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IPRs and Climate Change: the issue of the Technology Transfer

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List of Abbreviations

AIPPI	Association Internationale pour la Protection de la Propriété Intellectuelle
AWGLCA	Ad Hoc Working Group on Long-term Cooperative Action under the Convention
CCS	Carbon Capture and Storage
COP	Conference of the Parties
CRT	Climate Related Technology
CTCN	Climate Technology Center and Network
EGTT	Expert Group on Technology Transfer
EPO	European Patent Office
EST	Environmentally Sound Technology
FDI	Foreign Direct Investment
GATT	General Agreement on Tariffs and Trade
GCF	Green Climate Fund
GEF	Global Environmental Facility
GHG	Green House Gasses
ICTSD	International Centre for Trade and Sustainable Development
IPCC	Intergovernmental Panel on Climate Change
IPR	Intellectual Property Rights
OECD	Organization for Economic Cooperation and Development
PNAS	Proceedings of the National Academy of Sciences of the United States of America
PNG	Papua New Guinea
R&D	Research and Development
SBSTA	Subsidiary Body for Scientific and Technological Advice
SDG	Sustainable Development Goals
SME	Small and medium enterprises
TEC	Technology Executive Committee
TNA	Technology need assessment
TRIPS	Agreement on Trade-related Aspects of Intellectual Property
UNCTAD	United Nations Conference on Trade and Development

UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNWCD	United Nations World Commission on Environment and Development
WIPO	World Intellectual Property Organization
WMO	World Meteorological Organization
WTO	World Trade Organization

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Introduction

The effect of Climate Change we are experiencing these days is different from anything else we have seen so far, and it is rapidly becoming one of the most important issues we have to face in this third millennium. It is the plague of our times, causing significant damages to life and to the ecosystem, and it is threatening wealth and biodiversity of our planet.

On the basis of the latest estimates of the World Meteorological Organization (WMO) in 2019, in fact, the concentrations of carbon dioxide, the main greenhouse gas resulting from human activities, in the air, reached 407,8 parts per million (ppm), a new historical negative record.

It was in 1895 that the Swedish chemist Svante Arrhenius emphasized that humanity could boost the greenhouse effect by making carbon dioxide, a greenhouse gas. Nowadays the consensus is unanimous. The Bulletin of Science, Technology & Society by scientist James Powell, (geologist of the National Science Board of the United States) consulted more than 11.000 studies on climate change, and it has been noted that almost 100% of all these researches agree that growing emissions of greenhouse gases and other factors can all be attributable to anthropogenic activities.

The only mean we can adopt to fight these challenges is shifting the entire economy toward a more sustainable approach to the production of goods and services, as well as a wider use of renewable energies. The United Nations Framework Convention on Climate Change (UNFCCC) defines Environmentally Sound Technologies (EST) all those technologies that "*have the potential for significantly improved environmental performance relative to other technologies. ESTs protect the environment, are less polluting, use resources in a sustainable manner, recycle more of their wastes and products, and handle all residual wastes in a more environmentally acceptable way than the technologies for which they are substitutes*".

One of the biggest issues with EST is that if we really want to face climate change, we need to have these technologies implemented in both developed and developing countries by all the players in the market.

This being said, the intention of this work is to analyze the role of Intellectual Property Rights in relation to technology transfer of EST which is a very discussed topic in the last few years.
That's why dealing with climate change is becoming one of the world's greatest challenges for policymakers. They need to design a legal framework that could facilitate and incentivize the innovation process of new green technologies and their adoption and dissemination even in least developed countries. Due to a number of uncertainties and difficulties, adoption and diffusion of EST pose various issues requiring different policy initiatives, including an efficient political structure. This thesis is an essay to clarify some questions related to the technology transfer by analyzing relevant documentation on the innovation and diffusion process of ESTs. In other words the scope of this work is to analyze enabling factors for the effective diffusion of green technologies taking into consideration the role of intellectual property rights, usually embodied in patents or trade secrets. In particular the focus is on the role of Intellectual Property Rights, which constituted since the 1883 (The Paris Convention) the principal tool that has driven the innovation process.

The principal trade off associated with the use of IP rights for green technologies is the following: while developed countries see them as a strong mechanism that incentivizes innovation through the provision of exclusive rights, developing countries, not having the resources to invest in R&D or to pay licenses, consider IP as a formidable obstacle to the transfer of green technologies.
The intention of these thesis is to analyze which are the most critical points when dealing with the technology transfer of green technologies and to understand if IP really impedes the dissemination of new technologies.
Therefore, the most important question to bear in mind while reading this thesis is: do Intellectual Property Rights foster or prevent the diffusion of new green technologies in least developed countries?

The present work is structured in three different chapters, here is a brief recap of the main topics contained in each section.

- The first chapter deals with a general description of the phenomenon of climate change and frames it in the historical and political context of these days. After defining the

meaning of climate change and introducing it, the focus shifts to the description of adaptation and mitigation technologies that appear to be the main solutions proposed to the problem, but which are difficult to adopt and produce because they are often expensive.

Then the discussion moves towards the core of this thesis and the main features of Intellectual Property Rights are subsequently introduced, in order to better understand how and why companies usually invest in innovative technologies and which incentive policymakers use to encourage this innovation process.

The chapter ends by exposing the main issue of this thesis, the intention is to understand the role that IPR assume in relation to the transfer and to the adoption of green technologies on the world and questions how this transfer can be influenced by the use of this tool.

- The second chapter focus is on the policy function of the UNFCCC, the principal international organization that deals with IPR and the technology transfer of green technologies. The intention is to identify IP in a legal framework that could help understanding how this tool works and how policy has tried to answer to the aforementioned problems. Moreover, the chapter describes which are the most important steps in the history of IPR and concludes with a close up to the TRIPS Agreements. This last treat does not deal specifically with climate change technology but shapes how technology transfer works across nations and which tools policymakers have provided that help addressing EST transfer.

- The third chapter can be considered the ending point of this work and it is composed by two main parts. The first part concerns about major technology transfer channels and emphasizes the importance of analyzing the barriers that generally constitute the principal disincentives for investing in green technologies. This part also identifies the concept of absorptive capacity that seems to be one of the most crucial aspects when dealing with technology transfer of complex innovations (like EST). The second section tries to tackle the barriers connected to the EST transfer and in particular analyzes the scope of compulsory licensing as well as other possible policy tools that may grant more cooperation. This section puts the basis for discussion for future possible policy actions that could help addressing these challenges.

1. Green Technologies and the Technology Transfer

1.1. Climate Change and nowadays trends

Until the last hundred years, the climate has always changed due to natural factors like solar irradiance or volcanic eruptions, but in the last decades this phenomenon has dramatically changed due to human activities.

The leading cause of climate change is the constant increase of global demand for energy with the consequent growth of world's greenhouse gas (GHG) emissions, mainly driven by burning fossil fuels like gas, oil and coal.
What most people probably don't know is greenhouse gasses work as a blanket against cold temperatures outside the atmosphere, they partially trap the heat coming from the short-wave radiation from the sun before they are dispersed into space. These GHG are naturally present in the atmosphere but they increase when fossil fuels burn, releasing carbon dioxide into the air and eventually causing the planet to heat up[1].

Since the Industrial Revolution in the 18th Century, when James Watt introduced the first steam engine, the atmospheric concentrations of carbon dioxide, nitrous oxide, and methane have increased significantly.
Several studies highlighted that carbon dioxide concentration in the air during these days is almost 48% higher than pre-industrial period and it is rapidly increasing.
Climate change, the loss of biological diversity, and the exhaustion of the ozone layer are among the most important environmental problems contemporary societies are facing.
During the days I am writing this work, the future of the impacts of climate change on terrestrial life is being discussed in Madrid, during the 25th Conference of the Parties in December 2019. Among many potential scenarios presented in the report "Climate Science

[1] NASA (2019) Graphic: The Green House effect.

2019", one in particular concerns the condition of biodiversity, the title is "Threatened Guardian of Earth's Resilience”[2].
The main result is that an increase in temperature of two degrees would correspond to the disappearance of about 14% of all terrestrial species present today.

The United Nations Intergovernmental Panel on Climate Change (IPCC) funded in 1988, composed by expert scientists coming from 195 countries, was established to provide reviews and advice regarding the level of knowledge of the science of climate change and the economic and social impact of climate change.
From 1988 five major reports were created and in 2013 the IPCC stated that:

“*Warming of the climate system is in no doubt, and since the 1950s, many of the observed changes are unprecedented over decades to millennia*.”

It is clear then that human activities are one of the prevalent causes of the fast warming process Earth is facing, but most of the population is still not fully aware of all the risks associated with Global Warming.

From an article written by Giovanna dell’Ongaro and published on the online newspaper “Nature”, the Global Warming will affect not only the environment itself but human society and economy as well, it may lead to a crisis over the entire modern economy and not only developing countries will be affected by this phenomenon[3]. For the first time a team of economists estimated all the probable losses that will occur by this phenomenon in the high spending region of the world. There seems to be a straight connection between any increase in temperature and a fall in productivity.

Solomon Hsiang, Marshall Burke e Edward Miguel from Berkeley University, the authors of the article “*Global non-linear effect of temperature on economic production”* estimated that the total loss we could have in 2100 in terms of economic activities would be around

[2] IPCC (2019): Climate Science 2019
[4] Giovanna dell’Ongaro (2017): Il riscaldamento del pianeta influirà sull economia globale Giovanna Dall’Ongaro

23% compared to a possible scenario where all strategies against Global Warming are successful[4].

The study is based on the economy of the last 50 years and wants to show how Global Warming influenced the incomes of more than 150 countries all over the world. Researchers highlighted that even if at the very beginning countries that built their economy over agriculture will be more affected compared to those countries that have lower temperatures and a stronger economy, the general level of income decreases on average when temperatures increase or decrease. This means that poor tropical countries exhibit larger responses mainly because they are hotter on average, not because they are poorer. Hence micro and macro level analysis shows that temperature changes lead to productivity losses in both developing and developed countries and even if the phenomenon will be at first visible in the first category this will eventually strike the entire population.

According to Berkeley University research there exist an optimal climate condition where humans are particularly productive and passing this soil will inevitably drive to production losses. This is something every human being happened to test at least once in his life when the temperature gets higher: the heat makes more difficult to concentrate on daily works.

Furthermore, the study demonstrates that Global Warming will have a huge impact on the future of human society and shows that wealth, technology and experience might not be enough to face this challenge.

It is important to underline here that Solomon Hsiang, Marshall Burke e Edward Miguel mainly analyzed the effect of the phenomenon on the global economy but there are several other factors connected to Global Warming that could impact our society.

Another article from 2013 published on Proceedings of the National Academy of Sciences of the United States (PNAS) showed a linear connection between climate and violence, suffice it to think that in the last hundred years wars occurred mainly in those regions where temperatures are generally higher[5].

Unless we intervene, all these changes may drive to an irreversible scenario none of us will be able to face. The adoption of "Green Technologies" could be the solution to the

[4] S. Hsiang, M. Burke e E. Miguel (2015): Global non-linear effect of temperature on economic production

[5] O'Loughlin, A. M. Linke, and Frank D. W. Witmer (2016): Effects of temperature and precipitation variability on the risk of violence in sub-Saharan Africa, 1980–2012

complex situation we are dealing with these days and can counteract the consequences of climate change and pollution on our planet.

A transition toward a progressive sustainable future with lower emission of greenhouse gasses and the restoration of environmentally rundown areas asks for a different approach to the economy with production processes and technologies that aim to respect more the environment.

The general idea behind this approach requires a new way of intending our welfare that should give to the companies the possibility to think more of the added social value connected to the business rather than merely focusing on the cash flow generated from revenues and infrastructures.

In this field big steps have been made during the last few years, thanks to the contribution of important and less important people like Greta Thunberg, the world is starting to realize that we are fastly moving toward an irreversible situation that will affect inevitably and equally all the species.

Thanks to this greater awareness over climate changes, several initiatives started to take place and the business model of firms is slowly changing.

"Green economy" or ecological economy is a theoretical model of economic development that arises from a bio-economical analysis of the business where firms focus not only on the GDP (Gross Domestic Product) but try to take into account the impact of every production choice on the environment.

The report "Our Common Future" (the so-called Brundtland Report) of the United Nation World Commission on Development, written in 1987 helps to define what is a "Sustainable Development":

"Sustainable development is the development that meets the needs of the present without compromising the ability of future generations to meet their own needs"[6].

This will involve taking into consideration the whole productive cycle, that starts with the extraction of raw materials and over with the end of the lifecycle of every single product.

The term "Green economy" can be translated differently in every sector. What is important to note here is that this new holistic approach to the problem and this

6 World Commission on Environment and Development (WCED) 1987: Brundtland Report

commitment to environmental protection shows the real intention of the companies to change all business dynamics that degrade the environment for sustainable development.
What is still not clear at the moment is:

- which firms are working in a “Green Economy”

- which jobs can be defined as "Green”

Nonetheless, one the biggest issue here is that nowadays the “Green economy” is predominantly evaluated through the global performance of every single country but the ecological impact changes in every sector and for every firm and it is almost impossible to give a unique solution to the problem both for public and private companies. One theory suggests that defining a target to be reached in every single situation could be the path to follow but this generally requires a strong regulatory mechanism that cannot be always implemented in every country due to poor control mechanism or coercive power[7].

The focus on the role of business and private companies in sustainable development was already strongly expressed at the Earth Summit in Rio de Janeiro in 1992. Since then, endless endogenous and exogenous initiatives have been developed to make the industrial system a protagonist of change. All the United Nations Summits on sustainable development hosted a parallel Conference of industrial organizations until, with the green economy, the role of the industrial system took center stage. The echo of this decisive moment for sustainable development was heard loud and clear at the Rio+20 Summit and, since then, initiatives are no longer counted.
The economic and financial crisis of 2008 and subsequent years also had a multiplier and thrusting effect, after this serious failure, many operators and many organizations in the industrial sector have begun to consciously and proactively explore the paths of the green economy as a way out of the crisis for a stable and lasting future.
Since then, there have been many initiatives to assess the performance of companies in the light of sustainability principles.

Developing countries play an important role to achieve global green growth. They contribute at least in two major manners:

[7] T. Federico (2018) La Green Economy nel Mondo

- Primarily, the potential social and economic effects of environmental depletion are especially relevant for developing countries. They are the most exposed to climate change and compared to advanced economies they tend to be more susceptible to the exploitation of natural resources for economic growth.

- Secondly, many developing countries deal with economic, social and ecological threats from energy, food and water insecurity to climate change and extreme weather conditions. They risk of premature mortality caused by pollution, poor water quality and illness due to changing climate. All of these factors impact on their ability to focus more on implementing green solutions.

Important to say that although most developing countries are the ones that contribute the least to global greenhouse gas (GHG) emissions compared to the OECD (Organization for Economic Cooperation and Development) and major emerging economies, they will increase their emissions if they follow conventional economic growth patterns[8]. During these days emerging countries are becoming a major source of global economic growth and these will lead to wider use of raw materials and natural resources.
In order to tackle many of the growth and development challenges mentioned above without compromising future growth and poverty reduction goals, the concept of green growth has emerged as a new approach to reframe the conventional growth model and to re-assess many of the investment decisions.

Developing economies, therefore, have to take into consideration policies that could contribute to obtain real and quantifiable progress in terms of boosting more inclusive economic growth and incentivizing environmental sustainability.
Here comes one of the most important problems: developing countries suffer for a lack of resources to be able to adopt technologies for the sustainable growth challenge.

[8] Z. Eldredge (2018): Intellectual Property and Climate Change

There are chances for synergies between environmental and economic sustainability, especially for developing countries but most of the time, important initial costs for the shift toward green growth prove to be beyond their possibilities of these countries.
Most of the time these countries not only don't have resources to invest in these new and green technologies, but they also lack the competencies that help to implement these new methods, processes, and products. Indeed, one of the major enabling conditions for green growth is related to the transition of science, research, educational and training priorities to support the shift to a green economy. New awareness and capabilities are required for institutional top management, professionals, and workers, down to local levels; the structural employment and institutional changes required may also warrant support for the fair transitional costs of organizations and their employees.

Most of the time even basic technologies lack in most developing countries, especially those related to wastewater treatment, energy efficiency, and integrated water resource management. Moreover, one of the most important concern is that even if a developing country owns the technology, in most cases they are not able to be competitive in the market and they will need to import innovations from other countries. Removing barriers constituted by intellectual property rights becomes crucial to enable developing countries to move forward to the "Green Economy". A genuine transfer of green technologies and policy instruments between developed and developing countries should be detected and utilized in various combinations and levels, matching the national contexts where they are meant to facilitate this transfer[9].
Some synergies between climate change policies and the sustainable development agenda in developing countries already exist, such as energy efficiency, renewable energy, transport, and sustainable land-use policies. Notwithstanding still today there is scarce attention from policymakers to date, climate change policies could have important subsidiary advantages for the local environment, but in most cases, developing countries still not see the real added value of green technologies showing poor attention to climate change policies.

[9] F. Ludwig, C. Terwisscha van Scheltinga, J. Verhagen, B. Kruijt, E. van Ierland, R. Dellink, K. de Bruin, Kelly de Bruin and P. Kabat (2007): Climate change impacts on Developing Countries - EU Accountability

For policymakers there are three central areas to be taken into account when dealing with the creation of policies for climate change, that are the ones intended to improve sustainable development in developing countries:

1. The social impact of those choices: any decision will be lead by society's preoccupation regarding the risks linked to climate change technologies effects and by opinions on what can be considered "socially acceptable"

2. The economic point of view: any decision should address cost and policy requirements and should consider the actual level of contribution to GHG emission

3. The formalization of policies itself, in terms of objectives to be achieved and tools to be implemented

With all of these concerns in mind, policymakers should focus on increasing the technology transfer between developed and developing countries enabling all the players to work in a context where they can put more attention on Global Warming, taking it as one of the most important variables to be considered[10].
As seen in this introduction, climate change is becoming crucial in every context and the transfer of technologies, competences, and know-how is one of the most important support to the successful dissemination of green innovations within and among countries.

Defining rules that govern the technology transfer basically shapes how much all these new technologies will be adopted and who will use them. According to Environmentally Sound Technologies (EST), technology transfer is an integral part of moving know-how between developed and developing countries. The original United Nations Framework Convention on Climate Change (UNFCCC) of 1992, as well as the subsequent Kyoto Protocol, tried to address this issue, and for the first time the technology transfer was brought into the agenda for a better understanding of the process by which Intellectual Property Rights foster or humper the diffusion of green technologies.
The importance of successful divulgation and use of environmentally sound technologies is becoming of crucial relevance in nowadays discussions and will surely increase in the

[10]IPCC (2016): Special Report on Climate Change and Land

following decades. The intention of this thesis is to analyze the policy framework around Intellectual Property Rights (IPR) to see if it could help these challenges.

The different dimensions of sustainable development intersect with intellectual property in several places. Researchers focus in particular on the following questions:

- Is the intellectual property a stimulus or an obstacle to the development of environmentally friendly technologies and their diffusion to developing countries?
- What system of protection of intellectual property rights is needed to provide sufficient incentives for plant variety breeders without jeopardizing the economic survival and freedom of choice of farmers and smallholders?
- What contribution can intellectual property make in order to protect the traditional knowledge of indigenous communities and maintaining intact their social structures?
- To what extent can intellectual property help to eliminate, or at least hinder, the negative effects of climate change on future generations?
- What contribution can and should intellectual property make to ensure that the biological diversity of fauna and flora is preserved for future generations?

1.2. Political and economic context

Historically, global energy and environmental policies around the world have been influenced by two main factors: global energy demand, which is constantly growing; and the common agreement on the need to reduce GHG emissions on the planet.
As we shall see later, since 1990 the United Nations Convention on Climate Change (UNFCCC) has framed the climate and environmental problem we have been facing in recent years, and has stressed the concept that these resources are shared global and this is why this requires for a coordinated efforts. Moreover, the convention has defined a general action plan for the whole world, focusing mainly on the issue of climate change. Subsequently, in 1997, the Council met again, creating the Kyoto Protocol, which entered into force in 2005. The agreement provided for all those who signed it, a reduction in GHG emission through gradual reductions at national level.

With the advent of the new millennium, given also the lack of effectiveness of the actions implemented so far, climate change has become the key topic of political debate in many countries.
It is important to underline that in the last 30 years the world economic scenario has changed profoundly. The high rate of world growth in fact gave birth to new emerging economies, coming from even very different contexts, among them we can mention China, India, the Middle East, Brazil and many others.
It is not difficult at this point to imagine that this increasingly frenetic global economy, as well as the emergence of these new realities has dramatically increased aggregate energy demand worldwide.

In fact, since the 1990s, developing countries have seen a huge increase in their greenhouse gas emissions. To give an idea, only China has almost quadrupled its CO2 emissions (364 percent), while India (278 percent), Indonesia (215 percent) and Saudi Arabia (202 percent) have increased dramatically their emissions.

By 2030, global energy demand is expected to be around double its current level.
Given the context, renewable energy sources have attracted great interests in recent decades from both a political and business perspective and investments in wind, solar, water and geothermal technologies have seriously increased.
These and other climate-friendly technologies are named in technical jargon as "Environmentally sensitive technologies" or "Environmentally friendly technologies", a concept that we will discuss more in detail later on.

In 2007, agreement was reached in the European Council called the “20-20-20 climate and energy package”, where environmental impact reduction parameters are defined under the "20" banner.
The environmental programme had the objective of reducing GHG emissions from the various industries by 20% by 2020 compared to 1990 levels; it has asked for a 20% switch toward renewable energy sources and a 20% reduction in total expected primary energy consumption.
Other governments in many major economies, such as the US and China, have also committed to substantial investment in renewable energies.

