IIIEE Theses 2019:42

Testing Project Intervention Logic Against Principles of Technology Transfer

The Case of Two UNIDO Small Hydropower Projects

Andreea Miu

Supervisor

Philip Peck

Thesis for the fulfilment of the
Master of Science in Environmental Management and Policy
Lund, Sweden, September 2019

iiiee THE INTERNATIONAL INSTITUTE FOR INDUSTRIAL ENVIRONMENTAL ECONOMICS

Published in 2019 by IIIEE, Lund University, P.O. Box 196, S-221 00 LUND, Sweden,
Tel: +46 – 46 222 02 00, Fax: +46 – 46 222 02 10, e-mail: iiiee@iiiee.lu.se.

ISSN 1401-9191

Acknowledgements

First and foremost, I would like to thank my supervisor, Philip Peck, for his insights and guidance and for his patience and kind support during the challenging moments of this research. This thesis would not have been possible without his advice. I would also like to extend my gratitude to Beatrice Kogg, for her kind support during this process.

Special thanks go to UNIDO, and especially to Tareq Emtairah for giving me the opportunity to be part of this project. I would also like to thank him for arranging privileged access to UNIDO staff from its Department of Energy. Also, a hearty thanks to Nicholas Dehod for acting as first point of contact for many of my questions and not letting me get lost in the UNIDO headquarters. My gratitude is also extended to all other UNIDO staff who provided insights into their work and for welcoming me into their office.

Thank you to my EMP batchmates for all the amazing times we had during this program and for the memories I will forever cherish. You are an endless source of inspiration, comfort and laughter, and I consider myself lucky to have had the opportunity to meet each and every one of you. A special thanks goes to Tristan for always being there to provide support, encouragements and for doing what he does best – give feedback. And to all my flatmates, for the good times together and making the flat a home.

I also wish to thank everyone at the IIIEE, both faculty and students, for making the EMP experience an inspiring one!

Lastly, I would like to express my highest gratitude to my family for their unbounded love and support and for always encouraging my aspirations.

Abstract

Technology transfer (TT) is a process that allows countries to acquire, adapt, deploy, localise and innovate technologies from other countries. In the case of international development, TT can help enhance the technology capabilities of developing countries and empower them to boost their economic development. Facilitating access to technologies through TT is an element often found in UNIDO's activities, however some projects in its small hydropower (SHP) portfolio appear to have encountered some alleged challenges in fully achieving their intended TT results. This thesis used direct logic analysis to reconstruct and investigate the intervention logic behind two UNIDO SHP projects and test their validity against technology transfer principles highlighted in academic and specialised knowledge. It documents how technology transfer activities were planned in the two projects, compares them to the main factors that could influence the results of the technology transfer as highlighted in academic and scientific knowledge, and identifies apparent or potential strengths and weaknesses in the current approach. The results of the study suggest that UNIDO's current approach to technology transfer has valid strengths. However, the analysed data did not include sufficient evidence to support a position that the current approach systematically and comprehensively accounts for *all* the factors that can influence the process of technology transfer as highlighted in academic and scientific knowledge. This could be interpreted as part of the explanation for some of the current project implementation challenges. Nevertheless, the interpretations generated by this study did not address a scenario where all TT factors are actively considered in the current approach but then omitted in the final project design due to being judged at that time (with the evidence available) as not relevant to the project under consideration. From the perspective of transferring technology, this thesis provided ample evidence that it is important to have a clear, systematic plan for those actions that need to be taken to facilitate the process, as well as an understanding of why those actions are important and how they can be conducive to improved project results.

Keywords: technology transfer, intervention logic, logic models, logic analysis, small hydropower, international development, UNIDO.

Executive Summary

Problem Definition

Technology transfer refers to a broad set of processes that allow countries to acquire, adapt, deploy, localise and innovate technologies from other countries. It is a complex process, that involves many actors and institutions, that is dependent on pre-existing practises and capabilities, and that requires the adoption of new practises and development of new capacity. Nevertheless, in the context of the current climate crisis, having access to technology, and especially environmentally sound technologies, is vital for lowering global greenhouse gas emissions and adapting to the adverse weather events brought by the climate crisis. Apart from helping nations meet their climate goals, environmentally sound technologies also have the potential to decouple economic growth from intense greenhouse gas emissions and help nations move towards a more sustainable development of their economies. Therefore, helping countries gain access to new technologies through the process of technology transfer process represents a cornerstone in reaching a global solution to climate change and sustainable development.

The United Nations Industrial Development Organisation (UNIDO) is one of the UN agencies that undertakes projects and programmes aimed at facilitating the transfer of environmentally sound technologies to developing countries and economies in transitions. UNIDO sets out to promote, encourage and assist in the development, selection, adoption, and transfer of technologies from industrialised countries to developing ones and amongst developing countries, its mission being to accelerate inclusive and sustainable industrial development. The agency recognises that one factor relevant to achieving its mission is the transfer of environmentally sound technologies and therefore, facilitating access to technologies through technology transfer is often an element found in UNIDO's programmes and projects. One set of technologies UNIDO facilitates to transfer are renewable energy technologies such as small hydropower, solar, wind and biomass sources.

This thesis focuses on UNIDO's portfolio of projects involving the transfer of small hydropower (SHP) technologies to developing countries. The reason for inspecting this set of projects is that some internally-commissioned project evaluations highlighted that projects involving the transfer of small hydropower technology appear to have encountered challenges during project implementation. These challenges allegedly resulted in the technology not always being confidently transferred to the local stakeholders, and to the projects being extended - sometimes by a few years and with financial implications – past their intended completion date. It is important to note that these projects intend to achieve complex results in systems that evolve over time, involve a number of different stakeholders, national and international organisations, funders and donors, the local population etc. This meaning that the reasons as to why technology is not always successfully transferred is not always clear cut. For example, it could be the fact that SHP might be a more complex technology when compared to e.g. solar or wind, or the fact that the technology recipient country does not have the national characteristics, policies, and capabilities in place to fully absorb such a technology. It can also be the fact that the technology does not cater for the actual needs of the people on the ground, or that the local community is completely left out of the project decision making and end up rejecting the technology.

One suspicion as to why technology was not always successfully transferred is the possibility that the projects were designed in a way that unintentionally failed to assess and plan for all the main factors that could influence the results of the technology transfer element. Introduced in the context of this thesis as "technology transfer influential factors" these factors represent aspects relating to the characteristics of the technology recipient country or relating to elements of the project itself that have the potential to either hinder or maximise the success of the technology transfer process.

Following on the point above, the suspicion is that issue lies in the project design phase, therefore at project inception stage and more specifically, in the principles on which the project design is built. Referred in this thesis as "intervention logic" these principles are a set of statements that define how and why a project it supposed to work, under what conditions the project results occur, what the predicted outcomes and impacts are, and what requirements are necessary to bring about the desired project effects. Academic and specialised publications often refer to this term as being synonymous with "theory of change" and "program theory".

Based on the above, the first hypothesis that underlies this thesis project was drawn:

H1: *The intervention logic that underlines the technology transfer strategy behind UNIDO's small hydropower projects logic omits some technology transfer influential factors.*

In order to define "technology transfer influential factors", this thesis assumed that such factors have been previously studied and can be identified in the academic knowledge and specialised publications on the topic. This assumption forms the basis of the second hypothesis that underlies this study:

H2*: There is existing knowledge in academic and specialised literature that describes which factors to pay attention to and plan for when engaging in transfer of technologies from one country to another.*

Aims and Research Questions

The main aims of this thesis were to investigate how technology transfer activities are planned in UNIDO's small hydropower projects; to document if the intervention logic can highlight areas where there may have been omissions in assessing and planning for the main factors that could influence the results of the technology transfer; to identify strengths and weaknesses in the current approach; and derive scientifically-informed lessons that could lead to a more effective project design. Based on the aims of the thesis the following research questions were delineated:

1. *What are the factors that are said to influence technology transfer to developing countries?*
2. *How are these factors captured and planned for in UNIDO's SHP project intervention logic?*
3. *How does UNIDO's current SHP project intervention logic perform when compared to the technology transfer factors identified in academic and specialised knowledge?*

Methodology and Research Design

This thesis was scoped as a case study of past small hydropower projects pursuant to input from UNIDO's Department of Energy. From the start UNIDO was able to make a number of its SHP projects available for investigation which allowed for insights into the agency's approach to small hydropower projects based on actual 'real-life' examples. Two projects were selected as exemplary case studies, both UNIDO projects that aimed to transfer small hydropower technologies from one country to another.

In order to answer the research questions and fulfil the thesis' aim, this study conducted a direct logic analysis on the two case studies, a method which uses scientific knowledge to determine the strengths and weaknesses of a project and find alternatives for achieving the project's intended outcomes. Direct logic analysis was used as an analysis method in order to understand the projects' main components, see if the optimal conditions have been assembled to achieve the desired outcomes and which elements should be added to improve the results. Conducting direct logic analysis consisted of three steps:

1. *Building the logic model of the project*: a logic model is a visual method of presenting the idea behind a project, a picture of how the implementors believe it will work. Logic modelling was used to reconstruct the projects' intervention logic to ascertain how they were believed to work, their structure, the technology transfer principles and assumptions upon which they were built, their intended outcomes and the resources and activities thought to be required to achieve these.
2. *Developing an analytical framework:* a thorough review of academic and specialised literature on the topic of technology transfer was conducted to identify the "technology transfer influential factors". Then, for each factor a set of determinant criteria was defined, and the results were compiled in the analytical framework (see Table 3-1 on page 35).
3. *Evaluating the theory of the intervention:* the projects' intervention logic was then tested against the framework to determine whether they were designed in a way that can logically produce the desired technology transfer results. This produced a new understanding of the projects' strengths and weaknesses and identified elements that could be added in order to improve the technology transfer results.

Data collection

The data collection involved two phases: the first involved regular collaboration with UNIDO and culminated in a study trip to the agency's headquarters in Vienna, where the author was given direct access to staff and resources from the Department of Energy. UNIDO had a relatively active role in this phase suggesting potential research scopes, data sources and research strategies. Ultimately the final decision regarding research scope and approach was taken by the author independently of UNIDO. The second phase consisted mainly of independent research on the topics of technology transfer, intervention logic, logic analysis etc., and the two case studies. The data collected and reviewed for reconstructing the intervention logic of the two cases was sourced from project documentation such as the "Project Document", the main document outlining the *how* and the *why* of a project, UNIDO's own independent project evaluations, project advocacy material, website articles, etc. Most data were sourced from the publicly available UNIDO Open Data Platform, and the Project Evaluations page of the UNIDO website.

Main Findings

The Technology Transfer Influential Factors

Through a recent review of literature this thesis identified and produced a new synthesis of the main factors that are said to influence the technology transfer process:

General influential factors – "macro level" factors that involve a zoomed-out view of the recipient country context:

1. *Absorptive Capacity* – refers to the ability of a country to utilize and absorb external knowledge in the form of information and resources.
2. *National Innovation System (NIS)* – refers to the national network of institutions in the public and private sectors whose interactions can initiate technology acquisition, adaptation, deployment, localisation, diffusion and innovation.
3. *Enabling National Policies* – refers to the main sets of national policies that may influence technology transfer.

Project-specific influential factors – "micro and meso level" factors that involve a more in-depth assessment of the technology and the conditions of where the technology is to be transferred:

4. *The Technology* – refers mainly to the complexity of the technology to be transferred from a technical, quality, and financial perspective.
5. *The Local Environment* – refers to the local stakeholders that are the ultimate beneficiaries of the technology (in the form of local communities, local small and medium-sized enterprises, local governments, organisations, end-users etc).
6. *Finance and Costs* – refers to the monetary aspects of technology transfer such as the necessary funds for the initial implementation of the technology, the replication efforts, the operation and maintenance of the technology, and in certain cases the ability to pay for the service that the technology provides.

Technology transfer influential factors and the small hydropower intervention logic

The purpose of this study was not to evaluate the two small hydropower projects as a whole but to examine those elements of the projects pertaining to technology transfer. This thesis reconstructed the intervention logic for the two case studies and investigated how technology transfer influential factors are captured and planned for in UNIDO's current approach with the use of the analytical framework.

In summary, the findings can be interpreted to suggest that UNIDO's current approach to technology transfer does capture all technology transfer factors – this being based on the observation that it captures *at least one* determinant criteria (as defined in the analytical framework) for each factor and therefore, by extension, it captures the factor itself. However, this interpretation did not elucidate if the team of project planners actually actively *acknowledged the influence* of *all* factors on the results of the projects, and/or if project activities were *specifically planned* to account for the influence of *all* factors. This meaning that the identified presence of at least one determinant criteria for each factor can be attributed to other planned project activities which happened to also apply to technology transfer. For example, it is often the case that at the pre-planning stage of every potential new project, a thorough stakeholder analysis is routinely undertaken. Such an analysis is likely to account for the influence of the local actors on the results of the project and project activities are planned to account for this influence – this consequently also accounting for the influence of 'local environment' factor on the technology transfer process. With this argumentation in mind however, it is important to note that the interpretations provided here cannot address a scenario where the project planners did actively consider all the factors but then chose to omit them in the final project design as they judged at that time (with the evidence available) that they were not relevant to the project under consideration. In this thesis the analysis of the document-based evidence identifies such omissions however, it does not rule out that the omissions were deliberate as described above.

In this thesis an influential factor was considered to be captured and planned for 'integrally' if there was evidence to suggest that all its determinant criteria were accounted for in the reconstructed intervention logic. If a factor was found to be captured integrally it suggested that, when compared with lessons from academic and specialised knowledge, the UNIDO approach with regard to that factor is valid.

In that regard, this thesis found indications in the reconstructed intervention logic to suggest that the project planners deliberately accounted for the potential influence of *some* factors integrally such as the 'local environment', 'financing and costs" for both case studies. To some extent it also found that there was planned work to mitigate the influence of the pre-existing 'absorption capacity' on the results of the project; though not all aspects of absorption capacity were considered. As for the other factors, the results were less clear on whether their influence was integrally accounted for. Therefore, the results showed that – when compared to lessons from academic and specialised knowledge - UNIDO's approach to technology transfer was valid in some regards and less so in others.

Nevertheless, even though the results showed a certain degree of validity in the UNIDO approach, a weakness identified by this thesis was that there was little evidence in the projects' documentation to suggest that all the factors that are said to influence the process of SHP technology transfer have been *systematically identified, considered and planned for*. Indeed, this thesis found the presence of certain characteristics pertaining to the technology transfer influential factors in the reconstructed projects' intervention logic and this serves as evidence that the current approach does draw 'inspiration' from technology transfer scientific knowledge. However, there was not enough evidence to suggest that this 'inspiration' is fully based on recent academic and specialised knowledge on technology transfer and that the current planning approach is based on a systematic, step by step, scientifically-informed technology transfer plan (e.g. in the form of an internal 'technology transfer guideline' or similar document/manual/framework that can be used to inform technology transfer planning). This interpretation cannot rule out the pre-existence of a UNIDO technology transfer plan – indeed a technology transfer framework has been identified in a UNIDO document dated 1999 and UNIDO does undertake regular research on its technology transfer activities. However, this study was limited with regard to obtaining certainty on whether such a plan was used in designing the two case studies. The implications of not using such a plan is that there is potential that some projects that involve the transfer technologies may be designed based on the previous experiences and tacit knowledge accumulated by the responsible staff. Thus, the technology transfer aspects of each project might include an element of ad-hoc planning, with the quality of the plan being determined by the experience, skill level, and diligence of the persons that designed the project.

Conclusions and Recommendations

This study highlighted the planned strategies employed by UNIDO in projects based on small hydropower technology transfer by reconstructing the intervention logic of two case studies. This tool provided a useful glimpse into UNIDO' technology transfer activities, how the projects were planned, what they intended to achieve, etc. Based on the intervention logic, this study tested the validity of UNIDO's technology transfer activities against technology transfer principles from academic and specialised knowledge. The results generated by this investigation contributed with further understanding of existing technology transfer strategies, the strengths in the current approaches, and the weaknesses and areas where further improvement ins necessary to maximise technology transfer in future projects.

Two sets of recommendations that could improve the effectiveness of UNIDO's technology transfer projects were suggested:

Codify Knowledge

While, this study cannot rule out the pre-existence of a UNIDO manual/document/framework that can be used to inform technology transfer planning, it is held that an up-to-date such document would be of value. Hence, a recommendation is to ensure that one such document indeed exists and is up-to-date with the most recent review of literature on the topic of technology transfer and the influential factors. UNIDO has been facilitating technology transfer for a number of decades and therefore tacit knowledge on the topic is bound to already existing among UNIDO staff, as well as internal and external reports or other forms of institutional memory that tackle the issue in one way or another. The evidence gathered in this study thus supports a position that UNIDO will benefit if it were to gather all this knowledge, including the knowledge generated by this thesis, and codify it in a 'technology transfer checklist' or similar document that can then be used internally as point of reference when starting to plan for the technology transfer elements of a project. Such a checklist could explain, for example, what each of the technology transfer influential factors are, how they should be documented in a project proposal and how they may be planned for. The checklist could be an UNIDO internal tool used at project design stage to verify what technology transfer influential factors have been accounted for in the plan. This checklist could therefore allow for a more standard planning approach to technology transfer across UNIDO projects.

Design projects with an Intervention Logic as a starting point

A further recommendation is that UNIDO should develop their future technology transfer projects based on an intervention logic generated from the start of the project – in the pre-planning phase. Building a project based on an intervention logic from the start highlights the principles on which a project is based, including the desired long-term results, what conditions should be in place for these results to occur and the causal links between project components. This is especially relevant in the case of projects involving technology transfer. Documenting the underlying project assumptions about how technology transfer is intended to be achieved in a project can: 1) ensure that all technology transfer influential factors are accounted for in the project design and 2) generate knowledge that can be codified on what works and why when transferring technology to developing countries. This in turn could lead to more effective future project designs.

Table of Contents

List of Figures

List of Tables

Abbreviations

FDI - Foreign Direct Investment

IL - Intervention Logic

IPR - Intellectual Property Rights

NIS - National Innovation System

R&D - Research & Development

SHP - Small Hydropower

TT - Technology Transfer

UN - United Nations

UNIDO - United Nationals Industrial Development Organisation

List of Key Terms

Intervention - a set of deliberate activities organized within a project intended to influence events and have consequences (Belcher & Palenberg, 2018).

Intervention logic - a set of statements that describe a particular project, which explain why, how, and under what conditions the project results occur, predict the outcomes and impacts of the project, and specify the requirements necessary to bring about the desired project effects (Sharpe, 2011).

Logic model – a visual representation of a project's intervention logic. It contains a representation of the causal links between a project's resources/inputs, activities, outputs, outcomes and impact (W.K. Kellogg Foundation, 2004).

Technology transfer – the process that allows a country to acquire, adapt, deploy, localise, diffuse and innovate technologies from other countries (Chen, 2018).

Technology Transfer Influential Factors – the factors that are said to influence the results of the technology transfer process.

1 Introduction

To avoid the most severe impacts of climate change, the international community has agreed through the 2015 Paris Agreement, that the global average temperature rise should be kept well below 2°C compared to pre-industrial levels (UNFCCC, n.d.-f). In order to achieve this, a global concerted response to the current climate crisis has been decided, one that involves putting a halt to the rise of global greenhouse gas emissions, increasing countries' ability to mitigate climate change impacts, and intensify the investment needed for a low carbon future (UNFCCC, n.d.-f). In 2015 the international community has also affirmed its ambition to achieve sustainable development through the 2030 Agenda and its 17 Sustainable Development Goals (SDGs). The SDGs provide a blueprint to end poverty, protect the planet and ensure that all people enjoy peace and prosperity, all while tackling climate change (UN, n.d.-c). Together, the Paris Agreement and the 2030 Agenda for Sustainable Development provide the foundation for a sustainable, low-carbon future under a changing climate (UNFCCC, n.d.-a). One course of action in reducing greenhouse gas emissions, mitigating the adverse effects of climate change, and moving towards sustainable development is through the deployment of innovative, environmentally sound and low carbon technologies (European Commission, n.d.).

Provision of energy services is central to sustainable development and "access to reliable, efficient, affordable, and safe energy carriers can directly affect productivity, income, and health, and can enhance gender equity, education, and access to other infrastructure services" (Pachauri et al., 2012, p. 1407). Not having access to energy is a fundamental barrier to human welfare, and this is an issue mainly in developing countries for those segments of the population that are remote, poor, or both (World Bank, 2018). Expanding access to energy, be it from fossil or renewable sources, to all populations is necessary for lifting people out of poverty and improving well-being. However, sustainable development cannot be achieved without affordable, reliable and *clean* energy (Bhattacharyya, 2012), which is why clean and renewable energy is a key development enabler for many SDGs (UN, n.d.-a). The deployment of renewable energy technologies is therefore a building block of sustainable development, as it is for climate action. Pursuing renewable energy technologies, environmentally sound and low carbon technologies offers a strong approach in achieving objectives under the Paris Agreement and the 2030 Agenda for Sustainable Development (UNFCCC, n.d.-a).

Environmentally sound technologies, low carbon technologies, or climate technologies can be defined as "any piece of equipment, technique, practical knowledge or skills for performing a particular activity that can be used to face climate change" (CTCN, 2014). They can, for example, be renewable energy technologies or energy efficiency systems that have the potential to reduce greenhouse gas emissions and support green growth. Therefore the research, development and deployment (R&D) of new and existing climate technology play an important role in moving towards sustainable development and tackling the current global climate crisis (European Commission, n.d.), as it has the potential to decouple economic growth from intense greenhouse gas emissions, especially in sectors such as energy (Blohmke, 2014).

Research and development, deployment, and access to technology do not happen at the same rate across nations. The process of R&D is concentrated in a small number of centres around the world, more commonly in industrialised, developed countries. These are the countries that have the necessary capacities to come up with radical technological innovations, that have national policies, financial mechanisms, and business models in place that support these innovations and the deployment and diffusion of new technologies (Kaplinsky et al., 2009). The story is different in developing countries as they have a markedly different political, economic and social settings to those seen in developed countries, and these allegedly have a diminished support for R&D and where technological innovation and deployment of new technologies is more challenging (R. Lema, Iizuka, & Walz, 2015). As it is held that having access to technologies and innovation can boost a country's level of self-reliant development, increase industrial capacity, and alleviate poverty; acquiring new technologies is thus a good motivator for developing countries that want to boost their economic development (Blohmke, 2014). When technological innovation and deployment of new technologies is challenging one solution to helping developing countries gain access to new technologies and technological knowledge is through *technology transfer*.

Technology transfer (TT) refers to the series of processes that allow countries to acquire, adapt, deploy, localise and innovate technologies from more developed countries (Chen, 2018). It principally involves the movement of a physical technology from one nation to another but often also goes further to also transferring the knowledge necessary to allow the recipient country to further develop and manufacture the technology (Saad, 2000). Traditionally, TT occurs across various axes: from R&D to businesses, amongst businesses, from governments to businesses and vice-versa, from a country to another etc. (Saad, Cicmil, & Greenwood, 2002).

The role of technology transfer in mitigating climate change has been recognised by multilateral environmental agreements such as the United Nations Framework Convention on Climate Change (UNFCCC) which calls for technology transfer from developed countries to developing countries in order to achieve its objectives (Kovič, 2010). In its Article 4.5 the UNFCCC states:

> "[t]he developed country Parties and other developed Parties included in Annex II shall take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and knowhow to other Parties, particularly developing country Parties, to enable them to implement the provisions of the Convention."(UNFCCC, 1992).

Blohmke (2014, p.238) states that "developing countries understand access to technology as key for economic development and by joining the United Nations Framework Convention on Climate Change (UNFCCC), they see the chance to gain stronger technology ownership and reduce their technological dependency on the developed countries". Apart from boosting economic development, it is believed that in order to achieve the ultimate objective of the UNFCCC rapid technology innovation and access to technology, including through TT, will play a vital role in both mitigating greenhouse gas emissions and adapting to the adverse weather events brought by climate change (IPCC, 2000). Transferring environmentally sound technologies is therefore relevant at a global level with Lema & Lema, (2012, p. 24) calling the process "a cornerstone in reaching a global solution to climate change".

There are a number of channels that lead to technologies being transferred between countries: either through international organisations or through the private sector (Kirchherr & Matthews, 2018). With regard to international organisations, the UN system is heavily involved in environmentally sound technology transfer and development with the aim being to promote diffusion and uptake of technologies as well as promoting practices focused on achieving national climate goals (UNSCEB, n.d.). The importance of technology transfer in the UN system has been highlighted in the 2007 Bali Action Plan, in the context of an international climate policy framework. The framework, which sits under the UNFCCC, aims to enhance technology transfer and highlights five technology related themes: technology needs and needs assessments, technology information, enabling environments, capacity building, and mechanisms for technology transfer (UNSCEP, n.d.). The UN system is supporting enhanced implementation of the UNFCCC on these five themes through a number of UN specialised agencies and UN programmes and funds (UNSCEB, 2008).

The United Nations Industrial Development Organization (UNIDO) is one of the UN agencies that is supporting enhanced implementation of the UNFCCC. UNIDO's mission is to promote and accelerate inclusive and sustainable industrial development. The agency works with developing countries and economies in transition, where it carries out programmes and projects aligned with its four strategic priorities: creating shared prosperity, advancing economic competitiveness, safeguarding the environment, and strengthening knowledge and institutions (UNIDO, n.d.-f). UNIDO achieves its mission through taking action under four complementary and interlinked core functions: "(i) technical cooperation, (ii) analytical and research functions and policy advisory services; (iii) normative functions and standards and quality-related activities; (iv) and convening and partnerships for large-scale investment, knowledge and *technology transfer*, networking and industrial cooperation" (UNIDO, 2017, p.4).

UNIDO recognises that technology plays a key role in achieving its mission of promoting and accelerating inclusive and sustainable industrial development (UNIDO, n.d.-b) and that the transfer of environmentally sound technologies and low carbon technologies are critical in managing the transition towards sustainable production and access to clean energy (UNIDO, n.d.-e, n.d.-b). One set of technologies promoted by UNIDO is renewable energy technologies and its portfolio encompasses projects based on small hydropower, solar, wind and biomass sources, solar thermal systems, gasifiers, and biomass cook stoves. These projects include using these technologies as basis for setting up mini-grids aimed at aiding with rural electrification and for energy generation for productive uses (e.g. for industrial application in energy intensive manufacturing industries and productive activities of small and medium size enterprises) (UNIDO, 2015a).

Amongst UNIDO's portfolio of renewable technologies sits small hydropower (SHP), a technology that uses the flow of water to generate electricity. While the definition of what consists small hydropower differs from country to country[1], it is generally understood to be a hydroelectric system with a total installed capacity of 10MW[2] and below, which is enough electricity to be "applied to satisfy low-to-medium voltage electric needs such as lightning or telecommunication and to provide motive power for small industry" (UNIDO, n.d.-d).

1.1 Problem Background

Some projects in UNIDO's portfolio of small hydropower projects present a number of supposed challenges that will be documented in the following section. It should be noted that the information below has been compiled based on communications with UNIDO representatives in the Department of Energy, including staff from the Office of the Director, the Climate Technology and Innovations Division, the Energy Systems and Infrastructure Division, and the Climate Policy and Partnerships Division. Therefore, unless otherwise specified, the source of the following information is these communications.

UNIDO believes that "higher technology levels promote the inclusive and sustainable industrial development" of countries and to address this, the agency conducts programmes and activities with a focus on technology, science and innovation (UNIDO, n.d.-c). For example UNIDO provides technical assistance for countries to upgrade production processes, machines and skills;

1 The definition varies from country to country based on national policies – for example, in cases where renewable energy technologies are eligible for incentives, subsidies, or tax breaks, the national governments have set definitions for what constitutes a large or small installation to be able to say which incentive rates, tax break levels etc apply for each installation.

2 It is noted that not all countries define small hydro power as 10MW and below and that the definitions vary from country to country. The maximum output for what is considered a small hydro power plant is 50 MW and this is the case on countries such as China and Pakistan (UNIDO, 2016). Different terminologies are also used for hydroelectric installations with electricity outputs below 10MW. For example, a mini hydropower plant generally has an output of 1MW, a micro hydropower plant 500kW, while everything less that 100kW is considered a pico hydropower plant.

to build capacity on intellectually property rights and innovation; and to provide access to advanced technologies through technology transfer (UNIDO, n.d.-c). UNIDO sets to promote, encourage and assist in the development, selection, adoption, transfer of technologies from industrialised countries to developing ones and amongst developing countries. Therefore, facilitating access to technologies through TT is often an element found in UNIDO's programmes and projects.

In a nutshell, the alleged TT strategies employed by UNIDO in its projects[3], are based on the idea that by: demonstrating a technology at a (or a number of) site(s) in the country, assisting with building the capacity of the local population, helping develop viable business models based on the technology and enabling the creation of a favourable investment environment, then eventually the project will result in:

1. The local stakeholders being able to access the technology for e.g. production, agriculture and rural electrification;
2. The local stakeholders being able to replicate, further develop, and diffuse the technology in the country;
3. A positive impact on the country's achievement of its climate goals; and
4. Realised technology replication potential which will further benefit the country and the global environmental efforts.

In reality, these strategies may not always lead to the intended project results. UNIDO observed this to be the case in its portfolio of projects involving the transfer of SHP technologies to developing countries. In some cases, internally-commissioned project evaluations highlighted potential challenges during their project implementation stage. These challenges allegedly resulted in the technology not always being confidently transferred to local actors, and to the projects being extended past their intended completion date - sometimes by a few years and with financial consequences. It is important to note that these projects intend to achieve complex results in systems that evolve over time, involve a number of stakeholders, national and international organisations, funders and donors, etc. This meaning that the reasons as to why technology is not always successfully transferred can vary. For example, it could be due to insufficient resources such as funds and expertise, insufficient local capacity, national characteristics and policies that do not enable TT, or the fact that SHP might be too complex of a technology.

Brief History of UNIDO's Small Hydropower Portfolio

The first hydropower projects started under UNIDO's Department of Energy were focusing on plants with small total installed capacities, many of them being considered pico-hydro installations. These were launched in the early 2000s and up until 2010, more than 20 such projects were started. It is alleged that in 2018 roughly only half of the total installed capacity cumulative from all these projects was operational[4]. In 2008, the UNIDO Evaluation Group started conducting an independent thematic review of UNIDO's small hydropower portfolio which was published in 2010. The review had a number of findings, many of which highlighted issues with the agency's approach to SHP. Among findings were the following: the SHP projects undergone to that point had a "weak programmatic basis" with "no evidence of systematic programmatic planning, collection and analysis of data" (UNIDO, 2010, p. ix); the feasibility studies were of poor quality which led to costly plant design corrections, maintenance problems, technical failures; there was "weak reporting, accountability and learning mechanisms" which led to no explicit lessons being drawn from the projects (UNIDO, 2010, p. x); the main use of

3 This reconstruction is built on the assumptions observed by investigating a number of UNIDO small hydropower projects.

4 According to a 2018 internal investigation of UNIDO's small hydropower portfolio (Abhishek, 2018).

the generated electricity was rural lighting and there was almost no degree of energy generation for productive uses (despite UNIDO's commitment to it); in some cases the generated electricity was not cheaper than grid electricity and many locals could not afford the connection to the mini-grid based on the SHP; UNIDO installed the small hydropower plants for free which led to a hidden subsidy: the electricity tariff was below true cost which had potential to jeopardize government efforts to develop commercially viable business models based on SHP; UNIDO's activities were biased towards community-based models, not private sector approaches (despite UNIDO's commitment to the latter) and there was no evidence that the former were set up in a stable manner that would be able to sustain the model long-term (UNIDO, 2010). One last finding of the review was a direct criticism to UNIDO's decision to use its allocated budget to jump directly into a large number of pilot projects without a credible strategy. The review suggested that a more effective use of the budget would have been to focus on strategic studies and advice to deliver services such as "the systematic mapping, assessment and matching of renewable energy resources and energy needs and advice for developing renewable energy strategies or building the capacity of newly created national energy agencies" (UNIDO, 2010, p. xi).

