A FEASIBILITY STUDY OF ENTERING THE SOLAR ENERGY MARKET: THE CASE OF HELIOREC

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ABSTRACT

This paper analyzes the market feasibility of HelioRec's business idea in entering the solar energy market. The business idea is to build an offshore solar power plant based on recycled plastic waste, which produces off-grid green electricity in the sea. The solution will provide both cost-saving electricity and plastic waste optimizing solution. This innovative idea of recycling plastic waste into a floating structure of the power plant is very new and has no similar innovation in the market. Nevertheless, the feasibility of entering the market must be studied before establishing the business.

The main objectives of this study are to conduct the analysis of the company and global market to see HelioRec's competitive advantages in the global energy market, the market attractiveness assessment and to provide recommendations to HelioRec when approaching potential investors.

The findings indicate that HelioRec is feasible to enter the solar energy market, which is continuously adding to the global energy capacity every year. The tools used in this study helped HelioRec to prepare the business plan in order to attract potential investors and progress with their business implementation in the future.

KEY WORDS: Offshore Solar/ Renewable Energy/ Solar Energy/ Market Feasibility/ Plastic Recycling

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LIST OF ABBREVIATIONS

AI	Artificial Intelligent
FiT	Feed-in-Tariff
HDPE	High Density Polyethylene
kWh	Kilowatts per Hour
LCA	Life Cycle Assessment
LCOE	Levelized Cost of Energy
ML	Machine Learning
MWh	Megawatts per Hour
OTEC	Ocean Thermal Energy Conversion
PV	Photovoltaic
R&D	Research and Development
SDG	Sustainable Development Goals
TRL	Technology Readiness Level
TSM	Toulouse School of Management of Université Toulouse 1 Capitole
UN	United Nations
UNDP	United Nations Development Program

CHAPTER I
INTRODUCTION

1.1 Background

Over the past decade, the world's major electricity supply has been generated from traditional energy sources such as natural gas, coal and oil. Propelled by the global economic expansion, an increasing demand for these energy sources becomes the most important player in global energy-related carbon emissions. According to IEA (2019a), fossil-fuel-related carbon emissions hit a record of 33.1 billion metric tons, accounting for 1.7 percent of carbon emissions rising from last year. Evidently, this rapid change affects not only on the global climate but also impact population concerns such as human health issues, ecosystems, and economy (IPCC, 2019). As a result, businesses, government and private sectors are progressively promoting renewables to be alternative sources. Introducing these renewables such as solar, wind and biomass, it is believed to diminish public concerns. In contrast to the non-renewables, renewable energy is naturally unlimited in availability and accessibility. Hence, there has been an increase in numbers of global companies actively and voluntarily invest in self-generation of renewable energy (IRENA, 2018). Due to decreasing costs and evolving technologies from time to time, the demand for electricity and the need for a corporate sustainability have unprecedentedly growing. Moreover, with favorable policies support in many countries, they have helped a rapid expansion of renewable energies in a global energy transformation.

Among all renewables, solar energy has acknowledged as one of the most speedily growing renewable sources of electricity generation. Solar alone installed more generation capacity than all fossil fuels and nuclear together (Solar Power Europe, 2019). Driven in part by supportive policies, this prosperous solar photovoltaic (PV) market has an annual growth rate of 27% over the past five years (Wanner, 2019) as a result of an affordable cost of solar-based renewable that

significantly helps endorse the green electricity to the commercial-scale market. Typically, this electricity generated from solar energy comes from solar PV, also called solar cells, which can be installed either on ground, rooftops, or on the water surface (offshore). Rooftop or ground-mounted solar power plant is perhaps fascinating for those who live in land availability areas. However, as the electricity demand grows in condensed population areas, land scarcity, space constraint and limited roof space such as Singapore (Sunseap Group, 2019), an offshore floating solar power plant has become a suitable solution to produce electricity to these specific areas.

Thus, HelioRec, a solar-energy tech startup, recognizes the importance of developing an offshore solar power plant technology to suit this growing demand of electricity whereby existing electricity power cannot be sufficiently produced. In addition, it can also provide independent electricity source for remote islands such as El Hierro, the smallest and most remote island of the Canary Islands, Spain (Sperling, 2018). The floating platform is manufactured from recycled plastic waste. It is innovatively designed with the ability to be deployed in the sea and is simulated to withstand high waves.

Concerning the global issues, the startup aims to attract investors or buyers who find the need and benefits of offshore solar power plant and invest in its initial pilot project. The solution will not only serve the electricity demand, but also resolve three main challenges: mismanaged plastic waste, land scarcity due to fast-growing population, and greenhouse gas emission.

Thanks to the collaborative support from HelioRec's founder and CEO, Miss Polina Valensiko, the team of researchers had an opportunity to interview the product development team in order to understand the overall concept and process of the technology prototype and project initiative.

Today, numerous new technologies of solar energy generation have been introduced to the businesses as a feasible option to reduce cost of electricity, improve their brand reputation and gain competitiveness. Thus, HelioRec is eager to learn about the current competition in the solar energy industry with the purpose of providing not only cost-saving electricity but also plastic waste optimizing solution.

Figure 1.1 The Floating Solar Power Plant Prototype Designed by HelioRec
Source: HelioRec (2018)

1.2 Problem Statement

HelioRec is trying to find energy investors or buyers who recognize the green electricity generated by offshore solar power plant either as a major energy source or additional source to the existing power plant. To acquire funds for developing the prototype, the understanding of renewable energy industry and the analysis of competitors existing in the energy market would help determine competitive advantages. Hence, recommendations of approaches to potential investors would be provided.

1.3 Research Objectives

In accordance with HelioRec's project of developing offshore solar power plant technology, the researchers study the concept of energy power generation and analyze the competitive advantages alongside the following objectives.