1.3. Climate-Related Technologies

Despite increasing awareness over "Global Warming", our emissions of greenhouse gases continue on a relentless rise and reducing the effects of climate change is mandatory to reach sustainable development and equity, comprising poverty eradication.
Having all of that in mind, now it is central to identify here what kind of technologies can be considered climate related technologies.
But it is not easy to clarify which products, processes and skills can fall under the category of climate technologies. Nevertheless the definition of "Environmentally Sound Technology" (EST) also helps us to identify which are the fields of research that show a better capability to produce results in line with green economy standards of environmentally friendly innovation and for this reason need financial support. Policymakers need to design interventions that can help promote EST but this cannot be done if there is no agreed definition over what can be considered a climate technology.

It is not clear whether certain technologies may be properly considered to be technologies that can better deal with climate change like nuclear energy. Usually the most widely used definition for Environmentally Sound Technology comes from Article 34.1 of Agenda 21 of the Rio Declaration:

"Environmentally sound technologies protect the environment, are less polluting, use all resources in a more sustainable manner, recycle more of their wastes and products, and handle residual wastes in a more acceptable manner than the technologies for which they were substitutes".

The following Table lists some of fields related to green economy in which the research is making passes:

Biomass	Solid fuels based on materials of non-mineral origin (animal or plant); engines operating on such fuels (e.g., wood)
Insulation	Elements or materials used for heat insulation; double-glazed windows

Heating	Heat pumps, central heating systems using heat pumps; energy recovery systems in air conditioning
CCS	Extraction, transportation, storage, and sequestration of CO2
Cement	Natural pozzuolana cements; cements containing slag; iron ore cements; cements from oil shales, residues, or waste; calcium sulfate cements
Electric vehicles	Electric propulsion of vehicles; regenerative braking; batteries; control systems specially adapted for hybrid vehicles
Geothermal	Use of geothermal heat; devices for producing mechanical power from geothermal energy
Hydro	Hydropower stations; hydraulic turbines; submerged units incorporating electric generators; devices for controlling hydraulic turbines
Lighting	Compact fluorescent lamps; electroluminescent light sources
Methane	Equipment for anaerobic treatment of sludge; biological treatment of wastewater or sewage; anaerobic digestion processes; apparatus aiming at collecting fermentation gases
Marine	Tide or wave power plants; mechanisms using ocean thermal energy conversion; water wheels
Solar	Solar photovoltaic (conversion of light radiation into electrical energy), including solar panels; concentrating solar power (solar heat collectors having lenses or reflectors as concentrating elements); solar heat (use of solar heat for heating and cooling)
Waste	Solid fuels based on industrial residues or waste materials; recovery of heat from waste incineration; production of energy from waste or waste gases; recovery of waste heat from exhaust gases

Wind	Wind motors; devices aimed at controlling such motors

[11]

Table 1

In most cases environmentally sound technologies are reunited under two categories: Mitigation technologies and Adaptation technologies. Under these two categories there can be listed many other potential sub-categories, but we will leave this discussion to more-technical contexts.

According to the UNFCCC (United Nations Framework Convention on Climate Change) mitigation and adaptation technologies can be defined as follows:

- **Mitigation** - reduction of environmental impact: involves reducing the flow of greenhouse gases that imprison heat into the atmosphere. This can be achieved either by reducing the use of fossil fuels used for transport and for the production of heat and electricity, or by strengthening the "sinks" that absorb these gases (trees, oceans and land). The aim of mitigation is to prevent human beings from interfering with the climate system so as to "*stabilize greenhouse gas levels within a time sufficient to ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to allow economic development to proceed sustainably (*from the 2014 Report on Climate Change Mitigation of the United Nations Intergovernmental Panel on Climate Change, p. 4).

- **Adaptation** - adapting to climate change: implies progressive adaptation to the present or expected future climate. The aim is to limit our sensitivity to the dangerous effects of climate change (such as extreme weather events, sea level rise or food uncertainty). This also requires exploiting any potential beneficial opportunities linked to climate change (e.g. longer growing seasons or larger land areas in some regions).

  This approach requires a more strategic analysis between different sectors and the government concerned, in order to properly address the consequences of impacts and to ensure that adaptation measures are time effective. An adaptation strategy implies

[11] A. Dechezlepretre, M. Galachant, I.Hascic, N. Johnstone, Y. Meniere (2011): Invention and Transfer of Climate Change – Mitigation Technologies: A Global Analysis.

each sector to identify which are the most important actions to address future climate change[12].

Dual Externality

Talking about Climate Related Technologies it is crucial here to recall the concept of externality in order to better understand of the impact of different production choices.
The externality is the cost or the benefit deriving from an activity that does not pertain to the organization or person performing on the activity, *e.g.* damage to the environment[13]. Low-carbon innovations, compared to many other technologies, poses particular due to the presence of double externalities. Firstly, because environmental pollution has a negative externality and its social costs may outweigh its private costs[14]. As a result, polluters cope with a few market incentives to develop greener technologies as a society collectively bears the cost of pollution. Secondly, technology and skills needed for the development of an EST may have the characteristics of a public good, i.e. non excludability and non rivalry. Thus, the good has to be accessible and usable to everyone and nobody can limit the enjoyment to any other player.

This dual externality represents a real challenge to all potential actors, as the R&D and commercialization of green technologies unfailingly causes leakages of knowledge and consequently impacts to the effective value created by their commercial and financial investments. This all leads to a reduction in incentives for innovation in the private sector and for the commercialization of new and existing technologies and expertise with other players.

1.4. Innovation and IP rights

[12] NASA: Responding to Climate Change

[13] J. Black, N. Hashimzade, G. Myles (2012): A Dictionary of Economics

[14] D. Popp, R.G. Newell, A. Jaffe (2010): Energy, the Environment, and Technological Change.

Innovation and IP are distinct but closely related concepts. Innovation often leads to the creation of IP, and intellectual property rights help to provide a mean to obtain funding for the innovative development of ideas and to position them in the market.
In recent years IP rights have proved useful in the circulation and dissemination of technology, providing companies with a clear framework for the circulation of know-how, especially for Small and Medium Enterprises (SME). IP rights have also enabled the commercialization of new technologies, making easier for companies to appropriate part of the added value of their inventions to develop them and bring them to the market.

Patents and Trade Secrets mostly arise when there is a need to address externality emerging when there is imperfect appropriability of knowledge. Patents, in particular, are the instrument that gives the owner of the new technology the strongest possibility of exclusion. Moreover, when wide powers of exclusion are recognized and patents are granted, innovative companies have to report the value of their inventions on the market, to attract potential partners, as well as to gain new potential investors. This facilitates the reduction of information asymmetries resulting from the inability of outsiders to properly assess R&D projects. In some cases, IP rights can put the basis for various ways of collaborations and technological partnerships by promoting the transfer and diffusion of new technologies. Besides, in larger companies they often help to justify technological investments to all those who have an interest in the company.

However, the problem that emerges from the use of this type of protection system is the "duplication of efforts". In fact, the mechanism of rewarding ex-post those who first succeed in developing new technologies granting exclusive rights generates problems for all the other organizations that have invested in R&D and don't achieve any result. In other words, in the rush for development of new technologies only one can be the winner and the resources used by all the other competitors (companies) are inevitably wasted causing a loss for society (also called allocative inefficiencies).
Moreover, this race is conducted under strict secrecy, a factor that influence negatively coordination of efforts because nobody knows if other firms are investing in the same technology.
To overcome the duplication of efforts associated with exclusionary power granted by IP rights, there are usually two approaches that can be followed:

- Ex ante: entails solutions that can be put in place before the new technology is discovered, like cooperative R&D. This approach allows firms to reach a result in a faster and more cost-effective way by enabling companies to jointly develop new technology.

- Ex post: when coordination of efforts it is not possible before the creation of the new technology, allocative inefficiencies can be managed ex post through licensing. This entails paying royalties to the owner of the patent in order to get access to the new technology[15].

As we mentioned earlier, patents are the most regulated IP rights because of the broad powers they grant to the owner, but they are not the only mechanism that can give exclusive rights. Another important tool that is important to name here is "Trade Secrets". This tool allows companies to protect the most sensitive business information that generally gives a competitive advantage to the owner and a particularly useful means for the protection of tacit knowledge, in particular, uncoded know-how needed for planting and upgrading climate adaptation technologies[16]. In addition, Trade Secrets are less expensive than patents and can be granted more easily to applicants, they are extremely helpful in securing an exchange of knowledge, developing a secure channel for the dissemination of know-how[17]. Trade secrets are often combined with other intellectual property tools, such as patents themselves, thus allowing greater protection for those who use them.

Contemporarily, trade secrets are an efficient substitute for the physical and contractual restrictions that companies would otherwise put in place to avoid acquisition of their sensitive information from someone else. Without the effective protection given by trade secrets, companies would risk over-investing in other means to ensure the protection of their secrets, thereby reducing the total amount of resources invested in innovation. In fact, a Papua New Guinea' (PNG) study (Law and Innovation: Evidence from State Trade

[15] M. Granieri (2015): Intellectual Property for Managers

[16] K.E. Maskus (2012): Private Rights and Public Problems: The Global Economics of Intellectual Property in the 21st Century

[17] J. Brant, S. Lohse (2014°): Trade Secrets: Tools for Innovation and Collaboration. Innovation and Intellectual Property Series.

Secrets Laws) in 2012 shows that greater protection of trade secrets is related to increased investment in R&D.

Moreover, since trade secrets are considerably cheaper to get, maintain and apply than patents, SMEs are inclined to lean entirely over them to protect their innovations[18].

An important aspect of intellectual property management, particularly visible in licensing, is the overlap between patents (which require full disclosure) and trade secrets (which are confidential). Practically, they are often complementary to each other and can be used synergistically to obtain the best protection possible, and this is why a lot of innovations in the market are covered by both patents and trade secrets.

It is important to highlight here that IP rights are particularly useful when we talk about "open innovation" systems, which seem to be the new innovation paradigm of the 21st century. According to this model, rather than having a single company who develops and commercializes processes exclusively within the boundaries, companies work with third parties to improve the innovation process. However, this approach requires companies to protect and at the same time share sensitive information with these employees. For example, patent “cross-licensing” is a useful exchange tool that allows a company to offer its own technologists in exchange for the use of other people's innovations[19]. Considering the complexity of the technology in discussion and the global nature of climate change, open innovation is particularly important for the adoption of EST.

Patents are suitable to foster innovation, to incentivize the initial diffusion of knowledge, but, however, they are not particularly functional in increasing the dissemination of technology.

In many circumstances, the holder of the exclusive right aims at restricting the dissemination of knowledge in order to be the only one to enjoy the new invention.

For the moment it is important to keep in mind that IP rights protection determines the circulation of new technologies and the speed with which it occurs and at least in richer countries they contribute to the transfer of green technologies as well. The question that

[18] J. Brant, S. Lohse (2013): Enhancing Intellectual Property Management and Appropriation by Innovative SMEs.

[19] J. Brant, S. Lohse (2014a): Trade Secrets: Tools for Innovation and Collaboration. Innovation and Intellectual Property Series.

needs to be answered as to whether IP protection can interfere with the diffusion of EST in the least developed countries.

In "The New Climate Economy", an exhaustive study commissioned in 2014, it seems that IP rights can hinder the technology transfer of green innovations, primarily because they increase the costs to get access to those new resources and lastly because countries with poor institutional power inevitably miss the authority to make firms adopt the new know-how.
But this is not always true, evidence shows that when poor IP protection is at stake generally foreign firms tend to avoid licensing the new technology because they will be more exposed to missuses or unpaid royalties. In addition to this, weak IP rights can discourage investing in R&D activities, lacking the incentive (excludability power) generally granted to the owner of the patent, foreign venture capitalist and subsidiaries.

The situation in the least developed countries does not seem to be clear yet. A research on the protection and ownership, focuses on figures of seven emission-reducing energy technologies taken from a significative sample of low-income countries with strong intellectual property rights in 1998-2008, discovered very few patents registered, implying that intellectual property rights "cannot be an obstacle" to the transfer of green technology[20].
On the other hand, it seems that these economies do not import green technologies despite low barriers to trade and strict intellectual property rights, which are not sufficient factors for technology transfer. Therefore, in developing nations, the aim should be on building technological capacity[21] .

1.5. Technology Transfer

[20] Copenhagen Economics and the IPR Company (2009): Are IPRs a Barrier to the Transfer of Climate Change Technology?

[21] M. Glachannt, D. Dussax, Y. Meniere (2013a): Greening Global Value Chains: Innovation and the International Diffusion of Technologies and Knowledge.

Technology transfer relates to all those activities that support the displacement of a number of factors (including knowledge, manufacturing methods, technology, skills, production samples and services) from scientific research to the market.

The creation of new knowledge and its transfer are important for local cultural and industrial development. The concepts of "Innovation" and "Technology Transfer" are central in a competitive system. Innovation activities allow the development of new products, processes or methodologies able to meet certain needs or solve technical problems. Technology Transfer activities are, on the other hand, the most effective method to encourage and accelerate the cultural and methodological adaptation of companies or sectors to new innovative knowledge.

When dealing with technology transfer many definitions can be found in the world, over the last 50 years several meanings have been attributed to this term which over time has become synonymous with an increasingly wide range of activities. Generally, technology transfer is defined as the process that leads to the conversion of a given scientific research to its application in a product[22], service or production process to which an application usable on the market[23]. The term "technology transfer" often refers to: a) the granting of a protected intellectual property license to another economic entity; b) the reduction of an idea to a practice in a prototype; c) the process by which technological know-how is encoded in professional documents or patent applications. However, the term technology transfer is also identified as the systematic transfer of knowledge for the manufacture of a product, the application of a process or the provision of a service[24] (Draft International Code on the Transfers of Technology, 1985).

In the course of the history several models have been developed to schematize and analyze this process and they are all relatively complex, but I found the conceptual model elaborated by J. P. Lane very interesting and clear.

This model focuses on technology transfer as having one process, two initiating forces, three critical events, four activity areas, and five stakeholder groups. Joseph P. Lane's

[22] A. Reismann (1989): Technology Transfer: a Taxonomic View.

[23] E. Feulner (1992): Technology Transfer and information science: Vanguard of the 21st Century.

[24] K. J. Dakin (1991): Technology Transfer: Financing and Commercializing the high tech product or service from research to roll out.

intention was to exemplify the understanding of this phenomenon and some researchers considered this model as an introduction to technology transfer.

It all begins when a given technology is translated into the application of a new product or process.
Usually this phase involves the creation of ideas that are then tried to be converted into a possible practical application that usually leads to the creation of prototypes. These in turn are tested and refined until they lead to the creation of a product that has potential for the market.
At this point in the discussion, it is important to bear in mind that the requirements for a transformation clearly distinguish the concept of technology from the concept of product in order to understand the model. The technology transfer process refers to both technologies and products, whereas generally a given technology is not a product in itself, but is usually embodied in a product, in fact what often happens is that the details of the transformation process are peculiar to each transfer process.

The model under examination, as I have found in other discussions, distinguishes two forces that generally push for the creation of new technology that can be linked both to the concept of technology and product.
Usually these two forces are defined: "supply push" and "demand-pull" and are described as:

- **Supply push**: the process starts with those who have the knowledge of a given technology and want to convert it into a new product that can have a value on the market. The new product and therefore the technology it contains aim to serve a possible unsatisfied demand on the market[25]. An example would be a colour case where someone familiar with composite materials used in aircraft manufacturing could apply their techniques in the automotive, recreational and commercial construction industries.

- **Demand-pull**: this time the process starts from the market itself, first an unsatisfied need on the market is identified and an economic agent is dedicated to research and

[25] R. H. Paul (1987): Improving the new product development process: Making technology push work.

subsequent creation of a new technology that can meet that need[26]. Briefly: the demand for a product pushes scientific research towards it. An example could be someone who knows the need for lighter frames for wheelchairs and who researches new techniques to meet this need.

In the first scenario, inventors or researchers can sell the new technology applying them to products and so by transferring the new knowledge toward people who consume the product in which the technology is contained.
So on the contrary, when it comes to technologies created to meet demand, people who consume products by buying (e.g. end users and service providers) may themselves be the promoters of technology transfer, directing those who invest in technology research and development or attracting those who produce in order to meet unmet market needs[27].
In short, both types of thrusts lead the same to the creation of new technologies, the common characteristic is therefore that of recognizing an opportunity on the market that can be satisfied and this happens either because the new technology produced shows applications that can be resold on the market or because it is the market itself that shows a desire that is not satisfied in any existing product.
A case in point that has managed to meet both requirements is the Gore-Tex laminating technology. This has been successfully integrated and transferred to sportswear products because the technology provided has met a market demand for a product. Outdoor lifestyles demanded a fabric that was impermeable to water droplets but permeable to water vapor (sweat). Gore-Tex met both supply and demand.

So it is clear that as with the Gore-Tex technology under consideration, supply and demand can be two sides of the same coin. Regardless of what the type of trigger is, it is essential to understand that you cannot talk about technology transfer when there is no manufacturer on the market able to convert a given opportunity (of both kinds) into a technology that in turn can be integrated into a product.
At the same time, the above-mentioned manufacturer must be clear whether the technological solution is looking for a problem (supply push), or whether the problem is looking for a technological solution (demand-pull). This is fundamental for a better

[26] E. Von Hippel (1986): A source of novel product concepts.

understanding of the criticisms during the research process and helps to determine the starting point of this process.

As previously mentioned, the model outlines three main steps during the technology transfer process that may lead to difficulties during their development. The three phases are thus identified the idea, the prototype and the product[28]:

- **Idea**. The idea event is the phase that bring to the creation of the idea (conception of the idea). When at this initial stage it is still not possible about any tangible development, this can only be considered the birth of the idea. During this initial phase a person or a group of people confronted each other on a particular topic, giving rise to a clear concept that could take shape through the creation of a technology. Recalling the above example, one can speak of an idea when an individual (or more) recognizes that composite materials from the aerospace industry could be used in different contexts finding different applications, such as the wheelchair. These new materials could in fact give new chairs greater strength or flexibility.

  One of the major criticisms during this phase is hidden behind the tendency to consider the idea as a fact. This means that an innovator must always keep in mind whether an idea is really able to satisfy a need and whether it can really be considered new on the market. When this is not carefully evaluated most of the time this leads to the failure of the technology that expresses the initial idea. In order to prevent this from happening a possible producer must always reconnect with the market and understand through an in-depth analysis the feasibility of the idea and its novelty.

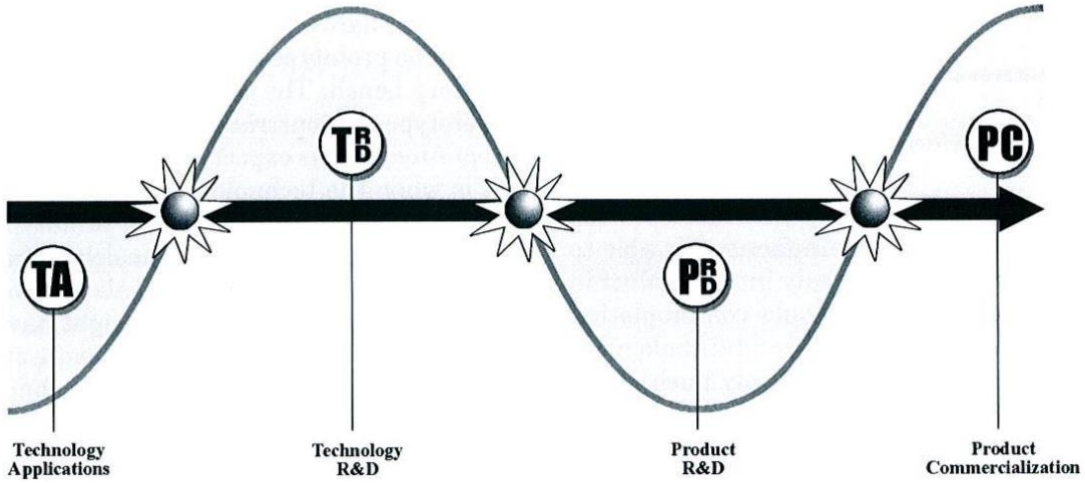
- **Prototype**. It happens when the idea of a given technology is integrated in a concrete and functional prototype. The most crucial aspect is when the prototype has to demonstrate that the integrated technology works in a real application, that occurs when the new idea is firstly integrated into a product and then tested. An example of a prototype event is when new frames from composite material were created for bicycles and wheelchair in a workshop, at first these prototypes were difficult to sell, but this was enough to determine the technological duability within those specific product applications. It is important to add here that before reaching the desired results, many prototypes might be built. Nevertheless, in the prototyping process different

[28] M. Rogers (1995): Diffusion of Innovation.

interactions need to be explored like: production options, operational features or performance parameters. The prototype event can be considered completed when a prototype fully captures the idea that has been produced during discussions. The final version of the prototype is ready to transform into a product, but firstly it is crucial to assess that the prototype still has the novelty characteristic mentioned above. This means that developers should focus on finding similar products on the market and examine patent applications submitted to the Patent and Trademark Offices.

- **Product**. This phase happens when the prototype, after its refinement, is ready for the distribution in the market. This usually occurs when the design and characteristics of the prototype appear reliable and reproducible in large quantities. As in the example above, the recent multiplication of bicycle and wheelchairs frames, together with products such as limb supports, tennis rackets and golf club shafts, show that the market is able to absorb products containing the same technology, applied to different contexts. This phase an take place in a workshop or even in a garage, but it is relevant to notice that the product will once again have to be considered new on the market, unless it is intended to compete with other existing technologies.

