96/ World Bank (2011). Fostering Technology Absorption in Southern African Enterprises. Washington, D.C. p.

97/ Ibid p. 175

exercising IPRs[98]. Technologies for eco-innovation, as the result of leading edge research and development, may rely on the protection of IPRs, e.g. through patents, to recover upfront investment costs. Ownership of intellectual assets limits the extent to which competitors can free ride on the research and development efforts of others, enabling the owners of the technologies to profit from their innovation and investment[99]. IPR protection is thus a policy initiative that can provide the incentive to undertake creative and innovative activity.

One of the institutional issues is the extent to which IPRs are protected in developing and emerging economies[100]. For instance, South Africa is among one of the few countries in Africa that has laws related to IP ownership and technology transfer. In 2010, South Africa implemented the Intellectual Property Rights from Publicly Financed R&D Act, which defines a number of obligations ranging from disclosure, IP management and inventor incentives, to the creation of Technology Transfer Offices and policies regarding entrepreneurship.[101]

Conversely, other critics argue that IPR protection can hamper the sharing of eco-innovation solutions by restricting technology transfer[102]. Indeed, IPRs are not always necessarily a pre-requisite for the development of technologies. Often technologies for eco-innovation may be developed purely out of a need for solutions, without the express purpose of commercialising them, and they may also come about through collective efforts to develop public benefit. These cases still require complementary measures to support innovation. For example, policies can support the commercialisation of IP by public universities, but these policies can only be successful if universities enact rules allowing licensing to the private sector or the creation of spin-offs.[103] Important to note here, is that the effects of IPR and their strengthening are often dependent on their relationship with other factors such as the size of the domestic market, infrastructure and stability of the macro-economic environment.[104]

98/ The innovation Policy Platform (2015). "Why are Intellectual Property Rights Important for Innovation?". Available online at: **https://www.innovationpolicyplatform.org/content/intellectual-property-rights**

99/ WIPO (2011) World Intellectual Property Report

100/ ICSTD & UNCTAD (2004) Encouraging International Technology Transfer. ICSTD/UNCTAD Issue Paper, No. 7, UNCTAD-ICSTD Project on IPRs and Sustainable Development. Prepared by K.E. Maskus.

101/ WIPO (2011) World Intellectual Property Report

102/ ICTSD (2008): Climate Change, Technology Transfer and Intellectual Property Rights, ICTSD Background Paper, Trade and Climate Change Seminar, June 18-20, 2008, Copenhagen Denmark

103/ Innovation Policy Platform. 2015. "Policy Design for IP." Accessed online at: **https://innovationpolicyplatform.org/content/policy-design-ip?topic-filters=12209**

104/ UNEP, EPO and ICTSD 2010, Patents and Clean Energy: Bridging the gap between evidence and policy

3.5 EASING ACCESS TO FUNDING

Funding is a key challenge to the development, adoption, or transfer of technologies for eco-innovation. Grants and other incentives from governments can help spur local technology development, thus avoiding more traditional methods such as importing or reverse engineering, adapting them to the local context. The introduction of technologies in new markets usually requires significant and sustained funding, whether for research and development, adaptation, licensing, installation, training, operations or commercialization. In some developing countries, the private sector's ability to pay and government's ability to support these investments can be limited[105]. In addition, these technologies are not always ready for the mainstream market and can initially be more expensive than incumbent technologies, especially when costs depend on scaling up production (see Box 24). In addition, competition from existing technologies that are embedded and even subsidized can be high. Support provided for the commercialization of technologies to enable them to be cost competitive on the market can help to overcome this.

Box 24: 'Mountain of death' for **new technological innovation**[106]

The process of rising and then falling per-unit costs is referred to as the 'mountain of death' for new technological innovation. It can deter R&D by requiring substantial upfront costs to develop and build products that, for a while at least, are not commercially viable. The 'mountain of death' is a key reason that private companies are reluctant to invest in pilot and demonstration plants, and thus contribute significantly to the 'valley of death' phenomenon.