1. To explore existing energy sources available in the market, both renewable and non-renewable ones, in order to gain competitive advantages and compete in the industry.

2. To assess the market attractiveness and HelioRec's business analysis using SWOT framework and business model canvas.

3. To provide recommendations to HelioRec when approaching potential investors.

1.4 The Scope of Research

In compliance with the consulting internship project between Toulouse School of Management (TSM) of Université Toulouse 1 Capitole and HelioRec, a team of researchers was assigned to study and analyze business strategies of HelioRec in order to attract potential investors for the future pilot project.

This study focuses on the possibility of global market entry into renewable energy industry for HelioRec as a startup in Paris, France. HelioRec's competitive advantages will be highlighted and recommendations on business development strategy will also be provided.

CHAPTER II
LITERATURE REVIEW

This chapter describes the main theories and frameworks applied in the study. The relevant background of renewable energy industry, solar technology and plastic recycling industry are introduced. Afterwards, SWOT analysis and business model canvas are presented to analyze the business competitive advantages and market attractiveness. Lastly, the energy frameworks of the Levelized Cost of Energy (LCOE) and the Technology Readiness Level (TRL) assessment, which are crucial when approaching potential energy investors, are also included.

2.1 History of Energy

Energy has been explored throughout the history of mankind. From wood heating to industrial powering steam engines, human technologically advanced various energy sources to meet the demand for consumption in each era. Significantly, in the late 19th century, there were concerns of running out of fossil fuel supply as they have been gradually exhausted and non-renewable. People seek to develop green energy in order to escape from the dependence on coal and oil (Motyka; Slaughter, & Amon, 2018). Particularly, there has been an increasing consumption of energy worldwide as people progressively use electricity and electronic devices in their everyday life.

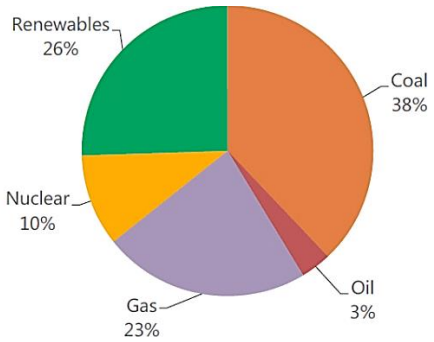


Figure 2.1 Electricity Generation Mix in 2018

Source: IEA (2019a)

2.2 Renewable Energy Industry

Renewable energy is the energy harvested from renewable resources, that are naturally replenished and infinite, such as solar, wind, hydro, geothermal and biomass. The term ‘renewable energy’ is frequently used compatible to alternative or green energy as it is produced less environmental impact than the non-renewables. Renewable resources are the most matured energy existed known to human. For instance, people harness the wind energy to sail ships over water or bathe in a hot spring, which is from geothermal energy source. Today, these resources provide energy in four major areas: electricity generation, water or air heating/cooling, transportation, and rural off-grid locations (IRENA, 2018). Some types of renewable energy are hydro-power, sunlight, tide, biomass, and geothermal energy (Figure 2.2).

In addition, the United Nations Development Program (UNDP) highlights the global goals recognized as the Sustainable Development Goals (SDGs) (Appendix A). The 17 SDGs released in 2012 to help tackle global challenges on environmental sustainability, poverty reduction, equity, etc. (UNDP, n.d.). Renewable energy embraces SDG 7 on ‘affordable and clean energy’ and SDG 13 on ‘climate action’. The goals aim to increase the global share of renewables to be widely accessible and to reduce greenhouse gas which contributes to the global warming. Moreover, renewables are crucial to achieve to the Paris Climate Change Agreement’s goals, which limit the global average temperature to prevent the worst impact from climate change (UN, 2015).

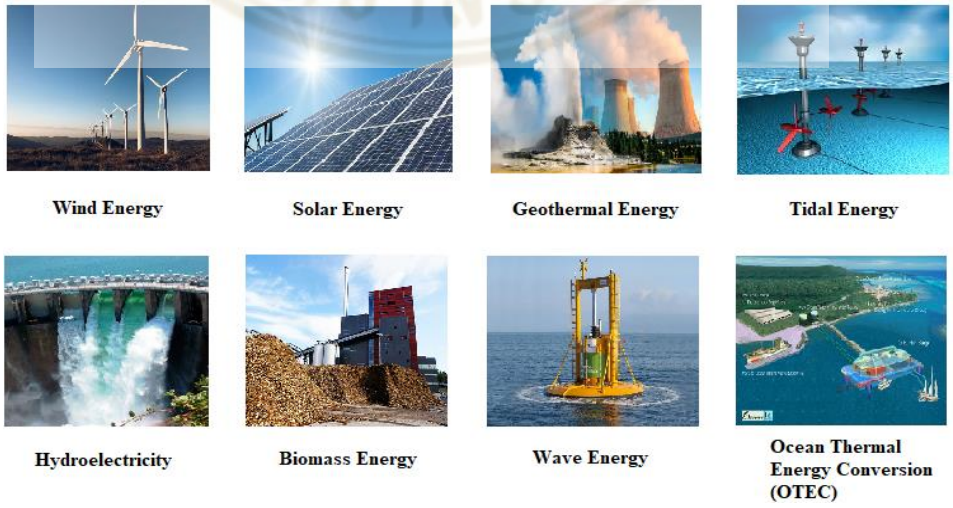


Figure 2.2 Types of Renewable Energy for Electricity Generation

Source: Own Illustration

2.3 Solar Power Technology

Solar power technology is not new. It has long developed throughout history since the 1200s A.D. (IEA, 2019b). The importance of solar energy was increasingly aware during the 20th century when the theory of peak oil crisis emerged. Many companies recognized the need to cultivate renewables to replace the current non-renewables, which caused the global warming. Today, solar technology is one of the pioneer technologies that lead to energy transition in many countries. The evolution of solar and wind technology has been the dynamic force of the transition to a low carbon world (UNDP, n.d.). According to the IEA report (2019c), solar PV technology shares the largest capacity on electricity generation since 2015 (Figure 2.3). The boost in solar technology is largely because of its remarkable cost development (BNEF, 2018). Technical improvements and an increase in solar module facilities affect a declined cost and price of solar power generation.