The model envisages that there are four activities that enclose the three steps above. The three critical steps are considered as single points in time that show the endpoint of the previous activity and the initial point for the next activity. Figure 1 represents the confines between the four activities by superimposing a sine wave on the time-line. The four resulting areas represent the technology transfer activity that includes the three critical steps: Technology Applications, Research and Technological Development (R&D), Product Research and Development and Product Commercialization.



[29]

Figure 1

Figure 1 displays several important insights. The time-line represents an anchoring for the three critical steps above as they advance from left to right.

This time-line is also the borderline between internal activity (below the time-line) and external activity (above the time-line). The internal activity can be referred to a single person to or a small group, when referring to the random thinking and discussion preceding the idea (technological application), or internal to a company, when referring to a product development project (product R&D). Whereas external activity can be referred to either a small group (e.g. in the case of the owner of the idea looking for a partner or resources to develop a prototype; Technology R&D) or external to a company (in the case of Commercialization of the Product). Both external and internal activity may require public dissemination or the need for proprietary protection, which may affect the future success of technology transfer.

The graph in Figure 1 shows the dynamism of the technology transfer. Each activity shows phases of expansion and phases of contraction, this is determined by the fact that those who are part of the process at first evaluate an increasing range of possibilities and then focus on a specific direction.

Technology application

[29] Joseph P. Lane (1999): Understanding Technology Transfer. VOL. 11

The activity of the technology application is represented by all the exploratory activities and individual ruminations that anticipate the birth of a new idea[30].

The area of technological applications is composed of the existing scientific and technological base and the potential new and innovative applications of existing technologies. Obviously all these new and innovative applications could concern the most diverse horizons of interest such as assistive technology for example. Pre-idea activity is a very important part of the technological process and should be considered as an integral part of the process itself. As such, it must be well identified from the very beginning in order to be reconstructed and documented for the purpose of recognizing the ownership of intellectual property which is at the origin of the idea itself.

Figure 1 shows how the area of Technological Applications decreases from left to right, while the boundary line has a positive slope. The decreasing area shows a gradual convergence of thought on technology and application possibilities, which develops as all the subjects involved in the process develop the conceptual maze leading to the generation of the idea. The Technological Applications area is below the timeline because this activity typically takes place within a person's mind or within a small group.

The Technological Applications activity ends precisely at the generation of the idea, because at this point, all possible new and innovative combinations of technologies and applications have been made on a specific idea. If the idea does not lead to the new and innovative application of the existing technology, it cannot be considered a technology transfer process. The development of any product, be it the design of a new aircraft or the writing of a new version of a software program, follows a similar conceptual model, but if a new and innovative application of a certain technology has not been developed, this development does not constitute technology transfer.

Technology R&D

The research and technological development activity, which starts after the development of the idea, concerns all those activities, both intellectual and physical, that must be carried out to transform the idea into a technological application in the guise of a prototype[31]. We

[30] J. Lane (1996): Products for people with disabilities: What exits and how to market your invention.

[31] T. S. Schoenecker, D. D. Myers, P. Smidt (1989): Technology transfer at land grant universities.

are in an important moment of the process in which the various actors are of the opinion that they have in their hands the possibility to develop a new product able to satisfy an expressed need (demand-pull).
Figure 1 shows us how the area of Research and Technological Development initially tends to expand. The expansion is intended to indicate how the initial phase of exploration of the prototype development process gives rise to a wide variety of possible applications. This is a delicate phase, in order to continue the process, the various participants will be forced to decide which options should be eliminated. This is shown in Figure 1 where the decreasing area indicates the scope of the technological R&D effort to focus on the chosen prototype as work continues. How easy it is to understand this is a complex technology transfer step, which inventors do not particularly appreciate.
The invention process is a stimulating intellectual effort, it may continue to generate several interesting alternatives, but it cannot remain a mere intellectual exercise.

The area of technological research and development is represented in Figure 1 above the timeline, in fact it represents all the external communication that must be carried out in order to recruit collaborators and to concretise the idea into a working model. Unless one finds oneself in a fortunate situation of unlimited financial resources and availability of all the necessary information, those responsible for technological R&D must recruit other participants in order to achieve the desired success. It will be necessary not only to develop a physical representation of the idea, but also to request evaluative feedback from producers and consumers of the final product to be realised[32].
This activity generates legal issues, including intellectual property rights and disclosure, protection (e.g. patents and trademarks) and remedies for infringements. The conceptual model obviously considers that a certain level of external disclosure is inevitable, but also necessary in order to continue the process of technology transfer. This is a critical moment in the process: if the owner of an idea or invention does not consider it appropriate to protect it or is not willing to disclose it properly, there are serious risks that the process may end.
The area of technological research and development decreases to the point where it intersects the timeline at the event point of the prototype.

32 M. Q. Patton (1989) How to use qualitative methods in evaluation.

The prototype event is the key point represented by the intersection of technological activity and product activity. This is the moment when the idea for the application of technology has physically transformed into a prototype. The prototype then becomes a tangible representation of the potential value of the technology in a new or innovative application. Sometimes the person who develops the technology is also the person who develops the product, as happens when R&D is internal to the company. In all other situations the technology developer will have to identify a product developer, i.e. a manufacturer who is able to implement the transition from technology to product.

In this phase, the time dilation and the increase of the necessary resources may also increase the risk of losing the target market, of seeing the cost of the investment rise excessively and also the possibility of a competitor developing the same product first. The other risk involved is that of not being able to find a producer to produce the product, in which case the technology transfer process would end here.
A solution to partially reduce this risk could be to attract a potential production partner at an early stage in the process. This partner could play an important role already in the definition phase of the idea, and then focus on research and technological development and prototype design to ensure that it conforms to the availability of raw materials and production capacities.

Product R&D

Product research and development consists of all those activities that are deemed necessary for the transformation of the prototype into a product that can be marketed[33]. The R&D of the product therefore starts after the development of the prototype and when the developers have found a partner who can support them in production. This phase, perhaps the most difficult of the whole process, is defined in the literature concerning product development as "the valley of death"[34]. The reason for this name is that at this stage many attempts are eliminated and only a few remaining are considered capable of responding to the required activities. These activities are related to the development and testing of working models,

[33] A. Scherer, W. McDonald (1988): A model for the development of small high.technology business development.

[34] U. S. Department of Energy (1991): From Invention to Innovation: Commercialization of new techniology by independent and small business investors.

the engineering of prototypes, the equipping and finalisation for production, and the selection and procurement of raw materials and various components to be assembled. At this stage it is extremely important to ensure the solidarity of the chosen partners and the availability of all the necessary resources, obviously if all this is seasoned with a good dose of luck the result will benefit[35]. This is certainly the time when considerable investments of capital and skills are needed, otherwise the project risks to be completed before it can be commercially viable for the market[36].

In Figure 1 the research and development activity of the product is represented below the timeline, this means that at this moment the actors in the process have decreased the demand for information externally and have focused on an internal team dedicated to the design and development of the pre-production versions of the product.

Also in this case, as in the previous phase of technological research and development activities, the people involved in this phase will create a wide variety of versions to be implemented to transform the prototype into a finished product. Some options will be more interesting, more or less expensive, more or less easy to implement, others may require various iterations within the process or follow parallel paths.

The end of the product R&D phase then comes to the solution of all these problems, as the activity is completed with the final design, which leads to the production and marketing of the product. Figure 1 shows the product R&D area that narrows to the point where it intersects with this product event.

There is no certainty at this stage. The project may be one of those that fail to pass the valley of death or the product may prove to be a commercial failure. In product research and development investments are generally very high and the losses that may occur are significantly higher than those that may occur in previous phases.

Product Commercialization

Product Commercialization comprises all activities related to the production, distribution, sales and marketing support of the product. The activities related to this phase are very important for the technology transfer process, because the decision of a company

[35] HUSAT Research Institute (1996): USER fit – A handbook on user-centred design for rehabilitation and assistive technology.

[36] U.S. Navy (1997): Critical path templates and BMP templates.

evaluating a transfer opportunity will always be strongly influenced by all "downstream" costs. But successful commercialization often requires a substantial and constant investment from the manufacturer and if commercialization is not successful no one will get the expected royalties.

Figure 1 shows the commercialization activity positioned above the timeline as the product is placed on the market. The area of product commercialization activity originally grows as it shows the investment and support activity for the product as its market share grows. When the product reaches maturity, the area will tend to flatten out and decrease as sales and market share decrease. Eventually, the area may even stop if the product is replaced by a more innovative or simply by an improved product.

Stakeholder group	Members of stakeholder group
Technology Producers	Independent inventors; researchers in university, federal, or corporate laboratories.
Technology Consumers	Private sector manufacturers; government agencies; intellectual property brokers.
Product Producers	Private sector manufacturers; distributors; value-added retailers.
Product Consumers	End users; family members; professional service providers.
Resource Providers	Government agencies; private insurance companies; technology transfer intermediaries.

[37]

Figure 2

Five Stakeholder groups participate in the process, every kind of transfer implies transactions between at least two parties. Both Technologies and Products have producers and consumers. In order to conduct the technology transfer process all producers and consumers necessitate internal or external resources. Figure 2 introduces stakeholders groups, they all give vital contribution to the technology transfer process[38]:

- **Technology producers**. This group includes inventors and researchers who are responsible for generating the idea that matches the technology with a new application. Technology Producers looking for resources or expertise to develop their projects often seek for Technology Consumers to gain extra capacity.

- **Technology Consumers.** The Technology Consumers convert technologies into prototypes. These include private sector manufacturers looking for new products based

[37] Joseph P. Lane (1999): Understanding Technology Transfer. VOL. 11

[38] G. Verberg, S. McPherson, L. Blancher, J. Blancher (1993): Consumer researcher, industry collaboration: An approach to device and appliance evaluation.

on advanced technologies, intellectual property brokers in the business of reselling technologies or government agencies having the mission of employing innovative technologies to fulfill national needs.

- **Product Producers**. The Product Producers transform prototypes into products. They are manufacturers, distributors and added value retailers who sell products but also services to support the products. Often Technology Consumers provides tests and prototypes to facilitate the transfer process and sometimes involves Product producers during the testing phase to obtain useful information for making good business decisions.

- **Product Consumer**. The Product Consumer is the final customers who use the products and services. They represent the demand side of the supply/demand equation looking for new enhanced products to meet their requirements. Product Producer attention is fully focused on Product consumer satisfaction. The Product commercial success is fully linked to the capability of the new Product to meet Consumer expectations.

- **Resource Providers**. Resource Provider is an important group that includes government, private entities, insurance, professionals, intermediaries and programs that provide financial support, content expertise and technical expertise to fund and conduct technology transfer. The Resource Providers are involved in all steps of the technology transfer and are crucial for those Products with small or very small markets (assistive technology).

1.6. The issue with the Technology Transfer for EST

One of the greatest challenge of the world for policymakers today is tackling climate change. They need to design a legal framework that could facilitate and incentivize the innovation process of new green technologies and their adoption and dissemination even in least developed countries. Due to a number of uncertainties and difficulties, adoption and diffusion of EST create issues that need a series of political intervention among which an

efficient policy framework. This thesis has the purpose to deepens some issues related to technology transfer by analyzing relevant literature concerning the process of innovation an dissemination of EST. In other words the scope of this work is to analyze enabling factors for the effective dissemination of green technologies considering the role of intellectual property rights. The most important question to bear in mind while reading this thesis is: do Intellectual Property (IP) rights foster or hamper the diffusion of new green technologies in developing countries?

Most studies in recent years suggest that while developed countries consider IPRs as a key incentive for the development and diffusion of new technologies, by contrast developing countries see IPRs as a major obstacle to the rapid transfer and the largest possible dissemination of such technologies.
This dichotomy is clearly expressed in the next two opposite examples. The first: "Climate Change and Intellectual Property" (2009), a report by the International Chamber of Commerce, concludes that "*far from being a barrier to the dissemination of the vast breadth of technologies needed to address the climate challenge, IPRs assure necessary private sector investment in the invention, development, and deployment of the technologies needed to reduce emissions*". The second is a publication by the non-profit organization Third World Network, entitled "Brief Note on Technology, IPRs and Climate Change" (2009), argues the opposite: "*Developed countries should not treat patents or IPRs as something sacred that has to be upheld at all costs. That would send a signal that climate change is not a serious threat, as commercial profits for a few are more important on the scale of values and priorities than are the human lives that are at stake due to global warming. Technology transfer to developing countries to enable them to combat climate change should be the far higher priority*".

First of all, it is important here to define which are the privileges these tools grant to the owner.
The patent system is the mechanism that awards inventors of innovative technology with a protection, which gives them the exclusive property rights to the invention.
This means that the inventor alone has the right to prevent anybody else to use the invention to make profit from it, and to amend it.
Without the property right, the inventors would have to protect their invention by keeping it secret. This would be tedious and detrimental for the business of the inventor, and if

everybody keeps their inventions a secret, the general growth of society would be extremely slow. Thus, patents grant the protection to inventors, while opening the knowledge up to the society. This increases transparency and dissemination of knowledge and prevents free riding and imitation.
However, patents might also delay the market flow and increase prices.

One criticism is that although patents can stimulate innovation by promoting the initial dissemination of knowledge, other than licensing, they are not particularly aimed at increasing the dissemination of technology.
This is a heavy issue which questions an entire global system of IPRs, as well as the legitimacy of international agreements such as the TRIPS, because, in the end, they play a big role in whether IPRs are suitable to deal with the important issue of green technology diffusion.
The biggest difference with monopolistic position is that the owner of an IPR can only prevent others from using, making and selling his property but law does not say anything on how to use that excludability power to gain a monopolistic position in the market. The ratio behind IP protection is rooted, as we have said, in the belief that granting private property generates value that incentivizes investing in innovations.

This can be seen straight if we compare this scenario to another where a regime of commons rules[39]. In this scenario nobody has a real interest to invest in R&D because the added profit generated from the creation of a new technology would be shared with other firms. That's why even if exclusion generates cost for the society every decision related to the creation of exclusive power should be taken as a trade-off decision between what will be lost in terms of excludability and what can be reached with the creation of a new technology.
That being said, it is important here to stress that IPRs should be evaluated also for their ability to transfer EST technologies even in developing countries.

But why it is so crucial that these policy tools could work also for developing countries where companies are poorly oriented toward innovation and green practices?

[39] M. Granieri (2015): Intellectual Property for Managers.

First of all because these economies, as we have seen before, seem to be the first that will face problems due to the "Global Warming" because their economies are heavily rooted upon agriculture that can change due to climate changes.
Secondly because these countries, having the cost of labor that is generally much less than what is paid in richer countries, are usually seen as an opportunity for companies to outsource manufacturing activities and R&D activities in the case of skilled labor.
Lastly, low-income countries can be considered potential new markets for products and technologies coming from richer economies.
For all these reasons emerging economies need to embrace policies that could help them to achieve concrete and measurable progress to stimulate economic growth and to promote environmental sustainability.
That's why effective responses to climate are becoming mandatory both in public and in private sectors, especially when the new technology has all the features of a public good.

Bearing this in mind, it becomes even more important now to deal with IP rights to see if they can really facilitate the creation and diffusion of EST technologies.
From one side IP protection, granted through patents and other IPRs, are an essential tool for the creation of new knowledge (and so for the creation of EST), especially in those countries that have enough resources to invest in R&D. But what about developing countries?
These realities don't have enough funds to invest in R&D or to pay licenses, how in this regime can IPRs incentivize the creation of new green knowledge and at the same time how can it favor the diffusion of this new technologies even in the poorest regions of the world? As said previously, the issue becomes crucial especially when dealing with technologies and skills that need to be adopted on a mandatory basis against "Climate Warming".
IP rights can be used as a tool to enhance market power of companies as well as an efficient strategic asset for the creation of competitive advantage, but the intention of this thesis is to analyze in which way they can be designed to make them a useful instrument also for the dissemination of new EST and to address climate change.

2. Legal Framework for Technology Transfer

2.1. The evolution of Technology Transfer

Over the last few years, a large number of academics and experts from a wide range of fields have offered their point of view to analyze the connection between IPR and technology transfer, but the discussion is still open and there is no agreed consensus on some topics.

To better deal with the complexity of the problem related to the role of intellectual property transfer, the first step is to examine how IPRs have been addressed throughout history and how they have been tackles in environmental law issues.
Today the most relevant international commission to address Global Warming issues is the United Nations Framework Convention on Climate Change ("UNFCCC"). However, this body follows a number of issues and the transfer of green technology covers only a small part of the wide range of objectives addressed by the UNFCCC.

In 1988, the two United Nations organizations, the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO), created the Intergovernmental Panel on Climate Change ("IPCC"), which is still considered to be the main scientific and technical body of the UN with the objective of analyzing climate change. The main function of the IPCC is to publish "assessment reports" on a cyclical basis. In 1990 the IPCC published its first report, which later became the basis on which the UNFCCC is based.
In 1992 the UN Earth Summit in Rio de Janeiro, together with the "Convention on Biological Diversity" and the "United Nations Convention to Combat Desertification", led to the creation of the UNFCCC.
Officially, it was not until 1994 that the UNFCCC entered into force and since then has been the main international instrument addressing climate change issues. Every year since 1994, Parties to the Convention have met in rounds called "Conferences of the Parties" (COPs) to consider how to promote the creation of EST and their adoption and dissemination worldwide.

The role of IPRs was already part of the discussion within the Montreal Protocol which aimed at analyzing ozone-depleting substances (1987) but it had to wait until the 13th session of the Conference of the Parties in 2007 in Bali (COP-13) for these rights to be assessed for their impact in relation to the transfer of technology related to Global Warming. Already in those years the issue was no different than we are used to seeing it today, developing countries (Cuba, India, Indonesia, Tanzania and China) were used to seeing IPR as a barrier to the spread of these technologies while countries like the United States looked at IPR as a strong instrument that should remain strong in international intellectual property laws.

So only after 2007 with the Bali Action Plan, the UNFCCC was the real moment when the importance of IPR in relation to technology transfer was stressed and addressed.
However, after Bali COP-13 the discussion on IPR was temporarily shelved and only in 2010 the plan was resumed during the Cancun Conference during the first meeting of the UNFCCC's Technology Executive Committee ("TEC").
At that time, India was asking for a further discussion on these rights, arguing that IPR leads to "prohibitive costs" on crucial technologies. In 2010 the creation of the Technology Mechanism, consisting of two main bodies, the Technology Executive Committee (TEC) and the Climate Technology Centre and Network[40] (CTCN), seriously helped countries to facilitate the adoption of CRTs that could help them address climate change issues, but many challenges remained unresolved.

Subsequently, several meetings focused on the analysis of the issue and several independent organizations took part in the discussion. The International Association for the Protection of Intellectual Property ("AIPPI"), established a Committee (Q189), called "IP and Green Technology", which was created with the intent to clarify the relationship between environmentally friendly technology transfer and intellectual property rights.
In recent years, several reports have been created by "The International Centre for Trade and Sustainable Development" ("ICTSD") Programme on Innovation, Technology and Intellectual Property to discuss different issues related to this topic.

[40] A. A. Latif et al (2011): Overcoming the Impasse on Intellectual Property and Climate Change at the UNFCCC: A Way Forward.

In 2012, the UNFCCC Working Group on Long-term Cooperative Action (AWG- LCA) tried to propose different solutions on how to address intellectual property rights in order to facilitate the implementation of plans supported by the UNFCCC. In addition, the Climate Technology Centre and Network (CTCN) and the Technology Execution Committee, which deals with policy issues, were created in 2012 to further accelerate the technology transfer process.

2.2. UNFCCC

Since the creation of the UNFCCC, the transfer of green technology has been seen as one of the key issues to be resolved in order to address what appears to be the main objective of the Committee, which is the "*stabilization of greenhouse gas concentrations in the atmosphere at a level that avoids dangerous anthropogenic interference with the climate system*"[41].

The two principal ways in which climate change must be tackled have been identified over the years in climate mitigation and adaptation technologies.
In order to enable the dissemination of these techniques, the process leading to the creation of innovation and the global dissemination of this technology are of utmost importance. This is why, as can be seen in the articles below, the development of green technologies, as well as their transfer have always been a critical point of discussion for the UNFCCC, that states:

Article 4.1 "*All Parties ... shall: (c) Promote and cooperate in the development, application and diffusion, including transfer of technologies, practices and processes that control, reduce or prevent anthropogenic emissions of greenhouse gases..."*

Article 4.5 "*The developed country Parties ... shall take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound*

[41] UNFCCC (1992): Rio, Earth Summit.

technologies and know-how to other Parties, particularly developing country Parties, to enable them to implement the provisions of the Convention..."