Other financing options typically include loans, supplier credit, subsidy, tax incentives, equity finance, tariff protection, and preferential terms of trade or government endorsed promotional programmes.[107]

105/ Interview with Mr Cilliers and Mr McKuur from the NCPC South Africa; Interview with Mr Nguyen from the Vietnam Cleaner Production Centre.

106/ Accelerating Clean Energy Technology Research, Development and Deployment (report)

107/ Equity finance is essentially the sale of a stake in a company to raise funds to put into the company.

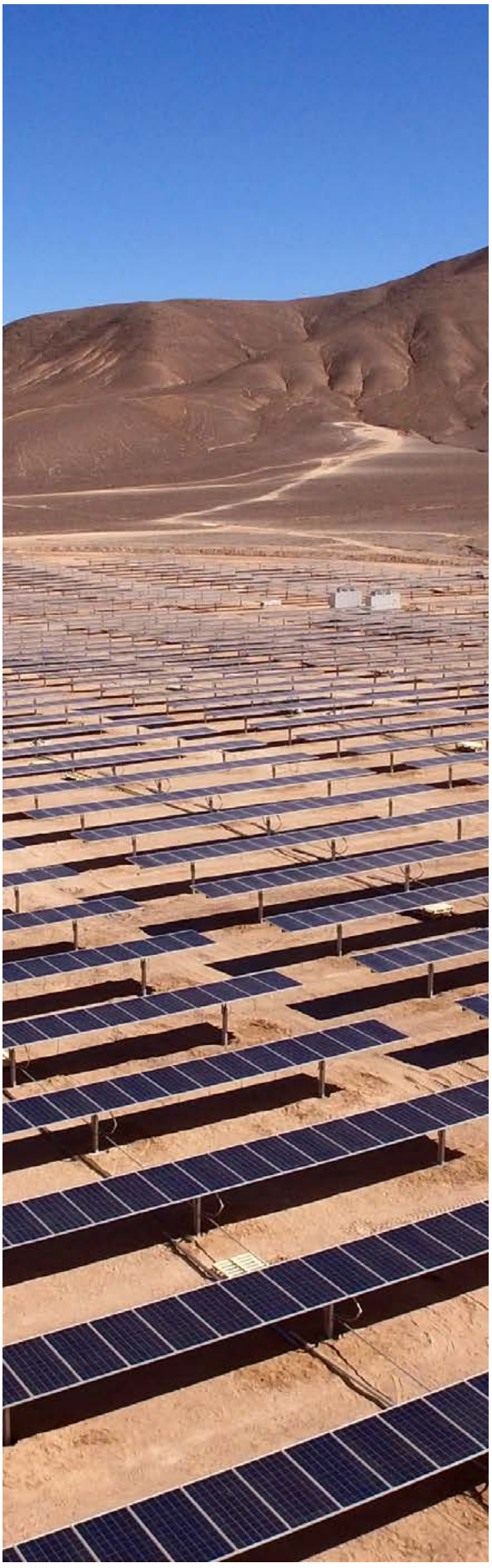
108/ Source: Climate Policy Initiative, 2012 San Giorgio Group Case Study

109/ National Cleaner Production Council from Chile (2014); http://www.cpl.cl/Acuerdos%28APL%29/

Box 25: Effective and Innovative Policy improved the **availability of finance in Tunisia[108] and Chile[109]**

The ProSol initiative in Tunisia is an example of how a country can align domestic and international support to level the playing field between low carbon technologies and heavily sub-sidized fossil fuel based alternatives. A combination of investment subsidies and consumer loans managed and guaranteed by the state-owned utility have enabled growth rates in the Solar Water Heater market of more than 25% for several years. It was an initiative of the Tunisian Ministry of Industry, Energy and Small and Middle Size Enterprises; the National Agency for Energy Conservation of Tunisia; and UN Environment.