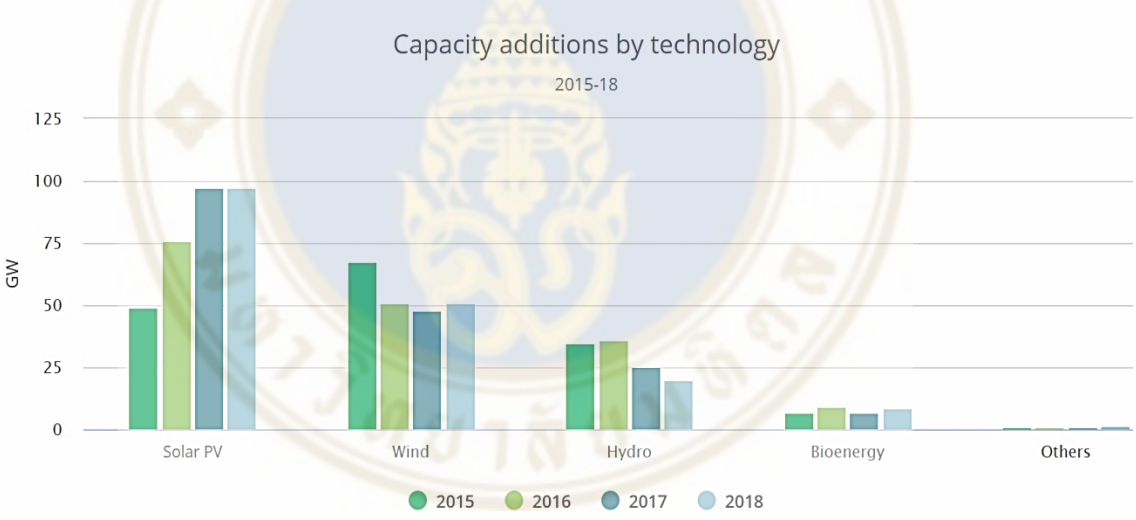


Figure 2.3 Capacity Additions by Technology

Source: IEA (2019c)

2.3.1 Solar Photovoltaics

In 1885, Werner von Siemens discovered the solar photovoltaic (PV) or solar cell from the experiments of harnessing sunlight to generate affordable electricity. Solar panels are manufactured from silicon PV cells connected to adjacent panels in order to produce direct current electricity from sunlight through cables. Because the demand for solar panels grows rapidly, there has been a cost decline for

the past four decades (Figure 2.4). From the empirical analysis results of ADBInstitute, one of the main mechanisms contributed to this is a tremendous increase in solar PV cumulative capacity globally (Taghizadeh-Hesary; Yoshino, & Inagaki, 2018). The government efforts and support policies play an important role in accelerating the deployment of solar PV and its cost reductions; for instance, lower interest rates or finance green technology (Wanner, 2019). Besides, R&D improvements in solar power generation technology and production process significantly support exponential growth of the solar PV capacity worldwide.

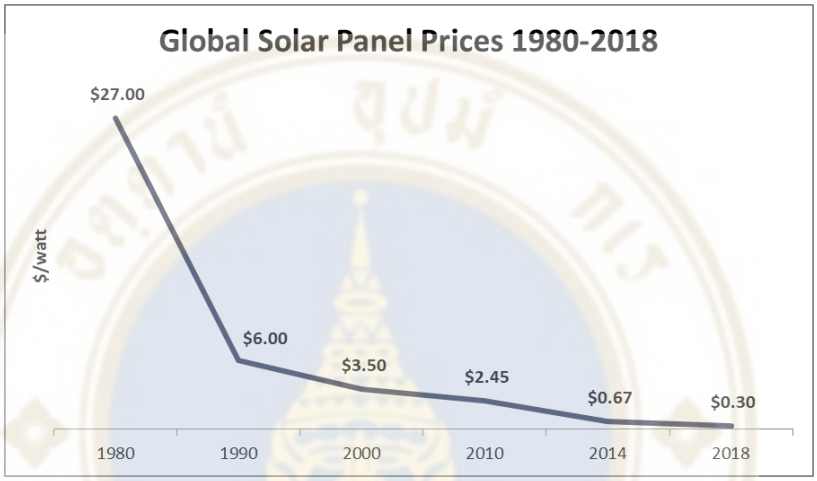


Figure 2.4 Global Solar Panel Prices 1980-2018

Source: Solar Tribune (2019)