To sum up, the main negotiations taken from the UNFCCC are described in the table below[42]:

[42] A. Goldar, S. Sharma, V. Sawant, S. Jain (2019): Climate Change & Technology Trasnfer – Barriers, Technologirs and Mechanism

Date	COP/Summit	Key Outcome/Mandate
1992	Rio, Earth Summit	Technology development and diffusion – Fourth Commitment of the parties in Article 4
1995	Berlin, COP1	Establishing an inventory of technology transfer projects; investigating technology transfer financing; establishing networks of technology centres and identifying needed adaptation technologies
1997	Kyoto, COP3	Decision to consult with the Global Environmental Facility (GEF) and other relevant international organisations to support the work of (an) international technology information centre(s)
1998	Buenos Aires, COP4	Buenos Aires plan of action – called on industrialised countries to provide lists of publicly-owned, environmentally sound technologies and on developing countries to submit reports outlining their technological needs
1999	Bonn, COP5	Subsidiary Body for Scientific and Technological Advice (SBSTA) to hold consultations among parties and outcome of the process to incorporate a draft text on a framework for meaningful and effective actions to enhance the implementation of Article 4.5 of the Convention
2001	Marrakech, COP7	Adopted technology framework; established expert group on technology transfer (EGTT)
2002	New Delhi, COP8	SBSTA to conduct consultations and facilitate collaboration among expert groups established under the Convention, to the extent practicable, on their work programmes on cross-cutting issues, including those relating to technology transfer and capacity-building activities
2004	Buenos Aires, COP10	Encourage parties to undertake joint research and development programmes/projects between Annex II parties and parties not included in Annex I
2006	Nairobi, COP12	Extension of EGTT for one year including its current membership
2007	Bali, COP13	Identify technology as one of the four pillars of an expected post-2012 climate change regime; collaborative research and development
2008	Poznań, COP14	Strategic programme on technology transfer; provision for Global Environment Funding for climate technology development and transfer activities
2010	Cancún, COP16	Establishment of a Green Climate Fund and a fully operational technology mechanism to promote innovation by 2012; setting up the Technological Executive Committee (TEC) and Climate Technology Centre & Network (CTCN); conclusion of EGTT's role
2011	Durban, COP17	Arrangements to make the technology mechanism fully operational in 2012
2012	Doha, COP18	Arrangements to make the Climate Technology Centre and Network (CTCN) fully operational, report of the Technology Executive Committee (TEC) and enhanced action on the provision of financial resources and investment to support action on mitigation and adaptation and technology co-operation
2013	Warsaw, COP19	Adoption of the modalities and procedures of the CTCN
2015	Paris, COP21	Paris Agreement, to identify linkages between the technology mechanism and the financial mechanism of the Convention, and to enhance climate technology development and transfer through the technology mechanism
2017	Bonn, COP23	Report on the independent review of the effective implementation of the CTCN and renewing the memorandum of understanding between the Conference of the Parties and the United Nations Environment Programme regarding the hosting of the Climate Technology Centre
2018	Katowice, COP24	Requested subsidiary body for implementation to assess progress in enforcing the linkages between the technology mechanism and the financial mechanism to recommend a draft decision on strengthening the technology mechanism and financial mechanism linkages for consideration and adoption at COP26.
2019	Madrid, COP25	The Subsidiary Body for Scientific and Technological Advice (SBSTA) and the Subsidiary Body for Implementation (SBI) considered the performance and activities for 2019 of the two bodies of the Technology Mechanism, the Technology Executive Committee and the Climate Technology Centre and Network (CTCN). The SBI also initiated its consideration of the alignment between processes pertaining to the review of the CTCN and the periodic assessment of the Technology Mechanism. In addition, the SBI considered the GEF progress report on the Poznan strategic programme on technology transfer and the recommendations contained in the updated TEC evaluation report of the Poznan strategic programme.

Table 2

As seen before, the principal task of the UNFCCC is stabilizing greenhouse gas concentrations in the atmosphere in order to impede dangerous anthropogenic interference with the environment and especially toward the climate.

The Convention serves to provide an open field of discussion for all the countries that are party to it, where everyone can freely communicate their interests for the future and internal issues.
The UNFCCC also provides useful documents for future meetings, tracks COP decisions and collects conclusions from the Subsidiary Body for Scientific and Technological Advice (SBSTA) and the Subsidiary Body for Implementation (SBI).

In order to better understand what is at the basis of the Global Technology Transfer logic, it is useful to retrace all the most important historical phases, the main conventions and the most relevant institutions that have contributed to the creation of the project. A recent United Nations publication recounts the 20 years of history of the Framework through the description of five key moments.

The report shows that since 1992 the UNFCCC has proven to be a tool to support member states during the process of climate technology transfer both locally and internationally.
In recent years, something around 90 developing nations around the world have at least partially managed to address some of the technological needs of climate change while at the same time trying to improve their internal development level. In recent years developing countries have implemented more than 800 projects with mitigation technology transfer targets and the Global Environment Facility (GEF) has managed to support the success of these projects with more than USD 45 billion in funding and co-financing. Furthermore, over the last 20 years the GEF has invested nearly than USD 1,7 billion in over 350 projects worldwide with the objective of transferring adaptation technologies[43].

The mentioned summary includes works on technology through the consultative process, Technology Transfer Framework, Technology Needs Assessments, and the Technology Mechanism and describes the central role of these instruments in relation to climate change technology.

[43] Global Environmental Facility (2019): FINANCING ADAPTATION TO CLIMATE CHANGE AT THE GLOBAL ENVIRONMENT FACILITY

In my opinion is not possible to talk about the framework without mentioning all the steps that gave birth to the actual framework itself for the technology transfer[44]:

- **The Beginning – 1992**

Preventing "dangerous" human interfering with climate and transferring technologies to support an international action against climate change, constituted the foundation elements from the beginning of the UNFCCC process. The first convention was arranged in the 1992, and as we have seen in the previous section, yet in this first step, countries stressed the importance of Climate Related Technologies. (art. 4 par 1 and 5).

It is important to underline that when UNFCCC took effect, there wasn't much scientific evidence on the issue and the convention was quite remarkable for those times.
The UNFCCC draw a line from the previous Montreal Protocol, probably the most important environmental treaty in history (1987): the Convention aims to assess the vulnerability of countries to the effects of climate change and calls for a real financial effort to address this challenge and this is particularly true for those countries suffering from funding shortfalls.

- **Consultative Process 1995-2001**

At an initial stage, countries where mostly concerned with achieving a common consensus at a global level of the various issues related to climate change.

The first phase focused on: exploring all the information available on the innovation process and on the technology transfer; the principal technological needs of developing countries; the mechanism through which the international community provides support; and which technologies or products could have helped reducing GHG emissions and adapting to climate change.

In the years 1997 to 2001, starting with the more sensitive issues mentioned above, countries, that where seeking a global action engaged in a consultation process on the transfer and development of climate-related technologies. Local level workshops in

[44] UNFCCC (2016): Technology and the UNFCCC: Building the foundation for sustainable development.

Latin America and Africa, the Pacific, Asia and the Caribbean have helped to uncover a wide range of climate technology issues at national, regional and international level.

In addition, a technology provision was introduced in 1997 under Article 10(c) of the Kyoto Protocol with the intention of encouraging the development and transfer of climate technology). Article 10 says:

"*All Parties...shall: (c) Cooperate in the promotion of effective modalities for the development, application and diffusion of, and take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies...in particular to developing countries...*"

- Technology Transfer Framework 2001-2010

With the clear intention of fixing what we have defined as "common consensus" on existing climate issues, reached with the above mentioned "Consultative process" in 2001, the countries belonging to the UNFCCC moved to create the "Technology Transfer Framework", still known today as the official reference framework that aims at the effective implementation of Art. 4 paragraph 5 of the convention.

In addition, during this period, the United Nations have set up the so-called Expert Group on Technology Transfer (EGTT) in order to support and facilitate the adoption of this Framework.

In the Technology Transfer Framework five key topics are covered:

- Technology needs and needs assessments
- Technology information
- Enabling environments for technology transfer
- Capacity-building for technology transfer
- Mechanisms for technology transfer

Moreover, in 2007, Nations identified 4 sub-categories underlying the different technology transfer mechanisms; these new sub-categories are: innovative financing,

international cooperation, endogenous technology development and collaborative research and development.

During these ten years, both the Technology Transfer Framework and EGTT have helped developing countries to overcome the various issues related to technology transfer and have supported several countries in the adoption of new processes and techniques.

It is important to add that in many cases these new support mechanisms have also often contributed to the consolidation of processes for assessing internal issues and thus the specific needs of each country. When developing countries clearly identify their technological needs, EGTT helps them to understand how to make the best use of the technology financing and how capacity building can facilitate the creation of local solutions to their problems.

Regional guidebooks and workshops started to take place at the same time and qualified project developers started to prepare project proposals for funding. These forms of funding put the basis in 2008 which then led to the creation of the Global Environment Facility's Pozna Programme, which was designed to urge the GEF in facilitating the long-term adoption of green technologies.

The EGTT, on the other hand, was therefore able to monitor the effective implementation and effectiveness of this Framework and generated several paths to be followed in order to effectively achieve technology transfer also in the long term. However, a few years later, the EGTT's mandate expired in 2010, giving way to the Technology Mechanism and the UNFCCC requested the Technology Executive Board (TEC) to accelerate the implementation of the Technology Transfer Framework.

Technology Needs Assessments

One of the most useful tools within the Technology Transfer Framework was probably the Technology Needs Assessments. This tool in fact allows developing countries to have at their disposal a series of activities that can help them to understand their real needs in technological terms in order to better face the climate challenge. Since 1999, resulted to be quite effective and until now almost 90 countries have used this tool to identify their needs.

The system allows for:

- Finding tools to face climate changes and enhance the development at a national level
- Achieve national sustainable development through the creation of national capacity
- Develop action plans to show feasible implementation of new technologies

The Global Environmental Programme (GEF) grants support to developing nations to assess the TNAs, together with the United Nations Environment Programme (UNEP) in partnership with the Technical University of Denmark (UNDP), and the United Nations Development Programme. Nowadays the UNDP is trying to implement the GEF-funded TNA Global Project (phase 2) which helps 24 countries providing them with funds and technical support to follow the TNAs. In the next 2017 those participating countries should present their results on their TNAs.

Climate Finance

As we just mentioned, the Global Environment Facility (GEF) and the Green Climate Fund (GCF) give financing to least developed countries to implement climate related technologies.

As of 1991, more than 800 projects, and more than USD 5 billions of funds and USD 40 billions in co-financing have been made by the GEF with the intention to transfer mitigation technologies. The GEF has also facilitated thanks to the "Least Development Countries Fund" and the "Special Climate Change Fund" the transfer of adaptation technologies. These two have demonstrated to be an efficient tool for the transfer of such technologies and supported more than 300 projects with adaptation technology transfer goals providing more than one billion USD.

Moreover, since 2009, GEF sustained climate technology activities through the Poznan Strategic Programme. The programme, has been set with a budget of USD 50 million with the intention to increase the level of investments for technology transfer, thus helping developing countries addressing their necessities of EST.

The GCF, which began in 2015 dispelling resources, will have a critical role in sustaining countries to adapt to Climate related technologies. To accelerate the process of tech transfer to enable climate actions, countries are improving the connections between the UNFCCC Financial Mechanism and the Technology Mechanism.

- Technology Mechanism – 2010

In 2010, countries put more efforts into climate technology and established the Technology Mechanism.

The Technology Mechanism is composed by two complementary sections: the Technology Executive Committee (TEC) and the Climate Technology Centre and Network (CTCN).

The TEC analyses technology policy questions and gives recommendation to help countries in improving their climate technology activities and generally is considered the policy arm of the Technology Mechanism. It is composed by 20 technology experts which represent both developing and developed countries.

On the other side, the CTCN is considered the implementation function. It provides three central services: technical support based on the request of developing countries; free availability to knowledge on climate technologies; collaboration among CRT participants. The UNEP together with the United Nations Industrial Development Organization, hosts the CTCN, thanks to the support of 11 partner institutions.

Since its was founded, the TEC has become a real policy support for green technologies. It focuses on current issues related to climate technologies and works on possible policy solutions for countries. TEC has addressed problems such as: enabling environments and innovation; climate technology financing; technological needs; mitigation and adaptation technologies; technology research, development and demonstration.

The CTCN has made itself as a center that could support climate technology know-how and information. It has a global network of more than 150 organizations which support developing countries to find climate solutions. Since 2016 the CTCN is supporting, on climate technology issues, more than 100 requests from least developed countries. The huge number of requests deals with a wide range of both mitigation and adaptation matters and shows the various problematic that each country has to face.

Today more than 140 nations have established national entities that could help them in submitting requests to the CTCN for technical help.

- **Paris Agreement 2015 onwards**

In Paris in 2015, UNFCCC member states countersigned an innovative agreement that represents a real milestone on the road to a global action toward climate change. The agreement, also known as COP 21, put the basis for the development and transfer of climate technologies, but differently from the past.

At this stage, countries secured the so-called Technology Mechanism and gave it a central role in the implementation of the Paris Agreement. In addition, the Technology Mechanism has been reinforced, requiring further investments in research, development and technology demonstration for EST.

The Paris accord has also established a technology framework that can serve as a general guide to the use of the Technology Mechanism and in the coming years countries are expected to use this framework more and more to improve their technological attempts. The Technology Mechanism and the Technology Framework will help countries in limiting Global Warming and adapting to climate change.

Moreover, the Paris Agreement establishes a long-term view on climate technology, in fact Article 10, paragraph 1 states**:**

"*Parties share a long-term vision on the importance of fully realizing technology development and transfer in order to improve resilience to climate change and to reduce greenhouse gas emissions*."

2.3. TRIPS Agreements

History of Trips

Today, the present legal and political framework that governs intellectual property (IP) and technology is embodied in the Agreement on Trade-related Aspects of Intellectual Property

(TRIPS). Actually, it is not clear yet if it influence negatively or positively the diffusion in developing countries of both adaptation and mitigation technologies.
Before TRIPS, developing countries in general had feeble intellectual property rights regime (IPRs) while developed countries had robust systems of IPR protection. The industrialization process of modern economies in the 1970s and 1980s stressed international IP laws, concerning developed nations. From one side, developing countries wanted easier access to patents, considered commercial monopolies after the Paris Convention (1884), while Western nations were mostly worried that such policies could have expropriated private property[45].

At that time the institution governing global legislation upon IPR was the General Agreement on Tariffs (GATT) used principally in European nations, in the United States, and in Japan. Unlike WIPO, GATT had an enforcement mechanism, and under request of developed nations, a stricter patent protection was negotiated.
It was just during the Uruguay Round in 1994 that countries reached an agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS), an international accord on standards and regulations for the protection of intellectual property. Seven years and a half was the time needed for negotiations and for the implementation of the World Trade Organization and its inauguration in 1995. Incentivized by industrialized nations, confirmation of TRIPS was mandatory for WTO membership, thus assuring that developing nations accepted an applicable intellectual property system.

In 2001 in Qatar, during the fourth Ministerial Conference in Doha, developing countries tried to expand the scope of the TRIPS agreement because richer countries were making too stringent interpretations of the Treaty, as the enforcement of patents for pharmaceutical products vital for combating mortal diseases. Tensions regarding public health escalated fastly as developing nations got stuck in a situation where from one side, they were facing health emergencies and from the other they were struggling with high prices and lack of sufficient access to key pharmaceutical resources[46].

[45] P. Lewis, (1982): U.S. and the Third World at Odds Over Patents. New York Times, October 5, 1982.

[46] Intervention by H. E. Mons. Diarmind Martin at the Fourth Ministerial Conference at Doha. (Qatar, 2001).

Although Article 31 of the original TRIPS Agreement enabled compulsory licensing of drugs in the event of a national emergency, after exhausting all possible options for licensing, lowest developed nations were asking for both easier access to patented drugs (or cheaper generics) and an increase in the scope of a "national emergency" to include a range of epidemics and diseases. In contrast, developed nations believed that extending the definition of health emergency could have potentially led to the inclusion of non-epidemic diseases. After many negotiation and litigations, in 2003 WTO members reached an agreement and modified and expanded TRIPS compulsory licensing of pharmaceutical drugs in cases of public health emergencies[47].

TRIPS agreements and the technology transfer

The WTO TRIPS Agreement mainly deals with developing a safe environment for investments and trade by patent holders.

The TRIPS Agreement sets stringent minimum requirements for the protection of intellectual property that can provide a favorable context for a climate change regime. As previously said TRIPS does not treat specifically climate change technology or environmentally sound technologies (ESTs), hence developing nations chased protection on public health topics by recalling Article 31(b):

"..In situations of national emergency or other circumstances of extreme urgency, the right holder shall, nevertheless, be notified as soon as reasonably practicable"

Through the statement above, least developed countries could have access to ESTs thanks to compulsory licensing, as we will discuss later on, by defining climate change as a national health emergency, but it was clear since then that ESTs are not equal to pharmaceuticals[48]. First of all ESTs require many diverse technologies (generally owned by different firms) while drugs are generally protected by only one patent; secondly, a specific drug is unique while green technologies are sometimes interchangeable. The different characteristics of ESTs compared to pharmaceuticals, brought ESTs being

[47] P. Boulet, P. Hanvoravongchai (2003): IPR, Innovation, Human Rights and Access to Drugs.

[48] Copenhagen Economics A/S and The IPR Company ApS, (Copenhagen: 19 January 2009): Are IPR a Barrier to the Transfer of Climate Change Technology?

handles outside the field of public health within TRIPS. Finally, coupling ES technologies to public health and other national emergency provisions threatens to allow an unfairly broad interpretation of the agreement as, under TRIPS, "*each Member has the right to determine what constitutes a national emergency, or other circumstances of extreme urgency*." Thus, WTO members may use compulsory licensing in "a very broad set of circumstances"[49].

As a result of the package generated by the WTO agreement, developing countries have succumbed to the demand from developed nations to have more stringent intellectual property rights than before, but in return developing countries have achieved greater market opening by richer countries. The sectors where this was most evident were agriculture and textiles.

An important feature of the TRIPS Agreement is the possibility of removing certain technologies from the protection that is usually granted to patent holders. Depending on the case, these exemptions from IP rights are specifically designed to be better adapted to each country's unique needs.
This instrument could, on the one hand, encourage the adoption of new climate techniques by low-income developing countries, thus providing for the exclusion of certain climate-related technologies. On the other hand, developing countries with high average incomes could be granted license for the use of certain technologies through voluntary licenses that do not necessarily provide for remuneration for the patent holder. In agreement with TRIPS, the country dimension could also be used as a useful tool for choosing the most appropriate type of flexibility. In fact, one case could be where a small developing country, even if it has a medium-high income, does not find it economically sensible to invest in a license containing a climate technology. The situation could only change if such a license is granted at no cost and the developing country's sole purpose is to take advantage of the outlet to new possible export markets. Indeed, royalties at no cost, or at least heavily reduced, could be extended from a national to a regional market.

This is therefore one of the major turning points of the TRIPS Agreements, given that it appears to be the possibility to have access to a technology even if patented and without

[49] World Trade Organization, The Uruguay Round Agreements (Geneva: 1994): Agreement on Trade Related Aspects of Intellectual Property Rights. Article 5.2.

the consent of its holder, in case public or national emergency situations require a timely intervention.

One of the major difficulties that may arise in relation to the use of this instrument is the vagueness of the regulations that define the circumstances in which it can be used. In terms of climate change technologies, it has recently been studied that carbon dioxide is a pollutant that endangers public health. This has also made it possible to use these instruments for pollution-related issues which, as we have seen above, are related to public health issues.

In order to avoid abuse of these concessions and to push investment in possible new technologies, the TRIPS agreements severely limit the transfer of a given license by the person who has already bought it to any other economic agent. This is the case of a producer who has been granted a license and who may be tempted to transfer the technology back to another producer. It is true that, on the one hand, the increase in 'parallel imports' usually results in lowering the costs of a particular good on the market[50], but, on the other, the occurrence of such a situation would profoundly undermine the drive for innovation of many entrepreneurs. For this reason, the TRIPS limit the use of the concession to the internal market only, even if a well-balanced agreement should on the one hand favor the diffusion of a technology (especially if instrumental to overcome environmental issues) and on the other should encourage private initiative to invest in these same technologies.

Once again, therefore, it is important at the regulatory level to recreate a framework that can promote investment in R&D both in favor of creators and possible users, with the ultimate goal of increasing the overall welfare rate of the community.

Since sometimes limiting the diffusion of technologies on the market undermines the development of economies of scale that could make the technology more economically attractive,

There are historically cases where the law has derogated from certain provisions, such as in the pharmaceutical sector, where the so-called licenses are in the past extended beyond internal borders trying to encourage the development of economies of scale for products that should in theory serve public health more than private profit.

[50] P. Fortunato, R. Kozul-Wright, R. Vos (2009): Technology Transfer and Climate Change: Beyond TRIPS.

In summary, it is not surprising that there is no clarity about the effect that strong patent protection on technology transfer in developing countries can produce. The debate at this point is mainly focused on the complex dynamics and significant compromises that can result from the adoption of a system of strong patent protection. It is obviously impossible to define the right level of patent protection because the benefits and barriers to technology transfer will vary depending on different factors such as the type of technology, the industry concerned and the country in question. According to TRIPS, developing countries must comply with minimum standards of protection, which means 20-year patent terms and cannot favor innovation on national industries. Probably this will not be an incentive for all countries, especially for those who do not have the capacity to license new technologies or who do not attract the FDI that the stronger patent laws provide. TRIPS are likely to be a barrier to technology transfer[51] in all situations where minimum levels of patent protection make technologies prohibitive (and for which developed countries do not pay through development assistance or GEF) or fail to attract FDI. LDCs have to identify to which degree strong patent protection supports development of their economies via technology transfer. The TRIPS agreement provides great flexibility on what is patent-protected, on which principles, how claims should be handled, allowed exceptions, compulsory licensing and anti-competitive practices. In the opinion of many experts, this flexibility represents a great opportunity that developing countries can draw on with satisfaction[52].

[51] Li, Qiu (2014): IPR, Trade, FDI, and technology.

[52] JH Reichmann (1997): From Free Riders to Fair Followers: Global Competition Under the TRIPS Agreements

3. Channels and Barriers to EST Transfer

3.1. Major channels for Technology Transfer

The concept of Technology Transfer was born from the necessity to promote and smooth the transfer of results and knowledge from the world of research to that of industries, companies and institutions. As discussed earlier, it becomes clear now that it is almost impossible to talk about ESTs and their adoption in the market without mentioning technology transfer.

The key channels for technology transfer are: international Trade in intermediate goods; Foreign Direct Investments (including Joint Ventures) and Licensing. These channels differ from one another in terms of diffusion mechanism and the extent of knowledge transferred:

- Trade: It is the case of a country importing technology and capital goods from a foreign developed country. Usually this process is activated in order to improve the production techniques of the host country, through the purchase of machinery and capital goods from a more advanced nation. The trade thus allows an advancement from at least two different sides: from an engineering point of view new scientific capacities are acquired by the host country, and secondly many trades may give birth to advantages because it allows the creation of possible trade relations on a global scale.