Chile's Cleaner Production Voluntary Agreements facilitated by its Clean Production Council (CPL Chile) demonstrate an effective way of catalysing investment into cleaner technologies using public and private partnerships. These agreements have been signed with 10 industrial sectors, and more than 1200 companies have participated in their application. The Chilean government provides 70% of the funding to cover the sustainability assessment of the sector, internal audit, technical assistance, training, certification, impact studies and the overall coordination of the agreements. Private companies within each sector that sign the agreements fund the remaining 30% of the costs involved. For example, the voluntary agreement for the foundry sector has promoted technological innovation for the air emission reduction and legal compliance in the Metropolitan Region, therefor incentivising investment for 3 billion Chilean pesos (approx. 5.5 million US$).



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Cassava flash drying technology in Uganda © CAVA II Project

The Role of **Business intermediaries**

CHAPTER **FOUR**

This chapter aims to summarise the role that business intermediaries can directly or indirectly play in the process for technologies for eco-innovation described in Chapter 2 as well as key policy related factors outlined in Chapter 3. It also provides links to the practical application of this role through the eco-innovation approach described in Chapter 1.

Given the nature of their role, business intermediaries can be instrumental in developing and supporting enabling conditions for technologies for eco-innovation. As mentioned earlier, the importance and role of business intermediaries such as National Cleaner Production Centres in the development and diffusion of relevant science, technologies and capacity building was also acknowledged in the Addis Ababa Action Agenda of the Third International Conference on Financing for Development in 2015.

Whether they are providing a service to private clients, implementing a national project by an international development organisation, or working on behalf of national government agencies, business intermediaries' work often begins as part of an effort to correct for market failures or to pilot new processes that do not yet have a market. This is a crucial first step in assessing technologies for eco-innovation and testing the methods for their development or transfer. Thanks to their function, business intermediary organizations can be well positioned within varied networks with access to a wide variety of expertise and insights. They are the bridges connecting the available opportunities e.g. funding schemes or technology providers and needs of the market.

Box 26: CTCN relies on business intermediaries to **deliver technical assistance at the government request**[110]

The Climate Technology Centre & Network (CTCN) is a supporting mechanism of the United Nations Framework Convention on Climate Change that promotes the accelerated transfer of environmentally sound technologies for low carbon and climate resilient development at the request of developing countries. It provides technology solutions, capacity building and advice on policy, legal and regulatory frameworks tailored to the needs of individual countries.

153 Countries are able to submit requests for technical assistance through their National Designated Entities, and this amount could grow the more are accredited. CTCN often works with business intermediary organizations to deliver technical assistance, which ranges from enhancing technological literacy, facilitating the provision of information, and training to support for strengthening the capacity of emerging economies to identify and select technology options. They also build the capacity to operate maintain and adapt technologies.

By being "hands on" with the ultimate users, developers, and beneficiaries of technologies for eco-innovation (businesses and their value chains), they can also use this experience to support policy makers in raising the systemic issues that might require a policy intervention as well as helping to create better coherence and targeting of policies to facilitate the development, transfer and diffusion of technologies. Given that many will have a direct mandate to support government entities, they are also directly contributing to policy implementation and monitoring and evaluation through their support to companies. Their role in this process has been adapted from the UN Environment publication ***"Mainstreaming Sustainable Consumption and Production Policy for Eco-Innovation"***, and integrated into the table below.

© Financial Tribune

110/ http://ctc-n.org/

111/ One useful starting point are the country-level technology needs assessments (TNAs) that have been prepared as an outcome of the climate negotiations , through a programme funded by the Global Environmental Facility (GEF).

112/ Klewitz, J. & A. Zeyen (2010) The Role of Intermediary Organizations in Eco-Efficiency Improvements in SMEs: A Multi-Case Study in the Metal and Mechanical Engineering Industries in Germany. SSRN Paper Series, January; Nguyen, Hong Long (2013) Interview conducted by Wayne Visser on 23 April 2013 with Mr Nguyen from the Vietnam Cleaner Production Centre.

113/ Potential partners for collaboration can be identified through the assessment of Life cycle stakeholders and value chain pressures in the Eco-innovation Manual. Stakeholders in the value chain will share the risks, and can also share the benefits of the solution, which would make them more likely to be strategic partners.