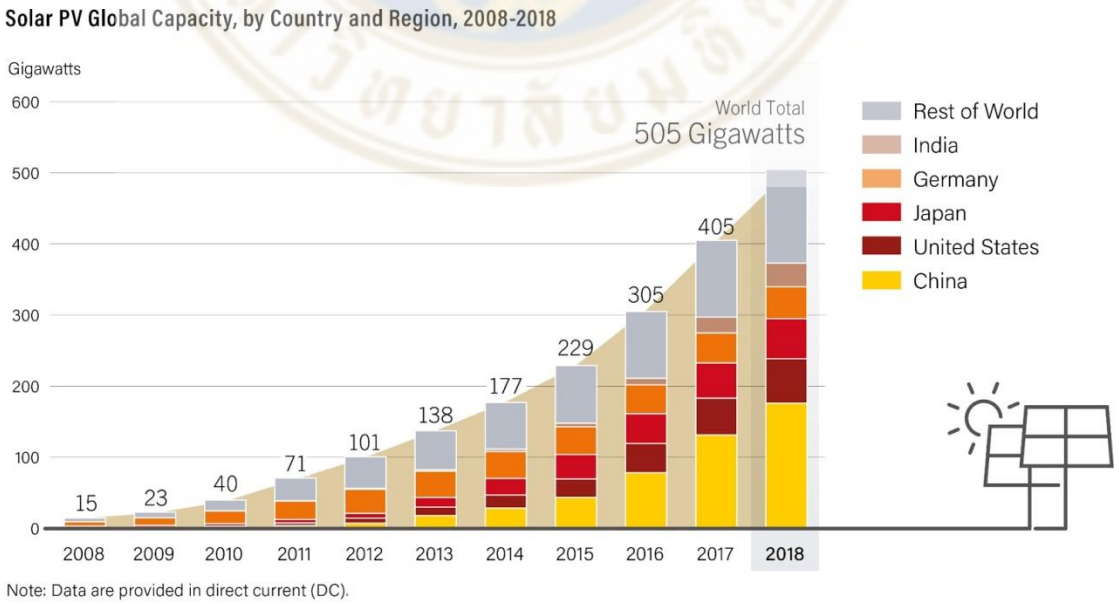


Figure 2.5 Solar PV Global Capacity, by Country and Region, 2008-2018

Source: REN21 (2019)

2.3.2 Solar Power Systems

When solar cells produce direct current electricity, it will be converted to alternating current electricity by the solar inverter which is inside any solar power system. There are three common forms of solar power systems: on grid (integrated system), off grid (stand-alone power system), and hybrid.

On grid system, also known as grid-tie inverter, mounted on the roof or ground is the most common in homes and businesses. The main power supply is connected and depends on the utility supplier with no power storage. It largely helps to reduce electricity cost. Therefore, in some countries, the government is unwilling or legally inept to provide infrastructure to connect the 'on grid' system to the main utility grid such as South Africa, Nigeria, etc. (World Bank Group, 2017).

Accordingly, 'off grid' system is more beneficial as it uses batteries to store power to be used all day or even when solar panels produce less electricity, i.e., on cloudy days or at nighttime. Likewise, when the system has more electricity than required, the surplus can be used to recharge the batteries. This way, it brings electricity independently to any remote area. Thus, 'off grid' provides flexibility and stability for electricity generation, particularly for an offshore power plant, while solving grid balancing problem and power resilience.

Lastly, the hybrid system is a combination of existing 'on grid' and battery storage in one. This means it will store solar energy produced during the day and use it at night which allows consumers to benefit from both systems. However, the price for this system is rather high for utility-scale consumption.

2.4 Plastic Recycling Industry

Plastic recycling industry is growing and more recycling facilities are being installed due to an increasing volume of disposable plastic consumption and production. According to Geyer; Jambeck & Law (2017), only 9% of the produced plastic is recycled. The huge majority is discarded (Figure 2.6). By 2050, people will have produced 26 billion tons of plastic waste. Accordingly, plastic pollution has become potential hazard to the environment as it emits greenhouse gases such as

methane and ethylene as well as pollutes water, soil and air (UNEP, 2018). People are increasingly aware of the plastic pollution and governments are starting to act upon the issue (e.g. increase awareness programs, ban of disposable plastic production, rising quantity of recycled plastics, etc.). Demand for recycled plastic is likely to reveal opportunities as many companies are adopting recycled plastic as their raw materials and into products.

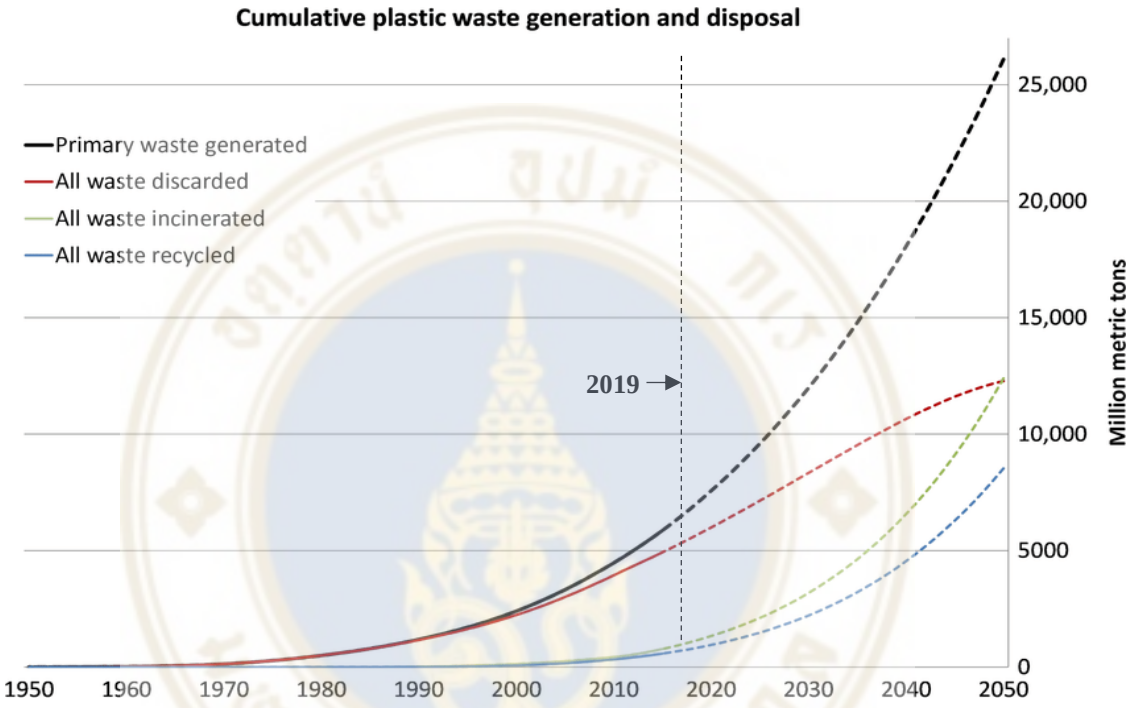


Figure 2.6 Cumulative Plastic Waste Generation and Disposal

Source: Geyer; Jambeck & Law (2017)