- Foreign direct investment (FDI): Looking at recent history FDI has probably been the most important driver of technology transfer for the wind energy sector[53]. It occurs when a large foreign company decides to invest in a foreign country through the establishment of an owned subsidiary. This process allows for a transfer of technological skills and knowledge to the host country, which in many cases results in a spill-over of knowledge more effective than pure trade. In fact, in this case the receiving country is able to learn directly from the company that owns some

[53] J. F. Kirkegaard, L. Weischer, T. Hanemann (2009): It Should Be a Breeze: Harnessing the Potential of Open Trade and Investment Flows in the Wind Energy Industry

technologies and this process is further advantageous if we are talking about partnerships or joint ventures.

- Licensing Agreements: It concerns the transfer from one company to another of technological resources through the use of contracts called licenses that grant for the transfer of the asset against periodic payments, called Royalties. It is considered the most direct and simple transfer system and for this reason also the most widespread on the market. This process of technology transfer has proved to be particularly useful in the pharmaceutical and high technology sectors. Since there is usually no strict regulation over the payment of royalties, licenses are not adapted to the poorest contexts as companies from such situations often do not have the funds to access costly licenses[54].

Using the taxonomy of technology transfer provided by Lema & Lema (2016), we can define "organizational arrangements" the method to enable technology transfer. Importing equipment and foreign direct investments (FDI) are conventional organizational arrangements while joint research collaborations and strategic acquisitions are examples of unconventional organizational arrangements that enable technology transfer. The taxonomy identifies four variables that define these organizational arrangements. These four variables are Location of equipment production, Ownership of equipment manufacturer, Origin of proprietary technology, and Ownership of proprietary technology. The following table describes a summary of the various types of technology transfer mechanisms[55].

Mechanism	**Location of equipment production**	**Ownership of equipment manufacturer**	**Origin of proprietary technology**	**Ownership of proprietary technology**
Trade	External	External	External	External

[54] M. Glachant, A. Dechezleprêtre (2017): What role for climate negotiations on technology transfer?

[55] A. Lema, E. Lema (2016): Low- carbon innovation and technology transfer in latecomer countries: Insights from solar PV in the clean development mechanism.

Foreign Direct Investment (FDI)	Internal	External	External	External
Joint Venture	Internal	Shared	External	External
Licensing	Internal	Internal	External	External/ conferred

[56]

Table 3

In general, different types of policies are required from different types of technologies to support them to achieve the level of commercial deployment.

Talking about technologies for improving climate resilience, they can be split largely into two categories: matured technologies like solar panels and wind turbines that have been sufficiently developed and commercialized, and emerging technologies like electric mobility technologies or bio-energy technologies that have significant potential for advancement from the point of view of economic affordability and efficiency.[57]

The choice of the technology transfer channel and the adaptation to local circumstances are crucial. Companies that own these technologies and that want to enter in developing countries probably find ideal looking for local partners through a mix of conventional and unconventional organizational arrangements, especially in matured technologies. The case of technologies in the bio-energy and electric mobility sectors could be a good example to clarify this matter.

In the Western world and especially in Northern European countries such as Sweden, Norway and Denmark, bioenergy technologies are widespread and have reached a good degree of maturity. They are an effective way to manage different types of waste, such as agricultural waste and municipal wet waste, and to convert them into energy. Businesses

[56] A. Goldar, S. Sharma, V. Sawant, S. Jain (2019): Climate Change & Technology Transfer – Barriers, Technologies and Mechanism

[57] Tom-Reiel Heggedal (2009): On R&D and the undersupply of emerging versus mature technologies.

and governments have worked hard on the development of these technologies and have successfully adopted the use of these technologies at national level.[58]

However, in developing countries, the adoption of these technologies is difficult, where transaction costs, and therefore fuel costs, are high. For example, in India, attempts have been made to import industrial-scale reactors directly into the country from abroad, but the initiative has not been very successful. Instead, companies that analysed and deepened the local context and did their own research and development to customize the technology according to local needs have survived and succeeded in implementing economically sustainable bioenergy projects in India. Therefore, in this case it was advantageous for companies from developed countries to enter into joint ventures with local companies and collaborative R&D. In this way their products and technologies could have been develop and been absorbed in those markets, which are among the largest and fastest growing in the world.

In the case of electric mobility, the business model of Western countries such as the United States, Europe and Japan, focuses on technologies associated with personal vehicles (electric vehicles). Here again, the importance of the local context is evident, and this model cannot be replicated in countries like India, where the population is high and where a high penetration of personal vehicles is unrealistic or will eventually lead to crowded and uninhabitable urban spaces. Therefore, the focus on electrification and growth of public transport has been the goal of electric mobility companies.[59]Thus, the technologies developed for electric mobility by companies in richer countries require to be modified and customized to adapt them to the needs and modes of public transport in developing countries. Local partners are valuable to support such customizations and can contribute decisively to the development of these technologies. Hence, it is in the interest of developed countries to constructively manage agreements with local partners.

A lot can be learnt also from the following China's experience in developing its renewable energy technology sector.

We can divide manufacturing of renewable energy technology into three types:

[58] E. Bjornstad (2011): Adoption of Bioenergy Technologies for a Sustainable Energy System.
[59] https://newmotion.com/en_GB/transition-to-electric-public-transport/ - The transition to electric public transport)

1. mass produced standardized goods (e.g. solar PV)
2. complex engineered products (e.g. wind turbines)
3. complex product systems (e.g. biomass power plant)[60] (Binz, Gosens, Hansen, & Hansen, 2017)

The development history of these three industries has been different. The standardized mass-produced goods industry has benefited from bottom-up policies (such as the encouragement of private-private partnerships); instead, complex product systems have been consolidated through a top-down approach (involving government-led joint ventures), while complex engineered products have required a mix of both.
In China, developed countries such as Germany and United States, supported the growth of the PV sector in the initial phase.
It was only later that Chinese companies started to innovate on their own, broke their dependence on technologies from abroad and developed a high-performance solar PV industry that they then exported worldwide.
The biomass power plant industry in China, on the other hand, was helped by a technology approved by Denmark.

Sharing technologies between developed and developing countries seems to be the virtuous path that, if done well, helps the latter to strengthen their technology sector and strengthens their innovation systems. Technology transfer becomes an exercise in capacity building by spreading the benefits throughout the supply chain. In the case of China, thanks to the skills acquired and technology exchange, in the solar and wind energy sector, industry and consequently the labor force have benefited greatly from development and companies have increased their innovation capacities. The decisive proof of this progress is the fact that to date China has most recent patents in the production of photovoltaic solar energy.

In conclusion, in assessing an effective climate change action plan, a decisive factor is the proper dialogue between industrialized and developing countries and the resulting transfer of technology. This transfer of technology would enable developing countries not only to meet their development needs, but also to comply with international climate commitments.

[60] Binz, Gosens, Hansen, & Hansen (2017): Towards technology-sensitive catching-up policies: Insights from renewable energy in China

However, the success of the operation will require the strengthening of innovation systems in the beneficiary countries and an appropriate choice of the channels involved for technology diffusion.

3.2. Barriers and uncertainties over the technology transfer

International negotiations are not going towards expected directions. As we have seen, the world is asking to address the responsibilities of developed and developing countries with concern to the decrease of GHG emissions and the mitigation of the negative effects of Global Warming. As seen previously, one of the most important topics regards the role of intellectual property rights in the development and dissemination of EST.

This chapter provides guiding supports for the identification of obstacles to the transfer and circulation of climate change technologies in order to put the basis to overcome them.

It is important here to analyze which are the most important factor that influence negatively the dissemination of green technology and their adoption, especially in least developed countries A thorough understanding of the phenomenon and the barriers to the transfer and diffusion of ESTs is crucial to design an appropriate portfolio of instruments to address this issue. This paragraph wants to enlighten main uncertainties that developing countries have to tackle when taking to consideration the decision to invest in this kind of technologies.

There are a lot of academic research relating the barriers of technology transfer between developed and developing countries. Here is a summary list reported in recent outcomes of TNAs.

- Economic and financial
- Technical
- Policy, legal and regulatory
- Information and awareness
- Market failure/imperfection

- Human skills
- Network failures
- Institutional and organizational capacity[61]

In general, it is easy to understand that a proper allocation of technology requires consideration of the macroeconomic conditions of the beneficiary countries, which therefore play a key role. In fact, one need only think of high import duties, an underdeveloped financial system, high interest rates, out-of-control inflation, onerous fiscal and tariff policies and uncertain political scenarios. All this hampers investment, which often takes a medium to long time, and the resulting transfer of technology.

More specifically, from a financial point of view, companies in developing countries have high debt costs because projects have low collateral value and, consequently, are subject to significantly high interest rates.

Political, regulatory, legal, information barriers include the absence of policies and regulatory frameworks, including codes and regulations. In addition, an inadequate understanding of local needs and demands plays an important role. For example, some industries or agricultural practices are often subsidized, and the adoption of alternative technologies find a barrier in it.

Another very important barrier is limited or insufficient access to technological data and knowledge and a poor understanding of emerging technologies. The needs of actors at national or sub-national level may be similar and the risk is that they end up duplicating their innovative efforts, wasting resources and time.

Another significant obstacle, as described further on, is what is called recipient countries absorption capacity, such as a lack of both institutional and human skills, as well as a lack of investment, and therefore an insufficient research and development environment.

[61] IPCC (2015): Global Challenge Report: Innovation and Diffusion of Green Technologies: The Role of Intellectual Property and Other Enabling Factors

Inadequate scientific and educational infrastructure, and even institutional corruption, are other factors that identify a low absorption capacity.

While all economic activities are more or less risky, entrepreneurs that invest in environmental technologies are strongly oriented toward innovation but are more concerned with uncertainties. Innovative businesses, being more uncertain than traditional technique, may grant greater revenues as well as wider costs. Uncertainty in innovation is dynamic and it can have multiple sources. A view of the uncertainties that a business has to face was offered in the 2012 by Haragadon[62] which identifies four sources of uncertainty for firms-innovators which are described below.

- Policy uncertainty. As described before, also Haragadon considers the future environmental policy choice as one of the most critical point. Policymakers when addressing innovation process should consider at the same time financial barriers and related technological, regulatory or political barriers. When different options are on the table firms has to take into account what public policies will be enacted, and how they will influence the technology they are evaluating. There are different forms that these policies can take, from standards regulations to taxes and subsidies. In other words when the regulatory environment of customers or suppliers, is characterized by a great dynamism, this inevitably leads to greater uncertainty.
  When policymakers ignore the linkages between financial and other barriers, they lose the opportunity to help efficiently and effectively critical industries such as clean-tech. A research based on data from 23 countries of the OECD (Organization for Economic Co-operation and Development) shows that a 10% increase in policy uncertainty between 1986 and 2007 caused a significant reduction in rates of environmental patenting, whilst an growth in government support for R&D over the same period enhanced innovation[63].

[62] E. Hargadon (2012): Risk, Uncertainty, and the Challenge of Sustainable Innovation.

[63] Kalamova, M., Johnstone, N., Haščič, I. (2013): Implications of Policy Uncertainty for Innovation in Environmental Technologies: The Case of Public R&D Budgets.

- Market uncertainty. Market acceptance is a major source of uncertainty. Customer preferences change over time due to various aspects and this inevitably influence the diffusion of a given product and the technology it contains.

- Business uncertainty. Profitability and sustainability of an innovation is a key concern when deciding whether or not to invest in a new technology. When evaluating different production option, companies need to consider what can be the next possible scenario they have to face, in terms of future costs and prices. These inevitably entails making assumptions over the future challenge the environment will have that will drive to change in the resource price.

  When a company assesses future savings, few factors need to be estimated, for example the future cost of resources, the operating costs related to the use of the energy. The process can drive to huge uncertainties because the decision to produce or not an innovation is based on that assumptions may not reflect the real future scenario.

  When companies decide to innovate, they try to take advantage of the benefit that comes from being the "first mover" and thus gain the advantage of being the first to analyze the experiences and feedback from consumers, suppliers and partners. However, the problem of profitability is that it is a volatile component and even slight changes in market conditions (i.e. for a supplier of key components or financial conditions) can profoundly change the value of an innovation.

- Technology uncertainty. Finally, technological uncertainty discourages companies from investing in R&D and prototyping. As described in first chapter of this thesis, a general concern is whether the new technology can actually improve production capacity by reaching commercial volumes outside R&D facilities. Therefore, it remains essential to understand whether the company will be able to produce in line with the expected quality criteria, as well as with the economy of the production process in terms of speed, energy used, materials used and waste. Another point that can generate uncertainty is how the product will interact, on a technical level, with other components or products that define its final use.

Other uncertainties of the environment that in my opinion are worth mentioning are

- Overestimation of costs and savings: existing literature happen to overestimate the magnitude of the energy cost savings while leaving other possible costs and benefits unexplored. “Is there an Energy efficiency Gap?” written by Hunt Allcott and Michael Greenstone in the 2012 talks about this aspect suggesting that especially the net present value of energy cost savings happen to be distorted. They also find a need in terms of policy for those researches that use randomized controlled analysis and experimental techniques to estimate returns on energy efficiency investments because they are probably the first cause of this overestimation.

- Intermittency of renewable energies: wind and solar power, which are usually considered the two principal sources of renewable energy, are not always available and their production can fall unpredictably. The “capacity factor” (CF) is the ratio between the energy actually generated in a certain interval of time and the energy that, potentially, could have been generated if, in the same period, it had worked continuously. The two energy sources named before have both poor CF compared to other source of energy which are not renewable, meaning that in many countries the use of these resources have to be incentivized through public subsidy. As we already know, countries with poor economies as well as resource cannot always grant these subsidies, making sometimes impossible the use of renewable energies[64].

An important factor to note is the decline in venture capital funding worldwide, from a peak of USD 16 billion in 2011 to less than USD 10 billion in 2016. This has obviously also had a negative impact on funding for the development of new environmentally friendly technologies[65].

Financial restraints come to be a crucial element in the effective implementation of technologies. Despite the global understanding of the needs, without an international solidarity many initiatives have been stuck and sometimes dropped due to the lack or limited financial resources. Often a high-risk perception associated with the development of new clean technologies is the basic reason for discouraging commitments from investors that generally act in a conservative way.

[64] R. Fares (2015): Renewable Energy Intermittency Explained: Challenges, Solutions and Opportunities.

[65] CEP (2016): Global Energy Venture Capital and Private Equity Volumes by Region, 2009-2016

In fact, one of the factors delaying the growth and use of new technologies is that since they are new, there is no credit history to assess their feasibility, and new investors are obviously hesitant to commit to financing[66]. This leads to a lack of investment and difficulty in raising low-cost capital, often associated with low levels of public investment. As a result, this hampers the process of diffusion of new environmentally friendly technologies into new markets, limiting and delaying the research and commercialization phase.

Moreover, in the field of environmentally friendly technologies, what is often required by the beneficiary countries is an adaptation of already developed technologies whose cost of production and diffusion is most often not taken into account when assessing the return on investment. This leads to losses and discourages companies from undertaking projects to develop new technologies.

As general consideration, we may say that the adoption of traditional investment models is not well adapted to the needs of the green technology sector.

The development of new environmentally friendly technologies requires a radical renewal of risk mitigation mechanisms in support of the sector and makes it more appealed to investors. Several instruments, such as credit enhancement helping to diversify risks and a mixed finance approach, have to be used to support the sector's financial needs. As well as the provision of more risk guarantees could help to push investors to develop projects in the sector.

Therefore, the main objective remains to attract more private investment and, as has been said, to accomplish that, the system must be provided with new and innovative means to meet financial needs and implements risk sharing mechanisms.

International public finance must move in this direction by coordinating a policy of public subsidies, supported by stable domestic policies, policy must play a crucial role in reducing the costs of the various technologies and the risks of investment and, in closing the profitability gaps between different countries.

It should also be point out that in the early phase of the development of environmentally friendly technologies, government interventions can have a big part, which express on

[66] D. Goldman, J. McKenna, L. Murphy (2005): Financing projects that use Clean Energy Technologies: An Overview of Barriers and Opportunities.

increased cooperation between the public and private sectors and support for research and development of new projects.

In recent years it has been discovered that adaptation to local characteristics is another important factor that shapes the adoption of a given technology.
Rather than relying on solutions that can be adapted to any context, effective innovation strategies should take into account the specific characteristics of each developing country they aim to serve. Particularly, geographical, technological, regulatory, and cultural characteristics put significant trials for both policymakers and innovators. Therefore, an adjustable innovation is crucial to develop technologies shaped on local conditions. It is important to be aware that, in addition to the advantage at local level, knowledge of adaptive technologies produces benefits for the whole market.
As the types of technologies required to adjust to climate change tend to vary according to indigenous conditions, R&D should also take into account future climate change and support adaptation options for poorer countries[67].

Furthermore, it is important to note that the diffusion of know-how depends heavily on customers options. It has been studied that the dissemination of green technologies is slower than a comparison between costs and benefits might suggest[68]. It has been observed that the biggest barrier is that customers are often unwilling to be the first to accept a new technology. The so-called "increasing dynamic returns" appear only slowly, as early adoptions are observed and copied by others, until the learning-by-doing effect is so important that circulation occurs on a large scale.

3.3. Absorptive Capacity

The ability to innovate, as seen, is clearly superior in advanced industrialized countries. Probably in these countries excellent private and public research universities are found, as

[67] Popp, D. (2012): The Role of Technological Change in Green Growth.

[68] Shama, A. (1983): Energy Conservation in US Buildings: Solving the High Potential/Low Adoption Paradox from a Behavioural Perspective.

well as laboratories and institutes that attract domestic and foreign talents. As a good start, the discovery of new technology is extremely important for competitiveness in the market, but if it is not well used, it does not guarantee success in a globalized competitive economy. Even business firms with strong technologies can lose market share or even go out of business if they are not able to test and convert new knowledge in the production process[69]. As seen, there are several barriers to the technological transfer that are poor infrastructure, inadequate laws and regulations, lack of qualified personnel, lack of funding, ignorance of technological problems, high costs of technological agreements, equipment suppliers' issues, and intellectual property rights.

The biggest concern when dealing with IPRs in the field of climate change is that Climate Related Technologies (CRT) is a wide formula that refers to technologies that may not be necessarily registered and protected by patents. Registering a new innovation can be a complex task, this generally results in a situation where lot of know-how may not be codified in IPRs.
Dealing with not codified knowledge concerns a radical perspective change. In fact, when a given technology is completely protected by a patent, the owner can allow someone to use it through licensing. On the other hand, when knowhow is not fully codified licensing cannot be the solution and other mechanism to transfer the technology have to be implemented. When uncodified knowledge is at stake, cooperation is essential[70].

When patents are granted, generally the transfer of knowledge is a mere act of reading documents. On the contrary dealing with uncodified techniques asks for a cooperative approach to the technological transfer because part of the new knowledge can only be dispatched through interaction between the transferor and the transferee. At this point it becomes clear that access to CRTs (that have both codified and uncodified knowledge) asks for both the ability to interpret what is written in the patent and to acquire unwritten knowledge through collaboration. Generally, in modern literature this is called "Absorptive capacity".

[69] Popp, D. (2012): The Role of Technological Change in Green Growth.

[70] M.Anvert, M. Granieri, A. Renda (2010): A New Approach to Innovation Policy in the European Union.

This new way of approaching to the technology transfer completely changes the scenario because it means that the transfer of know-how is not subjected solely on the proclivity of the owner, but also on the skill of the company that asks for it, to fully assimilate the technology.

The capacity to absorb advanced technology and diffuse it throughout the economy is crucial to retain the competitive advantage in the market. It provides a chance for developing countries to enhance their productivity and incomes. Catching-up leading industrialized countries make firms become progressively integrated in the global supply chains. The clear example of a successful story is provided by the Republic of Korea, as well as a number of transition economies in Europe and Central Asia that have been also catching up since 90s.

It is clear now that technology transfer is not simply the purchase of products or techniques at marketable prices. A key aspect of development and technology transfer is building local capacity so that institutions and people in developing countries can adapt and acquire new technologies that can be disseminated in the national economy. As United Nations Conference on Environment & Development Rio de Janeiro, Brazil, 3 to 14 June 1992 states (par 34.12):

"*the critical mass of research and development capacity is crucial for the effective dissemination and use of environmentally friendly technologies and their generation at local level*".

Developing countries get into in the process of technology transfer through three phases:

- Start-up phase, this is the phase in which technology is usually acquired;
- Internalization phase, a phase in which these countries assimilate knowledge under a more flexible IPRs regime;
- Generation phase, companies invest their own resources in new researches and development processes[71].

[71] UNCTAD (2007): Annual Report.

In phase 1, the country is heavily dependent on capital imports, some acquisitions can be very expensive (especially patented ones) due to the higher prices allowed by the exclusive power granted to the holder. In phase 2, costs can be reduced by locally produced versions. In phase 3, local companies are able to design and manufacture their own products. Therefore, technology transfer also involves the purchase and acquisition of specialized equipment and thus also the know-how to use, maintain. The process of technology transfer is therefore the sum of all these elements.

The creation of new knowledge and its transfer are important for local cultural and industrial development. The concepts of "Innovation" and "Technology Transfer" are central in a competitive system. Innovation activities allow the development of new products, processes or methodologies able to meet certain needs or solve technical problems. Technology transfer activities are, on the other hand, the most effective method to encourage and accelerate the cultural and structural adaptation of companies or sectors to the innovative effervescence of the most known advanced fields. These activities relate to all actions that support the displacement of a number of factors, including knowledge, manufacturing methods, technology, skills, production samples and services from scientific research to the market[72].