114/ Barahona, Cesar (2013) Interview conducted by Wayne Visser on 23 April 2013 with Mr Barahona from the Nicaragua Cleaner Production Centre; Charter, M. & T. Woolman (2013) Lessons Learnt Supporting SMEs in Eco-Innovation. Sustainable Innovation 12, Centre for Sustainable Design.

115/ EIO and CfSD (2013) Eco-innovate! A guide to eco-innovation for SMEs and business coaches. Eco-Innovation Observatory. Funded by the European Commission, DG Environment, Brussels.

116/ Cilliers, Kevin & Gerswynn McKuur (2013) Interview conducted by Wayne Visser on 24 April 2013 with Mr Cilliers and Mr McKuur from the South African Cleaner Production Centre; Ockwell, D.G. & A. Mallett (eds.) (2012) Low-Carbon Technology Transfer: From Rhetoric to Reality. Routledge.

Development or transfer activity for technologies for eco-innovation	Role of business intermediaries	Link to the eco-innovation manual steps or tools
Analyse current technology trends and existing technologies	In developing and emerging economies, various institutions (like local or international universities) can hold potential solutions, but business intermediaries are often critical to bridge the space between research and market application of technologies. Business intermediaries may also have access to international databases of technologies for eco-innovation or best available environmental technologies.	✔ Prepare (PESTEL tool and Market, Sector Analysis) ✔ Stakeholders mapping tool
Provide market intelligence	Business intermediaries can help with the 'technology intelligence' activities of 'want' or 'find'. They also support the firm's 'get' or 'manage' activities, but will need capabilities in facilitation, negotiation, partnership agreements, and intellectual property rights.	✔ Preliminary assessment ✔ Set Strategy template ✔ Nine Windows tool
Build institutional capacity	Business intermediaries can use their experience from working with companies on the ground to inform the various institutions involved in technology development or transfer of company needs and how to translate government policies into tangible support mechanisms for companies.	✔ Prepare ✔ Set Strategy ✔ Set Business Model
Assessing the characteristics of the company to develop or adopt technologies		
Establish the technology	The technological needs can be assessed at various stages of the eco-innovation process. Business intermediaries work with a variety of businesses, so they can offer a broader view of the relative performance and position of firms and help to identify needs. Through wide industry exposure and research experience, business intermediaries can bring the analytical skills that may be lacking in SMEs.[111]	✔ Business Model Canvas ✔ Nine Windows tool ✔ Build Roadmap ✔ Requirements specification tool
Conduct a feasibility assessment	This would include detailed technology and market feasibility studies that relate to the context in which the technology solution will be applied. It could be that new skills are required to use and maintain the technology. Business intermediaries can bring in-house analytical expertise, or help to identify credible third-party consultancies that are able to provide this assessment service.	✔ PESTEL tool ✔ Stakeholders mapping tool
Select a technology development or transfer approach	This includes assessing whether to do it alone, collaborate through open innovation, or seek to transfer a technology. Business intermediaries may be more objective in assessing the fit between a firm's core competencies – including their technical readiness or capacity – and market opportunities. They will also be able to share examples of methods chosen by others.	✔ Set Business Model ✔ Build the roadmap