Plastic recycling is contributed to a ‘Circular Economy’ (Appendix D) that aligns with the UNDP. The circular economy aims to close the plastic material loop through recycling, reuse, re-manufacturing, etc. It helps to develop the most sustainable option of plastic waste management and foster recycling to benefit the full potential of plastic life cycle (Rizos; Tuokko & Behrens, 2017). Plastic recycling industry absolutely can make a noteworthy contribution in achieving the global goals for a sustainable development.

2.5 SWOT Analysis

SWOT analysis was invented by Albert Humphrey and is a well-known framework used in value-based management which defines the relationship between the internal assessments and external benchmarking. It is a vital tool to analyze the position of a business within the industry from the internal to external perspectives (Hill & Westbrook, 1997). The analysis will be used to formulate strategies in order to distinguish strengths, weaknesses, opportunities and threats of the market attractiveness and business competitiveness. Hence, this framework combines a realistic assessment to direct the firm towards the right direction and gain a competitive positioning over its competitors.

Table 2.1 SWOT Analysis

STRENGTHS - Internal factors - Positive	**W**EAKNESSES - Internal factors - Negative
OPPORTUNITIES - External factors - Positive	**T**HREATS - External factors - Negative

Source: Own Illustration

2.6 Business Model Canvas

The business model canvas is a strategic tool to explain and interconnect a business idea, which considers the necessary features of a business, by organizing the concept in a lucid way. The canvas comprises of two main sides; the left side emphasis on the internal business while focusing on the customer (external business) on the right side (Osterwalder & Pigneur, 2013). Both internal and external factors meet around the value proposition or the value exchange between the business and customers. By using the tool, the business performance can be quickly and easily improved as all aspects in the value chain are made clear at a glance. Hence, the business can adjust its value proposition, improve strategies structurally and integrate them into an effective business plan.

Table 2.2 Business Model Canvas

<table>
<tr><td rowspan="2">Key Partners</td><td>Key Activities</td><td rowspan="2">Value Prepositions</td><td>Customer Relationships</td><td rowspan="2">Customer Segments</td></tr>
<tr><td>Key Resources</td><td>Channels</td></tr>
<tr><td colspan="2">Cost Structure</td><td colspan="3">Revenue Streams</td></tr>
</table>

Source: Own Illustration

2.7 Levelized Cost of Energy (LCOE)

The LCOE is used as a relative measure between alternative energy sources (Aldersey-Williamsa & Rubert, 2019). It has the unit cost (per kWh or per MWh) of a sum of the total cost of constructing and operating the power plant over its lifetime (EL-Shimy, 2012). Typically, the LCOE is calculated over 20-40 years of life. It is useful for benchmarking technologies with dissimilar operating characteristics. It tells how much the all-in cost in its lifetime such as operation, maintenance and cost of capital (Short, 1995) and how much energy it can produce over the period. The calculation needs to be clear on which costs to be included in such as local tax, environmental impact studies, or government subsidies. Moreover, the LCOE is often used as the minimum price for an energy project to sell energy to break even. The equation is shown on Figure 2.7.

$$\mathrm{LCOE} = \frac{\text{sum of costs over lifetime}}{\text{sum of electrical energy produced over lifetime}} = \frac{\sum_{t=1}^{n} \frac{I_t + M_t + F_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{E_t}{(1+r)^t}}$$