Conclusively, intellectual property rights has become one of the central issue when dealing with the development and transfer of new technology.
Nevertheless, in emerging economies, technology transfer through the acquisition of licenses, patents and investments (both domestic and foreign) significantly impact on the catch-up process. That's why it is important to bear in mind that a successful tool for the technology transfer should also address the acquisition of elementary and specialized skills in order to fully acquire advanced technologies from developed countries.

3.4. Some issues of EST Industries

[72] R. Omar, R. Takim, A. H. Nawawi (2011): Measuring absorptive capacity in technology transfer (TT) projects.

Environmentally sound technologies (EST) are currently scattered across numerous technical fields, here are few examples.

Energy Sector

As we have seen, the increase in greenhouse gases is highly dependent on the energy sector. In a market economy, unless there are exogenous constraints, it is normal for users to be concerned about the availability of reliable energy at a reasonable price, rather than the damage that the production of such energy can cause to the ecosystem. Therefore, energy from conventional sources that is reliable and affordable has an undisputed advantage over energy from renewable sources, even though we know that it can have a lethal impact on the environment. To date, therefore, any new technology, whether solar, wind or biomass, cannot compete with fossil fuel-based energy, and that is the problem upstream. The only way out of this impasse is a policy of incentives and subsidies, especially in the early stages, to compensate for the losses of power generation companies using alternative sources.

In the case of clean coal energy, modern technology transforms coal and other carbon-based fuels directly into gas under pressure. Investment costs play an even greater role in this sector than in other energy sectors. Furthermore, depending on the nature of the coal found and used at a particular site, the technology to be developed is likely to be local and different from country to country. For this sector, therefore, developing countries face financial constraints to promote the development of such alternative technologies.
We can state that, so far, while renewable energy sources, such as wind or solar, have potential lucrative markets, emerging technologies such as clean coal technologies need to be increased with technology push policies and programs, as markets are usually not ready[73] (Herzog, 2017).

In the case of biomass energy, it has been internationally recognized (according to the results of the Technology Needs Assessment) that technological research in this field is a high priority. However, several issues need to be explored and regulated in this area, also

[73] H. Herzog (2017): Financing CCS Demonstration Projects: Lessons Learned from Two Decades of Experience

considering that the problems are different for biomass/biogas. Indeed, the fuel for such plants is not regulated and different fuel inputs such as municipal solid waste, agricultural waste, etc. require different technologies.

Also decisive is the role of communities, which are also the primary generators and owners of biomass that the unregulated fuel supply makes very important. Finally, we note in this area the lack of information exchanged on technologies developed in several countries with similar needs, which, on the contrary, could be a decisive accelerator for technology implementation.

Electric Vehicles and Public Transportation Sector

It has been proven that the transportation sector is one of the major emitters of greenhouse gases and the development of electric vehicles is certainly the challenge for future mobility, both private and public. Many international companies are engaged in research but technologies for electric mobility are still evolving.

First of all, it should be stressed that the development of this sector is the prerogative of developed countries, which hold almost all the patents on electric mobility. However, this sector represents an opportunity for North-South research collaboration. Indeed, in many emerging countries such as India, China and Brazil, due to population growth and even more so due to increasing urbanization, the demand for private and public transport will provide a profitable market for electric vehicles.

However, so far, the lack of collaboration among countries and among developers has led and will lead once again to widen the technology gap and low-income countries will have much to catch up in the future.

Here too, the development of technologies, engineering processes and knowledge in emerging countries should be a priority for environmental protection. Once again, and even more so in the mobility industry, the dissemination of intellectual property or industrial patents will play a decisive role.

Energy Efficiency

In the field of energy efficiency, technology transfer is focused on the supply side of goods, both consumer goods for the use of households, and equipment for companies. Such initiatives generally have to be supported by public grants as well as organization and regulation.

It is interesting to note that a policy of energy saving compared to one of developing energy from renewable sources is less complex to apply as it is cheaper and can therefore be adopted especially in low income countries.

In this sense, a good example of energy saving policy is the one followed in India for the adoption of LED light bulbs for domestic use, which has known, are low consumption but are more expensive than incandescent bulbs. The initiative launched by the Indian government can be seen as a replicable model in many low-income countries in terms of ensuring the rapid diffusion of technology in the field of energy saving for domestic use. The scheme put in place by the Indian authorities allows customers to purchase LED lights at a low initial cost and then pay the remaining balance as part of their electricity bills in equal monthly instalments.

Of course, the model could be adopted in the case of large appliances such as air conditioning, heating, ventilation, agricultural equipment, etc..

As you can imagine, the success of such projects depends to a large extent on the low cost per unit of supply for end users. Therefore, such initiatives require large procurement to reduce unit costs in order to compete with prevailing obsolete but affordable solutions (e.g. incandescent light bulbs).

3.5. Compulsory Licensing for Green Economy

The Compulsory Licensing is defined as a "*governmentally mandated arrangement allowing third parties to use another's intellectual property upon payment of a specified fee regardless of objections of the owner of the intellectual property*"[74]. In other words, through this tool the third party doesn't have to be authorized to access the technology by the patent holder himself, in fact the authority forces the patent holder to give the possibility to utilize the patented technology even if the right holder doesn't want to. This can be applied when some peculiar conditions are met and in any case the patent holder is reimbursed for the loss generated with this expropriation.

[74] J. Thomas McCarthy et al (2005): McCarthy's Desk Encyclopedia of Intellectual Property.

It was only during the Paris Convention that for the first time the concept of compulsory licensing has been introduced for the Protection of Industrial Property ("Paris Convention") in 1883.

The discussion is still open these days and the compulsory is still alive in the TRIPS agreements which considered it as one of the exceptions to patent protection. It is mainly defined in article 31 of TRIPS which says, "*Where the law of a Member allows for other use of the subject matter of a patent without the authorization of the right holder, including use by the government or third parties authorized by the government, the following provisions shall be respected*". This definition is followed by some conditions, but we will discuss this more in detail later on, it is for the moment relevant to consider that the definition is very general, and the TRIPS agreements doesn't clearly specify the circumstances where this tool can be applied.

The Doha Declaration in 2001 changed a bit the definition to open up compulsory licensing in order to enable patents transferability. It was added as an amendment to the TRIPS Agreement on the 6th of December and became effective only on the 23rd of January 2017.

Legal Basis

Article 8(1) of TRIPS wants to create a sort of parachute for critical situations through compulsory licensing, by granting to the parties the right to "*adopt measures necessary to protect public health and nutrition, and to promote the public interest in sectors of vital importance to their socio-economic and technological development*".

The right of the member states to provide flexibilities to patent rights are mentioned, with some differences, within articles 30 and 31 of TRIPS. Art. 30 TRIPS grants the possibility of exceptions to the patent rights while art 31 deals specifically with compulsory licensing.

Article 31 of TRIPS reads:

"TRIPS

Article 31

Other Use Without Authorization of the Right Holder

When the law of a Member allows for other use of the subject matter of a patent without the authorization of the right holder, it is generally the case that the following provisions are respected:

(a) authorization of such use shall be considered on its individual merits;

(b) such use may only be permitted if, prior to such use, the proposed user has made efforts to obtain authorization from the right holder on reasonable commercial terms and conditions and that such efforts have not been successful within a reasonable period of time. This requirement may be waived by a Member in the case of a national emergency or other circumstances of extreme urgency or in cases of public non- commercial use. In situations of national emergency or other circumstances of extreme urgency, the right holder shall, nevertheless, be notified as soon as reasonably practicable. In the case of public non-commercial use, where the government or contractor, without making a patent search, knows or has demonstrable grounds to know that a valid patent is or will be used by or for the government, the right holder shall be informed promptly;

(c) the scope and duration of such use shall be limited to the purpose for which it was authorized, and in the case of semi-conductor technology shall only be for public non-commercial use or to remedy a practice determined after judicial or administrative process to be anti-competitive;

(d) such use shall be non-exclusive;

(e) such use shall be non-assignable, except with that part of the enterprise or goodwill which enjoys such use;

(f) any such use shall be authorized predominantly for the supply of the domestic market of the Member authorizing such use;

(g) authorization for such use shall be liable, subject to adequate protection of the legitimate interests of the persons so authorized, to be terminated if and when the circumstances which led to it cease to exist and are unlikely to recur. The competent authority shall have the authority to review, upon motivated request, the continued existence of these circumstances;

(h) the right holder shall be paid adequate remuneration in the circumstances of each case, taking into account the economic value of the authorization;

(i) the legal validity of any decision relating to the authorization of such use shall be subject to judicial review or other independent review by a distinct higher authority in that Member;

(j) any decision relating to the remuneration provided in respect of such use shall be subject to judicial review or other independent review by a distinct higher authority in that Member;

(k) Members are not obliged to apply the conditions set forth in subparagraphs (b) and (f) where such use is permitted to remedy a practice determined after judicial or administrative process to be anti-competitive. The need to correct anti-competitive practices may be taken into account in determining the amount of remuneration in such cases. Competent authorities shall have the authority to refuse termination of authorization if and when the conditions which led to such authorization are likely to recur;
(l) where such use is authorized to permit the exploitation of a patent ("the second patent") which cannot be exploited without infringing another patent ("the first patent"), further additional conditions shall apply: (i) the invention claimed in the second patent shall involve an important technical advance of considerable economic significance in relation to the invention claimed in the first patent; (ii) the owner of the first patent shall be entitled to a cross-license on reasonable terms to use the invention claimed in the second patent; and (iii) the use authorized in respect of the first patent shall be non-assignable except with the assignment of the second patent."

The main points of this set of rules are basically the following:

- the law of a state permits the use of a patent without the authorization of the owner;

- permission of such use has to be deemed on its individual merits;

- the scope and extent have to be restricted to the intent for which it was granted;

- such use has to shall be non exclusive and non assignable;

- the proposed user should have made attempts to receive authorization from the right holder by offering appropriate business terms and conditions and that such attempts have not brought the desired results within a reasonable period of time;

- this criterion maybe withdrawn by a nation in a situation of national emergency or under other conditions of utmost urgency;

- such use has to be authorized mainly for the provision of the internal market;

- the right owner should receive appropriate remuneration;

- the legal validity of any choice regarding the authorization of such use is subject to judicial review by the nation.

The revolutionary meaning of compulsory licensing is that the patent holder cannot reject the request of giving the license after an official demand coming from the authority. It is important to note here that art 31 doesn't even define peculiar situation where compulsory can be applied, it does only specify under which conditions "reasonable effort" are not required.
However there exist some exceptions to the rule, in fact art. 31 specifies that in case of "national emergency" or under circumstances of "extreme urgency", "reasonable efforts" are not essential. This was made to facilitate the process when critical issues may cause important damages to the country or the population.
The Doha Declaration underlines the relevance of public interest under the request for urgent situations, but at the same time the article suggests that each member state can define its own national emergency situation (health crises are generally the most common cause to ask for).
It is important to point out that the patent holder still has to be reimbursed with an adequate remuneration for his loss.

One of the biggest problems when dealing with patent protection is that these tools grant to the right holder the "power to exclude others" from utilizing the same innovation, somehow granting to the right holder some sort of monopolistic power. Compulsory license can disincentivize abuse from the owner because the TRIPS agreements doesn't see any limitation to the field where it can be applied. Compulsory licensing can also be asked against someone that uses its monopolistic power only to unreasonably restrain competition.
Other than in case a government wants to waive the obligation to first ask for the patent holder's approval, the TRIPS Agreement does not foresee any restriction to the reason why regular compulsory licenses may be issued in a member state[75]. Further, the Max Planck

[75] Max Planck Institute for Innovation and Competition (2014): Declaration on Patent Protection, Regulatory Sovereignty under TRIPS.

Institute even states that technically, compulsory licensing under TRIPS Article 31 can be used to remedy "*abuse of patent rights or for practices that unreasonably restrain trade or adversely affect the international transfer of technology, even when - the proposed licensee has not made prior efforts to obtain authorization from the patent holder, and - the use is authorized predominantly for the supply of foreign markets*."
Additionally, the government's use of the patents coming from compulsory licensing is not limited either, and an eventual third party would not even need it to be non-profit use.

Some examples

There have been interesting cases in adoptive compulsory licensing, especially in the pharmaceutical sector.
During an AIDS epidemic in 2005, the Brazilian government issued a suspension of the patents of all drugs that could treat HIV[76], so that generic versions could be produced locally. In 2007, Thailand issued a compulsory license for the AIDS drug Kaletra, after not being able to obtain a price reduction on the drug.
In other case the threat alone of the use of compulsory licensing had the direct effect of lowering prices of patented knowledge. An example is 2005-2006 when global bird flu epidemic started to spread all over the world. A few months later a famous Swiss pharmaceutical company, Roche, invented the Tamiflu, a drug that could beat the plague. The company was unable to produce quantities that could have satisfied the entire demand but to retain the primate in the market. The US publicly denounced Roche, while other countries, such as Taiwan, India, Thailand and Argentina threatened that they would have ignored the patent and make their own generic versions of Tamiflu. In the end Roche decided to lower the price to get the license for the production of the drug.

Fitting Compulsory Licensing for Green Technology

These spots in the TRIPS Agreements are quite useful tools to potentially make compulsory licensing work for green technology.

[76] J. Packard Love (2007): Research Note, Recent Examples of the Use of Compulsory Licenses on Patents. KNOWLEDGE ECOLOGY.

Nevertheless, the pharmaceutical sector is very different from clean technology sectors. A patented pharmaceutical is probably to be the unique solution to a certain necessity. Since there are typically no market alternatives to a patented pharmaceutical, the IPRs owner is in the position to impose huge royalty fees. This could put least developed countries in serious difficulties because even if in they are in a situation of great needs the country may not have enough funds to obtain such a pharmaceutical, that is why the use of compulsory licensing.

As just said TRIPS Agreements leave some space for compulsory licensing, and the fact that its applicable situations are not precisely defined, may constitute a facilitation to use this tool under severe adverse climate conditions. It has to be clear in mind that compulsory licensing was not specifically made to face this challenge and for years it remained ambiguous if drastic climate situations could be defined "case of national emergency" or "*other circumstances of extreme urgency*…" The many detrimental effects of climate change to humankind are well known. One of the biggest problems is air pollution, of which is deemed causes death of million people annually[77], and around ninety percent of those deaths happen in developing countries. Another example are the extreme temperatures that have caused more than 70.000 deaths in Europe during the heatwave of summer 2003. These situations could be assimilated to a "national emergency", especially since the risk of health impacts is increasing at a rapid pace[78].
It has to be noted that article 31 of TRIPS does not mention any prohibition to using it for green technology, nor does it give any limitations to the grounds of use whatsoever, for that matter. Also, article 27 of TRIPS gives the possibility to prohibit a patent in case it creates "serious prejudice to the environment", which at least indicates that environmental impact can be taken into consideration.

Establishing a law that allows for the use of compulsory licensing for green technology in a member state can easily be made in a way as to respect all the other conditions listed in article 31. In fact, as we have seen, the law should make sure that compulsory licensing

[77] R. Fair (2010): Does Climate Change Justify Compulsory Licensing of Green Technology?

[78] Richard C. Keller (2019): Europe's killer heat waves are a new norm. The death rates shouldn't be. Article-The Washington Post

may be only permitted if: each case was considered individually, the scope and duration is clearly set out for the purpose of the specific green technology; the use of the compulsory license will be non exclusive and non assignable, which perfectly fits the interest of green technology transfer; it will be used for domestic supply in the country to which it is licensed or, since this has been waived by the Doha Declaration, international technology transfer is easier; the right holder will be remunerated adequately; any issuances stay subject to judicial review.
Moreover, in case the government considers the patent holder of the targeted green technology patent is showing anti-competitive behavior, the member states have the right to ignore conditions 31(b) "made effort", to 31(f) "domestic market" of TRIPS in their provisions.

At first sight, the use of regular compulsory licenses can be considered as a method to allow for a better diffusion of green technology. In fact, when dealing with green technologies and their dissemination in the market the principal concern is price. Generally these technologies are costly for two main reasons: the first one is rooted in the nature of the product itself and the second one is the presence of IPR. Compulsory licensing could help tackling the problem because it could constitute a deterrent for those players that set too high prices[79].

Instead, some concerns have been raised about compulsory licenses meaning that they are not only detrimental for patentees but also for the countries in which they are granted.
In fact, a functioning patenting system is recognized to be important for innovation and diffusion of technology. Firms in developed countries might be discouraged to invest, especially into developing countries, if they assess the risk of their patents not being respected. Especially for the case of green technology this would be detrimental, since middle-income states, include China, India and Russia, who are the ones that contribute the most to increase the global pollution. And eventually, applying compulsory licensing could provoke the industry to bury more inventions into the domain of proprietary technology and trade secrets.

[79] M. Z. Abbas (2013): Pros and Cons of Compulsory Licensing: An Analysis of Arguments. International Journal of Social Science and Humanity.

Another backlash that could be considered in applying compulsory licensing is the risk of misleading commercial practice from the patent owner nation. Although a country would not necessarily risk being challenged by the WTO's dispute, in the past happened that United States imposed unilateral trade sanctions to Thailand after it issued compulsory licensing to the Kaletra drug.

Compulsory licenses deem to be bad since it hinders attempts to the establishment of an independent, research-based industry, that is able to meet the demands of its own market, especially in countries that are focused on imitation rather than innovation.

Moreover, as we have seen, if the hosting country is not equipped with know-how, software, qualified manpower and infrastructure, the license alone will not be able to make an effect to the full potential of the technology. In a situation of compulsory licensing, it would seem odd to expect the patent holder to voluntarily offer the needed know-how, especially since they can retain these information as "trade secrets".

Therefore, weakening of IPR would not only limit developing countries' access to expensive technologies, but would also make difficult accessing low cost technologies.

Finally, the fact that the field of green technology is so broad and undefined would make it a big deal to open the flood gates to compulsory licensing for green technology. It might "*effectively eliminate intellectual property rights on most innovative technologies and the incentives those rights create*."[80]

From the perspective of effectivity and success for green technology transfer, compulsory licensing does not seem a promising solution, especially in the long run. Free-market mechanisms seem to disfavor the adoption and dissemination of green technologies in the world.

But it is curious that much earlier of 1994 TRIPS and the compulsory licensing provision, some cases taken from US law suggested the possibility of open patents.

In fact, in the US Bayh-Dole-Act of 1980 is contained a term called "march-in" rights that gives the federal government the power to ignore the exclusivity right granted to the patented holder, licensing the technology to another user without the owner consensus.

In order to use this tool, the US policymaker sets one condition that has to be respected before justifying this action, that is: the action must be mandatory to avoid certain health

[80] Sidney A. Rosenzweig (2009): PFF on Cooling the World By Misappropriating Patent Rights.

and safety issues and can either be asked by a third party or the government itself. As agreed by several researchers, climate change can be considered a “health and safety need” especially in a peculiar situation.

The issue with the expropriation of exclusive rights is that inevitably discourages investing in new technologies for profit maximization, usually considered the principal reason to pursue new technologies.

In the past, the US governmental Department of Defense recurred to this tool in two main occasions, even if they didn’t match with the “health need” previously mentioned.

The “march-in right”[81] was invoked in the Gulf War for the manufacture of night-vision goggles and then to obtain the formula for the construction of “green-bullets”.

3.6. Other mechanisms for facilitating the Technology Transfer

One of the most important concerns when dealing with Global Warming is that even if all countries agree on the fact that that climate change is a very important issue that needs to be handled, the way this problem convert into peculiar condition in each individual nation in terms of intellectual property and climate change, seriously diverge. This means that each country needs to see an economic benefit in finding a common solution to the issue otherwise only slight changes will occur. Furthermore, the analysis of an unsustainable energy policy might not be sufficient to grant a modification to the IP system, especially when international cooperation is required.

A license to a patented technology does not correspond to a transfer of technology. Differently from a pharmaceutical patent, where disclosure of a chemical formula could be enough to allow production of the drug, a patent covering a clean technology may not provide enough information to really market the technology. Probably one of the biggest problems to be addressed is the presence of uncodified know-how (generally hidden under trade secrets). Because of this knowledge loss, technology transfer generally leads to situations where innovations are non-efficiently used or simply are not effectively adapted to local needs.

[81] John R. Thomas (2016): March-In Rights Under the Bayh-Dole Act

In the pharmaceutical field, a chemical formula may be enough for a developing country to manufacture a drug, and a compulsory license may provide sufficient information to start production. But in clean technology field, processes are much more complex, and the inventions generally necessitate more skill or knowledge to produce.

So as just seen, the role of IPRs in the climate change is extremely intricate and debated, and even the compulsory licensing seems to lack some of fundamental aspect that may grant a sustainable technology transfer. To unable a successful flow of technologies towards developing countries, and for the removal of barriers at a national level a multi-level approach is then required.
The aforementioned constraints might be solved through the use of other important tools which are: Green Technology Packages, Patent Pools and National Incentives.

Green Technology Packages

A green technology package is the key document or set of documents that set the basis for a successful green technology transfer, especially at international level.
This tool allows for gathering of all the information and the details included in patent's specifications, with the intention of collecting all the knowledge that is necessary for an efficient technology transfer. The green technology package may contain technical information, human resource plans and trainings, and many other important details and additional knowledge exceeding the scope of a patent. But one of the greatest benefits of this package is that it gives the possibility of grouping together several patents so that the potential licensee does not have to negotiate separate licenses.
Following this, a patent is granted to the owner of a given technology as an exclusive right, in exchange for the public disclosure of how to use and make the given invention.
Instead, in US, as in other countries, patent office asks to the owner a written description of the innovation that should be sufficient to one of "ordinary skill in the art" of how to make or use the new technology.
It is important to mention that patent applications often don't give any information on the know-how required to efficiently sell the technology in the market, the idea behind this view suggest that US policymaker doesn't equate the ability to produce a product with the ability to manufacture a quantity that is sufficient to be sold in the market.