Development or transfer activity for technologies for eco-innovation	Role of business intermediaries	Link to the eco-innovation manual steps or tools
Technology development		
Find strategic partners and resources	Strategic partners can bring technologies, knowledge and additional resources such as funding. Partners can include government or multilateral agencies, technology suppliers, universities or research institutes, funding institutions, civil society organisations, customer groups in the supply chain.[112 113], Business intermediaries can use their networks and credibility to help identify and broker these relationships and ensure a shared vision and mode of working. They can also help with formulating informal or contractual arrangements. Strategic partnerships are particularly important if the company is perusing open innovation.	✔ Prepare ✔ Set Strategy ✔ Stakeholders mapping tool
Support the technology development	Business intermediaries can play an important role in enabling in-house technology development in a more cost effective way by providing insights and inspiration from their accumulative experience and successful cases from one sector for example to match it with the needs of another; or getting the commitment of top management for development of new innovative and marketable products.	✔ Set Business Model ✔ Implement
Support open innovation	Business intermediaries can support open innovation using a variety of commercial approaches, such as charging a fee based on time spent, a success fee (e.g. % of revenue from a deal), a flat fee or a membership fee. The mode of engagement can be embedded (e.g. someone works in the firm for a period of time), through remote assistance, or the intermediary can organise and facilitate a workshop to get potential collaborators together.	✔ Implement ✔ Review
Technology transfer		
Ensure skills development	Most new technologies will require training of local personnel to ensure that the equipment or process is correctly installed, operated and maintained. Usually, the technology developer offers this training, but ideally it should be a collaborative effort with local experts in order to factor in local conditions and constraints. Business intermediaries can facilitate this collaboration and contribute their own expertise.[114]	✔ Build roadmap ✔ Requirements specification tool
Support policies for technology transfer	Once technologies have been developed or identified, business intermediaries can support policies to transfer them to a country or within the country by enhancing the absorptive capacity of institutions and companies. This service can range from identifying gaps in government policy to allow for technology transfer into or within the country (i.e. trade regulations, national infrastructure, national development plans), to using and supporting national policy instruments to ensure technology transfer (i.e. testing; training of staff; acting as a business or technology incubator).	✔ Prepare ✔ Build Roadmap ✔ Implement
Adapt and install the technology	Sometimes, this is as simple as importing and installing a piece of equipment, but it can also be a more complex project that involves building new facilities or adapting existing infrastructure or organizational methods. The intermediary may be directly involved (for simple technologies), but more likely would act as a trouble-shooter in case of problems and a verifier that agreements are being honoured.	✔ Implement

Development or transfer activity for technologies for eco-innovation	Role of business intermediaries	Link to the eco-innovation manual steps or tools
Maintain and improve the technology	One of the main reasons technology transfer fails is due to the lack of maintenance and continuous improvement at the post-installation stage. This can either be due to skills shortages, the high cost or unavailability of spare parts, or a weak and unsupportive relationship with the technology developer. Business intermediaries can be a witness and auditor of incorporation of on-going support by the technology developer. Please see the reference below for more information on this.[115].	✔ Review
Navigating the intellectual property rights process		
Inform policies for effective use of IPR	Business intermediaries can bridge the gaps between the IPR needs of companies and IPR policies of government by understanding which IPR policies support or hinder technology development or transfer. This allows them to bring credible information to government to inform policy changes (i.e. how IPRs are negotiated as trade instruments internationally and how IPRs are used domestically), as well as to communicate policy regulations to companies and support them to understand and use these to achieve identified technology needs.	✔ Prepare ✔ Build roadmap ✔ Implement
Secure intellectual property rights (IPR) or formal agreements for transfer technology	IPR should be explored prior to the release of public information about a technologies for eco-innovation. For example, business intermediaries can do a basic Patent Search on the various websites mentioned in this study. Technology transfer agreements can vary greatly, depending on the approach selected for adoption, and their effectiveness will depend on the strength of the legal and governance systems of both contributor and host countries. Business intermediaries may not be experts in IPR or transfer agreements, but should be able to recommend others who are (e.g. a patent lawyer). They may also be able to help companies with applications when they are required to 'bid' for transfer rights.[116].	✔ Build roadmap ✔ Implement
Financing for technologies for eco-innovation		
Access finance for TECHNOLOGIES FOR ECO-INNOVATIONs	Business intermediaries can have numerous roles in helping companies access finance. This includes using their networks and credibility to assist SMEs to find the right source of finance and initiate the process, providing information to firms about the financing options available, helping them understand the expectations of investors, and enabling firms to become investable and preparing investment ready material.	✔ Build roadmap ✔ Implement
Inform policies for access to finance	SMEs face numerous challenges when accessing finance, and sometimes more so when this is to invest in technologies for eco-innovation. Business intermediaries can inform policies that change this by bringing the experience of companies to government, and can further support policies on access to finance by being part of the supportive policies. For instance by offering their services as part of grant or subsidy mechanisms to companies or negotiating their services as part of a tax incentive scheme with government to support companies' ability to finance TEIs.	✔ Prepare ✔ Build Roadmap ✔ Implement