I_t : investment expenditures in the year t

M_t : operations and maintenance expenditures in the year t

F_t : fuel expenditures in the year t

E_t : electrical energy generated in the year t

r : discount rate

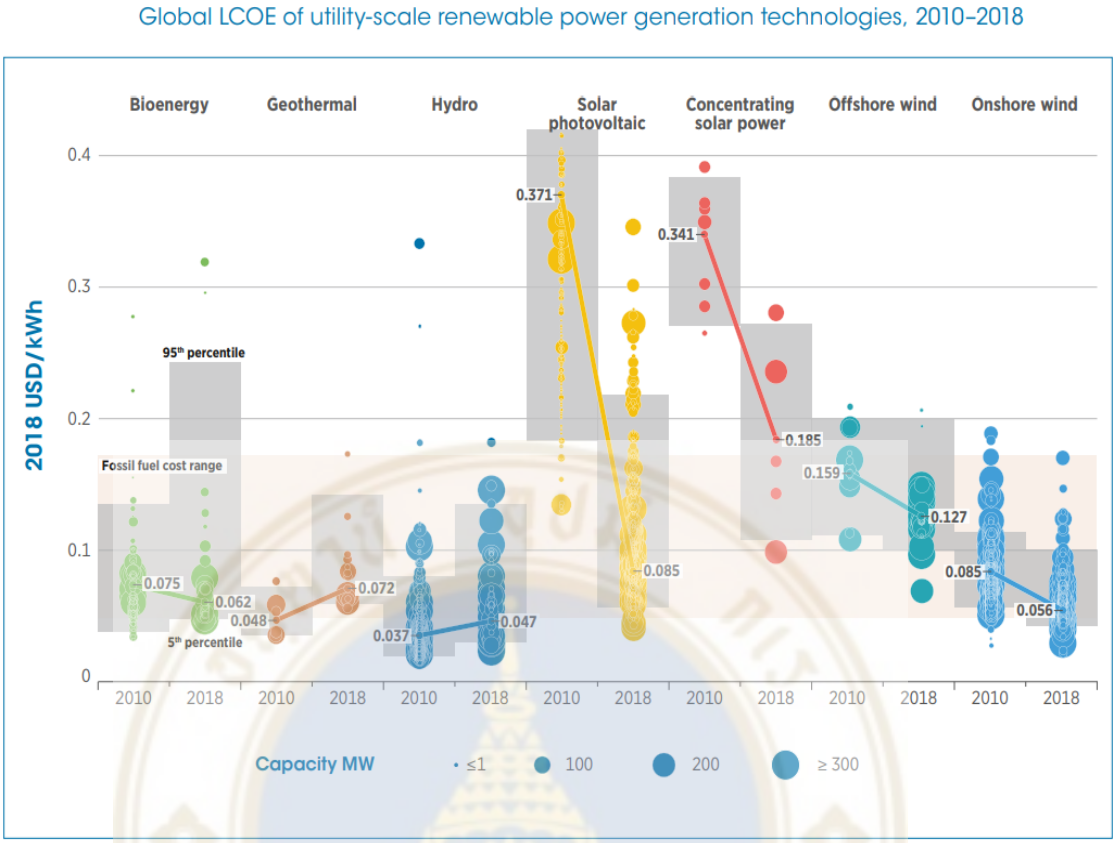
n : expected lifetime of system or power station

Figure 2.7 The LCOE Equation

Source: The Green Age (2018)

The LCOE presents the price of electricity where revenues would equal to costs and hence will make a return on the fund invested equivalent to a discount rate. Generally, if the LCOE of other alternatives is above this outcome, it would yield a higher return on capital. In contrast, if the price is below, it would mean a lower return and it may not be worth to invest. According to the Lazard Capital (2018), for instance, the solar power generation cost allows the electricity price to be as low as 0.02 USD/kWh range in various sunny places globally, which was decreased by approximately 14% in 2018. The link of the LCOE online calculator is available on the following link. https://www.nrel.gov/analysis/tech-lcoe.html

Figure 2.8 demonstrates the data of the global LCOEs for renewable power generation technologies from 2010 to 2018. The figure shows the trend of each energy's LCOE and the capacity for each one. For instance, the LCOE of the solar PV drops 77% since 2010 along with a larger capacity. Descending electricity costs for solar PV, onshore and offshore wind signal that renewables are taking the competitive mainstay of the energy sector transformation globally.



Note: This data is for the year of commissioning. The diameter of the circle represents the size of the project, with its centre the value for the cost of each project on the Y axis. The thick lines are the global weighted-average LCOE value for plants commissioned in each year. Real weighted average cost of capital (WACC) is 7.5% for OECD countries and China and 10% for the rest of the world. The single band represents the fossil fuel-fired power generation cost range, while the bands for each technology and year represent the 5th and 95th percentile bands for renewable projects.

Figure 2.8 Global LCOE of Utility-scale Renewable Power Generation Technologies, 2010-2018

Source: IRENA (2019)

2.8 Technology Readiness Level (TRL) Assessment

The NASA originally created this tool to enable companies to perform a self-assessment in terms of the readiness of technology execution. The tool consists of nine phrases as shown in Figure 2.9. This assessment is a knowledge-based readiness standard for evaluating the maturity of new technologies under development in a 1-to-9 measurement scale. The assessment can be categorized into three stages: early-stage research (TRL 0-3), development (TRL 4-5) and commercialization (TRL 6-9). It helps to monitor and adjust the progress route to a bigger system integration or market launch. Businesses piloting product development often use TRL to support a better execution in terms of project performance, budget and schedule. The scale is also valued for its ability to improve risk management, project coordination and resource allocation Many engineers, innovators, investors, international organizations and governments in many countries adopt it in the projects. The tool is crucial for project management which helps businesses keep track of activities and, specifically, helps in applying for funding from potential investors.