In recent years UNIDO revamped its approach to SHP by taking a number of strategic steps aimed at building its SHP development programme and delivering more effective projects. One such step focused on knowledge cooperation: UNIDO collaborated with the International Centre on Small Hydro Power (ICSHP) to develop the first hydropower knowledge platform providing a global assessment of small hydropower capacities and potential; it helped establish renewable energy training centres across the global south (e.g. in Nigeria, India, and Tanzania); and helped establish renewable energy and energy efficiency centres in different regions (Liu, 2017). Another step was to join the ICSHP and other experts[5] in the development of two World Small Hydropower Development Reports (in 2013 and 2016), two comprehensive publications intended to promote SHP as a renewable and rural energy source, overcome barriers to development, and provide comprehensive overviews of a large number of national policy landscapes (UNIDO, 2016). Another step focused on developing an international SHP standard: a technical guide (including information on basic technical knowledge, planning and feasibility, equipment, construction, and operation and management) providing a step-by-step approach to implementing small hydropower system in developing countries.

Since the late 2000s UNIDO transitioned towards projects with higher generating capacities and moved from a technology supply driven approach towards a market development driven approach[6]. In June 2018 17 SHP projects were ongoing, their initial capacity target being 44.87MW, however less than 13% of this was actually installed at that time[7]. In 2018 UNIDO commissioned internal investigations of their SHP portfolio in search of areas where their projects can be improved to become more effective. One such investigation was an evaluation of UNIDO's assistance in SHP projects that involved documenting the SHP portfolio and screening a sample of projects to understand UNIDO's existing strengths and weaknesses in the projects launched after 2010: Abhishek, 2018. Another investigation is represented by this thesis. This thesis was scoped as a case study of past small hydropower projects pursuant to input from UNIDO's Department of Energy with the intention to study past projects and put them in a theoretical context of technology transfer and derive theory-informed lessons that can be replicated in future project design.

5 i.e. "230 local and reginal small hydropower experts, engineers, academics and government officials across the globe" (UNIDO, 2016, p.6).

6 According to the aforementioned 2018 internal of UNIDO's small hydropower portfolio (Abhishek, 2018).

7 Ibid.

1.2 Problem Definition

One often desired result of projects based on small hydropower technology is the transfer of the technology to local stakeholders[8]. As discussed above some UNIDO's SHP projects did not manage to achieve this in a timely manner and some were extended past their intended completion date. There might be several reasons underlying this problem, however one suspicion is the possibility that the projects were designed in a way that unintentionally failed to assess and plan for all the main factors that could influence the results of the technology transfer element. Introduced in the context of this thesis as "technology transfer influential factors" these factors represent aspects relating to the characteristics of the technology recipient country or relating to elements of the project itself that have the potential to either hinder or maximise the success of the technology transfer process. Following on the point above, the suspicion is that issue lies in the project design phase, therefore at project inception stage and more specifically, in the principles on which the project design is built. Referred in this thesis as "intervention logic" these principles are a set of statements that define how and why a project it supposed to work, under what conditions the project results occur, what the predicted outcomes and impacts are, and what requirements are necessary to bring about the desired project effects.

Based on above, the first hypothesis that underlies the creation of this thesis project was drawn:

H1: *The intervention logic that underlines the technology transfer strategy behind UNIDO's small hydropower projects logic omits some technology transfer influential factors.*

In order to define "technology transfer influential factors", this thesis assumed that such factors have been previously studied and can be identified in the academic knowledge and specialised publications on the topic. This assumption forms the basis of the second hypothesis that underlies this study:

H2*: There is existing knowledge in academic and specialised literature that describes which factors to pay attention to and plan for when engaging in transfer of technologies from one country to another.*

1.3 Objective and Research Questions

The main aims of this thesis were to investigate how technology transfer activities are planned in UNIDO's small hydropower projects; to document if the intervention logic can highlight areas where there may have been omissions in assessing and planning for the main factors that could influence the results of the technology transfer; to identify strengths and weaknesses in the current approach; and derive scientifically-informed lessons that could lead to a more effective project design. In order to achieve this, the following sub-objectives and research tasks were formulated:

1. Identify the main factors that are said to influence the process of technology transfer to developing countries (*'technology transfer influential factors')* by scanning and analysing academic and specialised knowledge on the topic;
2. Reconstruct the intervention logic that forms the basis of the technology transfer strategy behind UNIDO's small hydropower projects;
3. Gain a deeper understanding of if and how the intervention logic captures and plans for the factors that are said to influence the success of the TT process;

8 While most projects include to some extent technology transfer, other focus more on upscaling and upgrading already existing capacity through e.g. strengthening local manufacturing of SHP turbines or upgrading existing installations; or only focus on a single step in the technology transfer process e.g. feasibility studies.

4. Compare the way technology transfer factors are currently planned for with lessons from academic and specialised knowledge and derive lessons on how the small hydropower projects can improve their technology transfer approach.

Based on the above the following research questions have been devised:

1. *What are the factors that are said to influence technology transfer to developing countries?*
2. *How are these factors captured and planned for in UNIDO's SHP project intervention logic?*
3. *How does UNIDO's current SHP project intervention logic perform when compared to the technology transfer factors identified in academic and specialised knowledge?*

1.4 Limitations and Scope

The research scope of this thesis will consider interventions that have, alongside other objectives, the intention to transfer a technology from one country to another. These interventions do not only focus on technology transfer, this being more a means to an end for the ultimate goal which can be e.g. augmenting rural electrification, increasing access to renewable energy and bringing about global benefits by reducing a considerable amount of CO2 emissions. These interventions ae usually aligned with UNIDO's strategic priorities, technology transfer being just one of the integrated elements.

These interventions are complex and are constituted of different elements that interact with each other and evolve over time. This thesis focuses only on those elements pertaining to technology transfer and therefore, the reconstruction of the IL and the subsequent analysis are centred around TT. This means that may have been certain intervention elements and strategies that were considered out of the scope of this thesis and deliberately left out of the investigation, one such example being UNIDO's strategies for gender mainstreaming.

Other limitations pertain to the generalizability of the findings of this thesis. These projects considered have a narrow focus on SHP as the technology to be transferred, which could pose a potential limitation to the generalizability of the findings to other technologies. Further, the technology recipient country in these cases are developing countries. This geographical limitation means that the findings of this study are unlikely to be generalizable to countries that have different political, economic and social settings.

This thesis also encountered certain data limitations which are further discussed in Section 2.3.4.

1.5 Ethical Considerations

This thesis was commissioned by UNIDO and part of the initial research was done in close collaboration with the agency. While UNIDO provided suggestions and inputs for the research direction, the final decisions on scope, research strategies, design, framework, material and methodologies are also the author's own, and were also made independently of UNIDO.

Several UNIDO staff members participated in the first phase of this study by providing context of the problem this thesis is attempting to address, previous work done on the topic, potential challenges and limitations etc. This input was provided mainly via face-to-face communications with no audio or video recording being taken and staff members' anonymity was protected by default. The ensuing generated data was only used in assembling the information in Section.1.1. Accuracy checks were requested by the author for the compiled information in that section.

The data pertaining to the case studies was all document-based and most of the documents are publicly available on the UNIDO Open Data Platform or on the UNIDO website, and it was therefore considered that they do not contain information that should not be in the public sphere. Still, in order not to share potentially sensitive information all references to country names, donors, involved institutions, etc. have been removed when describing the projects. Finally approval from UNIDO has been sought regarding the publication of the information contained in this thesis.

1.6 Audience

This study is intended to provide mainly UNIDO staff with a means of facilitating future project design plans in the area concerned with technology transfer. It draws from the field of technology transfer research to identify those aspects that should be carefully assessed and planned for when transferring a technology to a new recipient country as part of an international development aid project. In that respect the audience is not only limited to UNIDO as the findings of this thesis could also support other international development organisations engaged in projects and programmes that aim to transfer technology to developing countries or economies in transition.

While the main target audience is UNIDO staff, the findings of this thesis can also prove helpful for counterparts independent of UNIDO that are engaged in projects aiming to transfer technology to developing countries. Such counterparts could be local governmental institutions, academia, private organisations etc. that could use this work as a basis for understanding the areas of importance that need to be supported in order to maximise technology transfer. Furthermore, part of this study could also be directed at multinational organisations operating in the field of engineering, construction, finance etc. that undertake technology transfer operations.

1.7 Disposition

Section 1 provided the background to this research project by introducing the context of the project, some historical challenges faced by UNIDO's SHP projects, and how this thesis is aiming to address some of these challenges by investigating the TT 'red thread' in the project's ILs. It also provided the research questions that this thesis is aiming to answer.

Section 2 presents the methodological aspects that guided the research design of this thesis, as well as the data collection and analysis. *Section 3* delivers a literature review on the topic of technology transfer and identifies those factors that are said to have an influencing role on the process of technology transfer. At the end of this thesis the analytical framework that was used to guide the analysis of the intervention logics is presented.

Section 4 introduces the two case studies that came under scrutiny. An overview of the case studies is provided as well as their performance according to UNIDO's own evaluation. *Section 5* delivers the results and analysis generated by this thesis. It starts by introducing the intervention logic behind the two case studies, provides its analysis based on how it performed on planning for TT, its strengths and weaknesses and the observed dimensions of technology the interventions managed to transfer.

Section 6 goes on to present a discussion of the posed hypotheses and main research tasks undertaken as part of this thesis, as well as the main findings generated by this study. Finally, *Section 7* provides responses to the research questions and concludes the report with a number of recommendations.

2 Methodology

The following section presents the research method behind the study and the methodological steps that have been taken in order to answer the research questions presented in Section 1.3. The section starts with an introduction to the use of case studies as an appropriate research approach. Then and an introduction to 'evaluation research' and a qualification of *why* investigating a project's IL is worth pursuing followed by *how* a project's IL can be investigated. Finally, the data sources and data analysis method are presented.

2.1 Case-Oriented Approach

Considering the situation and the problem posed by this thesis, a case-oriented approach was suggested by UNIDO to guide the research design as it can provide the relevant insights into its approach to small hydropower projects and help fulfil part of research objectives. To this regard, UNIDO was able to make a number of its SHP projects available for investigation.

The case study is a research strategy aimed at providing a more in-depth insight into a contemporary phenomenon within its real-life context i.e. objects, events or processes that are usually bounded – by some sort of physical boundary, place, or in terms of time (Verschuren & Doorewaard, 2010; Yin, 2003). Doing an in-depth exploration of a specific bounded system allows for an analysis of how and why the system operates, or in the case of the UNIDO SHP projects: an understanding of how and why the intervention *was thought to work in theory*. The case study was chosen to guide the design of this thesis because it is an empirical inquiry that "tries to illuminate a decision or set of decisions: why they were taken, how they were implemented, and with what result." (Yin, 2003, p.12), and therefore can provide valuable insights into the SHP intervention logics: why were designed the way they were and how this design might lead to success or failure.

This thesis follows a multiple-case design i.e. case study research in which several cases are selected to develop a more in-depth understanding of the phenomena (Chmiliar, 2010). The rationale behind using multiple case studies is that the resulting evidence is often considered more compelling that from just one case study (Yin, 2014). In the context of this thesis, two case studies representing two SHP projects have been selected for analysis. According to Yin (2014, p.64) a "two-case" case study may offer substantial analytical benefits as the "conclusions independently arising from two cases will be more powerful than those arising from a single case study". The two selected case studies are expected to be quite similar in their intervention logics, however still different enough in their approach as to offer potentially contrasting results.

2.1.1 Case Study Selection

Potentially suitable case studies were identified via the UNIDO Open Data Platform. The Platform is a database devised as part of UNIDO's commitment to openness and transparency and it "displays an overview and interactive world map clustered by region and country, and presents detailed information on programmes and projects, such as financial data, project outcomes and outputs, timelines, project managers, gender-equality information, and more. The information is complemented by project documents and other related material, as well as statistical information on the country and donor." (UNIDO, n.d.-a). Nineteen[9] SHP projects were initially found on the platform, which were further narrowed down to 12 potentially suitable case studies as seven of these entries were considered historical.

The case studies for consideration in this thesis were selected based on a number of criteria:

9 Projects involving the development of the World Small Hydropower Report, and projects which defined their scope just as "renewable energy" were not included in this count.

1. The status of the project (completed/close to completion/still ongoing): preferably the selected projects should have been completed as this allows for reflection on the outcomes that were achieved by following the project's IL: did it lead to project success, what were the challenges met along the way, etc. The projects should have also had a final evaluation report produced as this is an important source of insights into the success of the project.
2. The technology: in order to fit within the scope of this thesis the project should have as a focus only small hydropower technology on its own i.e. the SHP is not part of a project focusing on multiple renewable energy technologies. This should allow for potential comparison and further replication of the results.
3. The project aim: one main project's aim needed to be the transfer and implementation of SHP technology to a new recipient country. While it is understood that technology transfer is embedded in UNIDO's core functions, this criterion was considered of relevance due to the fact that several UNIDO SHP focused on upgrading existing installations or on only one step of the technology transfer process e.g. carrying out feasibility studies, which would be outside the scope of this thesis. This should allow for further narrowing down of potential suitable case studies.

Eventually two case studies were selected for analysis in this thesis: Project A and Project B. In order not to share potentially sensitive information the projects have been anonymised with only their approximate context being described (please see Section 4). These projects were selected because they fitted all (Project A) or most (Project B) of the selection criteria. The only criterion not fulfilled by Project B was its status, the project not being operationally completed at the time of data collection. According to the UNIDO Open Data Platform the project had an expected completion date of late 2019. However, the project did undergo an independent terminal evaluation assessing whether the project has achieved or is likely to achieve the project objectives which was published on the Open Data Platform. These evaluations are usually commissioned by UNIDO and carried out three months before the operational completion of a project. It was therefore considered that the project is close enough to completion to allow it to be a suitable case for analysis.

The research was limited to two case studies mainly due to data availability limitations and scope issues. For most of the 12 projects identified as potentially suitable the author was able to source project documentation that would have allowed for the completion of the first part of the research task however evaluation reports were necessary in order to determine if the projects performed well on technology transfer. Evaluation reports were available for the two selected case studies, but not publicly available for the other projects. With regard to scope, several of the projects did not have a clearly stated technology transfer element incorporated in them, despite involving technology-related activities. As the main aim of this thesis is to understand how technology transfer activities are planned in UNIDO's small hydropower projects it was considered that only projects that have a clearly stated technology transfer element should be included in the research. This will allow for more accurate conclusions and further recommendations.

2.2 Evaluation Research

Part of this thesis' research design is inspired and guided by the field of evaluation research. Evaluation research can be defined as "a type of study that uses standard social research methods for evaluative purposes, as a specific research methodology, and as an assessment process that employs special techniques unique to the evaluation" (Powell, 2006, p.102). In the context of UNIDO's projects, evaluation can be considered a technique for establishing how well the goals of the projects have been attained. According to UN's Evaluation Manual (1986) (as cited in UNIDO, 1999, p.1) evaluation "is a process which seeks to determine as systematically and objectively as possible the relevance, effectiveness and impact of work in progress, or of work completed, by measuring accomplishments against the original objectives and by revealing the reasons for any significant deviation".

Nevertheless, evaluating how well the objectives of the two case studies have been attained sits outside the scope of this thesis; this activity having already been accomplished by UNIDO itself through its various evaluations of the projects. This thesis's however aims to evaluate the validity of the technology transfer elements found in the interventions' internal logic and identify improvement areas, thus contributing understanding of one area of goal achievement that is insufficiently understood. In order to achieve this task, several concepts from the field of evaluation research have been adopted and integrated in the design of this study namely: *intervention logic*, *logic analysis*, and *logic models*.

2.2.1 Intervention Logic: Meaning and Terminology

As stated in Section 1.2, the term 'intervention logic' (IL) is used in this thesis to refer to a set of statements that describe *why*, *how*, and *under what conditions* a project's effects occur, *predict* the outcomes and impacts of the project, and *specify the requirements* necessary to bring about the desired project results. This term is synonymous with 'theory-of-change', which is the terminology often used by UNIDO to refer to the same concept, sometimes alongside "logical framework". The author found that the terms 'theory-of-change' and 'logical framework' may have been used interchangeably in a number of UNIDO literature, even though they refer to complementary but ultimately different concepts:

- Theory-of-change, just as IL, refers to an approach to help clarify the links between project activities and long-term objectives and impacts. It is used to better understand the processes that project seek to influence by analysing the links between different elements of a system and the conditions required to achieve change (Zazueta, 2018). It focuses on how the project interacts with the wider system and indicates pathways that contribute to change (Zazueta, 2018).
- Logical framework provides a systematic view of the causal linkages in a project and is used to support the design, planning, management, evaluation, and communication of the project (Golini, Corti, & Landoni, 2017). It is a project management tool used as a means to measure and report the achievement of project objectives (Landoni & Corti, 2011).

The notion of 'intervention logic' also appears in a variety of terminologies throughout academic literature, conference papers, presentations, and grey literature. This variety of terms suggests that there is no "common vocabulary, definition, and shared conceptual and operational understanding" (Coryn et al., 2011, p.200) which makes it somewhat difficult to achieve a consensus amongst authors with regard to practice. To give an example, Rogers (2008) and Coryn, A Noakes, Westine, & Schroeter (2011) both took count of the wide variety of terminology used in their work. The variations are listed below:

- Rogers (2008, p.30): "programme theory, programme logic, theory-based evaluation, theory of change, theory-driven evaluation, theory-of-action, intervention logic, impact pathway analysis, and programme theory-driven evaluation science".
- Coryn et al., (2011, p.200): "program-theory evaluation, theory-based evaluation, theory-guided evaluation, theory-of-action, theory-of-change, program logic, logical frameworks, outcomes hierarchies, realist or realistic evaluation, and, more recently, program theory-driven evaluation science".

Based on the above one can note that the notions regarding how and why a project works (e.g. intervention logic, theory-of-change etc) are intermixed in literature with notions relating to examination (e.g. theory-driven evaluation, program-theory evaluation etc.). For clarity purposes in this thesis there will be a distinction between these two notions with:

1. Intervention logic – to refer to how and why a project works by following the definition at the beginning of this section.
2. Intervention logic analysis – to refer to the interrogation of the intervention logic. This will be further discussed in the next section.

2.2.2 Intervention Logic Analysis and Logic Modelling

Intervention logic analysis or simply 'logic analysis' belongs to the large family of theory-driven/programme theory evaluations etc. and is a specific type of evaluation. It is used to test if the intervention is designed in a way that can logically produce the desired results, based on scientific knowledge (Brousselle & Champagne, 2011). Logic analysis uses scientific knowledge to improve the intervention or to find alternatives for achieving the project's intended outcomes, and can be used for distinguishing the strengths and weaknesses of the intervention (Tremblay, Brousselle, Richard, & Beaudet, 2013). According to Rey et al., (2011, p.62) logic analysis can be considered "a distinctive type of evaluation because it raises a particular evaluation question about the validity and appropriateness of the intervention".

According to Brousselle & Champagne, (2011) and Rey et al., (2011) logic analysis can be conducted in two ways, either through:

- **Direct logic analysis***:* this type of analysis is mostly formative and facilitates the understanding of whether the intervention was designed in such a way as to achieve its desired outcomes by: identifying the crucial characteristics of the intervention; identifying the critical factors influencing the achievement of the desired outcomes; and providing information on which elements should be added to the intervention in order improve its impact, according to scientific knowledge.
- **Reverse logic analysis***:* this type of analysis is mostly summative and facilitates the confirmation or invalidation of the intervention being investigated. It allows the investigator to look for the best ways to achieve the desired project outcomes by determinising the alternatives that could also produce the intended outcomes.

In the context of this thesis *direct logic analysis* is used as an analysis method in order to understand the intervention's main components, see if the optimal conditions have been assembled to achieve the desired outcomes and which elements should be added to improve the results. Conducting direct logic analysis consists of three steps (Brousselle & Champagne, 2011):

4. **Building the logic model of the intervention**: logic modelling is used to represent the intervention's internal logic and the basis upon which it is supposed to lead to the desired outcomes. Logic modelling is further discussed below.
5. **Developing analytical framework**: using existing scientific knowledge identified through a literature review in order to understand the optimal conditions and causal mechanisms that might lead to the desired project results. There may be several fields of knowledge that could be explored in this step each leading to various theories. In the context of this thesis the framework is built using scientific knowledge from the field of technology transfer.
6. **Evaluating the theory of the intervention:** the intervention's internal logic is then tested against the framework to determine whether the intervention is designed in a way that can logically produce the desired results. This should produce a new understanding of the intervention that highlights its strengths and weaknesses, the strength of the causal mechanism towards the desired project outcomes and identify elements that could be added in order to improve the results.

Logic modelling

Logic modelling refers to the act of developing a logic model, a tabular or diagrammatic representation of a project's IL. A logic model is in essence a visual method of presenting the idea behind the project, a picture of how the implementors believe the project will work and they are often called "idea maps, frameworks, rich pictures, action, results or strategy maps, and mental models" (Wyatt Knowlton & Phillips, 2012, p.4).

For this thesis the IL of the two case studies was reconstructed using logic modelling in order to visualise the elements that UNIDO though were necessary in order to operationalise the project, the causal mechanisms between these elements, and how these were thought to lead to the intended results. It is worth noting that the two case studies both incorporate a 'logical framework' in their documentation, which is often also a tubular representation of the causal linkages in a project and is used to support the design, planning, management, evaluation, and communication of the project (Golini et al., 2017). Nevertheless, while logic models and logical framework are used for similar purposes, they are "fundamentally different but complementary tools" (Wyatt Knowlton & Phillips, 2012, p.4). Logical frameworks are useful tools for project visualisation and for anticipating the causal links between activities, output, outcomes and goals, but they are ultimately just 'frames' presenting the information in a succinct manner and may not capture some of the details of the project IL which is why logic models were considered a more appropriate approach in investigating UNIDO's small hydropower projects.

There seems to be a general consensus amongst academic and specialist literature as to what the components of the logic model should be (Figure 2-1), namely: resources/inputs, activities, outputs, outcomes, and impact (e.g. CDC, n.d.; Rey et al., 2011; Rogers, 2008; W. K. Kellogg Foundation, 2004). In this thesis, the case studies' logic models have been reconstructed using the W.K. Kellogg methodology as described in their 2004 *Logic Model Development Guide.* This guide has been chosen as it provides a simple and robust step-by-step explanation of logic modelling and due to an apparent acceptance of the guide among authors in peer reviewed journals (e.g. Lawton, Brandon, Cicchinelli, & Kekahio, 2014; Rey et al., 2011; Rogers, 2008).

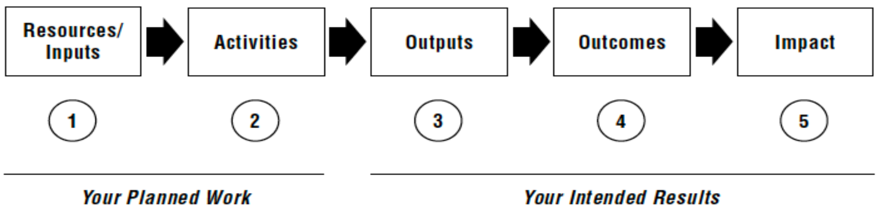

Figure 2-1. The basic logic model
Source: W.K. Kellogg Foundation (2004), p.1.

The five components, or "levels" of the logic model are categorised into 'Planned Work', describing what resources are thought to be needed to implement the project and what the implementors intend to do; and 'Intended Results', which describes all of the project's desired results i.e. outputs, outcomes, and impact (W. K. Kellogg Foundation, 2004). These components are defined as follows (unless otherwise cited, based on the definition used by Wyatt Knowlton & Phillips, 2012, p.36):

The Planned Work consists of:

Resources/Inputs – describe the resources needed in project that are essential for activities to occur. They can "include human, financial, organizational, community, or systems resources in any combination. They are used to accomplish named activities."

Activities –refer to the specific actions that are deployed as part of the project in order to secure the desired results. They can be "processes, tools, events, technology, and actions that are an intentional part" of the project.

The Intended Results consist of:

Outputs –describe the 'products' of the project activities which may include types, levels and targets of services to be delivered by the project. They may be quantified and/or qualified in some way

Outcomes –describe the changes produced as a result of the project. They can be changes in awareness, knowledge, skill, and behaviour of the stakeholders involved in the project. They can be short-term outcomes (usually attainable within 1 to 3 years), and long-term outcomes longer-term outcomes (usually attainable within 4 to 6 years) (W. K. Kellogg Foundation, 2004, p.2)

Impact – refer to a change/variation in state of affairs occurring in organisations, communities, systems etc, which "may happen at any point in time or place and may or may not be causally related to an intervention". (Belcher & Palenberg, 2018, p.480).

2.3 Data Collection

The data collection for this thesis involved a number of activities and approaches, namely a study trip to the UNIDO headquarters in Vienna, a literature review of the topics of intervention logic and logic analysis and technology transfer, project documentation and desk research. The data collection activities can be split into two phases based on the level of interaction between the author and UNIDO: the first phase involved regular communication with UNIDO representatives and culminated in the study trip, while the second phase consisted mainly of independent research with limited communication between the author and the agency.

2.3.1 Study Trip

As part of the data collection the author undertook a 10-day study trip to the UNIDO headquarters in Vienna. The purpose of the study trip was to:

- Collect background data regarding UNIDO's approach to small hydropower projects;
- Meet the in-house specialists in the field of technology transfer and small hydropower, as well as the project managers in charge of the small hydropower projects;
- Understand the context of the problem this thesis is attempting to address, the previous work done on the topic and potential challenges and limitations;
- Document the agency's approach to the IL (often called 'theory of change' by UNIDO), logic modelling and other project management tools e.g. the logical framework;
- Interact with, and experience UNIDO's organisational structure and culture and how this may impact the project approach.

During the study trip UNIDO provided the author an office space inside the agency's headquarters giving the author the opportunity to get direct access to UNIDO staff from its Department of Energy. During the 10 days period the author had daily communication and interactions with various representatives from the Department of Energy from the following divisions: Office of the Director, the Climate Technology and Innovations Division, the Energy Systems and Infrastructure Division, and the Climate Policy and Partnerships Division – including industrial development officers, division chiefs, technical experts, consultants and interns. Alongside the daily interactions, the author also participated in a number of one-on-one meetings with key staff members relevant to the research task, and participated in a workshop on the theory of change organised by UNIDO's Independent Evaluation Division. While in Vienna the author also had access to several internal documents and previous internal work done on the subjects of technology transfer and small hydropower.

This phase involved regular collaboration with UNIDO, the agency having a relatively active role in suggesting potential research scopes, data sources and research strategies. UNIDO did have a strong influence on determining that small hydropower projects should serve as exemplary case studies from its portfolio of programmes and projects involving the transfer of technology. UNIDO also had a relative influence in suggesting the investigation of projects' IL as research approach, nevertheless the final decision on how this will be done belongs to the author and was made independently of UNIDO. Furthermore, final decisions on scope, research strategies, design, framework, material and methodologies are also the author's own, and were also made independently of UNIDO.

2.3.2 Literature Review

The literature review was an integrated part of this thesis and it was conducted for both the topic of intervention logic and technology transfer. With regard to IL a general review of literature was conducted in order to get a deeper understanding on the method of analysis. A particular challenge in conducting this literature review was the multitude of terminologies used to describe the same or similar concepts (as discussed in section 2.2.1).

With regard to technology transfer a literature review was conducted both in order to answer one of the research questions on *TT success factors that can be found in academic and specialised knowledge* and in order to develop the framework for conducting direct logic analysis on the selected case studies. The aim of the literature review on technology transfer was to provide a holistic synthesis on the current knowledge on the topic and the many conceptual and practical considerations that may be applicable to the case studies. The review included both academic literature and grey literature in the form of reports, publications, working papers, conference papers, as well as presentations, webinars, websites etc. in order to cover a wide variety of sources and opinions. While academic literature forms the bulk of the sources, special attention was also given to publications from agencies and programmes from inside the UN system in order to understand how agencies related to UNIDO approach the topic of technology transfer.

With regard to sourcing the relevant literature academic search engines such as Scopus, Elsevier, Google Scholar, and LUBsearch were used as well as conventional web searches. A snowballing approach has also been used for identifying new sources. Furthermore, the publication databases of several UN programmes and agencies were also searched (e.g. the UNIDO publication database through the Open Platform, the UNEP Knowledge Repository, the UNCTAD publication database), nevertheless it is to be noted that several potentially relevant publications were behind a pay-wall and these could not be accessed.

2.3.3 Desk Research

Desk research was employed as a technique in collecting data on the two case studies. Building the logic models for the two case studies involved reconstructing them mainly based on following the internal logic of a number of documents, which are discussed below.

Since both case studies are projects that have been approved for implementation by UNIDO, donors, project stakeholders, etc, it means that they have gone through the process of developing a project concept note. The process of preparing the concept note usually includes an analysis phase that results in data regarding the project context, the why, how, and under what conditions a project's results occur, predict the outcomes and impacts of the project, and specify the requirements necessary to bring about the desired project results. This information is mainly gathered in a "Project Document" or "ProDoc", the main document outlining the *how* and the *why* of a project i.e. what is the context and motivation behind the project, what is its goals and how is UNIDO planning on achieving these goals. The project documents served as the main source of information for reconstructing the logic models, which were reverse engineered by the author by following the projects' narrative. Information on the success of the project, according to UNIDO's own independent evaluations, was sourced from the project's evaluation reports. These reports contain details on final results/the progress of the project in achieving its desired results, a reiteration of the project context, a synthesis of the project activities, observations about the project's results, and post-project activities, etc.

The author collected documents from UNIDO's Open Data Platform, and the Project Evaluations page of the UNIDO website. If any of these documents were not publicly available on the Open Data Platform, they were made available to the author by internal UNIDO parties. The collected and reviewed documents for each of the case studies are listed in Appendix A.

2.3.4 Data Limitations

The reconstruction of the logic models and the logic analysis was based on data available in official UNIDO project documents and evaluation reports. To the best of the author's knowledge these are the main documents pertaining to the case studies and the most relevant in terms of sourcing quality data. Nevertheless, there may be additional project documentation containing relevant data that the author was not aware of. For example, UNIDO has its own internal database however this was not made accessible to the author during the study trip which may contain further potentially useful documentation.

A further limitation comes from the use of documentation as the main source of information for the reconstruction of the intervention logic and as the main evidence for investigation. While the document-based data was considered to be suitable for the fulfilling the aims of this study and answering the research questions, additional interview-based data could have provided supplementary information regarding some of the project design decisions.

2.4 Data Analysis

The documents collected during desk research were analysed using document analysis. Document analysis is a form of qualitative research in which documents are interpreted by the researcher "in order to elicit meaning, gain understanding, and develop empirical knowledge" (Bowen, 2009, p.27). Document analysis is an iterative process that involves first superficial and then thorough examination and interpretation, a process which combines elements of content analysis and thematic analysis. Content analysis involves organising information into categories related to the central research task, while thematic analysis is "a form of pattern recognition within the data, with emerging themes becoming the categories for analysis" (Bowen, 2009, p.32). For this thesis the document analysis yielded excerpts and entire passages from the ProDocs and the evaluation reports which were then organised into themes (intended work, intended results) and then into categories (resources, activities, outputs, outcomes, results, impact). The data in the resulting categories was then first organised in a logic model tabular template (see Appendix B and C), and then synthesised in diagrammatic formats (see Figure 5-1 and 5-2).

The data resulting from the document analysis was then further analysed according to the direct logic analysis methodology explained in Section 2.2.2 above. After the logic models were reconstructed based on the data yielded in document analysis, an analytical framework (see Section 3.4) was developed based on the literature review covering scientific knowledge in the field of technology transfer. The analytical framework was built based on the main factors influencing the potential success of a technology transfer project in developing countries. The framework then guided the interrogation of the technology transfer elements found in the IL of the two case studies.

Finally, a cross-case comparative analysis was conducted in order to search for common patters as well as differences across the two case studies in the form of a tabulation and comparison exercise.

3 Technology Transfer

The following section delivers a literature review on the topic of technology transfer and is structured as follows: first, it provides a definition of technology transfer, its perceived role in climate action and the mechanisms that the international community has put in place to encourage TT; second it discusses technology as a whole and gives a breakdown of the most prevalent aspects of technology transfer; third it presents the main identified factors that are deemed to have the greatest potential of affecting the technology transfer process to a recipient country. The purpose of the literature review is to: A) provide the necessary background information to understand the processes behind technology transfer and B) provide a framing for the technology transfer success factors relevant for developing countries identified in academic and specialised literature.