Development or transfer activity for technologies for eco-innovation	Role of business intermediaries	Link to the eco-innovation manual steps or tools
Crossing the innovation diffusion chasm		
Build technological literacy	Business intermediaries can build technological literacy by sharing knowledge at for example recruitment fairs and educational institutions or business forums. This helps to increase the flow of knowledge on TECHNOLOGIES FOR ECO-INNOVATIONs by exposing companies to business intermediaries and their services, and vice versa. This again touches on one of the cornerstones of the eco-innovation approach – that of working with a company's wider value chain. Business intermediaries can operate business or entrepreneurship incubation platforms.	✔ Prepare ✔ Implement
Foster market demand through supportive policies	Business intermediaries can play two roles: firstly, to inform policies and support the implementation of policies that address market failures preventing technologies from being developed and diffused; and secondly, to lead verification programmes introduced through policy to independently test and verify new technologies, thus also contributing towards overcoming diffusion barriers.	✔ Implement ✔ Review
Scale up TECHNOLOGIES FOR ECO-INNOVATIONs	Once a technology has proven it can work in a particular organisation in a particular industry and a particular country, there is an opportunity to spread the solution more broadly. Business intermediaries can help verify the technology, collect data to inform government policy and monitor its implementation, build case studies to raise awareness of technologies for eco-innovation, and continue their support to companies and government in the sections highlighted above, which will ultimately result in the transformative, strategic, multi-level impacts that are the goal of eco-innovation.	✔ Review

Glossary of key terms

Adaptation is the process of adapting a technology to a specific context.

Absorptive Capacity is the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends is critical to its innovative capabilities[117] (Cohen, Levinthal 1990)

Appropriability describes the environmental factors that govern an innovator's ability to capture profits generated by an innovation.

Business model describes the blueprint of how a company does business. It is the translation of strategic issues, such as strategic positioning and strategic goals into a conceptual model that explicitly states how the business functions. The business model serves as a building plan that allows designing and realizing the business structure and systems that constitute the company's operational and physical form. (Osterwalder et al, 2005).

Business strategy describes the long-term goals of the company and the markets in which the company will operate (i.e. vision and mission). (Adapted from Andrews, 1997).

Eco-innovation is the development and application of a business model, shaped by a new business strategy that incorporates sustainability throughout all business operations based on life cyclethinking and in cooperation with partners across the value chain. It entails a coordinated set of modifications or novel solutions to products (goods and services), processes, market approach and organizational structure, which leads to a company's enhanced performance and competitiveness.

Decoupling means using less resources per unit of economic output and reducing the environmental impact of any resources that are used or economic activities that are undertaken [118]

Diffusion is the process by which technologies spread within and across economies (Stoneman PL, University of Warwick)Institutional Capacity is understood to encompass, on the one hand, the functions that institutions should have the competence to perform, and, on the other, the resources (human, technical and financial) and structures

117/ Cohen, Wesley, M. & Levinthal, Daniel A. Absorptive Capacity: A New Perspective on Learning and Innovation, ASQ, 35 (1990), 128-152.

118/ UNEP (2011) Decoupling natural resource use and environmental impacts from economic growth, A Report of the Working Group on Decoupling to the International Resource Panel. Fischer-Kowalski, M., Swilling, M., von Weizsäcker, E.U., Ren, Y., Moriguchi, Y., Crane, W., Krausmann, F., Eisenmenger, N., Giljum, S., Hennicke, P., Romero Lankao, P., Siriban Manalang, A., Sewerin, S.

they need to that end (Bhagavan, and Virgin, 2004).