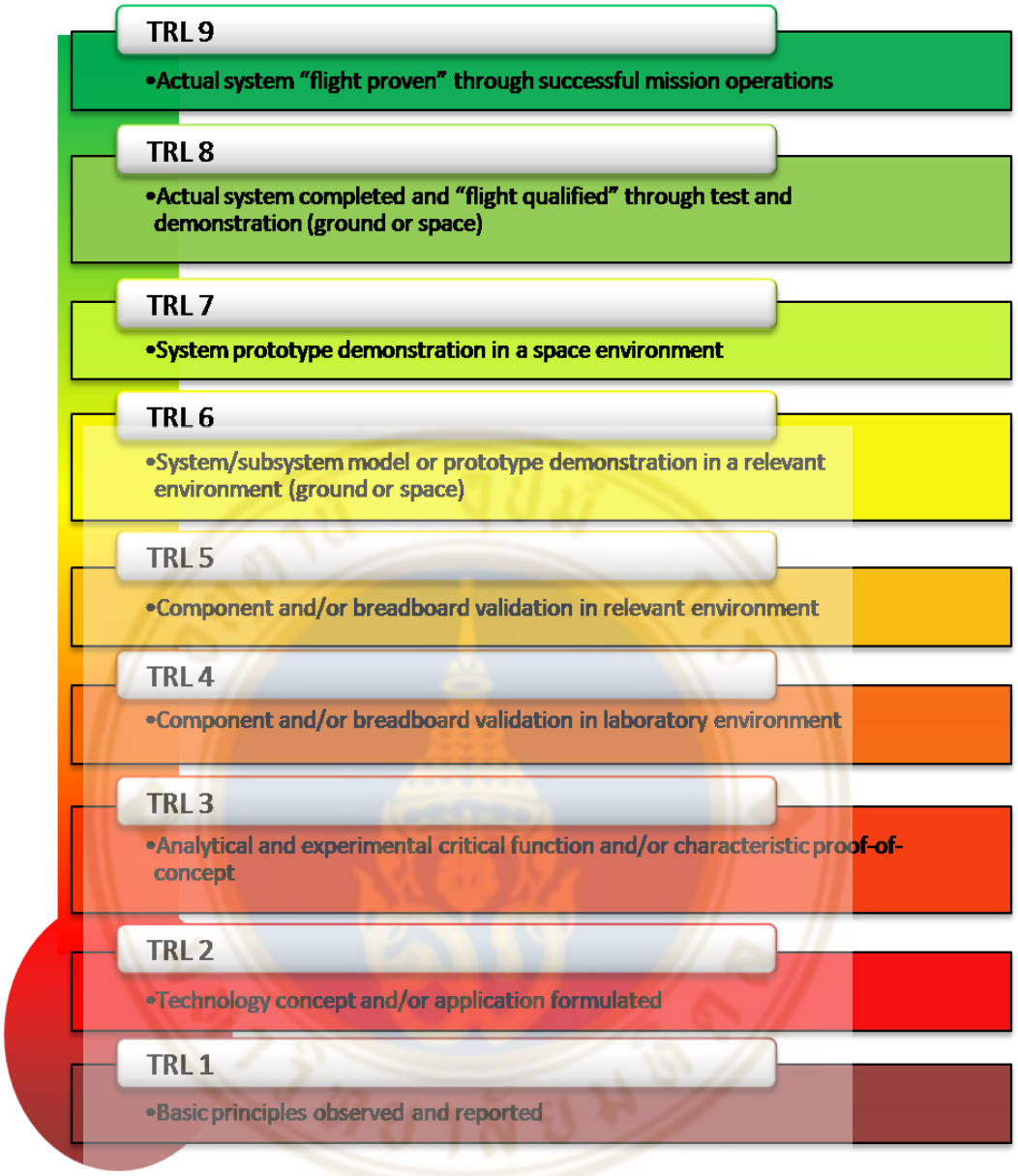


Figure 2.9 The Technology Readiness Level (TRL) Assessment

Source: NASA Official (2012)

CHAPTER III
RESEARCH METHODOLOGY

This chapter describes the research methodology and data collection used in this study. The research design consists of five phases: Problem Definition, Framework Development, Data Collection, Developing Tools, and Analysis.

3.1 Research Design

As an international school, Toulouse School of Management (TSM) assigned a multicultural team of three members as shown in Figure 3.1. The first member on the left is Mr. Ignatio Gomez, a Spanish national. The second in the middle is Miss Choltita Mukdahan, from Thailand. The member on the right is Mr. Lilian Labiste, a Frenchman. Prior to having a video conference with HelioRec, headquartered in Paris, the TSM team had a kick-off meeting together with the university advisor to discuss about the overall renewable energy industry. This consulting internship lasted two months and took place in Toulouse, France. The TSM team had a video conference with HelioRec weekly to update the progress and findings. The details and steps of this study are outlined in the following chapters.