3.1 Definition & Relevance in International Climate Action

Technology transfer (TT) as a concept does not have a universally agreed upon definition. As the name suggest the concept of TT involves the 'transfer' of technology: the movement of a technology from the place from where it originated to a different place where it can be used. However, the axis across which this happens depends on its context: for example technology transfer can mean the transfer of a technology from a R&D centre to another, or from R&D to the public or private sector, or from the private sector to the public or vice-versa; this would be considered technology transfer on a vertical axis (Saad et al., 2002). It can also mean the transfer of technology across borders, from one country to another, be it from developed country to developing country or from developing country to developing country; this would be considered a horizontal axis (Saad et al., 2002). In the context of this thesis, technology transfer should be viewed across this later axis i.e. the horizontal transfer of technology from one country to another. To this regard, the following 3 definitions of technology transfer are considered most appropriate in the context applied for this discussion:

"A broad set of processes covering the flows of know-how, experience and equipment […] amongst different stakeholders such as governments, private-sector entities, financial institutions, non-governmental organizations (NGOs) and research/education institutions" (IPCC, 2000, p.3).

"The horizontal technology transfers that allow developing countries to acquire, adapt, deploy, localise and innovate […] technologies from more developed countries" (Chen, 2018, p.1).

"The process whereby knowledge in some form changes hands from a person or organisation who possesses it to another individual or organisation" (Saad, 2000, p.34).

The process of technology transfer can be lengthy, complex and dynamic, have different objectives, and be undertaken through a number of mechanisms (Saad, 2000). With regard to the objectives of technology transfer to developing countries Hoffman & Girvan, (1990) draw three main ones: 1) the introduction of new technologies and techniques; 2) the improvement of existing technologies and techniques; 3) the generation of new technical knowledge.

The role of technology transfer in addressing climate change has been recognised at an international level during the 1992 United Nations Framework on Climate Change (UNFCCC) (Chen, 2018). In its Article 4.5 the UNFCCC states: "[*t*]*he developed country Parties and other developed Parties included in Annex II shall take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and knowhow to other Parties, particularly developing country Parties, to enable them to implement the provisions of the Convention.*"(UNFCCC, 1992).

Technology transfer was also the focus of a 2000 Intergovernmental Panel on Climate Change (IPCC) report, which also stresses the point for the importance of technology transfer in climate change mitigation: "*Achieving the ultimate objective of the UNFCCC […] will require technological* *innovation and the rapid and widespread transfer and implementation of technologies, including know-how for mitigation of greenhouse gas emissions. Transfer of technology for adaptation to climate change is also an important element of reducing vulnerability to climate change*"(IPCC, 2000. p.3).

On the basis of the above it can be said that in the context of climate change mitigation, the transfer of technology plays an important role. Access to technology is crucial to economic development in developing countries (Chen, 2018), however in order to achieve the low carbon economy that the international community strives towards, a certain degree of 'environmental leapfrogging' needs to take place. 'Environmental leapfrogging' is the concept that developing countries can skip the highly carbon intensive stages of industrial development and 'leapfrog' to cleaner, more resilient economies (UN, n.d.-b; Watson & Sauter, 2011). Therefore the transfer of low-carbon technologies is relevant at a global level in the light of the effort to curb carbon emissions with Lema & Lema, (2012, p. 24) saying that TT "is seen as a cornerstone in reaching a global solution to climate change.".

International Instruments

There is no international instrument that deals explicitly with technology transfer however, provisions related to technology transfer can be found in a number of multilateral, interregional and regional instruments and bilateral agreements. These instruments have an important role in technology transfer as they can set up explicit means and mechanisms to facilitate the transfer of technology, establish the regulatory framework in which states and private actors interact and technology is diffused, and create institutions that pool together technologies and knowledge and diffuse information. (UNCTAD Virtual Institute, 2012).

In the context of climate change mitigation, there are a number of international programmes designed to assist developing nations in obtaining environmental technologies, the bulk of these being under the auspices of the United Nations Framework Convention on Climate Change (UNFCCC). Historically there have been several established international mechanisms and frameworks for operationalising the move toward low carbon technology transfer, such as:

The Clean Development Mechanism (CDM) established under the Kyoto Protocol, which is a market-based instrument allowing industrialised countries to implement emission-reduction projects in developing countries (UNFCCC, n.d.). While the CDM does not have an explicit technology transfer aim, many projects undertaken under it imply the transfer of knowledge and equipment since some of the projects will have technology needs (Murphy, Kirkman, Seres, & Haites, 2015).

The Technology Transfer Mechanism and the Expert Group on Technology Transfers (EGTT), established under the Marrakech Accords in 2001. The TT framework defines the key elements for meaningful and effective actions: technology needs and needs assessment; technology information; enabling environments; capacity building, and mechanisms to facilitate institutional and financial support to technology cooperation, development and transfer; innovative financing; international cooperation; endogenous development of technologies; and collaborative R&D (UNFCCC, n.d.-d).

Nationally Appropriate Mitigation Actions (NAMAs) introduced in 2007 under the Bali Action Plan. The idea being that developing countries shall take NAMAs in the context of sustainable development, by considering TT, financing and capacity building (Blohmke, 2014). In order to take NAMAs, countries need to undertake Technology Needs Assessments (TNAs) to provide a means for determining technological priorities and barriers to technology deployment, which in turn will support national sustainable development, will build capacity and facilitate the implementation of technologies (UNFCCC, n.d.-c).

The Global Environment Facility (GEF) established at the 1992 Rio Earth Summit, is a funding mechanism designed to support developing countries comply with the environmental targets imposed by five[10] international conventions (GEF, 2016). After the Bali Conference, the GEF was tasked with elaborating a program to scale up investment in the transfer of low carbon technologies for the benefit of developing countries (GEF, 2008), which led to the creation of the Poznan Strategic Program on Technology Transfer (Verbeken, 2012). The program, contains GEF's Technology Transfer process namely: 1) support countries in undertaking TNAs, 2) finance pilot technology transfer projects based on the TNAs, 3) share gathered experience and demonstrated technology (GEF, n.d.).

The Technology Mechanism, established at the Cancun Climate Conference in 2010 is the latest mechanism that intends to establish a new institutional technology transfer architecture (Blohmke, 2014) to help countries develop and transfer low carbon technologies (UNFCCC, n.d.-b). It is said to "provide instruments, which shall facilitate the technology transfer as requested in NAMAs" and envisioning "the technology transfer, but also technology development and manufacturing in the technology recipient country" which will lead to the creation of a national value chain (Blohmke, 2014, p. 239). The Technology Mechanism consists of two bodies: the Technology Executive Committee (TEC) and the Climate Technology Centre and Network (CTCN). The TEC is the policy body in charge of providing policy recommendations to facilitate the development and transfer of technologies. The CTCN is the operational arm that provides technical assistance to developing countries on technology issues in order to boost capacity building, hosts a technology knowledge platform, and fosters collaboration (UNFCCC, n.d.-b).

3.2 Technology Transfer Breakdown

In order to understand technology transfer and what factors lead to a successful TT process, it is important to first understand *technology itself* and how transfer can happen. In the following section the concept of technology is discussed, together with what aspects of technology can be transferred. Then, the main types and drivers of technology transfer are introduced, and finally the channels through which TT can happen are outlined.

3.2.1 Technology Dimensions

Technology is defined as "the application of scientific knowledge for practical purposes"(Oxford Dictionaries, n.d.) but in reality it is a complex, diverse concept. There are a number of variations in what academia considers to be the dimensions of technology, some of which are synthesised below.

To start with, Dobrov (1979) proposed the idea of technology as an 'organised system', in its basic form consisting of *hardware*, *software*, and *orgware*. He defines hardware as capital goods such as equipment, tools, technical components, computers etc.; software as skills, instructions, programming, concepts, etc.; and orgware as "a set of organizational arrangements specially designed and integrated using human, institutional, and technical factors to support appropriate interaction of the technology and external systems" (Dobrov, 1979, p.83). He argues that technical means (hardware) and technical understanding and knowledge (software) are not by themselves enough for the advancement of technology, and that different organisational arrangements and activities need to be created to be able to manage technology once hardware and software are in place (orgware). The International Institute for Applied Systems Analysis follows the same formula of technology, with the view that orgware is comprised of institutional settings for generating knowledge and using technology (IIASA, 2013).

10 The 1992 Convention on Biological Diversity, the 2013 Minamata Convention on Mercury, the 2001 Stockholm Convention on Persistent Organic Pollutants, the 1994 United Nations Convention to Combat Desertification, and the 1992 United Nations Framework Convention on Climate Change.

Others define technology only within the bounds of hardware and software. For example, Kirchherr & Matthews, (2018), who state that hardware is the technology needed to create 'physical facilities' which could mean both capital goods and equipment but also engineering and consultancy services. They refer to software as the goods needed after the physical facilities have been built and they categorise them into *know-how* (i.e. skills needed for the operation and maintenance of the physical facilities) and *know-why* (i.e. the ability to understand the underlying principles of how the physical the physical facilities work – these being the skills necessary for technology replication and innovation (Kirchherr & Matthews, 2018).

This is a similar line of argument as the one found in Brewer (2008) who says that technology includes both tangible goods and intangible elements such as *explicit knowledg*e or know-how. On a similar line, Blohmke (2014) states that technology is both a capital good and codified information (i.e. patents, manuals, etc). Both Brewer (2008) and Blohmke (2014) also explain that the concept of technology also includes the notion of *tacit knowledge*, which is knowledge that one acquires from personal experience e.g. from working in a particular organisation, and not knowledge that is thought (Cambridge Dictionary, n.d.). Brewer (2008, p.518) calls tacit knowledge, "knowledge that is embedded in firm's procedures and personnel". Nevertheless the relevance of tacit knowledge to technology transfer depends on the maturity of technology – the likelihood that tacit knowledge associated with more mature, widely used technologies has been codified into explicit knowledge is higher than for newer, cutting-edge technologies that are still subject to change (Gandenberger, Bodenheimer, Schleich, Orzanna, & Macht, 2015).

Saad, (2000, p.32) reiterates the idea that technology is complex and that it can take a number of forms, from "simple technical processes to a very complex electronic or computer system". He states that technology is "a whole range of knowledge, skills, ideas, equipment, and facilities that organisations need to produce goods and services" (Saad, 2000, p.33). He goes beyond Dobrov's categorisation into hardware, software, and orgware and says that technology has four components: hardware (i.e. physical equipment etc.), software (i.e. the know-how about how to carry out a task); brainware or know-why i.e. knowledge needed to be able to understand the application of hardware and software, and support net (i.e. the complex network needed to "support the effective use and management of technology").

Inspired by the above definitions of technology, in this thesis technology dimensions are considered to be:

- **Hardware**: physical equipment, tools, energy, technical components, machines, etc.
- **Software or know-how**: the skills necessary for operation and maintenance of technology.
- **Know-why**: the skills necessary to understand, utilise and evaluate the technology that further permits the assimilation and exploitation of the technology through innovation and replication.
- **Innovation system**: the national network of public and private institutions whose activities and interactions initiate technology development, transfer, modification and diffusion.

3.2.2 Technology Transfer Flows

Bell, (1990) (as cited by Blohmke (2014) and Lema & Lema, (2012)) states that technology transfer flows between technology suppliers and technology recipients can be grouped into three categories:

Flow 1: capital goods i.e. equipment, design and engineering services, existing designs and specifications that can be licensed or purchased. It could also take the form of turnkey[11] or "product-in-hand"[12] projects. This flow focuses on 'tangible' elements of technology and 'paper-based' knowledge.

Flow 2: know-how and skills that are necessary for operation and maintenance of the equipment. This focuses on 'intangible' elements that flow through human and knowledge capital - this is what the aforementioned authors call 'disembodied technology'.

Flow 3: skills and knowledge for adapting and developing the initial acquired equipment or for achieving 'technological change'. While this flow also focuses on 'intangible' elements it also includes organisational assets. Lema & Lema (2012, p.25) state that this can "be further specified as 'delivering' and creating people embodied technology".

The first two flows of technology transfer can increase the technology production and operation capacity of the recipient country (Blohmke, 2014; Lema & Lema, 2012). In these instances, the technology supplier is the main actor who takes responsibility for the delivery of the technology i.e. concept, design, delivery, installation and commissioning of the technology, with local workers only being trained on how to operate and maintain the technology (Saad et al., 2002). These two flows of technology transfer do not add anything to the country's innovative knowledge base. It is the third flow of technology transfer that can increase the technology innovative capacity of a country (Blohmke, 2014) and, in the context of climate change mitigation, enable them to leapfrog to low-carbon technologies (Lema & Lema, 2012).

3.2.3 Technology Transfer Types

Kirchherr & Matthews, (2018) define two types of technology transfer, referring to the geographical axis across which they take place: North-South technology transfer and South-South technology transfer. The North-South technology transfer is seen as the traditional model: transferring technology from rich, industrialised, and 'innovating' countries to poor, developing, 'non-innovating' countries, while South-South technology transfer is seen as a newer type of transfer from developing country to developing country (Chen, 2018; Gallagher, 2015). South-South transfer happens when industrialised nations that are considered players in the South (e.g. China[13], Thailand, India) transfer technological expertise to catching up countries in the region (Norasingh, Machikita, & Ueki, 2015). South-South technology transfer also changes the view of players in the South, from passive recipients of technology to strategists with a global markets perspective in mind (Lewis, 2011).

South-South technology transfer differs from North-South technology transfer on a number of fronts: innovation, technology and institutions (Lema et al., 2015):

- *Innovation* in developing countries is considered incremental rather than radical and happens by means of technology diffusion and by 'learning by doing' (Kaplinsky et al., 2009). This is because developing countries often cannot afford expensive R&D deriving from universities or research centres and lack the capacity when it comes to personnel with technological competences (Lema et al., 2015), and therefore are more suited to innovate based on gradual

11 A project is turnkey when the technology supplier is responsible for all aspects of the projects such as concept, design and execution, and delivers a "ready-to-use" technology. There is minimal involvement of stakeholders in such a project and it implies the continuous reliance on the technology supplier (Saad, Cicmil, & Greenwood, 2002)

12 A project is "product-in-hand" when the local stakeholders are involved and the technology supplier provides training on the necessary operating and maintenance skills, and therefore focuses on increasing the local technological capabilities (Saad et al., 2002).

13 While the inclusion of China as a player in the South might be contested, the country is often given as an example of this in academic literature e.g. in (Chen, 2018; Kirchherr & Matthews, 2018; Norasingh, Machikita, & Ueki, 2015; Urban et al., 2015).

adaptation of technology (Chen, 2018). Kaplinsky et al. (2009) states that this disparity between the capabilities of developed v developing countries comes from: 1) insufficient investment in science and technology in developing countries, 2) the 'external brain-drain' prompted by skilled workers migrating to high income economies, and 3) the 'internal brain-drain' prompted by skilled workers moving from jobs in the public sectors to jobs in multinationals.

Nevertheless the innovation capabilities of any country will be greatly influenced by its growth patterns and pace of growth as well as by existent national policies, endowments, and technological capabilities (R. Lema et al., 2015). This is why there is such a great variation in the trajectories of innovation in developing and emerging countries, with some newly industrialised countries now having considerable potential to become technology providers while others lag behind (Walz & Marscheider-Weidemann, 2011).

- South-South TT is also different when it comes to the *technologies* being transferred. According to Kaplinsky et al., (2009), developing countries derive innovation for cheaper and easier to use technologies. Chen (2018) tries to explain this idea by saying that due to the fact that developing countries have a different market, regulatory environment, and innovation patters it is more often the case that technologies from other players in the South will be more "appropriate" for local transfer than technologies from the North.
- Finally, Chen (2018, p.2) makes the point that South-South TT "emphasises the importance of the recipient country organizational and institutional capabilities" by putting into evidence a number of studies that observed that national policies can help with facilitating technology transfer. National policies that can stimulate TT will be further discussed in Section 3.3.2.

3.2.4 Technology Transfer Channels

As discussed at the beginning of this chapter, technology comes in various forms and these often determine how technology is transferred. There is consensus amongst academic literature (e.g. Costantini & Liberati, 2014; Hoekman, Maskus, & Saggi, 2005; Kirchherr & Matthews, 2018; Lema & Lema, 2012; Lewis, 2011; Saad, 2000; UNCTAD, 2014; Urban, 2018; Gallagher & Zhang, 2013)) that the main conventional, market-based channels for technology transfer are international trade, foreign direct investment (FDI), licensing, and to some extent technology alliances and the non-market channels can be e.g. official development assistance and informal channels such as labour turnover and movement of people, imitation, reverse engineering, technology spillovers, open source innovation, access to technical information, etc. (UNCTAD Virtual Institute, 2012). Often the informal channels can be a bi-product of technology being transferred through conventional channels, such as the case of spillovers resulting mainly from FDI. The section below will focus particularly on the conventional, market-based channels, while the informal ones are discussed mainly in the context of these conventional channels.

International Trade in Goods & Services

Definition: "*Trade refers to the import of hardware developed and produced outside the [recipient] country. Trade can take place at arm's-length, with little interaction other than the transaction and its negotiation. Or it may involve broader 'interfaces' such as turnkey plants or service contracts.*" (Lema & Lema, 2013, p.305).

TT through international trade in goods and services happens when there is a change of ownership of hardware/software (i.e. goods or material resources) between one economy and another (OECD, n.d.-a). This often results in new knowledge and practices entering the recipient country embodied in products, machinery etc. Hoekman et al. (2015, p.1588) states that trade contributes to TT by "allowing local reverse engineering and access to new machinery and equipment". The argument being that as goods are transferred so is the technology embodied in them (UNCTAD, 2014), and innovative goods can therefore transfer novel ideas across borders which will benefit developing countries. Nevertheless, Schneider, Holzer, &

Hoffmann, (2008, p.2931) state that in the case of trade the recipients do not necessarily look for the most innovative technology but rather for the technology that is "best suited to the company's local needs and to its capacity to absorb the new technology".

Imitation, reverse engineering and learning by doing are often informal TT channels that result from trade flows. When a country has relatively basic technical capabilities for disseminating imported technology, and reverse engineering and imitating such technology, it often leads to that technology being transferred and diffused in the local economy (UNCTAD Virtual Institute, 2012). In the case of developing countries Costantini & Liberati (2014, p.28) argue that trade is considered to be the best channel for transfer as it "would expand the variety of intermediate goods and capital equipment available for domestic productions, may encourage the dissemination of information on production processes, product design, managerial methods and contract design that would otherwise be extremely costly to acquire domestically, and may help replicate foreign technologies embedded in traded goods or adapt them for local use.".

Hoekman et al. (2015), provides an overview of the impact of technology transferred through trade on the productivity of the recipient countries. They state that while there is a general positive impact on productivity, the level will actually depend on how open their trade policies are. Trade liberalisation in the form of reduced legal, regulatory and political trade barriers will make it easier for domestic business entities to adopt new technologies; the argument being that increased trade openness increases economic growth (UNCTAD, 2014). However, without strong absorptive capacity on behalf of the recipient country, open trade would not be sufficient to lead to further technological development in the country once the technology has been transferred, a view shared by both Costantini & Liberati (2014) and by Hoekman et al. (2015).

UNCTAD (2014) also argue that technology transfer through international trade has some potentially problematic implications, especially in the case of developing countries. The report states that in the case of innovative firms that are the source of the technology, their general intention is to control the rate of expanse of their technology and their geographical reach. The report further argues that when this is the case, the technological knowledge accessible in the goods being traded could be below the optimal levels for local economic development.

Foreign Direct Investment (FDI)

Definition: "*FDI refers to the establishment by a multinational company (MNC) of a wholly owned subsidiary in the [recipient] country. This mechanism refers to resource transmission from parent to subsidiary*" (Lema & Lema, 2013, p.305). The main aim of FDI is for the foreign investor to obtain long-term interest in the enterprise(s) in the recipient country.

FDI is an investment made by an organisation in one country in a business located in another country and usually takes place when the investor establishes a business entity in the new location (Chen, n.d.). Other methods of FDI include mergers and acquisitions, opening of subsidiaries or associated companies, or joint ventures (Chen, n.d.). With regard to TT, FDI allows the investor to share technology with the newly established or acquired business entity (Kirchherr & Matthews, 2018). This means that more efficient technology may enter the country leading to potential technological spillovers i.e. the unintentional "beneficial effects of new technological knowledge on the productivity and innovative ability of other firms and countries" (IGI Global, n.d.). According to UNCTAD (2014, p.16) technology transfer through FDI also includes the transfer of "many soft technologies such as managerial skills, marketing, or knowledge of standards and regulations" alongside providing capital and employment.

With regard to the aforementioned technological spillovers, UNCTAD (2014) notes that these can be demonstration effects, labour turnover, and vertical linkages. Demonstration effects refer to situations where local business entities imitate or reverse engineer hardware or software from foreign entities. Labour turnovers refer to situation where technological knowledge is transferred from previous employees of the foreign entities are employed by local businesses or establish their own entities (this will be further discussed below). Finally, vertical linkages refers to TT that occurs when the local businesses are part of the foreign entity's value chain e.g. as suppliers or when foreign suppliers sell to local buyers and the locals forward their competencies to keep up with technological advance (UNCTAD, 2014).

TT by means of FDI is held to have a number of effects, both positive and negative, on local domestic economies. It is said that FDI can lead to substantial TT and diffusion (Blomstrom & Kokko, (1997) as cited in Hoekman et al., 2015), nevertheless this effects is heavily influenced by each individual sector. The same publication also reminds that in certain industries the presence of foreign investors has been shown to lead to more productive sectors, however this is not always the case in all sectors. In later ones the local entities perform worse because the entities backed by foreign investors gradually take over their market share and attract the existing highly skilled labour by offering them better employment conditions (Hoekman et al., 2005).

Licensing

Definition: "*A legal contract in which the licensor transfers specified rights such as intellectual property rights to the [recipient] country licensee for a specified duration. This type [can] also include full (indefinite) purchase of property rights by the recipient firm*" (Lema & Lema, 2013, p.305).

The main objective of licensing is the authorizing of the use, reproduction, distribution, transfer of patents, trademarks, copyrights, designs, and other components mainly in the form of intellectual property (Saad et al., 2002). This makes it an important source of TT as these components can also include technology, technical information and know-how (Hoekman et al., 2005). Through licensing, a company can get access to new technologies without making substantial investments such as spending heavily on R&D, with the main advantage that the technology can get to the market faster (Saad, 2000). Licensing is said to provide a good business opportunity for both the technology provider and the technology recipient.

As a result of licensing technologies, firms in developing countries can also become more competitive in international markets (Mrad, 2017). However, licensing agreements usually contain terms and conditions designed to protect the licensor, who generally tends to be large technology suppliers with high bargaining power, which can lead to the licensee sometimes not being able to negotiate their terms. Licenses can also be relatively expensive and the licensee needs to have a certain level of capital, which is not always the case in low-income countries, making this channel potentially unaffordable (UNCTAD Virtual Institute, 2012).

Furthermore, a licensing agreement usually gives the licensor the security that their proprietary technological information does not leak through copying or defection of personnel (Hoekman et al., 2005), and sometimes it also not allows for further development and improvement of the licensed technologies. Licensing does not usually allow for informal TT channels such as imitation to result from it. This idea is mirrored by Saad et al. (2002) who state that the main disadvantages of licensing are the relatively low impact on domestic R&D capabilities, and the fact that licensing restrictions can impede informal technology transfer.

Labour Movement and International Migration

Skilled labour is the underlying prerequisite for any technology transfer through channels such as trade, FDI and licensing and it is a fundamental determinant of a country's ability to absorb the technology (UNCTAD, 2014). Although not a conventional technology transfer channel, labour turnover and international migration often features as a prevalent TT channel in academic literature.

Turnover of skilled labour can be a channel for technology transfer from multinational enterprises (MNEs) to local firms in cases where the latter are not far behind MNEs in terms of technological capacities (Hoekman et al., 2005) and thus the people embodied knowledge can flow between international and local players. The movement of people can also be a channel for technology transfer in cases where the technological knowledge is captured by nationals temporarily working or studying aboard or from foreign citizens immigrating into the country (Hoekman et al., 2005), or when skilled workers move from one country to another to e.g. install equipment, demonstrate techniques, and deliver training (UNCTAD Virtual Institute, 2012).

International migration however can also often have a negative effect on the knowledge stock of a country and its ability to receive technology transfers. A permanent migration of skilled, highly qualified, educated professionals ('brain drain') will result in a loss of people embodied knowledge in the country and the transfer of technology will be hindered by insufficient human capacity (UNCTAD, 2014). Brain drain is usually a result of people searching for better standards of living and a higher quality of life, higher salaries, and more stable political conditions and it is an issue more prevalent amongst developing countries (Dodani & LaPorte, 2005). In order to combat this problem some countries "have initiated a process of reverse brain drain by making it more attractive for intellectuals/businesspeople to return home after gaining experience in foreign countries. For instance, companies or governments may provide experienced expatriates with job security or tax benefits in setting up local businesses". (UNCTAD Virtual Institute, 2012, p.19).

Training, Education and Access to Technological Information

Training, education and access to technological information are all informal channels of technology transfer. Similar to the movement of people discussed above, this channel involves the transfer of knowledge acquired overseas e.g. through students, professors and lecturers that return to their home countries after they finish their education and/or training in other countries (UNCTAD Virtual Institute, 2012). On their return, these individuals "could serve as transferors as well as facilitators of technology transfer, since they return to their home countries with new knowledge, skills and experience acquired during their stay abroad." (UNCTAD Virtual Institute, 2012, p.19).

Furthermore, access to technical information in the form of scientific journals, patent documents, technical publications and reports, as well as exhibitions and conferences can be viewed as important channels of new technological knowledge. The role of education and access to information will be further discussed in the section below, as these are one of the most important enablers of a country's ability to utilize and absorb external knowledge.

Official Development Assistance

Another channel of technology transfer that sits outside the market-driven ones is official development assistance (ODA). In this case the technology transfer is initiated by governments through "government aid designed to promote the economic development and welfare of developing countries" (OECD, n.d.-b). Official development assistance can be provided bilaterally directly between the governments of donor and recipient countries or through multilateral development organisations such as UNIDO (Dinakar, 2011). It can take the form of technical assistance or loans (OECD, n.d.-b) with the later often taking the form of preferential loans when the technology "provider maintains an interest to secure access to the market of the recipient and/or natural resources in the country at question" (Kirchherr & Matthews, 2018, p.549).

Via this channel technology can be demonstrated via engaging in technology demonstration where a new or existing technology is brought into the recipient country in order to demonstrate its effectiveness and potential applications for major socio-economic benefits. These projects are also expected to provide the added benefit of the local recipients being trained and developing skills for further technological development (Pueyo, 2013). The means by which the technology is brought into the country can however be based on more conventional channels such as trade or through encouraging joint ventures.

In the context of this thesis, it is this technology transfer channel that is most relevant. In the case of international development, such as the activities embodied within UNIDO's interventions, the technology transfer is "often carried out in order to enhance the local technology capabilities" and for recipient countries to create new markets for their national companies (Putranto, Stewart, & Moore, 2003, p.43). Takim, Omar, & Nawawi, (2008) complement this by explaining that TT projects to developing countries enable local businesses to adopt new technologies and develop technical capabilities that would allow them to develop new products and processes in response to a changing economic environment.

3.3 Technology Transfer Influential Factors

The section above provided a dissection of the concept of technology transfer by providing a theoretical and practical perspective of technology and transfer flows, types, drivers and channels. The next section focuses on the main factors that influence the success of a country in acquiring, adapting, deploying, localising and innovating externally sourced technologies with the view that the technology transfer process can either be accelerated or slowed depending on the recipient country's characteristics such as "market conditions, fiscal and regulatory policies, availability of finance, access to information, the legal and institutional framework, human resource capacities, and the condition of infrastructure" (UNDESA, n.d., p.viii). In the light of this this thesis identifies five main factors that influence the technology transfer process: *Absorptive Capacity and the National Innovation System, Enabling National Policies, the Technology, the Local Environment,* and *Finance and Costs.*

3.3.1 Absorptive Capacity and the National Innovation System

The success of a technology transfer undertaking depends on the absorptive capacity of national actors and the national innovation system in which they operate, the two being interdependent (UNCTAD, 2014). In the following section the concept of absorptive capacity is discussed first, the followed by the national innovation system.

Absorptive Capacity

Technology transfer is a knowledge accumulation process and it is heavily dependent on the recipient country's prior knowledge stock and its innovation capabilities i.e. its ability to adopt and adapt new technologies (Blohmke, 2014). Innovation and knowledge are intertwined as "innovation is based on the application of new knowledge and at the same time, the application of new knowledge leads to change and innovation" (Murovec & Prodan, 2009, p 859). How able a country is to utilize and absorb external knowledge in the form of information and resources, i.e. its *absorptive capacity*, is held to determine the level of positive influence of TT on economic performance (Costantini & Liberati, 2014).

The concept of absorptive capacity was introduced by Cohen & Levinthal in 1990, as a new perspective on learning and innovation. They argued that the ability to evaluate and utilize external knowledge is a function of the level of prior related knowledge, and that it is this prior knowledge that permits the assimilation and exploitation of new knowledge. With regard to what prior knowledge consists of, they stated that it is a mix of knowledge "very closely related to the new knowledge to facilitate assimilation" and some can be "fairly diverse, although still related, to permit effective, creative utilization of new knowledge" (Cohen & Levinthal, 1990, p. 136).

There is consensus in academic literature (e.g. Blohmke, 2014; Brewer, 2008; Costantini & Liberati, 2014; Gandenberger et al., 2015; Hoekman et al., 2005; Kaplinsky et al., 2009; A. Lema & Lema, 2013; R. Lema & Lema, 2012; Lewis, 2011; Omar, Takim, & Nawawi, 2011; Saad, 2000; Saad et al., 2002; Takim et al., 2008; Urban, 2018) that absorptive capacity is one of the most important enablers of technology transfer and is necessary for a country to be able to recognise the value of new knowledge and technology, and to make efforts to acquire, use, and further advance them.

According to UNCTAD (2014) a country's absorptive capacity is determined by its: A) existing knowledge base; B) policy support for technological learning and innovation and C) cooperation between knowledge institutions and the productive sectors. The interplay between these three aspects will determine the strength of national capabilities and their growth potential e.g. if a country has a low existing knowledge base but introduced high policy support and strong cooperation between institutions and industry sectors then their capabilities will eventually rise.

A country's existing knowledge base can be seen as its 'human capital' composed of skills and competencies, scientific knowledge, awareness of practice in process and soft technologies that are a prerequisite for the integration of new technologies (UNCTAD, 2014). It also integrated in the concepts of a country's *innovation capabilities* and its *technological capabilities*.

With regard to innovation capabilities it is important to note that this does not only refer to a country's ability to invent new technologies but also encompasses its ability to adopt, adapt and improve existing technologies. To this end, as discussed in Section 3.2.3 in the context of TT types, a country's innovation capabilities can be radical, incremental and adaptive (Ockwell & Byrne, 2015):

Radical or breakthrough innovation refers new technologies that are the result of extensive R&D and this type of innovation is more common in advanced economies with more access to knowledge resources (Blohmke, 2014).

Incremental innovation refers to the process of improving a technology once it has been introduced, and it can refer to improving a piece of hardware or introducing a new or improved technique - these changes can add up to significant improvements over time (Ockwell & Byrne, 2015).

Adaptive innovation refers to the situation where technologies are adapted to better 'fit' a new physical, social or market contexts (Blohmke, 2014).

For a country to be able to absorb technical knowledge through technology transfer it needs to be able to have a basic level of incremental and/or adaptive innovation capabilities (Blohmke, 2014). Ockwell & Byrne (2015) state that having incremental innovation capabilities in basic engineering and managerial competence – and continuously working on strengthening these - is the foundational block in being able to absorb technology.

With regard to technological capabilities, these are composed of a variety of sources of knowledge and innovation and mastery of previous technologies. There are a number of exiting methodologies to measure a country's technological capabilities, such as UNIDO's 2003 Industrial Development Scoreboard which is an index of a country's industrial performance and capabilities, and UNDP's Technological Achievement Index, which measures a country's capabilities in: the creation of technology, the diffusion of new technology, the diffusion of old technology, and human skills. Building on UNIDO's and UNDP's indexes, Archibugi & Coco, (2004) state that measuring a country's technological capabilities may be determined by its performance on the following three dimensions:

1. *the creation of technology* – indicated by the number of granted patents to individuals or firms and the number of scientific articles produced by national universities, research centres and private sector actors.
2. *the technological infrastructure* – indicated by the availability and diffusion of infrastructures needed to support economic and social life and access to knowledge, e.g. electrification and electricity consumption, and the penetration of telephone and internet.
3. *the development of human* s*kills* – indicated by a country's literacy rate, mean years of schooling and tertiary science and engineering enrolment.