When saying “one of ordinary skill in the art” means that those willing to realize or use the invention it may be necessary to acquire gain considerable knowledge in the field of activity.
Moreover, generally the examination of the patents by the policymaker doesn’t tell if the information disclosed by the owner of the new technology are sufficient for a successful implementation of the invention. This means that there can be no guarantee that someone of “ordinary skill in the art” will have enough information to make or use the invention.
Additionally, law doesn’t usually ask for a full disclosure of all the elements contained in a given technology (as long as the technology is still useful) and some specific components might not be inserted in the information disclosure.

Another weak point of patent application is that companies may try to approach to the disclosure more strategically and instead of protecting the whole technology under one single patent, they might be tempted to protect the invention by filling separate patents for each component of the invention. This makes more difficult to understand and make use of the entire innovation, decoupling the knowledge.

It is clear then that green technology packages, compared to compulsory licensing, have the advantage of providing all the information needed to successfully adopt the innovation.

Another argument in favor of this tool is price comparability, in fact green technology packages allow for a better understanding of all the costs related to the realization of a given technology and might help to adjust prices for the demand of different technologies[82]. Grouping multiple patents together could also decrease the cost associated with the negotiation of separate licenses.

Although technology packages look very efficient for a successful technology transfer, especially for green technologies, empirical studies like European Patent Office licensing survey showed that there were scarce out-licensing to developing countries in clean technology sectors, suggesting that this mechanism didn’t really helped much in promoting green technologies acquisition[83].

[82] J. H. Barton (2006): Intellectual Property and Access to Clean Energy Technologies in Developing Countries: An Analysis of Solar Photovoltaic, biofuel, and Wind Technologies.

[83] UNEP, EPO, ICTSD (2010): Bridging the Gap Between Evidence and Policy: Final Report.T

The principal cause could be the lack of information over new technologies in the market with potential licensees. Taking a look at the reports produced by least developed countries on their technology needs assessments (TNAs) to the Global Environment Facility (GEF) it seems that developing countries are not conscious of the technical solutions already at disposal in the market. For this reasons EPO (European Patent Office) has created a new classification framework to improve the global awareness over new patented and non-patented innovations in green technology sectors.

Another possible solution to the publicity problem is a sort of a network hub that could facilitate the process by linking the demand of a developing country for a certain clean technology to a supplier of such technology, trying to link the two entities[84]. This subject, already treated in a draft written by the Expert Group on Technology Transfer concerning the Technology Mechanism of the Copenhagen Accord, has been partially addressed with the creation of WIPO Green. WIPO Green in the last years facilitated matching parties for a successful technology transfer and also helped countries to find solutions to their needs and helped providers discovering new potential markets. We will discuss this topic in the next sections.

Patent Pools

Another technology transfer tool is the patent pooling: a basket of rights that can facilitate the licensing and the sharing of green technology at affordable prices or possibly royalty-free. Patent pools have raised attention recently as they are widely utilized in many sectors and are defined by WIPO as:

"*Agreement between two or more patent owners to license one or more of their patents to one another or to third parties*".

In any case this instrument asks for a separate entity that should administrate the pool and which is generally independent from each patentee.

[84] UNFCCC (2010): Preparing for the Implementation of the Protocol Technology Mechanism.

This tool is typically used when dealing with complex technologies which may require a broad number of complementary technologies and products. That's why the creation of a patent pool is a good choice when dealing with EST because these innovations are one of the most difficult to implement and may happen that they overlap or have interconnected claims.

Patent pools are a traditional technique for technology transfer that can be pro-competitive and are valuable in a wide variety of sectors. In general, when a patent pools are properly developed, they can help firms at least in the following critical aspects:

- they can lower the transaction costs attached to negotiations and administering licensing programs;
- they can address the problem of high royalty rates;
- they can help attracting large and small licensors and offer licensing solution to the licensee;
- they can encourage and allow for a broader use and adoption of the pooled technology, and drive to a higher rate of return on research and development;
- they can spread the risks and the advantages of a given technology implementation among all actors in the arena;
- they can remove blocking patents may lead to reduction or elimination of the costs related to litigation[85].

The major advantage of a patent pooling is that they can heavily lower the transaction costs. They not only reduce the cost associated with litigation, but they also help reducing all the expenses related to the negotiation with a broad number of patent holders. The important thing to note here is that this tool may grant savings not only to the participant to the pool but also to the rest of the players.

The advantage for developing countries in terms of green technologies is that by obtaining a patent license from a pool of patents, a business can get all the necessary rights and information to use a given technology.

Moreover, patent pools may strengthen competition instead of limiting it. In fact, by allowing many actors in a market to access the technology with the same information and

85 WIPO (2014): Patent Pools and Antitrust – A Comparative Analysis.

green patents, makes more difficult the commercialization of products that incorporates the same technologies[86].

With regard to costs, the non-exclusive negotiation of a basket of rights, offered by an administrator of a patent pool to all participants at the same terms and conditions, is certainly much cheaper than the alternative of having each actor engaged in separate negotiations with different patent holders aiming to collect the same basket of rights separately. Another important advantage in obtaining a basket of rights through a well-constituted patent pool is the elimination of costs and risk management generally linked to the uncertainty generated by patent litigation and also to the commitment and time needed to negotiate with several licensees.
Another advantage of using a patent pool is that it limits the power that a patent holder could exercise in order to undermine new initiatives. For example, in today's market, when each patent required for a project is licensed separately from each individual patent holder, the cost of the last essential patent licensed may be more expensive than its scope and technical merits may deserve. Therefore, if a potential licensee moving in the meander of patents has licensed all but one essential patent, the last patent holder will have important power and control over the negotiations. The latter could in fact attempt to claim an unreasonable royalty because his patent is substantial for the successful use of the entire technology[87].

Nevertheless, creating a successful patent pool is not an easy task. First of all, building consensus and reaching the agreement on the proposed initiatives by all key patent holders and can be quite challenging. Even if pool participants agree to freely grant cross-licensing, the pool itself may be held hostage by patent holders not belonging to the pool. Secondly, patent pools are difficult to create and very expensive to administer. Bringing all or most of the major IP owners to reach an agreement on every detail of setting up a patent pool is very complicated. Each owner has its own strategic interests and it may not

[86] Esther H. Lim, Mandy J. Song (2010): Dealing with U.S. Patent Pools as a Third Party.

[87] F. Grassler, M. A. Capria (2002): Patent pooling: Uncorking a technology transfer bottleneck and creating value in the biomedical research field.

coincide with the others. In addition, the cost of setting up a pool and evaluating the patents it contains can be very important.

Despite these problems associated with patent pools, we have already seen that coupling IP rights together with the know-how to make an invention seems to be a winning and needed choice for developing countries and for emerging economies. It is evident that the provision of patent pooling has a unique advantage versus compulsory licensing that makes this tool more closely related to technology transfer and not just avoidance of IPRs. Developing nations, as per package licenses, through patent pools, could also evaluate more precisely the total costs associated with the implementation of an EST, thus decreasing the risk of some unknown element that might impede the commercialization.

National Incentives

One of the biggest concerns when dealing with technology transfer is that even if a technology, and all the know-how attached to it, are fully disclosed, a country may not have the infrastructure or resources to successfully implement innovation.

Imagine, for example, an emerging country that wants to implement a wind turbine project and has all the licenses and knowledge to implement it but does not have a power grid able to handle wind fluctuation. The technology in this case would be useless. Another example could be the existence of national subsidies for fossil fuels that can represent an insuperable block for a solar field at moderate prices. It will therefore be necessary to create at national level a system of transfer mechanisms that can cope with such internal barriers.

Certainly, one of the most important issues to consider is that there is no real coordination between companies investing in R&D and their governments, this could facilitate competition and ensure low prices for green technology packages.

As most clean technology research is publicly funded, the provision of affordable green technology packages for each clean technology marketed should be a requirement for receiving public funding from government.

For example, countries such as the United States would be required to amend existing laws, such as the Bayh-Dole Act, which encourages licensing to companies that produce

mainly in the United States. An exception to the Bayh-Dole Act for clean technologies would certainly benefit owners of clean technology patents in the United States, who could reduce the cost of marketing a technology by transferring labour and production to developing countries. Although this shift in employment could prove unpopular, it would actually allow the US to create more jobs in clean technology research and development than in production.

There are cases in the past where these incentives have been used successfully to disseminate certain innovations or to make already developed areas more competitive. Ethanol subsidies in the United States, and oil subsidies in Venezuela and Russia, are examples of ways to reduce prices in a determined technology area. Prizes and public funds, such as the X Prize in the United States for space flight or the California Public Utilities Commission Solar Initiative and Sustainable Energy USA awards, could also motivate innovators and be an example for developing countries that could implement similar initiatives in order to boost growth in this sector.

The incentive mechanism should incentivize developing countries in investing more in green technologies and their transfer, and this can be achieved either by positive or negative incentives (e.g. carbon taxes). In the first scenario they should work to enhance the level investments in EST itself, while in latter case they should try to shift the spending in R&D from fossil fuels technologies to green technologies[88].

Without these negative incentives the difference in terms of pricing between CRT and fossil fuel technologies will only depend on innovation. This mechanism generally entails long delays in the creation and adoption of clean technologies on a global scale, while Global Warming would still remain unsolved.
Furthermore, a successful incentive implementation can be compared to the advantages of a fruitful FDI: an enhanced clean technology sectors, as well as all the competences needed in the future for their development.
As a result, in the long run competition and global market demand grow, and least developed nations might use the global IP system to reinforce their own economy.

88 The Economist Times (2018): Incentives for green tech, artificial intelligence likely in new industrial policy.

The provision of giving incentives for the creation of new knowledge can be linked to the birth of new green technology packages at affordable prices. In fact, incentives could be used to boost the technology transfer process: a firm that gets public resources for investing in R&D, and that gives birth to a new technology, could be asked to offer on the market a green technology package at an affordable price. As we have just seen this will have the double effect of improving the spread of technology in the market as well as granting to the IP holder fair returns (royalties).

The biggest difficulty in terms of incentives is how to balance investments in different technological fields. In other words, when implementing national incentives, it becomes crucial to understand which technology innovation process wants to be favored, and this of course should be reconciled with the needs of the country. In particular, developing countries should focus only on the most efficient technology packages that should be framed them under local constraints.
Furthermore, incentives should face the need of dispersing the risk associated with the prevent dependence on a single technology.
Last but not least, another issue to be considered is that usually the strength of IP legal system related to national incentive could influence the price of developing country consumer. In fact some nations seem to be more risky due to disfavorable national IP laws. China, for example, has a reputation of being a risky country to invest in because of favoritism towards its citizens. This generally leads to situations of expensive investments which decrease the general level of FDI in the given country.

3.7. WIPO Green

And finally talking about mechanism that could facilitate the technology transfer it's worth mentioning the World Intellectual Property Organization Green (WIPO Green).
As noted in the previous sections, one of the main problems in relation to IP rights is the difficulties of licensors to connect with potential licensees, in other word to match the offer of new technologies with their demand. This is mostly due to the patent system that lacks

strong mechanisms that could publicly create awareness over the development of a new technology. This is particularly true in the green technology sector.

As mentioned earlier, one of the most critical point when dealing with patent is the "duplication of efforts" because when investing in R&D one firm does not know if somebody in the market is investing in the same technology. This is generally solved at a national level when the patent is registered, because this allows for the publicity of the new technology. But what does it happen internationally, when global awareness over patented and non-patented solutions is poor? This generally leads to wider wastes of efforts because of the aforementioned duplication or drives to situations where even if there exists a patented technology that could potentially solve a problem it is not used because no one knows its existence.

To answer all these problems and to facilitate access to relevant patent information, in the 2013 the World Intellectual Property Organization, gave birth to the WIPO Green, whose scope is:

"An online platform for technology exchange that will contribute to the accelerated adaptation, adoption and deployment of green technology solutions by connecting technology providers with technology seekers."

It is clear here that the intention of the organization is to create a sort of bridge between possible technology users and technology providers, to favor the exchange of green technologies.

Furthermore, WIPO Green was created with the aim to enhance the level of IP protection to give a stable and operative international system that could foster the innovation process toward a green economy.

The principal global challenges that WIPO Green wants to address are: global health, climate change and food security. The main reason behind the organization is that facilitating the technological exchange between seeker and providers of new EST, the world could better face these challenges, that are fastly becoming a real treat.

This is why since 2013 the WIPO Green actively engaged professional partners, experts, and an online marketplace to address these needs, and in the last 6 years more than 600 connections between provider and seekers have been created.

A worldwide pool of contributors, more than 500 large or small companies, help every day WIPO Green to achieve its goals, and more than 170 countries consult on a daily basis the marketplace looking for new technologies[89].
WIPO Green can be considered a ground breaking initiative because since its creation it has become the principal tool that supported the dissemination of EST, thus accelerating the transition toward a more sustainable economy. It wants to stress the importance of designing a proper IP framework to the face nowadays challenges and to meet the Sustainable Development Goals (SDGs).

WIPO Green underlines 3 important goals to be achieves within the 2023[90]:

- Linking EST providers and those that are looking for possible solution, to increase the level of green technology diffusion in the world
- Facilitating the access to green technology for developed as well as developing countries
- Supporting nations to leverage IP and innovation in global efforts to tackle the broaden policy issues in the field of climate change, food security and the environment

The Strategic objectives for the next 2019-2023, are defined as follows:

First objective – "increasing the capacity of the WIPO Green database to accurately, effectively and efficiently match technology needs with green technology offerings"

Green technology database is probably the most important milestone of the WIPO Green, which constitutes the backbone of the organization. The idea behind this first strategical point is enhancing both the quantity and the quality of the database to improve the technology transfer process so that someone looking for a solution could be able to find an exhaustive technology to his problems.

[89] WIPO Green Web Site

[90] WIPO Green (2019) Strategic Plan 2019 – 2023

The database should work as a link between technology providers and solution seeker and the more efficient are the patents contained the more useful it will be for addressing any need.
It is interesting to highlight that the database should serve even deeply different countries, that's why WIPO Green opted for a machine learning approach that can manage large amounts of data, linking the best solution to the context.
This huge database will leverage on more than 70 million patents globally registered in WIPO's Patentscope Database (one of the biggest in the world). Due to the high number of solutions contained there will be added more advanced search and filter that could facilitate all the queries.
This will be somehow similar to the package license mentioned in the previous sections, the idea is giving to the licensee the possibility to gather all relevant information on the patent that include complementary know-how, technical expertise which are essential for a successful implementation of a given technology. Ideally, after these updates, a user who is in search of a technical solution to a problem will be able to express the need and get a ranked list of possible solutions that can address the initial problem.

Second objective – "Build a critical mass of partners, market actors, users, and technology uploads through targeted outreach and engagement"

To improve the database in terms of number of technologies involved, WIPO Green opted for engaging multiple skilled actors coming from diverse categories, reflecting the different fields contained in the database.
To do so the organization will actively recruit his experts during technological fairs, exhibitions or events. The intention is also to attract people that could ultimately make use of new EST, that's why talents come from every context and both multinational corporations and small and medium enterprises are engaged. This latter case, in particular, represents those that are willing the most to adopt green technologies.

It is important to add here that WIPO Green wants to increase the number of green innovations listed under each specific thematic area and this will be achieved through "acceleration projects". This tool allows for a successful exchange of technology from a provider to a user, within a specific thematic area that is usually determined together with

stakeholders. It can also be geographically focused and generally also makes easier to access local or international networks.

One of the most important characteristics of the WIPO Green is the partner network that surrounds the organization. In fact, the aim of the WIPO Green for the next 2023 is to leverage more on this network, trying to implement actions that could increase the number of possible partners.
This may not only increase the effectiveness of future actions but could also enhance the level of visibility of the organization itself.

Third objective – "Strengthen WIPO Green's communications and marketing functions"

The last strategical point for the next future is developing more their marketing and communication systems.
The WIPO Green is connected to a broad range of stakeholders coming from various sectors even if resources available to the organization in terms of communication are quite scarce.
The intention behind the communication approach is to stress the importance of WIPO Green, in order to create awareness over the positive impact of this organization. This could even help to attract new possible strategical partners and increase the number of users.

To sum up, WIPO Green is a sort of a hub that facilitates would-be partners to connect one another.
As we have seen, IP rights play a critical role in terms of attracting possible shareholders, enabling entry into potential markets and allowing effective collaborations. By injecting greater transparency into the market for ESTs through the use of WIPO Green, the process that drives to the effective dissemination of new green technology could be improved.

Conclusions

Climate changes and Global Warming bears an innumerable amount of problems and challenges for our planet and transfer of technology plays a key role.
Human beings need a drastic change in the production and distribution of goods and services. In fact, we need to efficiently produce and store clean, low-cost energy, as well as to implement new ways of agriculture that can meet the food needs of populations while preserving the planet and its ability to renew itself. We need to develop new and efficient equipment in a sustainable way, both for personal use and for industrial production.
The only way to accomplish this transformation in effective ways is by implementing the right technologies throughout the world.

But since the economic world is divided in two, the economic growth of the countries in the South must learn from the mistakes made in the past in many countries of the North and cannot be based on the same model of development. In fact, following in the steps of a carbon hungry economic development as for developed countries would bring a catastrophe to the planet. In creating new economies for developing countries, they must be based on sustainable foundations, using the knowledge and technologies that are currently being developed in so-called developed countries. To accomplish this, we will need to focus on new mechanisms for sharing technology, to create a bridge between rich countries and poor countries, a technology flow from where is developed to where is needed.

As we have seen, new research and development activities are determined by the necessities and preferences of rich countries, as most of the research and development effort takes place in rich countries and therefore even the profit from green technologies consolidates the disparity of global wealth.

That’s way climate policy must face what is called “new colonialism”. We can prevent this by reconsidering the system accountable for technological embargoes, possible beginning from intellectual property.

But just starting from this assertion, we wish to avoid any misunderstandings: the intellectual property is still the solution, we have no other. However, all the system needs to be rearranged and modified, along with other instruments and our economic relations.
Being the global research and development dominated by rich countries, intellectual property is still a basic pattern. The idea of abolishing the system in order to permit opening the flood gates of technology, is suggestive but utopian, and doesn't work.
Patent-breaking alone won't adjust climate. It's a mistake to trust that we can overcome the climate crisis if only we discover the right technology or the smart device.

Shabalala (a researcher from Maastricht University) states that IP is a "necessary but insufficient condition" for technology transfer, but that it is more important to find solutions that balance IP and spillovers.
Under capitalist system the inevitable outcome is that research and development is determined by profit motivations and the prospect of future gains incentivize private investment by holders of capital. A functioning patenting system is recognized to be important for innovation and diffusion of technology. Firms in developed countries might be discouraged to invest, since big investments are needed along the value chain, especially into developing countries, if they assess the risk of their patents not being respected.

Therefore, compulsory licensing granted by government arrangements, or lowering intellectual property protection, does not seem a promising solution for the field of green technology that is so broad and undefined, especially in the long run. Free-market mechanisms seem to disfavor the adoption and dissemination of EST technologies in the world.
Some concerns have been raised about compulsory licenses in that they are not only detrimental for patentees but also for the countries in which they are granted. In fact, if developing countries absorptive capacity is not adequate, no transfer technology from developed countries will produce an automatic effect, with or without intellectual property protection.

Another backlash that could be considered in applying compulsory licensing is also the risk of misleading commercial practice from the patent owner nation.

Anyway, as long as private capital remains the prevailing source of research money, immediate public strategies have to focus on particular technologies and particular bad actors to discourage abusive patent behavior. We cannot risk hoping that the market which incentives a patent offers will inspire the correct technological development, because the period of patent protection is probably too long for the climate emergency.

Another aspect that needs to be pointed out relating to IP is the fact that the access to technology and its transfer must be remodeled in a more cooperative dimension. A virtuous process should include licensing, but it is not the only means.
In fact, as we have seen, the allocation of certain kinds of technologies, such as in green economy, is more interactive and needs large level of cooperation and collaboration between the players, either at national or international level.

As we have highlighted, a license to a patented technology does not necessarily associate to a transfer of technology and a clean technology patent may not reveal sufficient information to effectively commercialize the technology. Probably one of the biggest problems to be addressed is the presence of uncodified know-how, generally hidden under trade secrets. Because of this knowledge loss, technology transfer generally leads to situations where innovations are non-efficiently used or simply are not effectively adapted to local needs.

In the pharmaceutical sector, a manufacturer in a developing country to produce a drug, probably only needs a chemical formula, as a compulsory license might be sufficient knowledge to start production.
But in clean technology sectors, the inventions may require more skills or knowledge to produce and for the removal of barriers at a national level, a multi-level approach is then required.

Other important tools as Green Technology Packages and Patent Pools could be helpful in that sense. These tools are essentially set of documents that manage the basis for a successful green technology transfer, especially at international level. These packages can group multiple patents together facilitating the work of the potential licensee who does not have to purchase and manage separate licenses. The tools allow for gathering of all the knowledge beyond the information and the details contained in a patent's specification,

with the intention of collecting all the knowledge that is necessary for an efficient technology transfer. The green technology packages can include additional knowledge, such as technical information, skills training, and human resource plans.

Finally, talking about mechanism that could facilitate the technology transfer, it's worth mentioning the WIPO Green.
As we have seen, one of the main problems in relation to IP rights is the difficulties of licensors to communicate with potential licensees, in other words to match the offer of new technologies with their demand. This is mostly due to the patent system that lacks strong mechanisms that could publicly create awareness over the development of a new technology. This is what particularly happens in the green technology sector.
The scope of WIPO Green is creating a platform for technology exchange that will help to speed adaptation and deployment of green technology solutions by connecting technology providers with technology finders.