Licensing refers to an agreement whereby an owner of a technological intellectual property (the licensor) allows another party (the licensee) to use, modify, and/or resell that property in exchange for a compensation. The legal ownership of the intellectual property remains with the licensor.[119]

Life cycle- Consecutive and interlinked stages of a product or service system, from the extraction of natural resources to the final disposal. (ISO 14040:2006).

Life cycle thinking is a mostly qualitative approach to understand how our choices influence what happens at each of the stages of the life cycle of an industrial activity: from raw material acquisition through manufacture, distribution, product use and disposal. This approach is needed in order for us to balance trade-offs and positively impact the economy, the environment, and society (UNEP, 2004).

Open innovation seeks ideas from inside and outside the organisation to advance in the technology dimension of the innovation process. It therefore has two dimensions; the external ideas and technologies that are brought into the company's own innovation process and the un-used and under-utilized ideas and technologies from the company that are incorporated into others' innovation processes [120](Chesbrough, H.)

Organization structure refers to the range of activities and key resources (human and financial) within the company, in addition to those relating directly to production, that are dedicated to supporting the business model. These include procurement processes, distribution, key partnerships, customer relationships and interfaces, research and development, internal communication, and revenue generation.

Partners refer to parties in the value chain that provide or receive value including suppliers, outsourced workers, contractors, customers, consumers, clients, members, and others (ISO 26000:2010).

Stakeholder is any group or individual who can affect, or is affected by, an organisation or its activities. Also, any individual or group that can help define value propositions for the organisation. (Stakeholder Research Associates Canada Inc., United Nations Environment Programme, AccountAbility: Stakeholder Engagement, 2005)

119/ Licensing Executives Society – Arab Countries (2007) Guidelines for licensing and technology transfer Agreements

120/ Chesbrough, H. 2011. "Everything you need to know about open-innovation." Forbes. 21 March 2011.

The supply chain is a system of organizations, technology, activities, information and resources involved in moving a product or service from supplier to customer (Michael Porter 1985).

Sustainability hotspots are the most significant impacts in the value chain or the life cycle of a product or service system, which can be used to identify impact improvement opportunities and to prioritize impact reduction actions (UNEP/SETAC, 2014).

Transfer encompasses the diffusion of technologies and technology cooperation within and between developed, developing and transition economies. The process involves learning to understand, utilise and replicate the technology, including the capacity to choose and adapt to local conditions and integrate it with indigenous technologies. (IPCC, 2000)

Value is understood to involve creating economic value (the revenue that a firm gets in return for its goods or services) in a way that also creates positive outcomes for society by addressing its needs and challenges, taking into account economic, environmental and social considerations (adapted from Porter & Kramer, 2011)
A **value chain** is the entire sequence of activities or parties that provide or receive value in the form of products or services (e.g. suppliers, outsources workers, contractors, investors, R&D, customers, consumers, members). (ISO14001 CD2, 2013).

Value proposition refers to the products or services that an organization offers to a specific market segment that the organization believes will create value for that specific market segment.

The use of technology in business is vital for competitiveness in markets worldwide. The transition towards business models driven by sustainability, through an eco-innovation approach, generally relies on companies and their value chain to implement new technologies. Identifying the right way to develop these technologies is crucial for the success of the business model. Developing the technology in-house, using open innovation or outsourcing its development to a strategic partner has different benefits and implications.

For companies to do this, a supporting environment is needed. This favourable context requires a set of integrated policy actions that: strengthen institutional capacity, create market demand, boost absorptive capacity, put intellectual property rights to work, and ease access to funding. Local business intermediaries can function as an important bridge between policy makers and companies and their value chains, to support the development of an enabling policy framework.

This publication emphasizes the technological aspects relevant to eco innovation. It describes the role of technology within an eco-innovation approach, provides guidance on identifying, developing, and adopting technologies, informs on the role of policy-making, and highlights the role of business intermediaries. This publication is part of the Resource Efficiency and Eco-innovation in Developing and Transition Economies project, funded by the European Commission.

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