The paragraphs above show that a country's existing knowledge base is a vital prerequisite to the local transfer of new technology systems. The existing knowledge base however is not a static element and it can be expanded and enriched through national policy support for technological learning and innovation and through cooperation between knowledge institutions and the productive sectors, in order to build a skilled workforce that can handle new technologies (UNCTAD, 2014).

National Innovation System (NIS)

A country's absorptive capabilities are interlinked with its *national innovation system*. A NIS refers to a national network of institutions in the public and private sectors (e.g. firms, universities, research institutes, government departments, NGOs) whose activities and interactions initiate technology acquisition, adaptation, deployment, localisation, diffusion and innovation (Ockwell & Byrne, 2015; UNCTAD Virtual Institute, 2012).

According to UNCTAD (2014) and Arnold & Bell, (2001) a NIS is comprised of a number of major actors and conditions as depicted in Figure 3-1: the education and research systems, the productive sector, and the framework and infrastructure conditions:

The education and research systems encompass both public and private education, training, and research institutions.

The productive sector encompasses the business system of a country and it is where the transferred technology knowledge is translated into goods and service; this is one of the sectors where a high level of absorptive capacity will lead to better results.

The framework conditions are one of the main determinants of the performance of the national innovation system and it encompasses policies, regulations, strategies, taxation and incentives, the levels of trust (i.e. levels of corruption), the intellectual property rights regime etc.

The infrastructure system encompasses the national availability and diffusion of transport, energy, ICT etc. infrastructures.

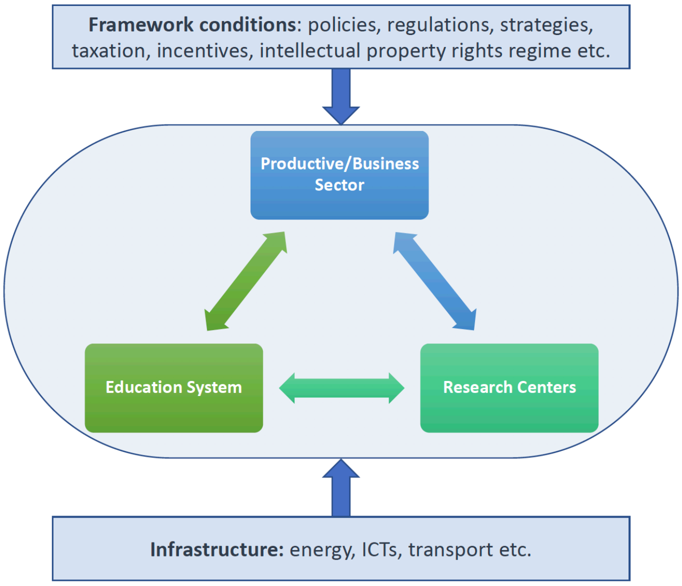

Figure 3-1. A national innovation system.

Adapted from: Arnold & Bell, (2001) and UNCTAD, (2014).

The strength and nature of the interactions between these actors determine how advanced a country's absorptive capacity is, as this is the system that can create learning opportunities, stimulate innovation, generate skills, enhance R&D etc. More developed countries tend to have more sophisticated and experienced national innovation systems than developing countries and therefore more advanced absorptive capacities.

It is, of course, also important to note that access to finance and the existence of a mature financial system is critical in supporting a country's NIS. In order to support technology transfer, building a national innovation system "involves addressing at the same time both market and systemic failures, combining action on horizontal issues such as education, training, access to finance, or knowledge dissemination with vertical ones supporting specific sectors or technologies. At the same time, they need to develop incentives to collaborative interactions between firms, universities and research centres." (UNCTAD, 2014, p.22).

3.3.2 Enabling National Policies

The section above touches upon the idea that the policies of a country are conducive to establishing a productive national innovation system and an increased level of national absorptive capacity. General national policies that provide a system that supports innovation, education, and infrastructure can foster and enable the process of technology transfer.

TT Channels Policies

Stemming from national policies that support learning and knowledge, come the national policies aimed at that can cater for the channels of technology transfer and make it easier for technologies to enter the country. According to Hoekman et al.,(2005), the main aim of these national policies should be the creation of an attractive investment environment and to reduce the cost of absorbing technology.

Policies aimed at trade liberalisation/open trade regime/fewer and lower trade barriers will allow for greater access to efficient, diverse and inexpensive technologies (OECD, 2011). The main inhibitors of technology transfer are believed to be trade barriers, administrative burdens (Blohmke, 2014), and in the context of this thesis, tariffs on environmental products. Removing these will enhance technology transfer as an open trade regime can more easily allow access to foreign technological and potential technological spillovers.(Hoekman et al., 2005).

Policies aimed at attracting more FDI will also lead to more technology transfer (Blohmke, 2014). This could be in the form of incentives for multinational companies to want to transfer technologies to recipient firms and removing restrictions on FDI. These incentives could take the form of subsidies, tax breaks, economic zones etc., and should be aimed at companies that are looking for local suppliers rather than local competitors as this will increase their willingness to share technology (Hoekman et al., 2005). In certain countries (mainly in middle-income and large developing countries) greater FDI can also be encouraged by establishing stronger IPRs protection policies (see next section below) as this will increase knowledge flows and inward FDI (World Bank, 2008).

Competition policies also come into play here as they affect the behaviour of actors in the private sector and how industrial sectors are structured. Promoting competition in the national economy through competition policies, sector regulation and privatization policies can open the market to new entrants and prevent anticompetitive behaviour that can hinder the transfer and diffusion of technologies. In its teaching material on technology transfer the UNCTAD Virtual Institute, (2012, p.49) states that "competition policy is an effective instrument for fostering efficiency, economic growth and international competitiveness. It could also be argued that competition policy promotes broad public interest and satisfies socio-political objectives like inclusive regional development, job opportunities and the promotion of employment. In more general terms, competition policy promotes total economic welfare, taking into account the actual and the potential cost-benefits to consumers as well as to producers.".

Intellectual Propriety Rights (IPRs) Policies

While competition policy attempts to reduce the barriers to competition, intellectual property rights protection are aimed at preventing the widespread copying new inventions and to some extent can create situations that restrict competition.

Intellectual propriety rights can be defined as exclusive rights of a person or company "to use its own plans, ideas, or other intangible assets without the worry of competition, at least for a specific period of time. […] The reasoning for intellectual property is to encourage innovation without the fear that a competitor will steal the idea and/or take the credit for it." (Business Dictionary, n.d.). Intellectual property can be in the form of industrial property or other intellectual property and according to Andonova (2017) the former can take the form of inventions (patents, utility models, plant varieties), distinctive signs (trademarks, trade names, geographical indications), aesthetic creations (design), while the later can be e.g. creations that are usually under copyright.

IPRs play an important role in the transfer of technology through any of the channels discussed in Section 3.2.4. There is however a contrast in opinions when it comes to whether technology transfer is more effective via weak or strong IPRs protection (Mrad, 2017). This debate has been around for decades, with the general view that the choice of weak or strong IPR protection depends on the level of a country's economic growth. To back this argument Kim (2003, p.1) stated that "the effects of IPRs on technology transfer to and local innovation in developing countries will vary according to countries' levels of economic development and to the technological nature of economic activities, and that these countries can reap long-term benefits from strong IPRs only after they reach a certain threshold level in their industrialisation.".

Falvey & Foster, (2006) discuss the factors that should be taken into consideration with regard to the strength of IPRs protection. They state that strong protection can make it difficult for rivals to enter the market and lead to a permanent monopoly of the innovators, which could disincentivise innovators from further development of technology. However, having a temporary monopoly can also be an incentive for further innovation and more efficient technologies and more developed countries seem to opt for strong IPR protection especially because if its potential to encourage further innovation. However when it comes to technology transfer to developing countries one view states that the innovators need protection in order to increase their willingness to transfer technologies to developing countries (UNDESA, n.d.). Another argument for strong IPR protection states that it can also benefit developing countries not just developed ones, as they will benefit from greater inflow of innovative technology transfer from enterprises in developing countries that are in favour of licencing their innovative intellectual property (Mrad, 2017).

In contrast to the views above, Falvey & Foster (2006) discuss that weak IPRs protection can lead to knowledge spillovers and actually stimulate R&D in many countries. For the developing countries that are looking to import technologies weaker IRPs protection would lower the cost of obtaining technology (UNDESA, n.d.). Furthermore, for countries with lower innovation capabilities, weak IPR protection allows for boosting the domestic economy through the rapid diffusion of knowledge and technological development based on imitation (Falvey & Foster, 2006). Limiting the extent of imitation will impede technology transfer and make it difficult to close the technological gap between developed and developing countries (Mrad, 2017).

The strengths of IPR protection can also influence technology transfer through formal channels i.e. FDI, licensing, or trade. It is believed that strong IPRs protection boosts technology transfer into developing countries by providing confidence to the firms in developed countries that their technologies will not be imitated. Strong IPRs protection developing countries will therefore improve the incentive for further innovation in developed countries (Mrad, 2017). With regard to the channels of technology transfer it is believed that:

- Strong IPR protection may encourage FDI as innovators from developed countries can shift production to developing countries and use their resources to focus on further domestic R&D instead (Mrad, 2017). This in turn will increase the rate of innovation and encourage more technology transfer through an increased rate of foreign investment (Falvey & Foster, 2006). Nevertheless, UNDESA (n.d.) states that in the case of poor countries, stronger patent rights will not attract more FDI.
- Strong IPR protection may encourage technology transfer through licensing technologies to developing countries, as it reduces the risk of imitation and enterprises are more willing to license their technologies (Yang & Maskus, 2009). UNDESA (n.d.) state that there is evidence that strong IPRs protection shifts the channel of technology transfer from trade and FDI towards licensing.
- The strengths of IPRs and their impact on trade are inconclusive. Weak IPRs may lead to imitation of the technologies obtained via trade, which has the potential to shift the competitive advantage for the production of imitated products from developed countries to developing ones. However weak IPRs protection can also lead firms in developed countries to mask their production technologies and limiting the extent to which these can be imitated through traded good (Falvey & Foster, 2006). An opposing view states that it is actually strong IPRs protection in developing countries that can stimulate inward technology transfer via trade by stating that stronger IPRs encourages the transfer of more efficient technologies. These in turn will make the domestic economy more productive and better positioned to access foreign markets (Maskus & Yang, 2013). UNDESA (n.d.) states that international trade flows were shown to respond more positively to strong IPRs protection in middle-income and large developing countries, however trade to poor countries were not sensitive to strong IPRs protection.

Despite the debate on whether strong or weak IPRs protection is more appropriate to facilitate TT, the international view is that in order to be part of the World Trade Organisation (WTO) and benefit from it, IPRs needs to be harmonized across countries. In order to do this the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) has been agreed and came into effect in 1995. The Agreement requests developing countries to conform to the IPRs protection systems already operating in developed countries (Mrad, 2017).

Sector Specific Policies

Technology transfer policies also need to take into consideration the industrial sector and its type of activity. For example, when considering IPR protection, strong or weak policies in high-technology industries may not be as important when transferring rudimentary technology for production facilities but may be of high relevance when transferring new or advanced technology (UNCTAD Virtual Institute, 2012).

Policies can also be aimed at specific industrial sectors with the aim of making them more effective (Hoekman et al., 2005). Sector-specific policies that stimulate economic activity may take the form of targeted subsidies in return for increased performance on behalf of local firms. An example of this is subsidies for electricity-generating technologies which can take the form e.g. direct subsidies, rebates, favourable tax treatment, import and export tariffs and non-tariff barriers etc.), R&D funding, or the external cost of energy production not being accounted in the pricing system (Badcock & Lenzen, 2010). In order to encourage the local manufacture of technologies countries may also choose to introduce policies that encourage joint ventures, or differential customs duties rules to favour importing technology components rather than complete machines in order to stimulate domestic assembly (Lewis, 2011).

3.3.3 The Technology

Alongside enabling factors that have to be in place at a national level to allow for successful transfer of technology, there are also a number of technology-specific aspects that should be taken into consideration when engaging in technology transfer.

In order to avoid project failure, it is necessary to have a clear understanding of the need to be met by the technology. While it was argued above that absorptive capacity and national innovation systems can ensure the transfer of a technology into a country, understanding the technological needs of a country can help determine which technologies should be prioritised for transfer in the first place. The technology in questions will need to cater for the needs and circumstances e.g. geography, resource potential, domestic industries etc of the recipient country. (Blohmke, 2014). However, when attempting to determine which technology to transfer one may end up with number of alternatives; if this is the case the relevance of each alternative should be considered in the local context, on the actual needs and abilities of the local stakeholders and the potential benefits they could draw from them (UNCTAD Virtual Institute, 2012).

Furthermore, there must be local demand for the technology in order for the transfer and implementation of new technologies to be successful. This demand can come from inside or outside the market e.g. when a national government seeks environmentally friendly technologies in order to reduce national vulnerability to negative environmental impacts (Klintenberg, Wallin, & Azimoh, 2014).

Technology Complexity

The complexity of technology is another aspect to consider in technology transfer. As discussed above different countries will have different technological and innovation capabilities to be able to deal with the technology once it is being transferred: e.g. low-income countries with low levels of absorptive capacities and a weak national innovation system will struggle to absorb and diffuse a highly complex, advanced technology, but they could have the incremental and adaptive innovation capabilities to transfer cheaper and easier to use technologies. Therefore, when engaging in technology transfer distinguishing between different complexities: low-tech and high-tech is necessary (Chen, 2018).

Blohmke (2014) discusses the topic of technology complexity and states that in order to properly asses this the technology should, if possible, be broken down into components. There are some highly integrated technologies that cannot be divided into different parts, however there are some that can. When a technology can be broken down into components then these can be sources from different suppliers - for the recipient country this also means that they can determine which parts can be manufactured domestically based on the existing national capabilities and which parts need to be imported. Therefore, technology complexity assessment can be a good indicator of how difficult the transfer of technology to the recipient country can be.

Blohmke further states that in order to evaluate the complexity of technology and its components, three complexity dimensions need to be considered:

1. *Technical complexity* – refers to the manufacturing processes of technology/components and encompasses the machinery and tools necessary for producing the technology/components as well as the manufacturing technique and how new to the market this is.
2. *Quality complexity* – refers the quality requirement for each manufactured component and whether the reliability of the component in the overall system is important.
3. *Financial complexity* – refers to the potential capital investment into expensive manufacturing equipment and machinery and the risk of investment into production facilities for specific components

With regard to renewable energy technologies Chen (2018) and Blohmke (2014) both agree that they are more complex when compared to e.g. technologies in the agriculture sector, and that they need a higher level of absorptive capacity to be able to be transferred and eventually manufactured domestically. Low income developing countries that have lower levels of absorptive capacity will therefore find it more difficult to transfer more complex renewable energy technologies and "in this context the question arises whether it is reasonable for a low income country to develop technology manufacturing capacities domestically, or, whether importing the technology on a competitive and potentially cheaper basis from more industrialized countries should be pursued." (Blohmke, 2014, p. 239).

3.3.4 The Local Environment

The idea that local technology needs should be assessed before engaging in technology transfer was touched upon in the section above. This section continues that idea by discussing the importance of actively engaging local stakeholders throughout the technology transfer process to stimulate local adoption and diffusion. The role of the local stakeholders is also brought up by a number of authors (e.g. Klintenberg et al., 2014; Loock, 2012; Mallett, 2013; Schillebeeckx, Parikh, Bansal, & George, 2012) in the context of transferring renewable energy technologies to developing countries, which is of relevance to this thesis.

In the process of technology transfer it is usually the local stakeholders, in the form of local communities, local small and medium-sized enterprises (SMEs) local governments, organisations, end-users etc., that are the ultimate beneficiaries of the technology and in certain cases also the group that bears its costs. According to Mallett (2013) the local stakeholders in the technology transfer process are often given a minor role, with most approaches putting more emphasis on the recipient country's public and private sector. She states that while local stakeholders are generally consulted before, during and after implementation of a technology project they tend to be excluded from the development, production and diffusion phases of the technology and therefore lose from the effectiveness of the transfer. Moreover, with regard to renewable energy technologies transferred to rural areas Cherni et al., (2007, p.1493) states that the prospective users are "hardly consulted when it comes to planning the improvement of local infrastructure and making final decisions on what are the most appropriate options".

Better community-involvement and understanding of the end users' needs could ensure that the technology is fitted to their local needs and meets their requirements. It could also be more conducive to the local stakeholders understanding the technology: how and why it works, what its local implementation involves, what are the different components and their complexity, which will increase the chances of long-term use of the technology and potential national replication and diffusion (Klintenberg et al., 2014; Schillebeeckx et al., 2012). In order to have more local stakeholder's engagement Mallet (2013) states that it is important to include the local stakeholders in the whole process of technology transfer, not just the outcome. She suggests that this can be achieved through promoting more efforts on deliberation, cooperation and partnership and encourage more local ownership and leadership. She states that engaging with the stakeholders throughout the TT process increases the "social acceptance of a technology (which includes use, public acceptance, policies, and collaborative decision-making)—which has been shown to play a role in fostering a market" and that "effective collaboration is more likely to happen when players feel as if they are an active, engaged partner" (Mallett, 2013, p.243).

3.3.5 Finance and Costs

Engaging in technology transfer can be an expensive endeavour and access to financial resources is an important enabling factor – TT rarely happens without financial support. Costs can be related to preparation, sourcing the technology, design and logistics, installation, adjustments and reconfigurations of the technology, training, operating and maintenance, and solving any other problems that might arise (UNCTAD, 2014).

TT requires access to predictable, sustainable channels of finance however finding and determining the appropriate financing method can be a complex matter and can differ from project to project. Investment finance for technology transfer can come from a number of sources: public sector, private sector, a combination of the two, or from multilateral institutions (Junaid Zaidi & Naeem, n.d.). The existence of a national mature financial sector, that can ensure an effective allocation of financial resources is also an important supporting factor for technology transfer. The availability of credit to finance technology transfer activities is crucial in the success of the TT process (Ingvarsson, 2013).

With regard to access of finance of renewable energy projects in developing countries, including in the case of small hydropower-based projects, these tend to receive funding in the form of a grant or in the form of a subsidy. This type of funding is very common also for projects that involve mini-grids, such as the selected case studies in this thesis, and these are usually community-owned projects with enterprise-based projects being a minority (HPNET, 2019). In the case of transferring technologies that also provide a service (e.g. provision of electricity), the ability of the local community to pay for the service also needs to be taken into consideration in order to have a successful implementation of the technology. In the cases where the technology is not subsidized the service would be provided at a cost reflective tariff which may be too high and the local community would be either unwilling or unable to pay; for a subsidised installation on the other hand, the electricity tariff is likely to not be reflective of the true cost of the technology which could increase the users' willingness to pay for the service (Klintenberg et al., 2014). To increase the users' ability to pay the transfer of renewable technologies should be based on a business model that not only focus on technology and production but also empowers representatives from the local community to establish small businesses based on the technology. Klintenberg et al., (2014, p. 812) argues that "[b]y establishing these businesses it is assumed that electricity users' ability to pay for services will increase, which will allow implementation of cost reflective tariffs making these initiatives more sustainable, compared to subsidized installations.".

3.4 Analytical Framework

Based on the review and analysis of literature the main factors that are said to influence the technology transfer process were identified and synthesised. The analytical framework was then developed to guide the analysis of the TT-related activities encompassed in the intervention logics of the two case studies. In Section 2.2.2 the methodology used for data analysis is explained in 3 steps. Steps 1) and 3) are be presented in Section 5 below, while step 2 is further explained here.

Developing the analytical framework involved analysing the literature on TT in order to identify and synthesises the factors that are said to influence the process. Then, for each factor a set of determinant criteria was defined and compiled in Table 3-1. For the purpose of this work these factors and their determinant criteria were grouped into two categories:

General influential factors – these could be called "macro level" factors as they involve a zoomed-out view of the recipient country context and include factors such as the country's absorptive capacity, its national innovation system, and policies that can facilitate the transfer of technology.

Project-specific influential factors – these could be called "micro and meso level" factors as they involve a more in-depth assessment of the technology itself and the conditions of the location where the technology is to be transferred.

Table 3-1. Analytical Framework

General Factors + Criteria		Criteria Details
Absorptive Capacity	The existing human capital/skills	Skills and competencies, scientific knowledge, awareness of practice in process and soft technologies that are a prerequisite for the integration of new technologies.
	Innovation type and potential	Incremental innovation capabilities in basic engineering and managerial competence – and continuously working on strengthening these - is the minimum foundational block required in order to absorb technology.
National Innovation System	Infrastructure	The national availability and diffusion of transport, energy, ICT etc. infrastructures.
	The education and research system	Public and private education, training, and research institutions.
	The productive/business sector with potential to acquire, adapt, deploy, innovate technology	The system where the transferred technology knowledge is translated into goods and service. This is one of the sectors where a higher level of absorptive capacity will lead to better TT results.
Enabling National Policies	Policies aimed at supporting education, learning and knowledge generation	Policy support for technological learning and innovation. These can increase the quality of the available human capital.
	Policies aimed at encouraging technology entry into the country	Policy support for the facilitation of channels of TT e.g. FDI, trade, licensing etc. policies, IPR regime.
	Policies aimed at encouraging technology uptake and diffusion, and the creation of business models based on the technology, including financial support	Policy support for technology uptake by encouraging productive uses via e.g. direct incentives, subsidies and rebates, favourable tax treatment etc.

Project-specific Factors + Criteria		Criteria Details
Technology complexity	The possibility to break the technology down into distinct and divisible components	When a technology can be broken down into components then these can be sources from different suppliers - for the recipient country this also means that they can determine which parts can be manufactured domestically based on the existing national capabilities and which parts need to be imported.
	Components that can be manufactured locally	Manufacturing components locally and being able to maintain these by local actors can lead to cost reductions.
	Capital investment needs to enable local manufacturing of components	The potential capital investment for manufacturing equipment and machinery and the risk of investment into production facilities for specific components.
	Components that need to be imported	Imported components can often be costly.
	Technology-specific skills that can be sourced locally	Skills necessary for manufacturing components, installation of the systems, operation and maintenance, after service etc. that can be sourced locally.
	Technology-specific skills that need to be sourced overseas	The ability to source skills from overseas when these are not available locally.
	Level and type of skills that need to be developed locally	The necessary capacity that still needs to be built locally.
Local Environment	Local needs and circumstances	The technology caters for the needs and circumstances e.g. geography, resource potential, domestic industries etc. of the local actors. The business models that are devised around the technology have consumer needs as starting point, they do not only focus on technology and production but also empowers representatives from the local community to establish small businesses based on the technology.
	Local stakeholders	The local stakeholders show interest in the technology/demand it/are not opposed to it. They are also actively involved in the project from the start (through deliberation, cooperation and partnership) and have an interest in local ownership and leadership.
Finance and Costs	Access to finance	A technology transfer endeavour requires access to predictable, sustainable channels of finance.
	Users are able to pay for the service	In the case of technologies that also provide a service (e.g. provision of electricity), the ability of the local community to pay for the service also needs to be fulfilled in order to have a successful implementation of the technology locally. Furthermore, the electricity tariffs are cost-reflective and there are no hidden subsidies making these initiatives more sustainable.

Source: Author's own elaboration

4 The Case Studies

This section provides an overview of the two case studies that were analysed in the context of this thesis and provides details on the interventions' origin, context and main objectives. It also presents a summary of what the interventions were able to achieve, and their shortcomings, according to UNIDO's own findings following their own evaluation of performance. In order not to share potentially sensitive information all references to country names, donors, involved institutions, etc. have been removed.

4.1 Case Study 1 – Project A

Case study 1 is an intervention started in early 2013 with an expected duration of two years. According to the Open Data Platform the project ended in early 2017, more than two years beyond its initial estimated end date. The project aimed to transfer a small hydropower technology from a developed country (origin country) to a developing one (recipient country). At the time of project conception, the technology was recently innovated and only available in its origin country.

The project was developed as a potential strategy to tackle the problematic energy situation in the recipient country. The country has a shortage of generation capacity and the existing generation is heavily reliant on fossil fuels. A large portion of the population does not have access to electricity or has access to electricity which is unreliable and costly, and this resulted in widespread use of diesel generators and kerosene. There is also a relative lack of alternative solutions based on decentralised renewable energy and mini grids. This is the case especially in rural communities which face issues of limited connection to central power grid and the lack of reliable electricity supply even where villages are connected to the power grid. The current situation of access to electricity hampers further development of rural industrialization, as well as any improvement of the living standards in rural communities.

In the view of the above the project was developed with UNIDO's assistance. One region in the recipient country was chosen due to it being a region with conditions ideal for generation of hydro-based renewable energy (RE) using the new technology. According to UNIDO's project document (p.2), the impacts of the project were foreseen to "guide a pathway to increase the number of people with access to sustainable energy and to promote innovative technologies with the prospect of delivering long-term green growth and jobs for the benefit of local communities".

The goal of the intervention was to increase the access of rural communities to renewable electricity in the selected region. The project mainly involved demonstrating the technology at three pilot sites. These sites were to be chosen in such a way that they could become representative of what can be achieved based on this technology and increase the replication potential of the technology in the region. The project also pursued: the creation of a favourable environment for the deployment of the SHP technology through the development of business models; building capacity for the mini grid operation/maintenance; and enabling local manufacturing of turbine units and spare parts. The targeted project beneficiaries were the existing energy and industry related associations in the local communities, local SMEs, technicians and communities, and the local university centre.

UNIDO Evaluation Conclusions

After the implementation of the project the evaluation comprised in the project's final report, found a number of achievements as well as shortcomings. The main ones are summarised below.

Achievements:
- The technology provider established an office in the recipient country and started the local manufacturing of turbine units and control panels with local private partners. Initial results showed that some SHP parts such as the control panel could be fully manufactured locally.
- A revised policy framework put in place that allowed for grid connection even for plants with small-scale energy generating capacities like these pilots.
- The private sector able to provide after-service for the technology with locally available consumable spare parts.
- The responsible ministry included the provision of subsidies for the new technology into their new policy guidelines, and the country's intended nationally determined contribution included the new technological sector development as a game changer for technology innovation in renewable energy.
- The focus region adopted a policy on the development of small hydropower projects.
- A completed technology master plan survey aimed at manufacturers nationally and internationally. This containing the most promising sites for technology replication and scaling-up. As a result of this, several national and international project developers and technology suppliers entered the market with a view to roll-out new projects.
- The dissemination initiatives boosted the awareness about the technology and the business opportunities, and as such have set in motion the creation of a new sector based on the technology.

Shortcomings:
- All three pilot sites encountered technical problems that the local counterparts could not deal with effectively, indicating that the technology was still very new for the recipient country and that many actions were new for almost all stakeholders.
- The required adaptation measures and rectifications showed a gap in local knowledge on hydrology for this type of system as well as technology customization.
- Local partners and stakeholders did not fully grasp the impacts and challenges of the application of this new technology in concrete situations.
- Despite additional training intended to counteract the above a certain risk remained that the systems based on the new technology will not be properly operated and regularly maintained, which would lead to damage and repair costs to the systems.
- The local industry partners did not have adequate expertise and infrastructure for manufacturing some of the technology's components at the start of the project.
- Initially, the quality of the locally manufactured components was inadequate, which led to technical issues with the system.

4.2 Case Study 2 – Project B

Case study 2 is an intervention with a start date of mid 2011 and an expected duration of 4 years. At the time of data collection in summer 2019 the project was still ongoing on the UNIDO Open Data Platform and expected to end in late 2019. An independent terminal evaluation, which usually takes place three months prior to the operational completion of the project, was conducted which indicates the subsequent completion of the project.

This project supported the development of small hydropower with capacities that can be considered as mini/micro hydropower. The project did not target a specific type of SHP technology to be transferred nor did it target a particular technology origin country.

The project was developed as a potential strategy to tackle the rural energy situation in the technology recipient country, where only a very small proportion of the population living in rural areas had access to electricity at the time the intervention was conceived. The population that lives in remote/off-grid areas relies on small diesel generators as primary electricity source, and sometimes kerosene for lighting and cooking. These energy sources emit GHG into the atmosphere, cause health problems to the local communities, and can be extremely costly for the proportion of the population living in poverty. It is alleged than half of the population who live in poverty in the recipient country spend more than a third of their household income to meet their energy needs. In the view of this, the project was initiated as part of the recipient country's efforts towards introducing mini-grids based small hydropower sources in order to increase rural electrification.

The goal of the project was to increase the access of rural communities to RE and reduce dependency on fossil fuels. The proposed intervention aimed to: 1) bring about global benefits by reducing a considerable amount of CO2 emissions.; 2) bring new technology, know-how and skill level to the recipient country; and 3) spur the growth of the productive sector due to the increased availability of electricity. The project also pursued transferring the SHP technology and strengthening the local capacity in developing, implementing, operating and maintaining SHP mini-grids and the development of viable business models based on these.

The project aimed to work with governmental, technical, and financial institutions, project developers, SHP and mini-grid operators, local equipment fabricators and engineering companies to implement SHP based mini-grids at nine potential sites in the recipient country. The successful system demonstration at these nine sites were to increase the replication potential as it would have enabled the government to further establish appropriate policy and regulatory frameworks, to strengthen institutions and to build capacity leading to the creation of a conducive market environment for increased private sector investment programmes in RE.

UNIDO Evaluation Conclusions

After the implementation of the project the evaluations comprised in the project's independent terminal evaluation and the mid-term evaluation, found a number of achievements as well as shortcomings. The main ones are next summarised below.

Achievements:

- A local centre for small hydropower established and inaugurated in the recipient country.
- Experts from the recipient country taken on training tour in Vienna.
- Study tour for TT and training in turbines manufacturing conducted in another developing country, where nine participants from different manufacturing actors were trained and received licenses for manufacturing the turbine.
- Capacity building programme facilitated for various groups of stakeholders including individual practising engineers, water basin authorities and academia.
- Various training courses delivered on SHP project development and technical design aspects.
- Capacity of private institutions developed to fabricate micro hydro turbines locally. Fifteen local institutions in which to transfer skills for equipment fabrication have been identified and the training programme was conducted in two phases.
- The local centre for SHP received training on crossflow turbine manufacturing and since fabricated four turbines. Two of the demonstration sites were using two of these turbines.
- The project supported and trained a workshop to manufacture the crossflow turbine in a region in the recipient country. The workshop is now producing turbines for installation in surrounding areas and one of these turbines has already been installed.
- Provision of scholarships for students in a small hydropower master's programme at a local academic centre was successful and added as a good practice for similar projects.
- Government incentives for RE sources in draft and preparation.

- An updated draft of the recipient country's national energy policy that now includes all RE sources. The draft, and the new government incentives, now fully support the private sector and industries in developing SHP.
- Eight demonstration sites initiated. Out of these four SHP were operating and the other four were under various stages of development.
- High levels of replicability: a large number of other projects for mini-hydro power plants in the recipient country have been assisted in the project preparation stages.
- Electro-mechanical equipment procured with UNIDO support for a number of sites.
- At one of the sites an initiative was put in place to buy electricity from the recipient country's main electricity supplier and connect people at a much cheaper price that they pay for the electricity from the diesel and kerosene generators in the surrounding villages in order to accustom people to electricity before start of working of the SHP. This initiate was deemed a best practice.

Shortcomings:

- In some of the demonstration sites, the revenue generated was not sufficient to cover the cost of operation of the technology. This is allegedly due to low income levels among households, particularly in rural areas, and their inability to pay for higher tariffs. This suggest a relatively weak financial sustainability of the technology at the respective site.
- More could have been done in terms of informing the public of the project and the possibility to invest in mini-grids based on the technology to augment rural electrification in the recipient country.
- Limited awareness regarding the government incentive and the grid connection requirements that could benefit developers.
- The small hydropower sector's growth is still facing challenges in terms of access to finance, awareness and technical knowhow. The implication of this could be that newly formed institutions such as the centre for SHP and the turbine manufacturing workshop may not have sufficient level of activity to keep them financially sustainable.