Last issue that we need to emphasize in relation to IPR and technology transfer for climate change is the key role of the governments and the international cooperation.
In fact, it is easy to realize that the political leverage is essential to face planet environmental problems and cooperation among governments is a basic requirement. An important issue is the international technological solidarity and a farsighted patent system must be supposed to act universally. In a global system it is not possible focusing only in one's own country climate policy, ignoring what happen in other country economies.
International organizations as UNFCCC e WIPO Green go in this sense.

Public expenditures play a massive role in climate action. For instance, a national incentive mechanism should boost companies in investing more in green technologies and their transfer. This can be achieved either by positive or negative incentives (e.g. carbon taxes). In the first scenario they should work to enhance the level investments in EST itself, while in latter case they should try to shift the spending in R&D from traditional technologies to green technologies. Incentives can be used to improve the technology transfer process: a firm that gets public resources for investing in R&D that leads to a new technology, could be required to offer on the market a green technology package at an affordable price.

Besides, governments must heavily support the research at national or international level, either through private or public institutions. On the other hand, in order to keep prices of green technology packages low, research companies in developed countries must coordinate with their governments to encourage sufficient competition.

Conclusively, public policy should bridge the system where research is done to optimize a company's market returns, with a system where research can be done to benefit human beings, with an emphasis on what good a technology can do for our survival, rather than what it sells for.

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IPRs and Climate Change: the issue of the Technology Transfer SUMMARY

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The effect of Climate Change we are experiencing these days are different from anything else we have seen so far, and it is rapidly becoming one of the most important issues we have to face in this third millennium. It is the plague of our times, causing significant damages to life and to the ecosystem, and it is threatening wealth and biodiversity of our planet.

On the basis of the latest estimates of the World Meteorological Organization (WMO) in 2019, in fact, the concentrations of carbon dioxide, the main greenhouse gas resulting from human activities, in the air, reached 407,8 parts per million (ppm), a new historical negative record.

It was in 1895 that the Swedish chemist Svante Arrhenius emphasized that humanity could boost the greenhouse effect by making carbon dioxide, a greenhouse gas. Nowadays the consensus is unanimous. The Bulletin of Science, Technology & Society by scientist James Powell, (geologist of the National Science Board of the United States) consulted more than 11.000 studies on climate change, and it has been noted that almost 100% of all these researches agree that growing emissions of greenhouse gases and other factors can all be attributable to anthropogenic activities.

The only mean we can adopt to fight these challenges is shifting the entire economy toward a more sustainable approach to the production of goods and services, as well as a wider use of renewable energies. The United Nations Framework Convention on Climate Change (UNFCCC) defines Environmentally Sound Technologies (EST) all those technologies that "*have the potential for significantly improved environmental performance relative to other technologies. ESTs protect the environment, are less polluting, use resources in a sustainable manner, recycle more of their wastes and products, and handle all residual wastes in a more environmentally acceptable way than the technologies for which they are substitutes*".

One of the biggest issues with EST is that if we really want to face climate change, we need to have these technologies implemented in both developed and developing countries by all the players in the market.

This being said, the intention of this work is to analyze the role of Intellectual Property Rights in relation to technology transfer of EST which is a very discussed topic in the last few years.

That's why dealing with climate change is becoming one of the world's greatest challenges for policymakers. They need to design a legal framework that could facilitate and incentivize the innovation process of new green technologies and their adoption and dissemination even in least developed countries. Due to a number of uncertainties and difficulties, adoption and diffusion of EST pose various issues requiring different policy initiatives, including an efficient political structure. This thesis is an essay to clarify some questions related to the technology transfer by analyzing relevant documentation on the innovation and diffusion process of ESTs. In other words the scope of this work is to analyze enabling factors for the effective diffusion of green technologies taking into consideration the role of intellectual property rights, usually embodied in patents or trade secrets. In particular the focus is on the role of Intellectual Property Rights, which constituted since the 1883 (The Paris Convention) the principal tool that has driven the innovation process.

The principal trade off associated with the use of IP rights for green technologies is the following: while developed countries see them as a strong mechanism that incentivizes innovation through the provision of exclusive rights, developing countries, not having the resources to invest in R&D or to pay licenses, consider IP as a formidable barrier to the transfer of green technologies.
The intention of these thesis is to analyze which are the most critical points when dealing with the technology transfer of green technologies and to understand if IP really impede the dissemination of new technologies.
Therefore, the most important question to bear in mind while reading this thesis is: do Intellectual Property Rights foster or prevent the diffusion of new green technologies in least developed countries?

The present work is structured in three different chapters, here is a brief recap of the main topics contained in each section. The first chapter deals with a general description of the phenomenon of climate change and frames it in the historical and political context of these days.

The adoption of "Green Technologies" seems to counteract the effects of climate change and pollution on our planet. But the transition toward a progressive sustainable future with lower emission of greenhouse gasses and the restoration of environmentally rundown areas

asks for a different approach to the economy with production processes and technologies that aim to respect more the environment. The current concept is identified in "Sustainable Development".

The so-called Brundtland Report of the United Nations World Commission on Development, written in 1987 helps to define it: *"Sustainable development is the development that meets the needs of the present without compromising the ability of future generations to meet their own needs"*. After defining what is meant by climate change and introducing the concept of sustainable development, the focus shifts toward the description of adaptation and mitigation technologies that appear to be principal means of this new approach.

After an analysis of the problem, the contest and after giving a solution approach, this section focuses on developing countries and on their difficulties to implement these technologies, which is the focus of this thesis. Many developing countries deal with economic, social and ecological threats from energy, food and water insecurity to climate change and extreme weather conditions. In these years emerging countries are becoming a major source of global economic growth and this leads to a wider use of raw materials and natural resources; this is why an adoption of green technologies in these areas is becoming of crucial importance.

Developing countries suffer from a lack of resources and are not able to adopt technologies for the sustainable growth challenge. Most of the time even basic technologies lack in most developing countries, especially those related to wastewater treatment, energy efficiency, and integrated water resource management. In addition, one of the most important concern is that even if developing countries own the technology, in most cases they are not able to be competitive in the market and they will need to import innovations from other countries. Removing barriers constituted by intellectual property rights becomes crucial to enable developing countries to move forward to the Green Economy.

Then the discussion moves towards the core of this thesis, where the main features of Intellectual Property Rights are subsequently introduced, in order to better understand how and why companies usually invest in innovative technologies and which incentive policy makers use to encourage this innovation process.

Innovation and IP are distinct but closely related concepts. In fact, innovation often leads to the creation of IP, and intellectual property rights help to provide a means to obtain funding for the innovative development of ideas and to position them in the market.

IP rights have also enabled the commercialization of new technologies, making it easier for companies to appropriate part of the added value of their inventions to develop them and bring them to the market.
IP rights can put the basis for various ways of collaborations and technological partnerships by promoting the transfer and diffusion of new technologies.
The first chapter ends by exposing the main issue of this thesis, the intention is to understand the role that IPR assume in relation to the transfer and to the adoption of green technologies in the world and questions how this transfer can be influenced by the use of this tool.
Some researchers state that IP rights can hamper the technology transfer of green innovations, primarily because they increase the costs to get access to those new resources and lastly because countries with poor institutional power inevitably miss the authority to make firms adopt the new know-how.
But some other evidence shows that when poor IP protection is at stake generally foreign firms tend to avoid licensing the new technology because they will be more exposed to miss used or unpaid royalties. In addition to this, weak IP rights can discourage investing in R&D activities, lacking the incentive generally granted to the owner of the patent, foreign venture capitalist and subsidiaries.
Summarizing, the principal concern of this work is analyzing if green technologies diffusion IP rights can be fostered or hindered through the use of Intellectual Property Rights.
In fact, IP protection granted through patents and other IPRs, are an essential tool for the creation of new knowledge (and so for the creation of EST), especially in those countries that have enough resources to invest in R&D. But can we say the same for developing countries?

After a disclosure of the problem and after analyzing which is the main idea behind the use of IP rights, the second chapter depicts them in the legal framework and starts to look at the way IPRs have been tackled throughout the description of environmental law and their history.

Addressing climate change is becoming one of the world's greatest challenges for policy makers. They need to design a legal system that could facilitate and incentivize the innovation process of new green technologies and their adoption and dissemination even in

the least developed countries. Due to a number of uncertainties and difficulties, adoption and diffusion of EST pose particular problems that need a range of policy interventions, including an efficient policy framework.

The first part starts with a description of the UNFCCC and its role with Intellectual Property, in fact, it is the main international organization that deals with IPR and the transfer of technologies, in particular against climate changes. Our intention is to identify IP in a legal framework that could help understanding how this tool works and how policy has tried to answer to the aforementioned problems.

Moreover, the chapter describes which are the most important steps in the history of IPR and concludes with a close up to the TRIPS Agreements that is the principal instrument that sets down the minimum standards for the regulation by national governments of many forms of these rights.

This last treat does not deal specifically with climate change technology but shapes how technology transfer works across nations and which tools policy makers have provided that help addressing EST transfer.

From policy aspect we have seen then that TRIPS Agreement signed by WTO nations mainly deals with creating an enabling environment for investments and trade by patent holders.

The TRIPS Agreement sets strong minimum standards for the protection of intellectual property, although TRIPS does not treat specifically climate change technology, it may offer a component of the enabling context for a climate change regime.

This agreement grants the possibility of exceptions to patent protection through what is called Compulsory Licensing that will be described further on.

The third chapter can be considered the ending point of this work and it is divided into two main sections.

The first part deals with major channels for the technology transfer and emphasizes the importance of analyzing the barriers that generally constitute the principal disincentives for investing in green technologies, especially in least developed countries.

These barriers and uncertainties can be either economic, financial, technical, polical, marketing related etc., and are briefly described in this work.

Then the chapter identifies the concept of absorptive capacity that seems to be one of the most crucial aspects when dealing with technology transfer of complex innovation (like EST).

In fact, when patents are granted, generally the transfer of knowledge is a mere act of reading documents. On the contrary dealing with uncodified techniques asks for a cooperative approach to the technology transfer because part of the new knowledge can only be dispatched through interaction between the transferor and the transferee. At this point, it becomes clear that access to technologies (that have both codified and uncodified knowledge) asks for both the ability to interpret what is written in the patent and to acquire unwritten knowledge through collaboration.

Nevertheless in emerging economies, technology transfer through the acquisition of licenses, patents and investments (both domestic and foreign) significantly impact on the catch-up process. That's why it is important to bear in mind that a successful tool for the technology transfer should also address the acquisition of elementary and specialized skills in order to fully acquire advanced technologies from developed countries.

The second part of the third chapter tries to tackle the barriers connected to the EST transfer and in particular analyzes the scope of compulsory licensing as well as other possible policy tools that may grant more cooperation. This section puts the basis for discussion for future possible policy actions that could help addressing these challenges.

Compulsory Licensing foreseen in TRIPS Agreement is defined as a "*governmentally mandated arrangement allowing third parties to use another's intellectual property upon payment of a specified fee regardless of objections of the owner of the intellectual property*". In other words, through this tool the third party doesn't have to be authorized to access the technology by the patent holder himself, in fact the authority forces the patent holder to give the possibility to utilize the patented technology even if the right holder doesn't want to. This can be applied when some peculiar conditions are met, and in any case the patent holder is reimbursed for the loss generated with this expropriation.

But compulsory licensing does not seem a promising solution for the field of green technology that is so broad and undefined, especially in the long run. Free-market mechanisms seem to disfavor the adoption and dissemination of EST technologies in the world.

In fact, some concerns have been raised about compulsory licenses in that they are not only detrimental to patentees but also for the countries in which they are granted.

Under capitalism system the inevitable outcome is that research and development are driven by profit incentives and the promise of future gains incentivize private investment by owners of capital. A functioning patenting system is recognized to be important for innovation and diffusion of technology. Firms in developed countries might be discouraged to invest, especially in developing countries, if they are afraid that their patents will not be respected. And eventually, the applying of compulsory licensing could provoke the industry to bury more inventions into the domain of proprietary technology and trade secrets.

Compulsory licenses deem to be bad since it hinders attempts to the establishment of an independent, research-based industry, that is able to meet the demands of its own market, especially in countries that are focused on imitation rather than innovation.

Moreover, as we have seen, if the hosting country is not equipped with know-how, software, qualified manpower and infrastructure, the license alone will not be able to make an effect to the full potential of the technology. In a situation of compulsory licensing, it would seem odd to expect the patent holder to voluntarily offer the needed know-how, especially since they can retain these information as "trade secrets".

So, as just seen, the relationship between IPR and climate change is extremely intricated. It will be partially solved if a successful flow of technologies towards developing countries will be enabled, and if a concrete removal of barriers at a national level a multi-level approach will be reached.

The aforementioned constraints might be solved through the use of other important tools as Green Technology Packages, Patent Pools and National Incentives, described in this part of the chapter.

A green technology package is the key document or set of documents that set the basis for a successful green technology transfer, especially at international level. This tool allows for gathering of all the information and the details included in patent's specifications, with the intention of collecting all the knowledge that is necessary for an efficient technology transfer. The green technology package may contain technical information, human resource plans and trainings, and many other important details and additional knowledge exceeding the scope of a patent.

Another technology transfer tool is the patent pooling: a basket of rights that can facilitate the licensing and the sharing of green technology at affordable prices or possibly royalty-free.
This instrument asks for a separate entity that should administer the pool and which is generally independent from each patentee.
This tool is generally used when dealing with complex technologies which may require a broad number of complementary technologies and products. That's why the creation of a patent pool is a good choice when dealing with EST because these innovations are one of the most difficult to implement and may happen that they overlap or have interconnected claims.

Coupling IP rights together with the know-how to make an invention seems to be a winning and needed choice for developing countries and for emerging economies. It is evident that, the provision of patent pooling has a unique advantage versus compulsory licensing that makes this tool more closely related to technology transfer and not just avoidance of IPRs.

One of the biggest concerns when dealing with technology transfer is that even if a technology and all the know-how attached to it are fully disclosed, a country may lack the infrastructure or the resources to successfully implement the innovation.
Therefore, a national level of transfer mechanisms will be required to counteract such internal barriers and research companies need to coordinate with their governments.
The incentive mechanism from national governments that can be found in this part of work, should incentivize developing countries in investing more in green technologies and their transfer, and this can be achieved either by positive or negative incentives (i.e. carbon taxes). In the first scenario they should work to enhance the level investments in EST itself, while in latter case they should try to shift the spending in R&D from fossil fuels technologies to green technologies.

Finally, in the last part of third chapter, talking about mechanism that could facilitate the technology transfer, we have mentioned the World Intellectual Property Organization Green (WIPO Green).
As noted previously, one of the main problems in relation to IP rights is the difficulties of licensors to connect with potential licensees, in other word to match the offer of new

technologies with their demand. This is mostly due to the patent system that lacks strong mechanisms that could publicly create awareness over the development of a new technology. This is particularly true in the green technology sector.
To answer all these problems and to facilitate access to relevant patent information, in the 2013 has gave birth to the WIPO Green.
The intention of the organization is to create a sort of bridge between possible technology users and technology providers, to favor the exchange of green technologies. In fact, WIPO Green is a sort of hub that facilitates would-be partners to connect one another.
As we have seen, IP rights play a critical role in terms of attracting possible shareholders, enabling entry into potential markets and allowing effective collaborations. By injecting greater transparency into the market for ESTs through the use of WIPO Green the process that drives to the effective dissemination of new green technology could be improved.

In the conclusion we can summarize that Climate Changes and Global Warming bears an innumerable amount of problems and challenges for our planet and transfer of technology plays a key role.
Human beings need a drastic change in the production and distribution of goods and services. In fact, we need to efficiently produce and store clean, low-cost energy, as well as to implement new ways of agriculture that can meet the food needs of populations while preserving the planet and its ability to renew itself. We need to develop new and efficient equipment in a sustainable way, both for personal use and for industrial production.
The only way to accomplish this transformation in effective ways is by implementing the right technologies throughout the world.

But since the economic world is divided in two, the economic growth of the countries in the South must learn from the mistakes made in the past in many countries of the North and cannot be based on the same model of development. In fact, following in the steps of a carbon hungry economic development as for developed countries would bring a catastrophe to the planet. In creating new economies for developing countries, they must be based on sustainable foundations, using the knowledge and technologies that are currently being developed in so-called developed countries. To accomplish this, we will need to focus on new mechanisms for sharing technology, to create a bridge between rich countries and poor countries, a technology flow from where is developed to where is needed.

As we have seen, new research and development activities are determined by the necessities and preferences of rich countries, as most of the research and development effort takes place in rich countries and therefore even the profit from green technologies consolidates the disparity of global wealth.

That's way climate policy must face what is called "new colonialism". We can prevent this by reconsidering the system accountable for technological embargoes, possible beginning from intellectual property.
But just starting from this assertion, we wish to avoid any misunderstandings: the intellectual property is still the solution, we have no other. However, all the system needs to be rearranged and modified, along with other instruments and our economic relations.
Being the global research and development dominated by rich countries, intellectual property is still a basic pattern. The idea of abolishing the system in order to permit opening the flood gates of technology, is suggestive but utopian, and doesn't work.
Patent-breaking alone won't adjust climate, and IPR are necessary even if they are not sufficient for technology transfer.
Under capitalist system the inevitable outcome is that research and development is determined by profit motivations and the prospect of future gains incentivize private investment by holders of capital. A functioning patenting system is recognized to be important for innovation and diffusion of technology. Firms in developed countries might be discouraged to invest, since big investments are needed along the value chain, especially into developing countries, if they assess the risk of their patents not being respected.

Therefore, compulsory licensing granted by government arrangements, or lowering intellectual property protection, does not seem a promising solution for the field of green technology that is so broad and undefined, especially in the long run. Free-market mechanisms seem to disfavor the adoption and dissemination of EST technologies in the world.
Some concerns have been raised about compulsory licenses in that they are not only detrimental for patentees but also for the countries in which they are granted. In fact, if developing countries absorptive capacity is not adequate, no transfer technology from

developed countries will produce an automatic effect, with or without intellectual property protection.

Another backlash that could be considered in applying compulsory licensing is also the risk of misleading commercial practice from the patent owner nation.
Anyway, as long as private capital remains the prevailing source of research money, immediate public strategies have to focus on particular technologies and particular bad actors to discourage abusive patent behavior. We cannot risk to hope that the market which incentives a patent offers will inspire the correct technological development, because the period of patent protection is probably too long for the climate emergency.

Another aspect that needs to be pointed out relating to IP is the fact that the access to technology and its transfer must be remodeled in a more cooperative dimension. A virtuous process should include licensing, but it is not the only means.
In fact, as we have seen, the allocation of certain kinds of technologies, such as in green economy, is more interactive and needs large level of cooperation and collaboration between the players, either at national or international level.

As we have highlighted, a license to a patented technology does not necessarily associate to a transfer of technology and a clean technology patent may not reveal sufficient information to effectively commercialize the technology. Probably one of the biggest problems to be addressed is the presence of uncodified know-how, generally hidden under trade secrets. Because of this knowledge loss, technology transfer generally leads to situations where innovations are non-efficiently used or simply are not effectively adapted to local needs.

In the pharmaceutical sector, a manufacturer in a developing country to produce a drug, probably only needs a chemical formula, as a compulsory license might be sufficient knowledge to start production. But in clean technology sectors, the inventions may require more skills or knowledge to produce and for the removal of barriers at a national level, a multi-level approach is then required.

Other important tools as Green Technology Packages and Patent Pools could be helpful in that.

These tools are essentially set of documents that manage the basis for a successful green technology transfer, especially at international level. These packages can group multiple patents together facilitating the work of the potential licensee who does not have to purchase and manage separate licenses. The tools allow for gathering of all the knowledge beyond the information and the details contained in a patent's specification, with the intention of collecting all the knowledge that is necessary for an efficient technology transfer. The green technology packages can include as technical information, skills training, and human resource plans.

Finally, talking about mechanism that could facilitate the technology transfer, it's worth mentioning the WIPO Green.
As we have seen, one of the main problems in relation to IP rights is the difficulties of licensors to communicate with potential licensees, in other words to match the offer of new technologies with their demand. This is mostly due to the patent system that lacks strong mechanisms that could publicly create awareness over the development of a new technology. This is what particularly happens in the green technology sector.
The scope of WIPO Green is creating a platform for technology exchange that will help to speed adaptation and deployment of green technology solutions by connecting technology providers with technology finders.

Last issue that we need to emphasize in relation to IPR and technology transfer for climate change is the key role of the governments and the international cooperation. In fact, it is easy to realize that the political leverage is essential to face planet environmental problems and cooperation among governments is a basic requirement. An important issue is the international technological solidarity and a farsighted patent system must be supposed to act universally.
International organizations as UNFCCC e WIPO Green go in this sense.

Public expenditures play a massive role in climate action. For instance, a national incentive mechanism should boost companies in investing more in green technologies and their transfer. This can be achieved either by positive or negative incentives (e.g. carbon taxes). In the first scenario they should work to enhance the level investments in EST itself, while in latter case they should try to shift the spending in R&D from traditional technologies to green technologies. Incentives can be used to improve the technology transfer process: a

firm that gets public resources for investing in R&D that leads to a new technology, could be required to offer on the market a green technology package at an affordable price.

Besides, governments must heavily support the research at national or international level, either through private or public institutions. On the other hand, in order to keep prices of green technology packages low, research companies in developed countries must coordinate with their governments to encourage sufficient competition. Conclusively, public policy should bridge the system where research is done to optimize a company's market returns, with a system where research can be done to benefit human beings, with an emphasis on what good a technology can do for our survival, rather than what it sells for.