5 Results & Analysis

The following section delivers the results generated by this study and is structured as follows:

1. An explanation on how to interpret the logic models which are the graphic representation of the case studies' intervention logic.
2. The results following the reconstruction of the intervention logic for each case study, including the diagrammatic representations of the logic models.
3. The results of the direct logic analysis based on the analytical framework in Section 3.4 as well as a summary of the intervention's strengths and weaknesses and a summary of the technology dimensions transferred as a result of the intervention. This later summary is presented according to the dimensions of technology (see Section 3.2.1) in terms of:
   Hardware: physical equipment, tools, energy, technical components, machines, etc.
   Software/know-how: skills necessary for operation and maintenance of technology.
   Know-why: skills necessary to understand, utilise and evaluate the technology that permits the assimilation, replication and exploitation of the technology.
   Innovation system: the national network of public and private institutions whose activities and interactions initiate technology development, transfer, diffusion etc.
4. The results of the cross-case comparative analysis.

5.1 How to Interpret the Logic Models

The logic model's vertical structure is divided into "planned work" and "intended results". The planned work comprises the resources/inputs and activities. The intended results comprise the outputs, outcomes and impact. The logic models (Figures 5-1 & 5-2) should be read as follows:

- The Resources/Inputs column refers to the **resources** UNIDO has access to so as **to operate the project**. There is no direct causal linkage on the horizontal axis between the resources/inputs and the activities etc. i.e. all the listed resources/inputs were assumed to apply to all activities, etc.
- There is a direct causal linkage on the horizontal axis between the rest of the columns and should be read as follows:
  1. Starting with the Activities column: *If* UNIDO has access to the pool of resources, then UNIDO can **use them to accomplish** these planned **activities**;
  2. Outputs column: *If* UNIDO accomplishes its planned activities, then UNIDO will **deliver** these intended **products/services (outcomes)**;
  3. Outcomes column: *If* UNIDO accomplishes its planned activities to the extent to which it intended, then the project **participants will benefit** in these ways;
  4. Impact column: If these benefits to participants are achieved, then certain **changes** in organisations, communities, or systems might be expected to **occur** (impact).

5.2 Case Study 1 – Project A

5.2.1 The Intervention Logic

The following section provides the assessment and analysis of the activities (work), outputs, outcomes and impacts (results) of the project via reconstruction of the project's intervention logic via logic modelling. The logic model is represented as a diagram (Figure 5-1) containing the essence of the IL and the causal linkages between the model's different components. For a more detailed account of activities, outputs, outcomes and impact see the tabular version of the logic model in Appendix B.

Figure 5-1 depicts the logic that Project A was built on. To start with, it shows which resources were considered necessary for the implementation of the project, then the planned activities and the intended results in terms of outputs and outcomes and overall impact.

With regard to resources it was considered that the required expertise can be sourced from both local actors and international ones. The local counterparts held knowledge and expertise on the local conditions of the selected region and the three pilot sites, renewable energy technologies, the applicable policy framework and administrative procedures that could support the technology, etc. The counterparts also showed willingness to provide support for the project and transfer the technology to the region and to learn and potentially innovate it. Other resources were embodied by human capital (e.g. UNIDO staff, the Project Execution Unit, international experts etc.), the equipment itself, financial support via voluntary contributions, and access to special training courses.

The activities and resulting outputs were devised to follow four stages:

1. *The Design stage* consisting of systematic assessments of socioeconomic needs, infrastructure, sustainability, technical applicability of the pilot sites, also including the electricity supply structure, the function of existing associations, existence and type of productive activities required, energy demand, availability productive assets for mini grid development, and available human resources and private sectors. This stage also includes assessments of the policy, legal and regulatory framework, and consultations with community leaders. The collected information was planned to be used as basis for detailed strategies for SHP implementation at the pilot sites.
2. *The System Demonstration stage* consisting of the actual installation of the SHP at the three pilot sites with the technology transferred from the origin country. Capacity building also forms part of this stage with planned initial trainings on the technology and establishing a training module at the research institute affiliated to the project. Finally, evaluation activities were planned for the systems following an observation period and start identifying a potential market for the technology.
3. *The Business Development stage* consisting of further capacity building activities linked to the local production chain in order to settle the transferred technology. This stage was also planned to consist of proposing viable business models based on the technology and the mini-grid system, setting up workshops and meetings for experts and the business sector and try to 'partner-match' enterprises to enable local production chains and productive business models via joint venture, retailing, after service, but also stimulating further R&D activities. Also planned was the development of a business plan to form the basis for a market potential analysis for the preparation of raising awareness to incentivize the proven technology in the local business community.
4. *The Strategy Development stage*, comprising of raising awareness of the technology and what can be achieved in order to stimulate further technology development, deployment and diffusion and mainstream and up-scale the technology beyond the pilot sites. Other planned activities were publishing positioning papers on the potential of the SHP technology for increasing access to energy for productive uses and the development of an action plan for productive uses to serve as guidance on how to develop productive activities based on the SHP. Also planned was the preparation of an assessment of market and investment opportunities to develop market-based replication strategy and policy recommendation of the utility of SHP technology.

If successful, these activities were envisaged to lead to outcomes for successfully implementing the technology at the three sites, the creation of a favourable environment that allows the technology to be acquired, adapted, deployed, localised and innovated locally, and the actual TT from the origin country to the recipient country. Ultimately the project was envisaged to result in somewhat improving the energy situation in the recipient country.

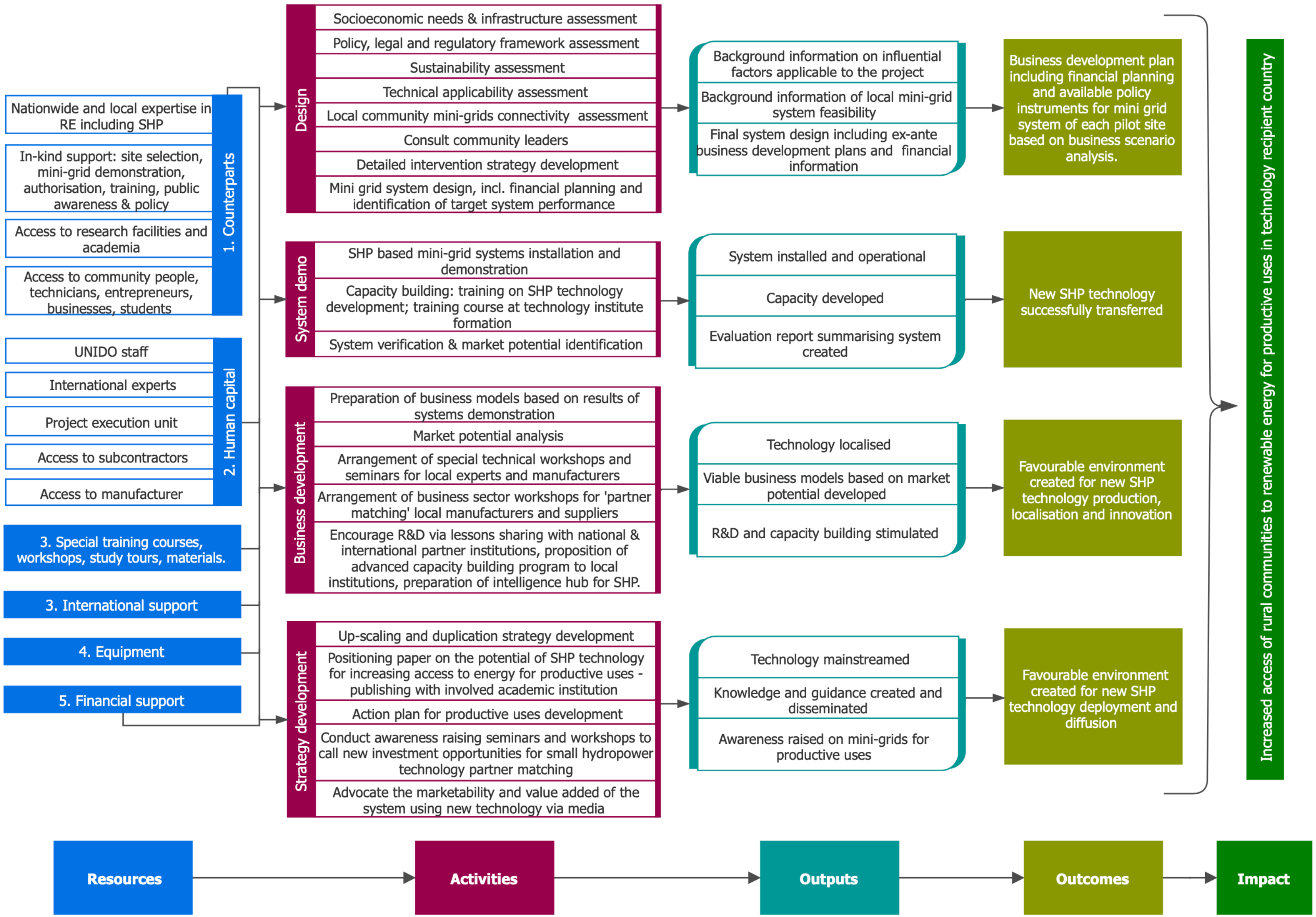

Figure 5-1. Logic Model for Project A in diagrammatic format
Source: Author's own data collection

5.2.2 Analysis of the Intervention Logic

The table below presents the results of the analysis (direct logic analysis) of the project's reconstructed intervention logic against the factors that are said to influence technology transfer. The data that the analysis is based on is document-based and when the documents showed little evidence that a certain factor was assessed it is indicated as such. This analysis does not rule out that such factors were considered but did not end up in the documentation as they were judged at the time (with the evidence available) that they were not relevant to the project.

Table 5-1. Results of the analysis of the intervention logic based on TT influential factors - Case Study 1

General Factors + Criteria		Analysis
Absorptive Capacity	**The existing human capital/skills**	Some evidence that the existing human capital and skills sets were assessed prior to the start of the project, but unclear regarding how effective this assessment was. The fact that skills should be better assessed in future project design is stressed in the final report (p.4): "include the identification of local technology and manufacturing partners, to be assessed for the quality and availability of system components […] and skill sets".
	Innovation type and potential	No evidence that the innovation type and potential were systematically assessed.
National Innovation System	**Infrastructure system**	The initial assessment of potential pilot sites did include an assessment of 'infrastructure'; however, it is unclear what type of infrastructure this implies. The above quote suggests that amongst others, "future project design should include the identification of […] adequate infrastructure", available to the manufacturers.
	Public and private education, training, and research institutions	There is a research institution involved with the project and their willingness to adopt the technology make their facilities and students available is clear. There is no evidence to suggest that other education institutions are systematically assessed. The benefit of having research institutions involved in TT especially in the case of new, innovative technology is recognised in the final report (p.4): "[it is] recommended that systems using locally manufactured components be tested first in semi-research conditions […], rather than in actual communities where immediate systems performance is expected". There is also no evidence to suggest that the national education and research system that supports the creation of national technical knowledge is considered as a good indicator of the potential quality of pre-existing human capital.
	The productive/business sector	The existence and type of productive activities required for the project were assessed.

Enabling National Policies	**Policies aimed at supporting education, learning and knowledge generation**	No specific evidence that learning policies are considered.
	Policies aimed at encouraging technology entry into the country.	No evidence of a specific assessment done on policies that can facilitate the channels of technology transfer to the recipient country. However, a policy, legal and regulatory assessment was performed, and it is possible that these have been considered as part of that. The available data also does not discuss any specific challenges regarding the channel via which the technology entered the country.
	Policies aimed at encouraging technology uptake and diffusion, and the creation of business models based on the technology, including financial support	A systematic assessment of current policy and legal/regulatory framework including market-based instruments was conducted and a policy summary report was prepared including business development planning advice.

Project-specific Factors + Criteria		Analysis
Technology complexity	**The possibility to break the technology down into distinct and divisible components**	This is not explicitly mentioned but there is evidence that implies that the SHP has distinct and divisible components.
	Components that can be manufactured locally	The project involves identifying local manufacturers for the production of system components and testing which components can be successfully manufactured. However, in this case, localising component manufacturing partners ended up requiring a lot of time and effort on the part of the technology supplier as the local fabricators did not have adequate expertise and infrastructure for manufacturing the new technology's components at the start of the project. This resulted in the initial locally manufactured components being of inadequate quality. As the project was supposed to build capacity this seems more like problem with the "expectation" that local manufacturers could easily be identified and quickly learn how to manufacture quality components. This is also recognised in the final report which states that in the future, local technology manufacturing partners with sufficient capacity should be identified prior to starting the project.
	Capital investment needs to enable local manufacturing of components	There is no direct specification of this being taken into consideration.
	Components that need to be imported	The components that will need to be eventually imported do not seem to be identified prior to the start of the project. However, over the course of the project it became very clear which components needed to be imported and which could be successfully manufactured locally.
	Technology-specific skills that can be sourced locally	The project document suggests that 'human resources' for the three pilot sites are assessed however it is not clear what this implies. Based on the fact that identifying local component manufacturers ended up requiring a lot of time and

		effort it can be assumed that the assessment of human resources does not fully capture the technology-specific skills that can be sourced locally to enable the TT process.
	Technology-specific skills that need to be sourced overseas	The technology supplier and international experts are both resources UNIDO had access to so as to operate the project from the start. However, it is unclear if the technology-specific skills that need to be sourced overseas were assessed beyond this to try to identify other potential sources of skills, if necessary.
	Level and type of skills that need to be developed locally	This does not appear to be assessed prior to the start of the project. As above, there is a 'human resources' assessment and it could be assumed that this assessment would have identified the gaps in capacity and what areas of skills need to be further developed. It is also noted that capacity building efforts are put in place to develop skills locally.
Local Environment	**Local needs and circumstances**	Feasibility studies were undertaken at the three pilot sites to assess, amongst others, the local needs. The assessment measured social, economic, environmental and technical aspects and focused on suitability of the sites for the technology, electricity supply structure, the function of existing associations, existence and type of productive activities required, energy demand, availability productive assets for mini grid development, and available human resources and private sectors.
Local Environment	**Local stakeholders**	The available data indicates that the community was consulted and regular meetings took place related to community contribution for shed construction and productive asset machine procurement, baseline surveys of the villages, involvement of community in SHP installation, roles of group members in business development, marketing, financial and account management, participation in training, planning for exposure visits, etc. The final report also suggests that the communities showed commitment to contribute cash and in-kind to the project and to run it sustainably.
Finance & Costs	**Access to finance**	Financial provisions for the support of the technology transfer have been assessed.
Finance & Costs	**Users are able to pay for the service**	The available evidence suggests that availability of productive assets for mini-grid development is assessed, and that the existence of these was envisaged to empower the locals to pay for the electricity service.

Source: Author's own data collection and analysis

5.2.3 Intervention Strengths and Weaknesses

Based on the comparison between the intervention logic and the factors identified in literature that are expected to influence the technology transfer process, the following strengths and weaknesses of the intervention were identified.

The intervention's strengths according to the logic model

- The assessment of the productive sector to identify a potential market for the technology and the development of business models based on the service that the technology provides.
- The inclusion of the education and research system (through the one academic institution) as an active facilitator of the TT process, and as the institution to host training and serve as a knowledge centre for the technology.
- The development and provision of training for local engineers/experts. The inclusion of specialists to train the local actors in order to transfer the skills necessary for operation and maintenance of technology, fabrication of equipment, implementation of a project based on SHP technology.
- The inclusion of experts to transfer know-how and know-why skills through capacity building activities.
- The planned cooperation activities proposed with national/international partner institutions that could stimulate further technology R&D.
- The planned preparation of an intelligence hub for SHP technology to enhance the marketability of the new system and to develop strategic local production systems.
- The assessment of policy, legal/regulatory framework, market-based instruments in order to identify and enable governmental financial support for the technology.
- The organisations of workshops to benefit the private sector to create local manufacturing and supply chains for the technology.
- The partner-matching for joint ventures and retailing systems for SMEs, business institutions, local entrepreneurs to enable technology replication.
- The assessment of local needs and circumstances for the adoption of the technology.
- The inclusion of the local community in the project from the beginning.
- The assessment of the sector-specific policies that can enable the replication of the technology and the provision of governmental advisory support to strengthen these.
- The planning for the users' ability to pay for the service provided by the technology.

The intervention's potential weaknesses

- The absorptive capacity of the local actors is not sufficiently assessed in order to determine the level of knowledge that could facilitate the assimilation of the technology and permit the utilisation and further replication and innovation of the new technology.
- The innovation potential of local actors is not assessed to determine if the basic level of incremental, adaptive innovation capabilities to allow them to absorb the technology exists.
- The national education and research systems are not taken into consideration as potential indicators of the quality of the existing human capital that could facilitate the TT process.
- The identification of potential, skilled local technology components fabricators in the national productive system is not thoroughly done prior to the start of the project.
- The infrastructure system that would facilitate the implementation of the technology is not fully considered (e.g. the infrastructure available for the potential equipment fabricators and the road infrastructure appear to be left out of the assessment).
- The technological complexity does not appear to be sufficiently evaluated. The ability to break down the technology into components and their technical complexity (the manufacturing process) are considered, however the technology quality complexity (the quality requirement for the manufactured components and the importance of the component in the overall system) and the financial complexity (the potential capital investment into expensive manufacturing equipment and associated risks) do not appear to be sufficiently appraised.

Other observations

- The policies allowing the technology to enter the country (e.g. policies encouraging FDI, the strength of the IPR system, competition policies) do not appear to be taken into consideration in the context of this project. It is unclear if this a potential intervention weakness or if the nature of the transfer means that such policies are irrelevant.

- The intervention was designed to specifically transfer the innovative SHP technology and therefore technology alternatives were not considered. This could be a potential weakness as a SHP alternative could have been more suited to the local context, the actual absorptive capacity of the stakeholders and their needs etc.

5.2.4 Technology Dimensions Transferred

Based on the above analysis, the following observations can be drawn with regard to the dimensions of technology that were transferred as part of this intervention:

- **Hardware**: the tangible elements of technology embodied by capital goods such as equipment, design and engineering services, specifications etc. were all 'transferred' at the three pilot sites in order to implement and commission the SHPs and the mini-grids. However, not all tangible elements were transferred for local fabrication that could facilitate the adoption of the innovative SHP in the recipient country, and further innovation and replication: only the turbine and the control panels. The rest of the physical equipment and technical components could not be successfully manufactured locally and had to be imported (e.g. gearbox, generator).
- **Software or know-how**: skills necessary for operation and maintenance of technology were attempted to be transferred through various capacity building training programmes however a certain risk remained that the technology will not be properly operated and regularly maintained. Because of this, this technology dimension was deemed only partially transferred.
- **Know-why**: to some extent there was a transfer of skills necessary to understand, utilise and evaluate the technology that further permits the assimilation and exploitation of the technology through innovation and replication; however, this appears to be somewhat limited to the local manufacturing of technology elements such as the turbine and the control panel and other consumable parts. The skills necessary to allow for a full understanding of the application of technology (e.g. hydrology knowledge or knowledge on how to adapt the technology to the local environment) were still somewhat limited at the end of the project and presented challenges for the implementation of technology.
- **Innovation system**: the national network of public and private institutions whose activities and interactions initiate technology development, transfer, modification and diffusion was somewhat enabled during this intervention through the establishing of a SHP centre at the local academic institution for training and R&D purposes, the various policy supports available and the provision of subsidies for the technology.

5.3 Case Study 2 – Project B

5.3.1 The Intervention Logic

The logic model for case study 2 is represented in Figure 5-2. A more detailed account of activities, outputs, outcomes and impact can be found in the tabular logic model (Appendix C).

The resources considered necessary to implement the project were: local counterparts who held the knowledge and expertise on the local conditions, the applicable policy framework and administrative procedures that could support the technology, etc; the project developers who had access and were recognisable in the local communities and were able to sensitise and mobilise the public, to conduct civil works and manage the SHP once installed; technological institution that were willing to make their staff and facilities available to host the training centre; governmental institutions that were committed to promote rural energy services, to facilitate modern energy projects for rural areas and to provide technical support for the developers. On the financing side, a credit line for providing subsidies to RE investments was available. The intervention itself had financial resources from donations and co-financing. With regard to human capital resources these were UNIDO staff, international experts in SHP, a project management unit and a steering committee.

The activities and resulting outputs were devised to follow four components/stages:

1. *Techno-economic feasibility studies for the identified demonstration sites ('Feasibility Studies stage').* This stage was envisaged as a thorough due diligence of technical, social, economic viability and management modalities of the potential sites.
2. *Capacity building of stakeholders in developing SHP-based mini-grids ('Capacity Building stage').* In this stage, it was envisaged to establish a training centre at a local academic institution to serve as a learning hub and provide technical support for transferring the technology. International experts were planned to train staff members at the new training centre, which in turn were to use their newly accumulated knowledge to further train planners, project developers, financial institutions, local engineering companies, mini-grid operators and construction companies based on training material developed with the help of national and international experts. To transfer the technology to local fabricators the first step proposed by the project was to conduct a demand assessment for local SHP equipment, evaluate the local capacity in manufacturing equipment and identify interested local fabricators. A next step proposed using international experts from other UNIDO–SHP centres to train the local fabricators at the local training centre on planning and designing aspects of the equipment, actual fabrication of the equipment and marketing strategies. With regard to actual manufacturing the project envisaged subcontracting an experienced and standard turbine manufacturing private company to transfer the technology to the local manufacturers. The TT channel was envisaged to be licensing and the necessary licenses were planned to be arranged for the trained local fabricators. The next planned step was to adapt, in collaboration with the recipient country's main electricity supplier, the existing guidelines and standards for large hydropower projects to include SHP, to make sure that the installation of SHP is done in compliance with accepted standards. Finally, the provision of incremental support for the government to develop a government incentive to support future replication efforts of SHP-based mini-grids was planned.
3. *Developing viable business models for SHP-based mini-grids ('Business Development stage').* This component was planned to include awareness programs on the available subsidies and credit lines, head-to-head meetings between the private sector and the local financing institutions for match-making and facilitating the development of SHP, liaising with the responsible government agency for the creation of separate window for SHP under the available subsidy/financing schemes. The output of this stage being the streamlining of the existing financing options to benefit local entrepreneurs interested in SHP.
4. *Demonstration of SHP-based mini-grids ('Demonstration stage').* This component included the actual installation and demonstration of the SHP at the selected sites. This consisted of launching a bid for sourcing SHP technology and the awarded bidder implementing the project under the supervision of an international expert. The necessary licenses, permits and contracts required for the construction and the operation of the SHP would have been arranged under this stage and detailed design of mini-grid system, distribution lines, connections, metering, etc. would have been carried out. After the completion of the project, the project would have been assessed to study its technical, financial, environmental and socio-economic performance. The results would have then been disseminated for increasing the replication potential.

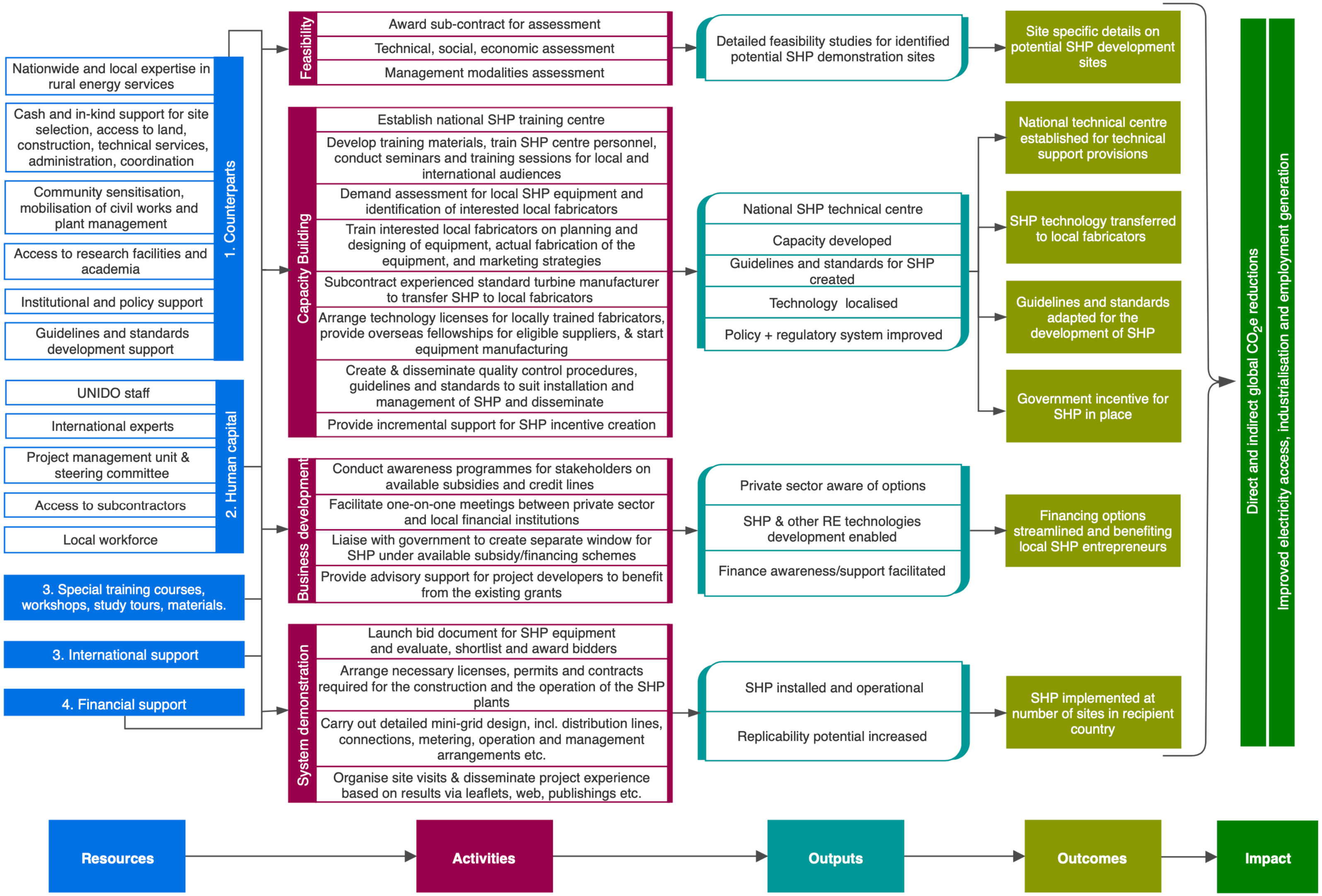

Figure 5-2. Logic Model for Project B in diagrammatic format
Source: Author's own data collection

5.3.2 Analysis of the Intervention Logic

The table below presents the results of the analysis (direct logic analysis) of the project's reconstructed intervention logic against the factors that are said to influence technology transfer. The data that the analysis is based on is document-based and when the documents showed little evidence that a certain factor was assessed it is indicated as such. This analysis does not rule out that such factors were considered but did not end up in the documentation as they were judged at the time (with the evidence available) that they were not relevant to the project.

Table 5-2. Results of the analysis of the intervention logic based on TT influential factors - Case Study 2

General Factors + Criteria		Analysis
Absorptive Capacity	**The existing human capital/skills**	The existing human capital/skills (the limited knowledge level and technical capacity) appear to have been identified as one of the leading barriers to improving the rural energy situation. Based on the subsequent planned actions of the project it could be that this is the reason why significant effort has been put into the capacity building element.
	Innovation type and potential	There was no evidence that the innovation type and potential were systematically assessed.
National Innovation System	**Infrastructure system**	Infrastructure is considered to some extent, but it is not clear what type of infrastructure.
	Public and private education, training, and research institutions	There is a research institution significantly involved in the project especially on the capacity building element. However, the available data did not provide any evidence that other education institutions are systematically assessed, if necessary.
	The productive/business sector	The existence and type of productive activities required for the project were assessed.
Enabling National Policies	**Policies aimed at supporting education, learning and knowledge generation**	There is no evidence that these are specifically assessed.
	Policies aimed at encouraging technology entry into the country.	These policies appear to be assessed. It is identified that the recipient country's government provides exemption on import duty for RE equipment
	Policies aimed at encouraging technology uptake and diffusion, and the creation of business models based on the technology, including financial support	This appears to be assessed. There were no market-based systems favouring SHP existed prior to the start of the project however the government was working on the development of a government incentive.

Project-specific Factors + Criteria		Analysis
Technology complexity	**The possibility to break the technology down into distinct and divisible components**	This is not explicitly mentioned but there is evidence to imply that the SHP has distinct and divisible components.
	Components that can be manufactured locally	The project takes into consideration the local availability of equipment fabricators (which were none before the start of the project) and intends to develop a local fabrication platform for some components.
	Capital investment needs to enable local manufacturing of components	There is no direct specification of this being taken into consideration.
	Components that need to be imported	This is assessed. At the start of the project all components would have needed to be imported as

		there were no local SHP equipment fabricators. For four of the demonstration sites the equipment was procured from overseas through the awarding of a bid to a foreign technology supplier.
	Technology-specific skills that can be sourced locally	The existing local capacity in manufacturing equipment is assessed in order to discover which skills can be sourced locally. While it is recognised that the technology-specific skills are minimal some institutions who have shown efforts in equipment fabrications are identified.
	Technology-specific skills that need to be sourced overseas	This appears to be an important consideration. Bids and tenders were launched to attract international expertise from technology suppliers and international experts are consulted.
	Level and type of skills that need to be developed locally	It is recognised that the technology-specific skills are minimal at the beginning of the project and the limited knowledge level and technical capacity have been identified by UNIDO as one of the leading barriers to achieving the goal of the project. Capacity building efforts are put in place to develop skills locally.
Local Environment	**Local needs and circumstances**	This appears to be taken into consideration. Feasibility studies were undertaken at the potential demonstration sites to assess local needs, including the geography, resource potential, domestic industries, etc.
	Local stakeholders	The local stakeholders were strongly involved from the project's identification stage, in many ways they were one of the main drivers for the project. The project was identified and prepared through cooperation with local stakeholders, and through the cooperation previously established within the recipient country. The project documentations states that the recipient country's government and the local project management office showed strong ownership of the project from the start. During the preparation stage for the project there was a consultation workshop with all concerned stakeholders for renewable energy. After the consultation workshop, nine feasibility studies for the demonstration sites where the SHPs can be positioned were made. Out of these nine, seven were selected, based on project viability, reproducibility, CO_2 impact, and technological and financial viability. These projects were proposed by industry, and that suggest their involvement and commitment from start.
Finance & Costs	**Access to finance**	A main component of the project activities relates to finance for the SHPs and replication. Subsidies and credit lines were made available and activities are organized to inform interested SHP project developers of these. Local financial institutions are also taken into consideration and match making meeting between these and the private sector were organised.
	Users are able to pay for the service	The availability of productive assets for mini-grid development is assessed, and that the existence of

		these will empower the locals to pay for the electricity service. Furthermore, at one of the demonstration sites an initiative of buying electricity from the main national supplier and connecting people at a much cheaper price that they pay for the electricity from the diesel and kerosene generators (around 1/3 of the costs for energy) in the surrounding villages in order to accustomed people to electricity before start of working of the SHP.

Source: Author's own data collection and analysis

5.3.3 Intervention Strengths and Weaknesses

Based on the comparison between the intervention logic and the factors identified in literature that are expected to influence the technology transfer process, the following strengths and weaknesses of the intervention were identified.

The intervention's strengths according to the logic model

- The assessment of the existing quality of the human capital and the identification of this as one of the leading barriers to development.
- The inclusion of the education and research system (through one academic institution) as an active facilitator in the TT process, and as the institution being able to host training and serve as a knowledge centre for the technology. The capacity built at the centre means that it is a key establishment for continuation of technical support after the end of the project.
- The assessment of the country's activities and potential in the business/productive sector to identify a potential market for the technology.
- The identification of policies aimed at facilitating the technology entry into the country and the arrangement for licenses for local fabricators.
- The assessment of and lobbying for policies aimed at encouraging technology uptake and diffusion, and the creation of business models based on the technology.
- The broad array of capacity building activities to strengthen the know-how skills for the operation & maintenance of SHP.
- The identification of potential interested technology component fabricators, the assessment of their skill sets and the inclusion of capacity building activities focused on transferring know-how and know-why skills through trainings, experience sharing and by providing fellowships in getting long term training in countries with advanced manufacturing technology.
- The inclusion of experts to transfer know-how and know-why skills.
- The apparent focus on South-South technology transfer (developing country to developing country) to facilitate for the transfer of a technology from a country with a similar context.
- The assessment of local needs and circumstances for the adoption of the technology.
- The active inclusion of the local stakeholders from the start of the intervention and their willingness to take ownership of the project.
- The focus on ensuring that there are financing options (e.g. subsidies, credit lines) available for and facilitating the development of projects based on the technology and that potential developers are aware of these.
- The assessment of the sector-specific policies that can enable the replication of the technology and the provision of governmental advisory support to strengthen these.
- The initiative to buy electricity from the main electricity supplier and connecting people at a cheaper price that they pay for the electricity from the diesel and kerosene generators in the surrounding villages in order to accustom people to electricity before start of working of the SHP.

The intervention's potential weaknesses

- The innovation potential of local actors is not assessed to determine if the basic level of incremental, adaptive innovation capabilities to allow them to absorb the technology exists.
- The education and research systems do not appear to be considered as potential indicators of the quality of the existing human capital that could facilitate the TT process.
- The infrastructure system, as part of the national innovation system, that would facilitate the implementation of the technology does not appear to be considered in detail.
- The users' ability to pay for the service provided by the technology does not appear to be assessed for all demonstration sites. At one of the sites the revenue generated based on the technology is not sufficient to cover the current operational costs of the plant. This is due to low income and inability of the local households to pay a higher tariff. At another site the nominal tariff set for electricity is too low and cannot fully cover the cost of operation and maintenance of the technology.

Other observations

- It is unclear if a full technology complexity assessment was undertaken. The ability to break down the technology into components and their technical complexity (i.e. the manufacturing process) are evident. It could be argued that a quality complexity (i.e. the quality requirement for the manufactured components and their importance in the overall system) was considered, it being the reason why mainly the turbine component was transferred for local manufacturing while the electro-mechanical equipment was always imported. It is also unclear to what extent the financial complexity (i.e. the potential capital investment into expensive manufacturing equipment and associated risks) was appraised.

5.3.4 Technology Dimensions Transferred

Based on the above analysis, the following observations can be drawn with regard to the dimensions of technology that were transferred as part of this intervention:

- **Hardware**: the tangible elements of technology embodied by capital goods such as equipment, design and engineering services, specifications etc. were all 'transferred' at the pilot sites in order to implement and commission the SHP and the mini-grids. However, not all tangible elements were transferred for local fabrication with the main focus being on only one component: the turbine. While transferring the turbine for local fabrication has proven successful, all the demonstration sites relied on imported electro-mechanical equipment.
- **Software or know-how**: activities to transfer the skills necessary for operation and maintenance of technology were undertaken. However, the overall success of this know-how transfer is unclear.
- **Know-why**: to some extent there was a transfer of skills necessary to understand, utilise and evaluate the technology that further permits its assimilation and exploitation; however, this appears to be limited to the local manufacturing of the crossflow turbine.
- **Innovation system**: the national network of public and private institutions whose activities and interactions initiate technology development, transfer, modification and diffusion was somewhat enabled during this intervention through the establishing of a SHP centre for training and R&D purposes, the institutions involved in producing guidelines for SHP development, the various policy and financial supports for the technology. Still, as noted in UNIDO's terminal evaluation, the longevity of some institutions in this system (mainly SHP centre) is uncertain as they may not be able to have sufficient level of activities to keep them financially sustainable.

5.4 Cross-Case Comparison: Results & Analysis

This sub-section presents the cross-case comparison. The process demanded the comparison of the intervention logic and technology transfer aspects behind the two case studies. A table containing the comparison is presented in Appendix D. This section outlines the main findings.

The Technology & the Stages

- Case study 1 (Project A) aims to transfer a newly innovated technology, up to that point only available in the technology origin country. Case Study 2 (Project B) aims to transfer a generic "small hydropower technology", an arguably already mature technology.
- Both case studies follow a similar structure and are planned around four stages.
- A main difference comes from the order of the stages e.g. Project A aims to demonstrate the technology first and then undergo activities to enable TT replication, while Project B focuses on activities to allow for the transfer of technology and replication first and the demonstration of the technology being the last component.

The Technology Transfer Strategies

- Both cases place emphasis on capacity building for strengthening technical capabilities involved in both operating and maintenance of the technology and fabrication of the technology. There seems to be more emphasis on capacity building in Project B both from the perspective of activities undertaken and the number of persons to be trained.
- Enabling local manufacturing for technology parts in Project A appears to go on the assumptions that some local fabricators already have the necessary skills and that they will produce some components at the quality level required. The technology manufacturer is actively involved in transferring know-how and know-why skills for those components that are not already locally manufactured, and efforts are being undertaken to determine which of the components will be able to be successfully locally manufactured and which ones will still need to be imported. In Project B the assumption is that local skills do not currently exist and neither do pre-existing local fabricators. The focus is mainly on enabling local manufacturing of the turbines with little evidence that other components were considered for local fabrication. A technology manufacturer is selected to undertake this activity. The rest of the main components (the electro-mechanical equipment) are purchased with UNIDO's support and not attempted to be transferred for local fabrication.
- In Project A, financial support for further transfer and replication of technology is mainly enabled at a private sector level with partner-matching efforts for joint venture etc. Additional support is provided by the government in the form of an incentive. In Project B, the financial support strategies mainly focus on credit lines from financial institutions. Additional support is planned to be provided by the government in the form of an incentive.

Technology Transfer Achievements

- **Hardware:** transferred in both cases at the pilot/demonstration sites
- **Software/Know-how**: transferred to some extent. In Project A there is the risk that this was not sufficient to ensure proper future operation and maintenance. It is unclear if there are any issues with this aspect in Project B.
- **Know-why:** transferred to some extent but it is unclear if this is sufficient to further assimilate and innovate the technology. In Project A the skills related to the installation and proper functioning of the technology were still somewhat limited in the local population. It is unclear if there are any issues with this aspect in Project B, but it is understood that a majority of this is still done through expertise not locally sourced.
- **Innovation system:** enabled to some extent. Both case studies included the establishment of knowledge centres for the technology and encouraging collaborations between institutions in both the private and public sector.

6 Discussion

In Section 1 of this thesis a number of hypotheses were drawn up to form the backdrop of this study, as well as a number of research tasks that can facilitate the proving/disproving of the hypotheses and help answer the research questions. This section discusses the hypotheses, the research tasks, and provides reflections on the main findings. It starts by discussing the intervention logic as a research tool and observations related to the approaches in the two case studies. After this, follows a discussion of the two hypotheses by examining the findings on technology transfer factors and how they were captured in the intervention logic in the two case studies. Hypothesis 2 is discussed before hypothesis 1 in order to present the findings in the chronological order in which the research tasks were conducted. The section concludes with further reflection on the principles of technology transfer and the influential factors.

6.1. The Intervention Logic

One of the first tasks of this research thesis was to reconstruct the intervention logic that forms the basis of the technology transfer strategy behind UNIDO's small hydropower projects. The reasoning for looking at the IL for identifying the technology transfer strategy is that these ILs can be a source for understanding the planned strategy of a project. An intervention logic describes why, how, and under what conditions the project results occur, predict the outcomes and impacts of the project, and specify the requirements necessary to bring about the desired project effects. By that reasoning the technology transfer actions planned by UNIDO should also be captured in the intervention logic which would allow for the subsequent comparison with the TT factors identified in academic and specialised publications.

It is imperative to highlight that the IL for the two case studies was 'reconstructed'. There are existing projects and programmes, including several UNIDO ones, that were built starting with an IL (or what UNIDO calls 'theory of change'), especially those programmes that intend to result in 'transformational change'. However, not all projects start with an IL, and according to Zazueta (2018) not all of them need one. It is, however, common practice for evaluators to reconstruct the intervention logic/theory of change of the project or a program in order to understand what and how the project/program was intending to achieve its results and in order to better evaluate it. The two studied cases in this thesis did not have a documented IL to begin with, at least not in the form of a visual representation of the principles in which the project was based, which is why these were reconstructed in the first place.

The intervention logic behind the two case studies was reconstructed using logic modelling, a method by which the author categorised the statements and information already existing in the project documents of the two case studies into 'intended work' and 'intended results'. Of course there are limitations to this approach as, by its definition, only provides a model of how the project was planned and intended to work and does not capture some of the finer intricacies and details behind some of the resources available to the project, the planned activities, the intended outputs and outcomes, and the final impact. It also mainly focuses on those planned activities that could have an impact on the technology transfer outcome, and deliberately leaves out some of the other actions planned as part of the projects, for example the gender mainstreaming aspects.

A further limitation of the logic model reconstruction comes from the sources of information that this was based on. The project documents and the final and mid-term evaluation reports contain abundant information to explain the 'why' and 'how' behind the case studies and, while piecing together the intervention logic, the author did not consider that there were any gaps in the data contained in these documents. However, as with most written documentation, there could be unclarities when extracting the meaning from these documents due to e.g. the style of writing and formulation of sentences. These unclarities might have led to an alternative interpretation of certain statements and therefore affected the information that went into the logic model. Interview data could have provided additional information on these unclarities.

The logic model is a means of visualising and synthesising the information in the project in a manner that is not fully present in UNIDO's documents. It is noted that the project documents of both case studies each contain a logical/results framework which is similar to the logic model in that it contains a tabular visualisation of the project's outcomes, outputs and impact as well as how to keep track of progress, but it does not capture the activities or the resources that are necessary to be undertaken to achieve these results. In that sense it does not capture the part that discusses the "planned work" that constitutes the basis for the project. Of course, it could be argued that the results are more important that the means and that in reality the planned work is unlikely to go according to plan and strategies will need to be adapted on site. But from the perspective of transferring technology, this thesis provides ample evidence that it is important to have a clear, systematic plan for those actions that need to be taken to facilitate the process, as well as an understanding of why those actions are important.

There is also a fundamental difference between an intervention logic (or a theory-of-change) and the logical framework, a tool often used by UNIDO and other aid organisations. Both tools stem from the area of project management and are complementary but ultimately serve different purposes. The logical framework is mainly a tool to monitor the performance of a project and assesses if the project is implemented as it was planned – in that sense it is a very important tool to understand if the project is on track and report on its achievements. This is also potentially the reason why many donor organisations insist on the presence of the logical framework in project documents and why the tool is ingrained in international aid organisations, such as the agencies and programs that form the UN system. On the other hand, the IL, is a tool that presents a theory about how and why an initiative could work and it can be used to plan a project to achieve its intended impacts. In that sense, it is a tool that should be employed prior to the formulation of a logical framework, as this later one could be built based on the intervention logic.

In Section 2.2.1 it was discussed that the notion of 'intervention logic' appears in a variety of terminologies throughout publication suggesting that there is no "common vocabulary, definition, and shared conceptual and operational understanding" (Coryn et al., 2011, p.200) for the notion. Indeed, the IL is a versatile tool that can be used in any ways such as to provide the information the person needs in the format that suits their purposes and is most helpful to them. The IL can be represented in many ways and have different types of flexible diagrams and tables. For this thesis a simple logic model was chosen as it is considered to "focus on project-level results" (W. K. Kellogg Foundation, 2004, p.7). These logic models are built on a number of *if-then* statements and in this case helped explain the causal links between project elements. In this thesis the intervention logic was represented by using a more applied rather than conceptual type of logic model, one that focuses on emphasising the interrelationships between different project activities and their outcomes. For the case studies, this type of logic model provides a useful glimpse of how the SHP technology transfer activities were planned and what each set of activities was intending to achieve.

However, there are limitations to the use of this type of model. It outlines the approach and results, and the expectations behind the projects but does not provide in-depth explanations for beginning to explore the idea for the projects in the first place. The more applied nature of this model means that the "big picture" thoughts and ideas that went into conceptualising the projects are not fully captured, nor are the reasons why the planned strategies were selected over alternative ones, of if these strategies are actually proven to work. The logic model used in this thesis can more practically guide the analysis of the case studies as it focuses more on the activities and outcomes. Its more detailed nature allowed for a better understanding of how technology transfer was planned for in the case studies, and the identification of strengths and weaknesses in the design. This type of model can help deduce the assumptions that the project planners held that influenced the way the projects were designed, and therefore provides areas to question during evaluation.

6.1.1 Reflections on the Approaches taken in the Case Studies

The results of the reconstructed intervention logic are presented in the Results Section above. This section discusses the main observation regarding the approaches that transpired from the reconstructed intervention logic of the case studies.

The two case studies have similar aims and end goals. In both case studies the ultimate aim of the UNIDO intervention is to augment rural electrification, and in order to do this in both case studies there is the intention to the transfer of technology for local fabrication and further replication of the SHP technology at other sites in the respective countries. The reconstructed IL illustrates the planned strategies that will lead to these intended outcomes. It shows that both case studies are built on a 4-stage structure, with many similarities between the two approaches but also notable differences that highlight different strategies for facilitating the transfer of technology and the achieving the planned results. Both projects start with stages including the of undertaking feasibility studies for potential sites where the technology can be demonstrated, both projects have a business development stage, and both projects have a system demonstration stage. The difference comes more on the strategies that influence a big part of the technology transfer process, mainly the capacity building element, as well as the financing options, as well as the order the stages are implemented.

With regard to the order the stages are implemented the results show two distinct approaches: in Project A the emphasis is on first undertaking feasibility studies then installing and demonstrating the system while concomitantly building capacity for design, operation and maintenance, civil works etc. After the system is demonstrated strategies for encouraging replications are taken such as developing viable business models, arranging partner-matching workshops for the business sector to enable local production chains via joint venture, and preparing a market potential analysis to incentivise the local business community. Finally, the last stage of Project A contains mainly strategies to disseminate the results of the demonstration in order to enable the upscaling and duplication of the technology at other sites. The strategy in Project B follows a different approach: first undertaking feasibility studies then building the capacity of the local actors so as, amongst others, the local fabricators have the necessary skills to design and actually manufacture equipment (in this case the turbine). Then after the capacity is built, the strategy focuses on business development through mainly focusing on the financing options for SHP and on making sure the local stakeholders are aware and can benefit from grants and credit lines. Only after all this is done, the approach attempts to install and demonstrate the technology at the different sites. This difference in approaches might be one reason for the different accomplished results: while the implementation of the SHP at the pilot sites in Project A encountered a number of challenges mainly based on lack of skills and the newness of the technology, the implementation of the SHP at the demonstration sites in Project B appears to be more streamlined and with less setbacks. There, of course, might be other reasons as to why Project B appears overall more successful than Project A, including the difference in the proportion of skill sets sourced locally between the two cases (Project A appears to have a higher proportion of skill sets sought locally than in Project B), or the difference in the ambition between the two projects with regard to what is actually to be transferred. This later remark will be further discussed in the paragraphs below.

It is important to note that the respective technology for each case study are ultimately different despite both being small hydropower technologies. The technology in Project A is a new technology, only available in its origin country up to the point of it being transferred to the recipient country. The technology in Project B is referred to just as SHP. Small hydropower is a mature technology that has been around for a long period. One aspect not explored by this thesis is whether this nature of technology has an impact on the success of the transfer. Considering that Project A was dealing with a new and possibly more complex technology that was only previously applied in its origin country, in a setting with markedly different characteristics, the fact that the transfer encountered some challenges is not unjustifiable. In Project B the technology itself does not even appear to play a very important role, it is mainly just talked about only as SHP and the main component that features is the crossflow turbine, a turbine that has existed for a long time before the inception of the project.

It is likely that the nature of skills that needed to be transferred also differ. Perhaps in the case of the more innovative SHP there needed to be a very specific skills set transferred that pertained to this exact technology while in the case of Project B the skills sets were more general. Since the more innovative technology has only been applied to the conditions in the origin country it is likely that transferring it to the recipient country (which has markedly different conditions) could involve a certain degree of trial and error until the technology can be adapted to the new local context. Ultimately this is also recognised in the project's final report where it is stated that testing the technology in 'laboratory' conditions would be a better strategy than directly installing it in a context where immediate performance is expected.

Still with regard to the technology, it also appears that in Project A there was an attempt to transfer the technology for local fabrication more completely than in Project B, and this is likely to have implications on the final TT results. In Project B the technology transferred to local fabrication appears to be limited to the crossflow turbine – the turbine being the element that the local actors learned to fabricate and received licenses for. The project does not appear to fully deal with the rest of the production chain, the electro-mechanical equipment being bought/imported with the support of UNIDO while the installation appears to be subcontracted and it is unclear of it is subcontracted to local stakeholders. In Project A there appears to be more focus on transferring the technology almost fully for local fabrication, which can of course be a reflection of the fact that the recipient country is an emerging industrial and manufacturing country with abundant resources. From the start of the project there are attempts to see which components of the technology can actually be transferred for local fabrication and the manufacturer also establishing an office in the recipient country to work with local actors. Therefore, it could well be that the technology in this case was just more difficult to transfer due to it being more complex, due to the attempt to transfer more components for local fabrication and due to its reliance on a specific type of water flow, specific types of hydrology knowledge and skills etc.

Another aspect not considered in this thesis is if the type of technology transfer might have an impact on the success. In Project A the type of TT is from North to South (from a developed to a developing country) and in Project B it is from South to South (from a developing to a developing). Chen (2018, p.8) states that the general view in academia is that "developing countries catch up […] initially through exposure and familiarity". This element of familiarity could mean that South-South technology transfer has a different impact due to the more closely related economic, political, and social setting between the technology provider country and the recipient country.

6.2 Technology Transfer

In this thesis, technology transfer is viewed as the process that allows a country to acquire, adapt, deploy, localise, diffuse and innovate technologies from other countries. This is a process that takes time to fully achieve its intended results and, as with most other processes, there are a number of factors that can facilitate or hinder its success. One of the hypotheses of this study was that technology transfer is a phenomenon that was previously studied by academia or by specialised institutions and that factors that are said to influence the process have been identified. This idea being presented in hypothesis 2:

H2: *There is existing knowledge in academic and specialised literature that describes which factors to pay attention to and plan for/around when engaging in transfer of technologies from one country to another.*

While researching this thesis it was found that technology transfer is not a new topic in academia, this field having been studied for several decades. It is important to note that TT does not have a universally agreed upon definition so what is considered 'technology transfer' in academic and specialised literature often varies from author to author. For example, for some it only consists of transfer of technology in the form turnkey or product-in-hand projects, while for others it consists of also transferring the knowledge that is embodied in technology, be it explicit or tacit. There are also nuances in what is considered to fall under umbrella of 'technology transfer', this being touched upon by Mallett (2013, p.237). When discussing the concept of 'technology cooperation' she states that "generally, the literature refers to this concept [technology cooperation] as 'technology transfer' or the 'management of technological change' […]. Related to this is the notion of technology diffusion […] a process through which actors learn about a technology through various communication channels". This suggests that there are a lot of variations in the scope and angles taken when studying technology transfer. There are publications that focusing on the vertical axis of TT (e.g. studying the process of TT from R&D to the private sector), or on vertical axis (e.g. from company to company or from country to country) and especially on the channels through which TT happens. There are also variations in publications focusing on a particular type of transfer and their characteristics e.g. North-North TT, North-South TT, and more recently South-South TT.

In the context of this thesis technology transfer was viewed from the angle of it being a horizontal phenomenon, happening between countries either on a North-South or a South-South direction. This thesis also put emphasis on all dimensions of technology and how these are transferred, namely: hardware, software or know-how, know-why, and innovation system. While other publications recognise the dimensions of technology, often in the context of technology transfer the main focus is on the transfer of hardware and software, therefore omitting the important dimensions that can enable a country's ability to adopt, adapt, deploy, and further innovate technologies from other countries. The inclusion of all technology dimensions in this thesis enriches the understanding of what the process involves and what kind of results can be expected from this process.

One of the research tasks of this thesis was to identify the main factors that are said to influence the process of TT to developing countries. The aforementioned broad array of research angles and scopes of technology transfer means those factors that are said to influence the process can vary according to the particular side of the technology transfer process studied. Nevertheless, the literature review supports the hypothesis that such factors have been previously identified and studied in academic and specialised literature. In this thesis a number of these are identified and presented namely: *absorptive capacity*, *national innovation systems*, *enabling national policies*, *the technology* itself, *the local environment*, *finance and costs*. Absorptive capacity and the national innovation systems are terminologies that have been identified and adopted from existing literature. However, the rest of the terminologies used for these factors are based on the author's own coding and categorisation of similar notions. This thesis therefore produced a new synthesis of technology transfer influential factors which can be used as points of reference when starting to plan for TT.

6.2.1 Technology Transfer Factors in the Intervention Logic

A next research task was to gain a deeper understanding of if and how the intervention logic captures and plans for/around the factors that are said to influence the TT process. This is an important step toward proving or disproving the first hypothesis of this thesis, namely:

H1: *The intervention logic that forms the basis of the technology transfer strategy behind UNIDO's small hydropower projects logic omits some TT influential factors.*

In order to undertake this task, the analytical framework was constructed based on the technology transfer factors identified and synthesised from academic and specialised literature. The analytical framework takes each of these factors and boils them down to those characteristics that could determine whether the factors were included or omitted in the intervention logic and in the project plan (i.e. the criteria). This is directly linked to the fourth research task of this thesis, namely a comparison of the way technology transfer factors are currently planned for/around against lessons from academic and specialised knowledge.

The analytical framework was constructed by taking each of the factors that are said to influence the TT process and identify its main determinant criteria. The criteria were then used to build the framework and guide the investigation of the IL. The justification being that the presence of these criteria in the IL can potentially determine whether those factors have been taken into account, either intentionally or unintentionally, and generate the required information to prove or disprove the hypothesis.

The results in Tables 5-1 & 5-2, generated by using the analytical framework, suggest that all factors have been taken into consideration to some extent in both case studies. This statement is based on the observation that the author managed to identify *at least one* determinant criterion for each influential factor in the intervention logics[14]. There is a limitation to this approach as it accepts that an influential factor has been captured even if just based on a single criterion. Still, one single criterion may not be sufficient evidence that the factor as a whole was acknowledged in the project planning phase and was intentionally dealt with.

Still, the presence of the identified factors in the IL could be explained two ways. On one hand, their presence could be attributed to other parts of the project planning phase (e.g. the stakeholder analysis) that are routinely undertaken and do not necessarily directly account for TT factors but which indirectly captures them (e.g. the 'local stakeholders' and the 'local needs and circumstances' are criteria that determine the 'Local environment' TT influential factor but both of these are captured through a stakeholder analysis, a standard step usually routinely taken in project planning). On the other hand, their presence could be attributed directly to

14 E.g. for the absorptive capacity factor, the 'existing human capital' criterion was identified for both case studies in the sense that the planned actions also involved assessing the level of local skill; but the 'innovation type and potential' criterion was not identified in either of the case studies in the sense that the intervention logic did not show that this was considered by the planners. Despite the latter omission the factor was noted as 'taken into consideration'.

the knowledge accumulated by UNIDO's coordinators/consultants from previously designing projects involving the transfer of technologies. This refers to tacit knowledge/institutional memory from previous experiences that allows the planners to intuitively know which aspects to pay attention to. It does not refer to explicit, codified institutional knowledge.

By following the above observation, it could be said that the hypothesis that the intervention logic behind the two case studies omits some factors that are said to influence the technology transfer process is disproven. Nevertheless, the results did not show whether all of these factors were actually taken into consideration integrally or intentionally. The only two factors that appeared to be taken into consideration integrally were the local environment and the financing and costs aspects. The analysis of the intervention logics suggests that proving or disproving hypothesis 1 is not actually a straightforward matter. While there are clear indications that technology transfer factors have been included in the planned strategy behind the two case studies, there are several criteria pertaining to some of the factors that are completely omitted. Furthermore, it is unclear if in the planning stage of the two case studies all of these factors were intentionally and validly planned for i.e. if the UNIDO planners knew that these factors have potential to influence the technology transfer process and therefore included activities in the strategy to account for them and produce desired results. For factors such as the local environment and finance and costs there is a clearer indication that these were intentionally taken into consideration as influencers for the TT process, while this is less clear for factors such as the national innovation system or some of the national enabling policies.

With the above argumentation in mind however, it is important to note that the interpretations provided here cannot address a scenario where the project planners did actively consider all the factors but then chose to omit them in the final project design as they judged at that time (with the evidence available) that they were not relevant to the project under consideration. In this thesis the analysis of the document-based evidence identifies such omissions however, it does not rule out that the omissions were deliberate as described above.

6.2.2 Factors' Relevance & Validity

The discussion in Section 6.2. identified the factors that are said to influence the technology transfer process and discussed if the results generated by this thesis showed that these factors have been captured in the intervention logic of the two case studies. Still, there are two main issues relating to the TT factors that stem from the above discussion, which will be further discussed below, namely:

1. **The relevance of the TT factors ('Relevance')** - Considering that TT has been previously studied from many angles and scopes, would the technology factors identified in this thesis be relevant for the kind of TT attempted by UNIDO in its SHP projects?
2. **The validity of the approach ('Validity')** – Considering that each factor had at least one determinant criterion that was identified in the IL, would UNIDO's approach be perceived as valid when compared to lessons from academic and specialised knowledge?

Absorptive Capacity

Relevance: This factor entails being able to absorb external knowledge and utilise it. In the case of UNIDO's SHP project this influential factor is very relevant. From the two cases studied it emerged that UNIDO attempts to achieve complex results: the transfer a broad array of specialised knowledge alongside the actual physical movement of the technology in the recipient country. These projects require skills to undertake feasibility studies which involves socio-economic and environmental knowledge; skills to build the infrastructure required to make the SHP operational which involves engineering knowledge; skills to mount and correctly install the SHP equipment, to build the mini-grids, to connect local actors to the mini-grids etc.; skills to operate and maintain the SHP, etc. Alongside this, there is the requirement for fabrication knowledge for certain parts, innovation abilities to be able to adapt the technology to local environment and to further develop it, as well as the business acumen required to see an opportunity and want to replicate the technology at a different site. It is unlikely that a low level of absorptive capacity will be conducive for the transfer of such knowledge and therefore assessing this national capacity can determine where to start with a potential strategy.

Validity: Academic and specialised knowledge suggests that absorptive capacity can be determined by exploring a country's 'existing human capital' and the 'innovation type and potential'. The results and analysis of the IL found that for both cases the human skills were aspects that were assessed, and activities were planned in order to increase these skills. However, in Project B this aspect appears to be more thoroughly planned for as the lack of skills is seen as one of the main barriers to the project, whereas in Project A there is an alleged assessment of skills, but it is unclear if this is done properly. This suggests that there is no "universal" method used by the UNIDO to determine the human capital of a country. Furthermore, the second determinant characteristic 'innovation type and potential' does not appear to be considered at all in any of the case studies (it is unclear if this was relevant). This implies that while both cases attempted to assess the absorptive capacity this is limited to assessing the human capital, but overall it is not completely clear what these assessments entailed.

National Innovation System (NIS)

***Relevance*:** This factor encompasses the network of public and private institutions whose activities support technology acquisition, adaptation, deployment, localisation, diffusion and innovation. This is the system that can create learning opportunities, stimulate innovation, generate skills, R&D, etc. In the case of UNIDO's SHP project this influential factor is also relevant. UNIDO collaborates with both public and private institutions in their projects to facilitate the TT and enable a support system for the replication of technology.

***Validity*:** Academic and specialised knowledge suggests that a NIS is mainly composed of the national 'infrastructure system', the 'public and private education, training and research institutions' and the 'productive/business sector'. The results and analysis of the IL found that the three components of a NIS appear to be considered when designing the case studies, but it is unclear as to whether the factor was planned for intentionally i.e. demonstrating knowledge that the NIS of the recipient country can influence the TT process. First, the infrastructure system for both case studies is assessed but it is unclear what this assessment entails. Indeed, both projects set out to improve the infrastructure system with regard to energy and augment rural electrification and include a thorough assessment of this particular type of infrastructure. Still, other types of infrastructures are not necessarily considered and in Project A's case this led to a few problematic issues during project implementation. Second, the education system for the two case studies is considered with regard to identifying and actively working with institutions that can host SHP knowledge centres and provide training to increase the SHP technical knowledge. Third, those actors in the private/business sector are also identified and actively involved in the transfer of technology. This suggests that all three characteristics of a NIS are assessed and planned for, but it is unclear whether these are seen as individual components or as part of a wider system.

Enabling National Policies

Relevance: This factor encompasses a number of policies aimed at supporting transfer, innovation, education, infrastructure etc. Again, it is a factor of relevance in the two case studies. For this factor this thesis touches upon policies aimed at enabling the TT channels, the IPR regime, and sector specific policies. These are relevant as they can determine the difficulty of e.g. equipment entering the country and the level of access the country has to efficient, diverse and inexpensive technologies. This is relevant in the case of the SHP projects as not all equipment pieces can be locally fabricated and therefore there is a certain reliance on technology components import. In the same category of enabling policies also fall sector specific policies that can stimulate economic activities such as subsidies, favourable tax treatment etc. These are also of relevance for enabling the implementation of the SHP and especially for providing an incentive for potential developers to further replicate projects based on the technology. Assessing these policies can therefore offer a glimpse into strategies for further technology diffusion and replication. One set of policies where their influence on UNIDO's SHP transfer projects is unclear, are IPR policies. IPR is not brought up in any of the two cases studied, still the literature is clear that the strength of the IPR regime affects TT efforts. Indeed, these affect the channels through which the technology enters a country, such as FDI or licensing, which are both relevant for UNIDO's TT efforts.

Validity: Academic and specialised knowledge suggests that the main policies that can influence TT are aimed at 'supporting education, learning and knowledge generation', 'encouraging technology entry into the country' and 'encouraging technology uptake and diffusion, and the creation of business models based on the technology'. The results and analysis of the IL found that the national policies aimed at supporting education, etc. were not necessarily considered important to support the TT process. However, for both case studies, supporting education, learning and knowledge generation is done at a project level through the various strategies employed for capacity building. With regard to the second set of policies, the results are inconclusive regarding the extent to which these are taken into account in Project A as there are no statements to refer directly to the technology entry channel. The fact that the technology manufacturer establishes an office in the recipient country suggests that the channel is FDI but there is no consideration given to policies that can affect this or the strength of the IPR regime and how this can influence this channel. In Project B these policies appear to be assessed prior to the project start as the high costs of imported equipment is listed as one of the project barriers. The technology appears to be licensed to local manufacturers from a foreign owner but as in Project A's case, there are no further considerations of how national policies affect this channel of entry. With regard to the third characteristic it can be said that the IL showed that UNIDO puts a lot of emphasis on working with the institutions that can influence and support the financial sustainability of projects based and on working to develop business models based on the technology. In both cases UNIDO works with the government of the respective recipient countries for the extension/creation of a government incentive to support SHP, working with the relevant institutions for creating guidelines for the technology etc.

The Technology

Relevance: The characteristics of the actual technology being transferred can influence the outcome of the process and this is relevant in the case of UNIDO's TT efforts. Choosing a technology that suits the local needs and level of skills can ensure that the technology is adopted and utilised and increases the chances for replication and diffusion. Ideally the technology should be demanded, and a careful assessment of the different technological alternatives can ensure that the fittest technology is transferred. Furthermore, carefully assessing the complexity of the technology from a technical, qualitative and financial point of view can determine whether the local actors have the necessary skills to deal with the technology. This is particularly relevant in cases where enabling local fabrication of certain technology equipment is desired. A complexity assessment can ensure that the identified potential fabricators have the necessary machinery, tools and techniques necessary for producing the technology, that any potential capital investment into manufacturing equipment is accounted for, and that the quality of the manufactured part is appropriate for the role that part plays in the overall technological system.

Validity: Academic and specialised knowledge suggests that the technology itself is very important in the transfer process and that the main aspects to pay attention to are the complexity of the technology (determined by the technological, qualitative and financial complexity of the technology) and the necessary technology-related skills sets and where they can be sourced from (e.g. 'skills that can be sourced locally', 'skills that need to be sourced overseas', 'level and type of skills that need to be developed locally'). Firstly, both case studies indicate clearly that the UNIDO planners took into consideration that the SHP technology can be broken down into individual components as there is the intention of attempting local manufacturing for some of these. There are activities in both case studies to suggest that there is a strategy for assessing and planning for the components that can be manufactured locally and those than need to be imported. However, there is a certain expectation in Project A that components will be easily manufactured locally, that local fabricators will be easily identified, and they will quickly learn how to fabricate. This expectation meant that initially equipment of poor quality was manufactured, and this ended up in technical issues with the overall system which further required the replacement of expensive equipment. Furthermore, there is no indication that the capital investments that can enable local fabricators to manufacture components is specifically taken into consideration in the strategy for the two case studies, even though it is possible that such aspects were covered in the financing options for enabling replication, such as the credit lines in Project B. With regard to the skills characteristics included in this factor, it can be said that the same observations apply as described in the absorptive capacity section above. Local skills are assessed and there appears to be a more thorough assessment of skills in Project B. In both cases international experts are involved to build capacity and as a source of skills that cannot be found locally.

The Local Environment

Relevance: The local actors that can stimulate local adoption and diffusion of technology are relevant for UNIDO's TT efforts. This factor can influence if the technology is accepted and adopted locally. It is usually the local actors that are the ultimate beneficiaries of UNIDO's TT efforts and involving them in the project from the start can ensure that they understand the technology: how and why it works, what its local implementation involves, what are the different components and their complexity, etc. which will increase the chances of long-term use of the technology and potential national replication and diffusion. From the two cases studies it transpired that UNIDO does heavily involve local actors in the process of TT, with the aim often being to empower them to build business models based on the technology.

Validity: Academic and specialised knowledge suggests that the main aspect of the local environment that influence the technology transfer process are the 'local stakeholders' and the 'local needs and circumstances' of the technology. For both case studies this factor was thoroughly covered indicating that UNIDO was mindful of the factor's potential influence on the project and decided to plan in such a way that the technology fits the local needs, circumstances, socio-economic aspects, geography etc., and ensuring that the local actors take ownership for the system so as it will be continued to be operated and maintained after

UNIDO's intervention ends. Indeed, this aspect can be argued that is a given in international development aid projects where the local stakeholders are the ultimate beneficiaries of the intervention and where projects usually involve a stakeholder assessment in the planning phases. Nevertheless, it could be that the local needs are not always taken into account thoroughly in all projects and a technology that does not meet the needs and skill sets of the locals is transferred. When this happens, the sustainable operation of the system is not ensured, and it may be that the system is shut down if something is faulty rather than being repaired. A technology that is not fit for the local circumstances will also eventually diminish the potential of it being replicated and diffused at other sites throughout the recipient country.

Finance and Costs

Relevance: Having access to the financial means to support the technology transfer process is perhaps one of the most influential factors in the TT process. In UNIDO's SHP transfer projects sustainable channels of finance are necessary for the implementation of the project but also mainly for ensuring proper operation and maintenance of the SHP and for providing an incentive for replication projects. Ensuring that financing options exist, either based on credit lines or based on partnerships between actors in the private sector, can empower the local actors to adopt and adapt the technology. Another influential factor falling in this category is directly related to projects such as UNIDO's SHP transfer, where the technology transferred also provides the service of electricity and relates to the costs of electricity. More often than not, small hydropower-based projects are community-owned rather than enterprise-based, with the houses connected to the mini-grid paying for the electricity service, including for the operation and maintenance of the SHP. Not being able to afford the cost of the electricity can mean that the local community decides to decommission the SHP due to insufficient funds for the operation, maintenance and/or repair.

Validity: Academic and specialised knowledge suggests that 'access to finance' and the 'the ability of users to pay for the service' are the main aspects that can influence the technology transfer process. As with the local environment, for both case studies this factor appears to be covered in the planning stage to ensure firstly, that the pilot/demonstration sites had the required funding to be implemented, that there are financing options and incentives available for replication. Also, in both cases steps were considered to ensure that the local actors can pay for the electricity service provided by the technology and to generate revenue to pay for operation and maintenance and technical optimisation of the system. However, this was not possible for all sites in Project B, suggesting that further attention needs to be paid to this aspect.

7 Conclusion

This thesis set out the investigate how technology transfer factors are captured in the intervention logic behind two small hydropower projects undertaken by UNIDO with the purpose of improving the understanding of whether this is an area where more attention needs to be given in order to improve the results of such projects. In this section the conclusions to this research are drawn by answering the three research questions and introducing recommendations for future project design and further research.

7.1 The Research Questions

Research Question (1): What are the factors that are said to influence technology transfer to developing countries?

While the field of technology transfer is broad and encompasses multiple research angles and scopes, a number of factors that may influence the TT process have been identified through a thorough literature review: absorptive capacity, national innovation system, enabling national policies, the technology, the local environment and finance and costs. Absorptive capacity and the national innovation systems are both factors that feature heavily in academic and specialised knowledge as the most influential aspects of technology transfer. Countries with low levels of absorptive capacities and a weak national innovation system will struggle to absorb and diffuse a highly complex, advanced technology, but they could have the incremental and adaptive innovation capabilities to transfer cheaper and easier to use technologies.

With regard to the other factors, their terminologies were based on the author's own coding and categorisation of similar notions. The enabling national policies are those policies that can influence TT from a number of perspectives: policies aimed at education that can boost/hinder the level of absorptive capacity of a country; policies aimed at strengthening the NIS; the policies aimed at facilitating the technology entry into the country; and policies aimed at supporting projects that are based on the technology from a financial perspective. The technology itself also influences the process due to its complexity: highly complex technologies will be more difficult to transfer; and due to its components: when a technology can be broken down into components then these can be sources from different suppliers - for the recipient country this also means that they can determine which parts can be manufactured domestically based on the existing national capabilities and which parts need to be imported. The local environment and especially the local actors that can stimulate the transfer process: this factor can influence if the technology is demanded, accepted and adopted locally. Finally, technology transfer would not be possible without access to predictable, sustainable channels of finance.

Research Question (2): How are these factors captured and planned for/around in UNIDO's SHP project intervention logic?

The results can be interpreted to suggest that UNIDO's current approach to technology transfer does capture all technology transfer influential factors – this being based on the observation that it captures *at least one* determinant criteria (as defined in the analytical framework) for each factor. However, this interpretation did not elucidate if the team of project planners actually actively *acknowledged the influence* of *all* factors on the results of the projects, and/or if project activities were *specifically planned* to account for the influence of *all* factors. This meaning that the identified presence of at least one determinant criteria for each factor may be attributed to other planned project activities which happened to also apply to technology transfer. For example, it is often the case that at the pre-planning stage of every potential new project, a thorough stakeholder analysis is routinely undertaken. Such an analysis is likely to account for the influence of the local actors on the results of the project and project activities are planned to account for this influence – this consequently also accounting for the influence of 'local environment' factor on the technology transfer process. Nevertheless, a limitation this results interpretation is that it does not cater to the scenario where the project planners did actively consider all the factors but omitted them in the final project design because they decided that some were actually irrelevant to the project at hand. In this thesis the analysis of the document-based evidence identifies such omissions however, it does not rule out that the omissions were deliberate as described above.

In this thesis an influential factor was considered to be captured and planned for 'integrally' if there was evidence to suggest that all its determinant criteria were accounted for in the reconstructed intervention logic. If a factor was found to be captured integrally it suggested that, when compared with lessons from academic and specialised knowledge, the UNIDO approach with regard to that factor is valid.

In that regard, this thesis found indications in the intervention logic to suggest that the project planners deliberately accounted for the potential influence of *some* factors integrally such as the 'local environment', 'financing and costs" for both case studies. To some extent it also found that there was planned work to mitigate the influence of the pre-existing 'absorption capacity' on the results of the project; though not all aspects of absorption capacity were considered. As for the other factors, the results were less clear on whether their influence was integrally accounted for. An example of this would be the national enabling policies: there is evidence to suggest that sector-specific policies that stimulate economic activity were targeted as influential on success of the technology transfer process, however less evidence that other influential policies such as the policies that could facilitate the technology entry into the country were considered.

Therefore, the results showed that – when compared to lessons from academic and specialised knowledge - UNIDO's approach to technology transfer was valid in some regards and less so in others.

Research Question (3): How does UNIDO's current SHP project intervention logic perform when compared to the technology transfer factors identified in academic and specialised knowledge?

The purpose of this study was not to evaluate the SHP projects as a whole but to examine those elements of the projects pertaining to TT. First, it is imperative to remind that in this thesis the intervention logic for the two case studies was 'reconstructed' because the two studied case studies did not have an intervention logic to begin with, at least not in the form of a visual representation of the principles in which the project was based.

The reconstructed IL for both case studies showed a number of strengths and weaknesses in their respective approaches, when compared to the factors identified in academic and specialised literature. An important strength is that - based on the determinant criteria - all influential TT factors appear to have either integrally or partially been accounted for in the design of the case studies. A weakness is that there was little evidence in the project documentation to suggest that at the planning stage of the projects, all the factors that are said to influence the process of TT have been *systematically identified, considered and planned for* by the planners and that a strategy was then devised around these.

Ultimately the analysis showed the presence of certain characteristics pertaining to the technology transfer influential factors in the projects' intervention logic and this serves as evidence that the current approach does draw 'inspiration' from technology transfer scientific knowledge. However, there was not enough evidence to suggest that this 'inspiration' is fully based on recent academic and specialised knowledge on technology transfer and that the current planning approach is based on a systematic, step by step, scientifically-informed technology transfer plan (e.g. in the form of an internal 'technology transfer guideline' or similar document/manual/framework that can be used to inform technology transfer planning). This interpretation cannot rule out the pre-existence of a UNIDO technology transfer plan – indeed a technology transfer framework has been identified in a UNIDO document dated 1999 and UNIDO does undertake regular research on its technology transfer activities. However, this study was limited with regard to obtaining certainty on whether such a plan was used in designing the two case studies. The implications of not using such a plan is that there is potential that some of UNIDO's projects that involve the transfer technologies may be designed based on the previous experiences and tacit knowledge accumulated by the responsible staff. Thus, the technology transfer aspects of each project might include an element of ad-hoc planning, with the quality of the plan being determined by the experience, skill level, and diligence of the persons that designed the project.

7.2 Contributions

This study highlighted the planned strategies employed by UNIDO in projects based on SHP TT by reconstructing the intervention logic of two case studies. This tool provided a useful glimpse into UNIDO' SHP technology transfer activities, how they were planned, what they intended to achieve, etc. Based on the intervention logic, this study further tested the validity of UNIDO's technology transfer activities against technology transfer principles from academic and specialised knowledge. The results generated by this investigation contributed with further understanding of existing TT strategies, the strengths in the current approaches, and the weaknesses and areas where further improvement ins necessary to maximise technology transfer in future projects. Apart from these, this study also had two main contributions extending beyond the two case studies, namely: a new synthesis of technology transfer influential factors and a technology transfer analytical framework.

New Synthesis

One important contribution is a recent synthesis of literature on what the author introduced as "technology transfer influential factors". These are the factors that are said to influence the process of technology transfer to developing countries and the synthesis brings together the ones most prevalently found in academic and specialised literature and highlights why and how they influence the TT process. Despite SHP being the exemplary technology in this study, the six identified factors (*absorptive capacity*, *national innovation systems*, *enabling national policies*, *the technology* itself, *the local environment*, *finance and costs)* relate to technology transfer in general and are not characteristic to a particular technology. Therefore, this synthesis can be consulted as a point of reference when planning for any horizontal (between countries) technology transfer project, be it by UNIDO, other international development organisations, or other actors involved in the process of technology transfer.

The Analytical Framework

A second contribution is the analytical framework constructed as part of this study to guide the investigation of if and how the technology transfer factors were accounted for in the ILs of the case studies. This framework contains all six influential factors, together with their main possible determinant criteria, and is not technology-specific and therefore can be applied to other technologies besides SHP. This framework can be used as an evaluation tool for other projects encompassing technology transfer in order to assess how the technology transfer aspects were planned for, determine potential gaps in existing strategies, and generate lessons for future project design. As with the aforementioned synthesis, this tool can be used by UNIDO, as well as other organisations wishing to evaluate their technology transfer efforts.

Furthermore, the framework can be modified from an evaluation tool to a planning tools and serve as a "starting point" for technology transfer planning. It can be used by international aid organisations or it could also be directed at multinational organisations operating in the field of engineering, construction, finance etc. that undertake technology transfer operations.

7.3 Recommendations

Two sets of recommendations that could improve the effectiveness of UNIDO's technology transfer projects are suggested:

Codify Knowledge

While, this study cannot rule out the pre-existence of a UNIDO manual/ document/framework that can be used to inform technology transfer planning, it is held that such would be of value. Hence, a recommendation is to ensure that one such document indeed exists and is up to date with the most recent review of literature on the topic of technology transfer and the influential factors. UNIDO has been facilitating technology transfer for a number of decades and therefore tacit knowledge on the topic is bound to already existing among UNIDO staff, as well as internal and external reports or other forms of institutional memory that tackle the issue in one way or another. The evidence gathered in this study thus supports a position that UNIDO will benefit if it were to gather all this knowledge, including the knowledge generated by this thesis, and codify it in a 'technology transfer checklist' or similar document that can then be used internally as point of reference when starting to plan for the technology transfer elements of a project. Such a checklist could explain, for example, what each of the technology transfer influential factors are, how they should be documented in a project proposal and how they may be planned for. The checklist could be an UNIDO internal tool used at project design stage to verify what technology transfer influential factors have been accounted for in the plan. This checklist could therefore allow for a more standard planning approach to technology transfer across UNIDO projects.

While, this study cannot rule out the pre-existence of a UNIDO manual/ document/framework that can be used to inform technology transfer planning, it is held that such would be of value. Hence, a recommendation is to ensure that one such document indeed exists and is up to date with the most recent review of literature on the topic of technology transfer and the influential factors. UNIDO has been facilitating technology transfer for a number of decades and therefore tacit knowledge on the topic is bound to already existing among UNIDO staff, as well as internal and external reports or other forms of institutional memory that tackle the issue in one way or another. The evidence gathered in this study thus supports a position that UNIDO will benefit if it were to gather all this knowledge, including the knowledge generated by this thesis, and codify it in a 'technology transfer checklist' or similar document that can then be used internally as point of reference when starting to plan for the technology transfer elements of a project. Such a checklist could explain, for example, what each of the technology transfer influential factors are, how they should be documented in a project proposal and how they may be planned for. The checklist could be an UNIDO internal tool used at project design stage to verify what technology transfer influential factors have been accounted for in the plan. This checklist could therefore allow for a more standard planning approach to technology transfer across UNIDO projects.

A 'technology transfer analysis' step in the pre-planning phase of a potential new project could be undertaken by using the checklist to allow for technology transfer to be accurately planned for in the subsequent project design phase. Planning for technology transfer relies partly on the assessment of the characteristics of the technology recipient country in order to understand the national situation so as to know potential barriers and solutions. Therefore, undertaking a 'technology transfer analysis' during the pre-planning phase can ensure that the national situation and the country's ability to absorb the technology is understood from the start. Such an analysis could also be linked with other pre-planning activities such as the analyses of the problem, stakeholders, objectives and options, in order to have a more synergistic approach.

A further recommendation is that the codified handbook should provide ample attention to all technology transfer influential factors and step-by-step guidelines could be developed to guide the assessment of these. The following remarks about several factors could serve as starting points:

- Absorptive capacity: a thorough assessment of this factor should include both the human capital and the innovation potential. Assessing these through looking at e.g. the number of technology patents, the state of the technological infrastructure, the country's literacy rate can help determine if the local stakeholders have the minimal amount of knowledge and mastery of previous technologies necessary to absorb the new technology.
- National Innovation System: an analysis of the national innovation system as a whole (the education and research system, the productive sector, the framework conditions, the infrastructure system) can identify those national-level aspects that have an impact on e.g. the ability of firms to learn, the quality of infrastructures and institutions, etc. Assessing the NIS could also potentially identify those components of the system that fail in supporting technology transfer and the resulting policy intervention areas.
- Enabling policies (1): an assessment of policies aimed at supporting education, learning and knowledge generation, including the country's literacy rate, mean years of schooling and tertiary science and engineering enrolment could be a determinant of the available national human capital. The existence of such policies could determine the recipient country's level of emphasis on the development of human skill that could eventually support the technology transfer.
- Enabling policies (2): an assessment of policies aimed at encouraging technology entry into the country can determine certain barriers that can be encountered with regard to FDI, licensing etc. This includes IPR policies which can hinder or facilitate technology entry into a country.
- Enabling policies (3): an assessment of the policies aimed at encouraging technology uptake and diffusion can determine the areas where UNIDO could intervene to provide policy guidance; that could lead to the later formulation of policies that can maximise TT.
- The technology: an assessment of the complexity of the technology from a technical, quality and financial complexity can facilitate the process of transferring the technology for local manufacturing as it identifies the manufacturing processes and techniques necessary for producing the technology, the quality requirement for each manufactured component and whether the reliability of the component in the overall system is important, and the potential capital investment into expensive manufacturing equipment and machinery and the risk of investment into production facilities for specific components.
- The Local Environment: this could be combined with the stakeholder analysis phase. It should include an assessment of local needs and an analysis of whether the technology meets their requirements or if there are alternative technologies that are better fitted.
- Finance and Costs: this could be combined with the financial options assessment. It is vital to also include an analysis of the costs of the technology, and when the technology also provides a service such as electricity, an analysis of whether the users are able to pay for it.

Design projects with an Intervention Logic as a starting point

A further recommendation is that UNIDO should develop their future technology transfer projects based on an intervention logic generated from the start of the project. In this thesis the intervention logic was reconstructed for the two case studies, however as discussed in Section 6.1. this implied limitations. Such limitations might be avoided if the intervention logic is built at the beginning of the project as: 1) it will capture the *what, how* and *why* of a project as they were thought out from the start and 2) it will allow for a more a precise appraisal and evaluation of the project or programme, which in turn will generate more effective lessons of what works and why that can be adopted in future project design.

Building a project based on an intervention logic from the start highlights the principles on which a project is based, including the desired long-term results, what conditions should be in place for these results to occur and the causal links between project components. This is especially relevant in the case of projects involving technology transfer. Documenting the underlying project assumptions about how technology transfer is intended to be achieved in a project can: 1) ensure that all TT influential factors are accounted for in the project design and 2) generate knowledge that can be codified on what works and why when transferring technology to developing countries. This could allow for a more effective future project design.

7.4 Further Research

First, further research should be done on the analytical framework, more specifically a sensitivity analysis of the technology transfer influential factors. Such an analysis could determine the importance of each of these factors and the magnitude of its effects on the ultimate technology transfer results. This analysis could be used to test scenarios such as one factor not being taken into consideration in project planning and how this impacted project results. Further, this study was developed on the hypothesis that the reason why technology was not always successfully transferred in the case of the SHP projects is the possibility that the projects were designed in a way that unintentionally failed to assess and plan for the main factors that could influence the results of the technology transfer element. Further research could determine the real-world impact of applying the lessons generated by this study on future project results and on the success of UNIDO's future technology transfer efforts.

Second, one of the recommendations of this study is to codify the knowledge and observations generated by this thesis as a starting point for the creation of an internal checklist to guide future technology transfer strategies. Further research can be done to also gather and codify the knowledge encapsulated in UNIDO's 'institutional memory' on what, how, and why certain strategies worked, and why some have not, in completed technology transfer projects so far. This may result in providing a blueprint to realistic technology transfer strategies.

Bibliography

Abhishek, K. (2018, June). *Evaluation of UNIDO's Assistance in Small Hydro Projects*. Presented at UNIDO Headquarters, Vienna.

Andonova, E. (2017). Technology Transfer and Intellectual Property Rights (IPRs). European Commission, DG Joint Research Centre presented at the Thessaloniki. Retrieved from https://ec.europa.eu/jrc/sites/jrcsh/files/2017052324-thessaloniki-andonova-en.pdf

Archibugi, D., & Coco, A. (2004). A New Indicator of Technological Capabilities for Developed and Developing Countries (ArCo). *World Development*, *32*(4), 629–654. https://doi.org/10.1016/j.worlddev.2003.10.008

Arnold, E., & Bell, M. (2001). *Some New Ideas About Research for Development*. Retrieved from Technology Policy Research, UK website: https://www.researchgate.net/publication/267956469_Some_New_Ideas_About_Research_for_Development

Badcock, J., & Lenzen, M. (2010). Subsidies for electricity-generating technologies: A review. *Energy Policy*, *38*(9), 5038–5047. https://doi.org/10.1016/j.enpol.2010.04.031

Belcher, B., & Palenberg, M. (2018). Outcomes and Impacts of Development Interventions: Toward Conceptual Clarity. *American Journal of Evaluation*, *39*(4), 478–495. https://doi.org/10.1177/1098214018765698

Bell, M. (1990). *Continuing industrialization, climate change and international technology transfer*. University of Sussex, Brighton: Resource Policy Group and Science Policy Research Unit.

Bhattacharyya, S. C. (2012). Energy access programmes and sustainable development: A critical review and analysis. *Energy for Sustainable Development*, *16*(3), 260–271. https://doi.org/10.1016/j.esd.2012.05.002

Blohmke, J. (2014). Technology complexity, technology transfer mechanisms and sustainable development. *Energy for Sustainable Development*, *23*, 237–246. https://doi.org/10.1016/j.esd.2014.09.003

Blomstrom, M., & Kokko, A. (1997). *How foreign investment affects host countries*. Washington, DC.

Bowen, G. A. (2009). Document Analysis as a Qualitative Research Method. *Qualitative Research Journal*, *9*(2), 27–40. https://doi.org/10.3316/QRJ0902027

Brewer, T. L. (2008). Climate change technology transfer: A new paradigm and policy agenda. *Climate Policy*, *8*(5), 516–526. https://doi.org/10.3763/cpol.2007.0451

Brousselle, A., & Champagne, F. (2011). Program theory evaluation: Logic analysis. *Evaluation and Program Planning*, *34*(1), 69–78. https://doi.org/10.1016/j.evalprogplan.2010.04.001

Business Dictionary. (n.d.). What are intellectual property rights? Definition and meaning. Retrieved 17 June 2019, from BusinessDictionary.com website: http://www.businessdictionary.com/definition/intellectual-property-rights.html

Cambridge Dictionary. (n.d.). TACIT KNOWLEDGE | meaning in the Cambridge English Dictionary. Retrieved 15 May 2019, from https://dictionary.cambridge.org/dictionary/english/tacit-knowledge

CDC. (n.d.). *Identifying the Components of a Logic Model*. Retrieved from https://www.cdc.gov/std/Program/pupestd/Components%20of%20a%20Logic%20Model.pdf

Chen, J. (n.d.). Foreign Direct Investment (FDI). Retrieved 12 May 2019, from Investopedia website: https://www.investopedia.com/terms/f/fdi.asp

Chen, Y. (2018). Comparing North-South technology transfer and South-South technology transfer: The technology transfer impact of Ethiopian Wind Farms. *Energy Policy*, *116*, 1–9. https://doi.org/10.1016/j.enpol.2017.12.051

Cherni, J. A., Dyner, I., Henao, F., Jaramillo, P., Smith, R., & Font, R. O. (2007). Energy supply for sustainable rural livelihoods. A multi-criteria decision-support system. *Energy Policy*, *35*(3), 1493–1504. https://doi.org/10.1016/j.enpol.2006.03.026

Chmiliar, L. (2010). Multiple-Case Designs. In A. J. Mills, G. Durepos, & E. Wiebe (Eds.), *Encyclopedia of Case Study Research* (pp. 583–584). https://doi.org/10.4135/9781412957397

Cohen, W. M., & Levinthal, D. A. (1990). Absorptive Capacity: A New Perspective on Learning and Innovation. *Administrative Science Quarterly*, *35*(1), 128–152. https://doi.org/10.2307/2393553

Coryn, C., A Noakes, L., Westine, C., & Schroeter, D. (2011). A Systematic Review of Theory-Driven Evaluation Practice From 1990 to 2009. *American Journal of Evaluation*, *32*. https://doi.org/10.1177/1098214010389321

Costantini, V., & Liberati, P. (2014). Technology transfer, institutions and development. *Technological Forecasting and Social Change*, *88*, 26–48. https://doi.org/10.1016/j.techfore.2014.06.014

CTCN. (2014). What we do. Retrieved 28 May 2019, from Climate Technology Centre & Network website: https://www.ctc-n.org/about-ctcn/what-we-do

Dinakar, R. (2011). *International Technology Transfers and the Role of Governments: A Study on Japanese Official Development Assistance to the Railway Sector in India* (University of Tsukuba). Retrieved from https://www.academia.edu/1371869/International_Technology_Transfers_and_the_Role_of_Governments_A_Study_on_Japanese_Official_Development_Assistance_to_the_Railway_Sector_in_India

Dobrov, G. M. (1979). The Strategy for Organized Technology in the Light of Hard-, Soft-, and Org-ware Interaction. *Long Range Planning*, *12*(2), 79–90.

Dodani, S., & LaPorte, R. E. (2005). Brain drain from developing countries: How can brain drain be converted into wisdom gain? *Journal of the Royal Society of Medicine*, *98*(11), 487–491.

European Commission. (n.d.). *Climate Technology Transfer*. Retrieved from https://ec.europa.eu/clima/sites/clima/files/docs/climate_technology_transfer_en.pdf

Falvey, R., & Foster, N. (2006). *The Role of Intellectual Property Rights in Technology Transfer and Economic Growth: Theory and Evidence* [Working Paper]. Retrieved from United Nations Industrial Development Organization website: https://www.unido.org/sites/default/files/2009-04/Role_of_intellectual_property_rights_in_technology_transfer_and_economic_growth_0.pdf

Gallagher, K. S. (2015). What makes technological transfer successful? *Climate Policy*, *15*(1), 180–182. https://doi.org/10.1080/14693062.2014.848139

Gallagher, K. S., & Zhang, F. (2013). *Climate Technology & Development Case study: Innovation and Technology Transfer Across Global Value Chains: Evidence from China's PV Industry*. Retrieved from Climate & Development Knowledge Network website: https://sites.tufts.edu/cierp/files/2018/02/Climate-Technology-and-Development-Case-Kelly-Sims-Gallagher.pdf

Gandenberger, C., Bodenheimer, M., Schleich, J., Orzanna, R., & Macht, L. (2015). Factors driving international technology transfer: Empirical insights from a CDM project survey. *Climate Policy*. https://doi.org/10.1080/14693062.2015.1069176

GEF. (2008). *Elaboration of a Strategic Program to Scale Up the Level of Investment in the Transfer of Environmentally Sound Technologies*. Retrieved from Global Environment Facility website: https://unfccc.int/resource/docs/2008/sbi/eng/16.pdf

GEF. (2016). About Us. Retrieved 14 May 2019, from Global Environment Facility website: http://www.thegef.org/about-us

GEF. (n.d.). Poznan Strategic Program. Retrieved 14 May 2019, from Global Environment Facility website: https://www.thegef.org/content/poznan-strategic-program

Gerring, J. (2004). What Is a Case Study and What Is It Good for? *American Political Science Review*, *98*(2), 341–354. https://doi.org/10.1017/S0003055404001182

Golini, R., Corti, B., & Landoni, P. (2017). More efficient project execution and evaluation with logical framework and project cycle management: Evidence from international development projects. *Impact Assessment and Project Appraisal*, *35*(2), 128–138. https://doi.org/10.1080/14615517.2016.1239495

Hoekman, B. M., Maskus, K. E., & Saggi, K. (2005). Transfer of technology to developing countries: Unilateral and multilateral policy options. *World Development*, *33*(10), 1587–1602. https://doi.org/10.1016/j.worlddev.2005.05.005

Hoffman, K., & Girvan, N. (1990). Managing international technology transfer: A strategic approach for developing countries. *The International Development Research Centre*. Retrieved from https://idl-bnc-idrc.dspacedirect.org/handle/10625/5934

HPNET. (2019, June). *Mini-grid Financing: Enabling the Role of Local Banks*. Presented at the Hydro Empowerment Network (HPNET), Webinar.

IGI Global. (n.d.). What are Technology Spillovers | IGI Global. Retrieved 14 June 2019, from IGI Global website: https://www.igi-global.com/dictionary/technology-spillovers/48092

IIASA. (2013). What is Technology? - IIASA. Retrieved 6 May 2019, from International Institute for Applied Systems Analysis website: http://www.iiasa.ac.at/web/home/research/researchPrograms/TransitionstoNewTechnologies/What-is-Technology.en.html

Ingvarsson, M. (2013). *North-South and South-South Technology Transfer – A Conceptual Framework. Working Paper—02/2013*. Retrieved from UNIDO website: https://www.unido.org/sites/default/files/2013-11/UNIDO-ICAMT_A_conceptual_framework_for_technologytransfer_Final_AI_0.pdf

IPCC. (2000). *Methodological and Technological Issues in Technology Transfer*. Retrieved from https://books.google.se/books?hl=ro&lr=&id=hs9Dp0DFA_MC&oi=fnd&pg=PP11&ots=7pndG1WeQz&sig=cS3KYT2wWHGF3spKPbDJphl8Lhk&redir_esc=y#v=onepage&q&f=false

Junaid Zaidi, S. M., & Naeem, T. (n.d.). *Financing Technology Transfer & Development*. Retrieved from COMSATS Institute of Information Technology website: http://www.sciencevision.org.pk/BackIssues/Vol7/Vol7No1-2/Vol7No1&2_6_Financing_Technology_Transfer_SMJunaid.pdf

Kaplinsky, R., Chataway, J., Hanlin, R., Clark, N., Kale, D., Muraguri, L., … Wamae, W. (2009). Below the radar: What does innovation in emerging economies have to offer other low-income economies? *International Journal of Technology Management & Sustainable Development*, *8*. https://doi.org/10.1386/ijtm.8.3.177/1

Kim, L. (2003). *Technology Transfer & Intellectual Property Rights | The Korean Experience*. Retrieved from United Nations Conference on Trade and Development website: https://unctad.org/en/PublicationsLibrary/ictsd2003ipd2_en.pdf

Kirchherr, J., & Matthews, N. (2018). Technology transfer in the hydropower industry: An analysis of Chinese dam developers' undertakings in Europe and Latin America. *Energy Policy*, *113*, 546–558.

Klintenberg, P., Wallin, F., & Azimoh, L. C. (2014). Successful technology transfer: What does it take? *Applied Energy*, *130*, 807–813. https://doi.org/10.1016/j.apenergy.2014.01.087

Kovič, M. (2010). Investigating technology transfer projects and institutional development in developing countries. *Management of Environmental Quality: An International Journal*, *21*(6), 761–772. https://doi.org/10.1108/14777831011077628

Landoni, P., & Corti, B. (2011). The management of international development projects: Moving toward a standard approach or differentiation? *Project Management Journal*, *42*(3), 45–61. https://doi.org/10.1002/pmj.20231

Lawton, B., Brandon, P. R., Cicchinelli, L., & Kekahio, W. (2014). *Logic Models: A Tool for Designing and Monitoring Program Evaluations. REL 2014-007*. Retrieved from https://eric.ed.gov/?id=ED544752

Lema, A., & Lema, R. (2013). Technology transfer in the clean development mechanism: Insights from wind power. *Global Environmental Change*, *23*(1), 301–313. https://doi.org/10.1016/j.gloenvcha.2012.10.010

Lema, R., Iizuka, M., & Walz, R. (2015). Introduction to low-carbon innovation and development: Insights and future challenges for research. *Innovation and Development*, *5*(2), 173–187. https://doi.org/10.1080/2157930X.2015.1065096

Lema, R., & Lema, A. (2012). Technology transfer? The rise of China and India in green technology sectors. *Innovation and Development*, *2*(1), 23–44. https://doi.org/10.1080/2157930X.2012.667206

Lewis, J. I. (2011). Building a national wind turbine industry: Experiences from China, India and South Korea. *International Journal of Technology and Globalisation*, *5*(3/4), 281. https://doi.org/10.1504/IJTG.2011.039768

Liu, H. (2017, May). *UNIDO and Small Hydropower Development*. Presented at the Vienna Energy Forum. Retrieved from https://www.viennaenergyforum.org/sites/default/files/documents/UNIDO%20and%20Small%20Hydropower%20Devlopment_0.pdf

Loock, M. (2012). Going beyond best technology and lowest price: On renewable energy investors' preference for service-driven business models. *Energy Policy*, *40*, 21–27. https://doi.org/10.1016/j.enpol.2010.06.059

Mallett, A. (2013). Technology cooperation for sustainable energy: A review of pathways. *Wiley Interdisciplinary Reviews: Energy and Environment*, *2*(2), 234–250. https://doi.org/10.1002/wene.54

Maskus, K. E., & Yang, L. (2013). *The Impact of Post-TRIPS Patent Reforms on the Structure of Exports*. The Research Institute of Economy, Trade and Industry.

Mrad, F. (2017). The Effects of Intellectual Property Rights Protection in the Technology Transfer Context on Economic Growth: The Case of Developing Countries. *Journal of Innovation Economics & Management*, *23*(2), 33–57.

Murovec, N., & Prodan, I. (2009). Absorptive capacity, its determinants, and influence on innovation output: Cross-cultural validation of the structural model. *Technovation*, *29*(12), 859–872. https://doi.org/10.1016/j.technovation.2009.05.010

Murphy, K., Kirkman, G. A., Seres, S., & Haites, E. (2015). Technology transfer in the CDM: An updated analysis. *Climate Policy*, *15*(1), 127–145. https://doi.org/10.1080/14693062.2013.812719

Norasingh, X., Machikita, T., & Ueki, Y. (2015). South-South technology transfer to Laos through face-to-face contacts. *Journal of Business Research*, *68*(7), 1420–1425. https://doi.org/10.1016/j.jbusres.2015.01.025

Ockwell, D., & Byrne, R. (2015). Improving Technology Transfer Through National Systems of Innovation: Climate Relevant Innovation-System Builders (CRIBs). *Climate Policy*, *16*(7), 836–854. https://doi.org/10.1080/14693062.2015.1052958

OECD. (2011). *Towards Green Growth*. Retrieved from https://millenniumindicators.un.org/unsd/envAccounting/ceea/meetings/UNCEEA-6-11.pdf

OECD. (n.d.-a). International trade—Trade in goods and services—OECD Data. Retrieved 12 May 2019, from Organisation for Economic Co-operation and Development website: http://data.oecd.org/trade/trade-in-goods-and-services.htm

OECD. (n.d.-b). Official development assistance (ODA)—Net ODA - OECD Data. Retrieved 14 June 2019, from The OECD website: http://data.oecd.org/oda/net-oda.htm

Omar, R., Takim, R., & Nawawi, A. H. (2011). *The Concept of Absorptive Capacity in Technology Transfer (TT) Projects*. Presented at the 2011 International Conference on Intelligent Building and Management, Singapore. Retrieved from https://pdfs.semanticscholar.org/8805/433abfa45ec975d2d6a10ca9d612b8e1441f.pdf

Oxford Dictionaries. (n.d.). Technology | Definition of technology in English by Oxford Dictionaries. Retrieved 6 May 2019, from Oxford Dictionaries | English website: https://en.oxforddictionaries.com/definition/technology

Pachauri, S., Brew-Hammond, A., Barnes, D. F., Bouille, D. H., Gitonga, S., Modi, V., … Zerriffi, H. (2012). Energy Access for Development. In J. Sathaye (Ed.), *Global Energy Assessment: Toward a Sustainable Future.* (pp. 1401–1458). Retrieved from http://pure.iiasa.ac.at/id/eprint/10069/

Powell, R. R. (2006). Evaluation Research: An Overview. *Library Trends*, *55*(1), 102–120.

Pueyo, A. (2013). Enabling frameworks for low-carbon technology transfer to small emerging economies: Analysis of ten case studies in Chile. *Energy Policy*, *53*, 370–380. https://doi.org/10.1016/j.enpol.2012.10.078

Putranto, K., Stewart, D., & Moore, G. (2003). International technology transfer and distribution of technology capabilities: The case of railway development in Indonesia. *Technology in Society*, *1*(25), 43–53.

Rey, L., Brousselle, A., & Dedobbeleer, N. (2011). Logic Analysis: Testing Program Theory to Better Evaluate Complex Interventions. *The Canadian Journal of Program Evaluation = La Revue Canadienne d'evaluation de Programme*, *26*(3), 61–89.

Rogers, P. J. (2008). Using Programme Theory to Evaluate Complicated and Complex Aspects of Interventions. *Sage Publications*, *14*(1), 29–48.

Saad, M. (2000). *Development through Technology Transfer: Creating New Cultural Understanding*. Retrieved from https://epdf.tips/development-through-technology-transfer-creating-new-cultural-understanding.html

Saad, M., Cicmil, S., & Greenwood, M. (2002). Technology transfer projects in developing countries—Furthering the Project Management perspectives. *International Journal of Project Management*, *20*(8), 617–625. https://doi.org/10.1016/S0263-7863(02)00024-8

Schillebeeckx, S. J. D., Parikh, P., Bansal, R., & George, G. (2012). An integrated framework for rural electrification: Adopting a user-centric approach to business model development. *Energy Policy*, *48*, 687–697. https://doi.org/10.1016/j.enpol.2012.05.078

Schneider, M., Holzer, A., & Hoffmann, V. H. (2008). Understanding the CDM's contribution to technology transfer. *Energy Policy*, *36*(8), 2930–2938. https://doi.org/10.1016/j.enpol.2008.04.009

Sharpe, G. (2011). A Review of Program Theory and Theory-Based Evaluations. *American International Journal of Contemporary Research*, *1*(3). Retrieved from http://aijcrnet.com/journals/Vol_1_No_3_November_2011/10.pdf

Takim, R., Omar, R., & Nawawi, A. H. (2008). International Technology Transfer (ITT) Projects and Development of Technological Capabilities in Malaysian Construction Industry: A Conceptual Framework. *Asian Social Science*, *4*(8), p38-46. https://doi.org/10.5539/ass.v4n8p38

Tremblay, M.-C., Brousselle, A., Richard, L., & Beaudet, N. (2013). Defining, illustrating and reflecting on logic analysis with an example from a professional development program. *Evaluation and Program Planning*, *40*, 64–73. https://doi.org/10.1016/j.evalprogplan.2013.05.004

UN. (n.d.-a). Energy access and main challenges in the LDCs | Support Measures Portal for Least Developed Countries. Retrieved 11 June 2019, from United Nations website: https://www.un.org/ldcportal/energy-access-and-main-challenges-in-the-ldcs/

UN. (n.d.-b). Goal 13: Take urgent action to combat climate change and its impacts. Retrieved 14 May 2019, from United Nations Sustainable Development Goals website: https://www.un.org/sustainabledevelopment/climate-change-2/

UN. (n.d.-c). SDG: Sustainable Development Knowledge Platform. Retrieved 11 June 2019, from Sustainable Development Goals website: https://sustainabledevelopment.un.org/sdgs

UNCTAD. (2014). *Transfer of Technology and Knowledge Sharing for Development - Science, technology and innovation issues for developing countries* (p. 71). Retrieved from United Nations Conference on Trade and Development website: https://unctad.org/en/PublicationsLibrary/dtlstict2013d8_en.pdf

UNCTAD Virtual Institute. (2012). *Virtual Institute Teaching Material on Transfer of Technology*. New York and Geneva: United Nations.

UNDESA. (n.d.). *Climate Change: Technology Development and Technology Transfer*. Retrieved from United Nations Department of Economic and Social Affairs website: https://sustainabledevelopment.un.org/content/documents/tec_technology_dev.pdf

UNFCCC. (1992). *United Nations Framework Convention on Climate Change*. Retrieved from https://unfccc.int/files/essential_background/background_publications_htmlpdf/application/pdf/conveng.pdf

UNFCCC. (n.d.-a). Action on Climate and SDGs | UNFCCC. Retrieved 11 June 2019, from United Nations Framework Convention on Climate Change website: https://unfccc.int/action-on-climate-and-sdgs

UNFCCC. (n.d.-b). Technology Mechanism. Retrieved 14 May 2019, from United Nations Framework Convention on Climate Change website: https://unfccc.int/ttclear/support/technology-mechanism.html

UNFCCC. (n.d.-c). Technology Needs Assessment. Retrieved 14 May 2019, from United Nations Framework Convention on Climate Change website: https://unfccc.int/ttclear/tna

UNFCCC. (n.d.-d). Technology Transfer Framework. Retrieved 14 May 2019, from United Nations Framework Convention on Climate Change website: https://unfccc.int/ttclear/tec/tech-transfer-framework.html

UNFCCC. (n.d.-e). The Clean Development Mechanism | UNFCCC. Retrieved 14 May 2019, from https://unfccc.int/process-and-meetings/the-kyoto-protocol/mechanisms-under-the-kyoto-protocol/the-clean-development-mechanism

UNFCCC. (n.d.-f). What is the Paris Agreement? | UNFCCC. Retrieved 28 May 2019, from United Nations Framework Convention on Climate Change website: https://unfccc.int/process-and-meetings/the-paris-agreement/what-is-the-paris-agreement

UNIDO. (1999). *In-depth Evaluation of Selected UNIDO Activities on Development and Transfer of Technology*. Retrieved from https://www.unido.org/sites/default/files/2007-11/43916_FINAL_EVAL_REPORT_TH_19991027_DTTCommon_0.pdf

UNIDO. (2010). *Independent Thematic Review | UNIDO Projects for the Promotion of Small Hydro Power for Productive Use*. Retrieved from United Nations Industrial Development Organization website: https://www.unido.org/sites/default/files/2010-02/e-book_small-hydro_0.PDF

UNIDO. (2015a). *Independent Thematic Evaluation: UNIDO Renewable Energy Trust Fund* (p. 105). Retrieved from United Nations Industrial Development Organization website: https://www.unido.org/sites/default/files/2015-03/Independent_Thematic_Evaluation_RETF_FINAL_20150316_0.pdf

UNIDO. (2015b). *Introduction to UNIDO Industrial and Sustainable Industrial Development Brochure*. Retrieved from UNIDO website: https://www.unido.org/sites/default/files/files/2017-11/DG_Brochure_February_2015_Web_0_0.pdf

UNIDO. (2016). *World Small Hydropower Development Report 2016*. Retrieved from United Nations Industrial Development Organization, Vienna, and International Center on Small Hydro Power, Hangzhou website: http://www.smallhydroworld.org/

UNIDO. (2017). Medium-term programme framework, 2018-2021. Comprehensive proposals by the Director General. *Industrial Development Board 45th Session*. Retrieved from https://www.unido.org/sites/default/files/2017-05/IDB.45_8_Add.2_2__E_Medium-term_programme_framework_2018-2021_1703143E_20170522__0.pdf

UNIDO. (n.d.-a). Information Disclosure. Retrieved 5 July 2019, from UNIDO OPENDATA PLATFORM website: https://open.unido.org/disclosure

UNIDO. (n.d.-b). Low Carbon Technology Transfer | UNIDO. Retrieved 30 May 2019, from https://www.unido.org/our-focus/safeguarding-environment/clean-energy-access-productive-use/climate-policies-and-networks/low-carbon-technology-transfer

UNIDO. (n.d.-c). Science, technology and innovation | UNIDO. Retrieved 14 August 2019, from United Nations Industrial Development Organization website: https://www.unido.org/our-focus/advancing-economic-competitiveness/investing-technology-and-innovation/investment-and-technology/science-technology-and-innovation

UNIDO. (n.d.-d). Small hydropower | UNIDO. Retrieved 31 May 2019, from United Nations Industrial Development Organization website: https://www.unido.org/our-focus/safeguarding-environment/clean-energy-access-productive-use/renewable-energy/focus-areas/small-hydro-power

UNIDO. (n.d.-e). Transfer of Environmentally Sound Technologies (TEST) | UNIDO. Retrieved 30 May 2019, from https://www.unido.org/our-focus/safeguarding-environment/resource-efficient-and-low-carbon-industrial-production/transfer-environmentally-sound-technologies-test

UNIDO. (n.d.-f). UNIDO in brief | UNIDO. Retrieved 15 March 2019, from https://www.unido.org/who-we-are/unido-brief

UNIDO. (n.d.-g). UNIDO Open Data Platform. Retrieved 5 July 2019, from UNIDO Open Data Platform website: https://open.unido.org/

UNSCEB. (2008). *Technology Transfer* (pp. 31–33). United Nations Chief Executives Board for Coordination.

UNSCEB. (n.d.). Technology transfer | United Nations System Chief Executives Board for Coordination. Retrieved 29 May 2019, from United Nations System Chief Executives Board for Coordination website: http://www.unsystem.org/content/technology-transfer-2

Urban, F. (2018). China's rise: Challenging the North-South technology transfer paradigm for climate change mitigation and low carbon energy. *Energy Policy*, *113*, 320–330. https://doi.org/10.1016/j.enpol.2017.11.007

Urban, F., Siciliano, G., Sour, K., Lonn, P. D., Tan-Mullins, M., & Mang, G. (2015). South–South Technology Transfer of Low-Carbon Innovation: Large Chinese Hydropower Dams in Cambodia. *Sustainable Development*, *23*(4), 232–244. https://doi.org/10.1002/sd.1590

Verbeken, A. (2012). Low-Carbon Technology Transfer Under the Climate Change Convention—Evolution of Multilateral Technology Support. In DG Ockwell & A. Mallett (Eds.), *Low-carbon Technology Transfer: From Rhetoric to Reality* (1st ed.). https://doi.org/10.4324/9780203121481

Verschuren, P., & Doorewaard, H. (2010). *Designing a Research Project* (2nd ed.). The Hague: Eleven International Publishing.

W. K. Kellogg Foundation. (2004). *Logic Model Development Guide*. Battle Creek: W. K. Kellogg Foundation.

Walz, R., & Marscheider-Weidemann, F. (2011). Technology-specific absorptive capacities for green technologies in Newly Industrialising Countries. *Int. J. of Technology and Globalisation*, *5*, 212–229. https://doi.org/10.1504/IJTG.2011.039765

Watson, J., & Sauter, R. (2011). Sustainable innovation through leapfrogging: A review of the evidence. *International Journal of Technology and Globalisation*, *5*, 170–189. https://doi.org/10.1504/IJTG.2011.039763

World Bank. (2018). Access to Energy is at the Heart of Development. Retrieved 11 June 2019, from World Bank website: http://www.worldbank.org/en/news/feature/2018/04/18/access-energy-sustainable-development-goal-7

Wyatt Knowlton, L., & Phillips, C. C. (2012). *The Logic Model Guidebook: Better Strategies for Great Results* (2nd ed.). Retrieved from https://www.sagepub.com/sites/default/files/upm-binaries/50363_ch_1.pdf

Yang, L., & Maskus, K. (2009). Intellectual property rights, technology transfer and exports in developing countries. *Journal of Development Economics*, *90*(2), 231–236.

Yin, R. K. (2003). *Case Study Research: Design and Methods* (3rd ed.). Retrieved from https://books.google.se/books/about/Case_Study_Research.html?id=BWea_9ZGQMwC&redir_esc=y

Yin, R. K. (2014). *Case Study Research: Design and Methods* (5th ed.). Thousand Oaks, California, London, New Delhi: SAGE Publications, Inc.

Zazueta, A. E. (2018, June). *Theories of Change: Elementary Principles & Examples of their Application*. Presented at the UNIDO Headquarters, Vienna, 27 June 2018. UNIDO Headquarters, Vienna.

Appendix A. List of Documents Analysed

This appendix contains a list of the collected and analysed documents for each case study. In order to not share potentially sensitive information and in order to keep project anonymity the titles of the documents have been removed with only the type of document and the approximate date (if applicable) being listed.

- **Case Study 1/Project A:**

Project Document:

1. Project Document, early 2013.

Evaluation Report(s)

1. Final Report, early 2018.
2. Independent Terminal Evaluation, late 2016.

Advocacy Materials:

1. Booklet, no date.
2. Project Progress Report, Issue 1, mid 2014

Other:

1. Presentation: Project, no date.
2. Presentation: Project, no date.

- **Case Study 2/Project B:**

Project Document:

1. CEO Endorsement, mid 2011.

Evaluation Report(s):

1. Independent Mid-Term Evaluation, early 2015.
2. Independent Terminal Evaluation, early 2019.

Advocacy Materials:

1. Booklet, no date.
2. Booklet, no date.

Appendix B. Project A tabular logic model

The follow table is a detailed, tabular logic model of Project A. A condensed version of this data is also represented in Figure 5-1 in Section 5.2.1

Table B-1. Logic Model for Project A in tabular format.

*The Impact column applies to the entire table.

UNIDO's Planned Work | *UNIDO's Intended Results*

	Resources/Inputs		Activities	Outputs	Outcomes	Impact*
Recipient country ministry for energy	National-wide expertise on renewable energy application for productive uses.	Design	Assessment of socioeconomic needs and available infrastructures for the three preliminary pilot sites.	Preliminary sites will be confirmed for implementation based on suitability of sites for system, electricity supply structure, functioning of existing associations, existence and type of productive activities required, energy demand, availability of productive assets for mini-grid development, available human resources, available private sectors.	Development plan including financial planning and available policy instruments for mini grid system of each pilot site based on business scenario analysis.	**Increased access of rural communities to RE for productive uses.**
	In-kind support.		Assessment of current policy and legal/regulatory framework including MBIs.	A policy summary report will then be prepared including recommendation for business development plan.		
			Assessment of sustainability for the 3 pilot sites.	Baselines data comprising measurable social, economic, environmental and technical aspects (e.g. productive activities, environmental co-benefits, socioeconomic impacts, hydrological parameters, silt load).		
State Government	Local expertise and in-kind support for election of pilot sites, demonstration of mini grid systems, authorization, training activities at the site, public awareness raising, and regional policy promotion.		Site-specific technical applicability assessment.	Resulting data to be used to propose mini-grid systems with targeting productive activities with financial options and to develop detailed intervention strategy to remove barriers for each site.		
			Assessment of connectivity of mini-grids to the community and villages close to the sites.	Resulting data to be used to determine mini-grid systems feasibility and the sites.		
			Consultation with both male and female community leaders.	Environment created so that both men and women benefit from the project through the mutual knowledge sharing.		

District development councils	In-kind support for local business promotion.		Development of a detailed intervention strategy for each site.	Ex-ante business development plan including financial planning and available policy instruments for mini grid system of each pilot site based on business scenario analysis.		
			Designing of mini grid system per pilot site, identification of target system performance, and devising financial planning.	System design including technical and financial aspects.		
	Job opportunities based on mini-grid systems.	System Demonstration	Installation of SHP and demonstration of mini-grid system with connection to productive uses.	SHP systems installed and operational.	SHP technology successfully transferred	
			Training sessions on the technology - several sessions organised by local educational institutions in collaboration with the producer.	Capacity developed.		
Involved academic institution	Expertise on micro hydropower technology.		Establishing training module at the involved academic institution, which will include: study tours to the micro hydropower units, theoretical training session conducted for design, operation concerning SHP turbines and systems, and 3 on-the-job-training sessions to develop local capacity for civil works, system configuration and operation skills of mini grids.			
	Support to develop/organise training programme(s).		Verification of the mini grid and identification of market potential for SHP technology.	Evaluation report prepared to summarise the factual system performance, system operation, lessons-learned, gap analysis, value-added and return on investment.		
	Access (inferred) to community people, technicians, entrepreneurs related to energy business, and engineering students.	Business Development	Knowledge management and capacity building activities ('partner matching') linked to the local production chain including local manufacturing via joint venture, retailing, after service, but also stimulating further R&D activities.	Transferred technology settled.	Favourable environment created for SHP technology production, localisation and innovation.	
	Academic human resources		Organise two business sector workshops for local production chain based on partner-matching for joint ventures and retailing systems for selected SMEs, business institutions, local entrepreneurs etc.	Local production chain enabled.		

	Access to research facilities		Update the business development plans based on actual system results.	Viable business models developed.		
Technology provider	Expertise on SHP.		Conduct market potential analysis based on the new business plan.	Market potential analysis report developed.		
			Organise three special technical workshops and seminars to local experts and manufacturers in close collaboration with local institutions.	Sustainable system operation with established training partners ensured.		
	In-kind support for the technology transfer.		Share lessons-learned to stimulate further R&D activities in the recipient country and any cooperative form with national/international partner institutions.	Further R&D and capacity building stimulated in the recipient country.		
UNIDO	Human capital in the form of personnel and expertise for overall project management.		Propose a R&D oriented advanced capacity building programme to local institutions.			
	Project execution unit responsible for overall coordination and facilitation of the project and establishing communication channels between the stakeholders.		Prepare an intelligence hub for micro hydropower technology.			
		Strategy Development	Organise several awareness raising activities.	New technology mainstreamed beyond the pilot sites.	Favourable environment created for SHP technology deployment and diffusion.	
			Develop up-scaling and duplication strategy.			
	Mobilisation of international support for the project.		Publish a positioning paper on the potential of micro hydropower technology for increasing access to energy for productive uses in the development context, in collaboration with the involved academic institution.	Positioning paper.		
	Access to international consultants for the provision of guidance and expertise where it is not locally available		Develop action plan for productive uses.	Guidance created on how to develop productive activities with the renewable energy assets.		
	Job descriptions for 11 national experts.		Assess market and investment opportunities.	Market-based replication strategy and policy recommendation on the utility of SHP technology developed.		
	Access to potential subcontractors for activities that cannot be performed by project staff.		Disseminate promotion materials.	Raised awareness of access to energy for productive uses in development context.		
			Advocate the marketability and value added of the system using new technology via media (press, brochure, TV etc).			

	Access to special training courses, workshops, study tours, course materials.		Organise awareness raising seminars and workshops to call new investment opportunities for micro hydropower technology partner matching.			
	Equipment for productive-use.		Prepare and present a policy recommendation paper and strategy on replication and up-scaling of micro hydropower technology to relevant stakeholders such as authorities and business community.			
	Funds		Explore further opportunity to leverage this project result at the late stage of project implementation.			

Source: Author's own data collection.

Appendix C. Project B tabular logic model

The follow table is a detailed, tabular logic model of Project B. A condensed version of this data is also represented in Figure 5-2 in Section 5.3.1

Table C-1. Logic Model for Project B in tabular format.

*The Impact column applies to the entire table.

UNIDO's Planned Work — *UNIDO's Intended Results*

<table>
<tr><th colspan="2">Resources/Inputs</th><th colspan="2">Activities</th><th>Outputs</th><th>Outcomes</th><th colspan="2">Impact*</th></tr>
<tr><td rowspan="4">Recipient country org. for energy</td><td>Expertise on rural energy services</td><td rowspan="3">Feasibility Studies</td><td rowspan="2">Due-diligence assessment of technical, social, economic viability and management modalities for the sustainability of the potential sites</td><td rowspan="3">Detailed feasibility studies prepared for identified potential plant demonstration sites</td><td rowspan="3">Site specific details on potential small hydropower sites available for further development.</td><td rowspan="8">Improved electricity access, industrialisation and employment generation</td><td rowspan="8">Global CO2e direct and indirect reductions otherwise resulting from diesel generators.</td></tr>
<tr><td>Cash and in-kind support</td></tr>
<tr><td>Construction support</td><td>Award sub-contract for carrying out the assessment</td></tr>
<tr><td>Technical services and electromechanical equipment</td><td rowspan="5">Capacity Building</td><td>Establish a national small hydropower technical centre at an academic institution</td><td rowspan="4">National small hydropower technical centre established to provide technical support for various technical institutions in the recipient country.</td><td rowspan="5">1. National small hydropower</td></tr>
<tr><td rowspan="4">Project developers</td><td rowspan="2">In kind (and sometimes cash) support for community sensitisation, mobilisation of civil works and plant management</td><td>Train personnel in the newly established SHP centre</td></tr>
<tr><td rowspan="2">Develop training materials for all future trainings to be conducted at the SHP centre</td></tr>
<tr><td>Plant equipment (for 1 site)</td></tr>
<tr><td>Workforce for the construction and necessary project land</td><td>Conduct international seminars on small hydropower at the training centre</td><td>Enhance confidence of stakeholders to develop small hydropower based mini-grid projects</td></tr>
</table>

Recipient country energy ministry	Institutional and policy support	Conduct training sessions to local stakeholders		technical centre established to provide technical support for various technical institutions in the recipient country 2. Technology transferred on local fabrication of small hydropower equipment 3. Existing guidelines and standards adapted to suit installation and management of small hydropower plant mini-grids in the recipient country 4. Government incentive for SHP in place		
		Prepare and publish guidelines and standards for the development of small hydropower projects.	Guidelines and standards for small hydropower implementation and management developed			
	In-kind contribution to project coordination and administration	Thorough demand assessment for local hydro-power equipment	Local fabricators transferred with small hydropower equipment fabrication technology.			
		Identify interested local fabricators for small hydropower equipment				
Recipient country main electricity supplier	Support for development and publishing guidelines and standards for the development of SHP	Train interested local fabricators at the SHP centre on planning and designing aspects of the equipment, actual fabrication of the equipment and marketing strategies				
		Arrange technology licences for locally trained fabricators				
		Provide fellowships for eligible suppliers in getting long term training in countries with advanced manufacturing technology				
Involved academic institution	Support to develop/organise training material, programme(s)	Start the equipment manufacturing simultaneously with the development of demonstration sites				
	Cash support for operation of technical centre	Subcontract an experienced and standard turbine manufacturing private company to transfer the technology to local manufacturers.				
	Support, staff and space allocation for national SHP technical centre					
UNIDO	Human capital in the form of personnel and expertise for overall project management.	Create quality control procedures and standards and recommend them to the recipient country's government for implementation.				

Project management unit responsible for overall day-to-day coordination, management and facilitation of the project and establishing communication channels between the stakeholders		Adapt existing large hydro guidelines and standards to suit the installation and management of small hydropower plants in the recipient country.	Ensure the installation of small hydropower technology is done on par with the accepted standards.			
		Disseminate new guidelines				
		Provide incremental support for the creation of government incentive for small hydropower projects.	Policy and regulatory system for small hydropower projects improved			
Project steering committee responsible for project development in line with the country needs and priorities and tracking progress, and promoting stakeholder partnerships	Business development	Conduct awareness programmes (e.g. seminars, informal meeting and consultative meetings) to enable the stakeholders to gain knowledge on the available subsidies and credit lines	Private sector aware of available government subsidies and credit lines	Existing financing options streamlined to benefit local entrepreneurs interested in small hydropower		
		Conduct head-to-head meetings between the private sector and the local financing institutions for match making and facilitating the development of RE technologies	The development of RE technologies (incl. small hydropower) enabled			
Access to international consultants and experts for the provision of guidance and expertise where it is not locally available		Liaise with government body for energy for the creation of a separate window for small hydropower projects under the available subsidy/financing schemes	Flow of financing from the available schemes to the new project developers facilitated			
		Provide advisory support for project developers to benefit from the existing grants	Project developers supported with grants guidance			
	Demonstration	Launch bid document (incl. detailed technical specification) for sourcing small hydropower equipment	Small hydropower plants installed and operational at different locations in the recipient	A number of small hydropower plants implemented in different locations within the recipient country		
Job descriptions for national consultant and the programme office		Evaluate, shortlist and award bidders based on a pre-set scoring mechanism				
		Awarded bidder will implement the project				
Administrative support and financial budgetary follow up		Arrange necessary licenses, permits and contracts required for the construction and the operation of the SHP power plants				

Access to special training courses, workshops, study tours, course materials.	Carry out detailed design of mini-grid system, distribution lines, connections, metering, etc., including detailed operational and management arrangements of mini-grids				
	Prepare and launch tenders and select company for mini-grid installation				
Funds	Monitor and present project results	Replicability of similar projects in recipient country increased			
	Organise site visits and disseminate project experience via leaflets, various publishing, website				

Source: Author's own data collection

Appendix D. Results and Analysis of the Cross-Case Comparison

This table presents a more detailed version of the results presented in Section 5.4

Table D-1. Cross-case comparison: results and analysis

		Planned Work	Intended Results	Technology Transfer Activities	Cross-case Analysis
Stage 1	Case Study 1	1. Design Stage Includes feasibility studies, community consultations, design of SHP plants and implementation strategies for the 3 pilot sites.	Background information on influential factors applicable to the project and the feasibility of local mini-grid systems at potential sites. Final system design including ex-ante business development plans	Preparatory work for transferring the technology	Both projects are planned to start in a similar way, with a feasibility study to assess the suitability of the potential pilot sites. For case study 1 this stage is also planned to contain a number of other activities such as consultations with the community leaders, the development of the project strategy for each site and the design of each plant.
	Case Study 2	1. Feasibility Studies Stage Includes feasibility studies.	Detailed feasibility studies for identified potential SHP demonstration sites	Preparatory work for transferring the technology	
Stage 2	Case Study 1	2. System Demonstration Stage Includes the installation and demonstration of the SHP technologies at the three pilot sites, capacity building activities and the identification of market potential for the technology	Installed and operational SHP-based systems. Built capacity for local actors. SHP technology market potential identified.	This stage focuses on all dimensions of technology. **Hardware:** transferred at pilot sites **Know-how**: attempted to be transferred through capacity building activities **Know-why**: attempted to be transferred through capacity building activities **Innovation system:** attempted to be enabled	By following the intervention logic narrative, the capacity building element appears to be stronger in case study 2 where there seems to be more attention given to the identification of the interested fabricators, ensuring that they receive training not only on fabrication but also on planning, designing and marketing the equipment. The training is also done both at the newly established SHP training centre but also in countries that have advanced manufacturing technology. Attention is also given to the channel of TT which in this case is licensing, where licences for the technologies are arranged for the fabricators as part of the project. Nevertheless, there is

	Case Study 2	2. Capacity Building Stage Includes mainly capacity building activities, but also the adaptation of guidelines and procedures for the installation and management of SHP in the recipient country, and incremental support for the creation of financial incentives for SHP projects.	A national SHP centre in the recipient country. Built capacity for the local actors Technology transferred to local actors.	This stage focuses mainly on know-how, know-why and innovation systems. **Hardware:** not transferred **Know-how**: attempted to be transferred through capacity building activities **Know-why**: attempted to be transferred through capacity building activities **Innovation system:** attempted to be enabled	also capacity building involved in case study 1 where a SHP centre is also established. Training is offered to local engineers/experts and include study tours to the SHP units in the recipient country, a theoretical training session conducted for design, operation concerning SHP turbines and systems, and 3 on-the-job-training sessions to develop local capacity for civil works, system configuration and operation skills of mini grids. The difference in case study 1 is that this stage also involves the installation and demonstration of the technology at the pilot sites, whereas in case study 2 the capacity building appears to take place prior to starting the installation of the technology, however it is stated that the equipment manufacturing starts simultaneously with the development of the demonstration sites. A notable difference between the case studies is that there seems to be a lot more emphasis on the identification of potential local fabricators in case study 2. Indeed, this is also one of the lessons from the final report of case study 1 which states that local technology manufacturing partners should be identified prior to the start of the project.

Stage 3	Case Study 1	<u>3. Business Development Stage</u> Includes partner matching of local fabricators with enterprises for joint venture, retailing, after service, R&D; more capacity building activities, and further market potential analysis.	Favourable environment created for SHP technology production, localisation and innovation. SHP technology transferred to local fabricators. Business models developed based on actual market potential. Capacity built. R&D stimulated.	This stage focuses on the innovation system and transferring know-why skills. **Know-why**: attempted to be transferred through capacity building activities **Innovation system:** attempted to be enabled	Case study 2 focuses more on enabling the private sector to develop SHP from a financial perspective, and again focuses mainly on developing the capacity surrounding financial knowledge. Case study 1 has a broader approach focusing on strengthening the market-based replication of the SHP systems that were planned to be demonstrated in an earlier step. This step focuses on developing the productive sector based on a business development plan that will include information such as how to allocate the electricity for productive activities, and how to secure the self-sufficient income/cost balance to maintain the demonstrated mini grid system.
	Case Study 2	<u>3. Business Development Stage</u> Includes awareness and capacity building activities, head-to-head meetings between the private sector and financial institutions, advisory support, liaison with the government for SHP subsidy/financing schemes.	Private sector aware of financing options for SHP. Private sector enabled to develop SHP.	This stage mainly focuses on the innovation system. **Innovation system:** attempted to be enabled	

Stage 4	Case Study 1	4. Strategy Development Stage Includes developing a replication strategy and raising awareness on the potential of SHP-based energy for productive uses via a number of channels.	Various advocacy materials created and disseminated. Market-based strategy & policy recommendations developed. Technology mainstreamed. Environment created for SHP replication.	This stage mainly focuses on the innovation system. **Innovation system:** attempted to be enabled	Case study 1 focuses mainly on raising awareness and advocating for SHP technology in order to create a favourable environment for its replication as well as the creation of an up-scaling and duplication strategy to mainstream and uptake the new technology beyond the pilot sites. The final project stage is markedly different in case study 2, where the focus is on the installation and the demonstration of the SHP technology at the selected sites. This component focuses on identifying contractors for the implementation of the SHP and the installation of the mini-grids. It is unclear if the contracts are planned to be awarded to local enterprises or foreign ones.
	Case Study 2	4. Demonstration Stage Mainly focuses on implementing SHP at the demonstration sites including: launching and awarding a bid for sourcing SHP equipment and for implementing the project, arranging the necessary documentation for the construction and operation of the SHP, design the mini-grid system and select company for its installation, and document project results and advocate SHP.	SHP installed and operational at the demonstration sites. Advocacy materials disseminated for boosting replication	This stage focuses on all dimensions of technology. **Hardware:** transferred at pilot sites **Know-how**: attempted to be transferred through capacity building activities **Know-why**: attempted to be transferred through capacity building activities **Innovation system:** attempted to be enabled	

Source: Author's own elaboration