Figure 3.1 The Photograph of the TSM Team in Toulouse

Source: Own Illustration

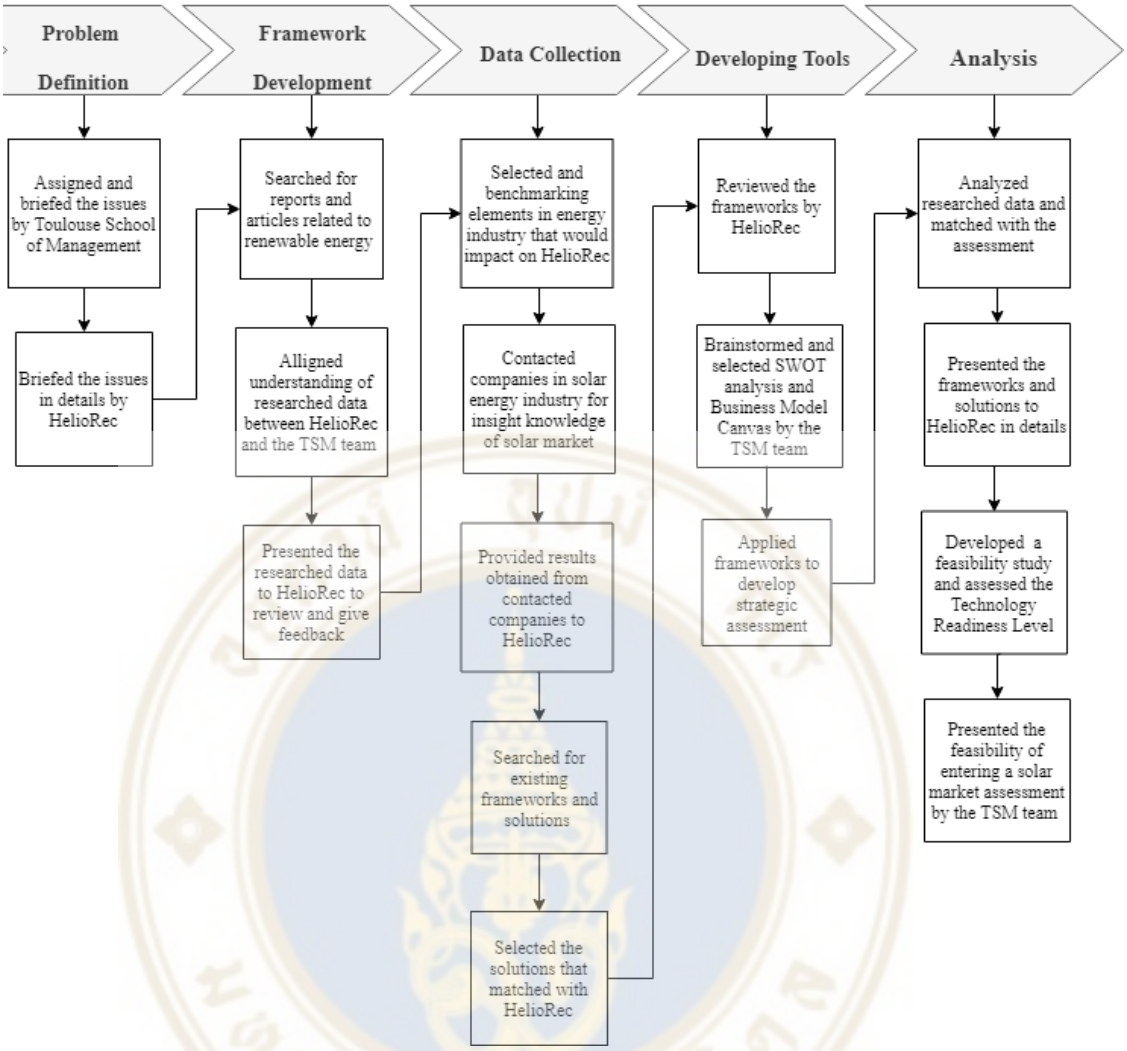


Figure 3.2 The Flowchart Diagram of Overall Workflow Between HelioRec and the TSM Team

Source: Own Illustration

From Figure 3.2, the flowchart diagram displays the overall workflow between HelioRec and the TSM team from Toulouse School of Management. There are five different phases; Problem Definition, Framework Development, Data Collection, Developing Tools and Analysis.

3.1.1 Problem Definition

In the first stage, the TSM team was assigned with the topic “renewable energy industry” from Toulouse School of Management. The university advisor informed that HelioRec is lacking of strategic plan of entering the solar energy market.

Afterwards, the TSM team had a Skype conference with the CEO of HelioRec in order to obtain more details (Figure 3.3). HelioRec, as a startup, was considering a move in the renewable energy business with an innovative solution of floating solar power plant which can be deployed in the sea. HelioRec aims to assess the readiness of its new technology and research the market and competitors before entering. Being a startup, investors naturally have doubts of investing in the project. Assessing the readiness and market research will give HelioRec several useful parameters to plan their project toward the future trend of energy transition.

Figure 3.3 Screenshot of the Video Conference with HelioRec (the CEO, Ms. Valensiko, is on the left)

Source: Own Illustration

3.1.2 Framework Development

As a new startup in the solar energy market, internal assessments and external benchmarking are the keys to identify market attractiveness and its business competitiveness. HelioRec has never done an internal or external factor analysis before. SWOT analysis will aid this startup to formulate strategies for future development. Besides, since the idea of recycled plastic-waste floater is still novel to the market, we need to define and communicate this concept by using the business model canvas template. This will help to identify all relevant aspects in its value chain. As a result, HelioRec can adjust its value proposition and structurally improve the strategies. This is a prerequisite for the company to enter the market and grow

sustainably. Lastly, to monitor the progress to a market launch, the TRL assessment will be applied in this study. This scale will benefit the company in improving risk management, project coordination and resource allocation as a small company.

3.1.3 Data Collection

The information was generally collected from secondary sources such as the Internet, online reports and articles. To have a better understanding of the renewable energy industry, the TSM team contacted companies to gain insights and knowledge of the current solar market. Additionally, the team also tried to contact the competitor companies that implement offshore solar power plant, for example, Swimsol, which is the first company to develop offshore solar power plant on low waves in Maldives. Hence, Swimsol should have substantial information that makes them succeed in the new era of energy transition. Unfortunately, they were unwilling to share the sensitive company information to outsiders. Once HelioRec reviewed the presentation of the results, the TSM team proposed the frameworks and solutions that best fit with the startup's capacity to enter the energy market.

3.1.4 Developing Tools

After the TSM team suggested the frameworks, HelioRec reviewed and agreed with the proposed frameworks and solutions. Because HelioRec is a small startup, it needs to attract investor to invest in the initial project. This means that it must come up with the business plan and viable solutions to be competitive from current competitors in the market. To do so, HelioRec will be analyzed from its potential capability to the overall value chain to assess whether the company is ready to enter the market or not. Therefore, the TSM team brainstormed and selected the first analysis tool that is the SWOT analysis framework which includes the LCOE as a key tool to attract cost-conscious investors. The LCOE comparison contains the global electricity costs of energy sources existed in the energy market.

Subsequently, the team developed the second analysis tool to assess the business model using the business model canvas to analyze its activities that can create value propositions to prospective targets. In order to assess the readiness of HelioRec's

technology, the TSM team applied the TRL assessment, which evaluates the maturity of its technology and monitors the project's progress.

3.1.5 Analysis

Initially, HelioRec provided the TSM team with brief information of its innovative technology on the power system and floating devices. However, since the technology is not yet patented, the company could not disclose detailed information to the team. Hence, the TSM team had to analyze the solar technology and environment based on the data available online which is rather broad. After analyzing the data, the team proposed ten categories of potential targets that will benefit from the technology. In addition, the team also suggested market entry strategies for startups to raise brand awareness because the company is new to both the renewable energy market and sustainable development program for its recycled-plastic-waste floating solar structure. Lastly, the TSM team selected one best geo-opportunity location in the global market to enter and find investors to be presented to HelioRec.

CHAPTER IV
FINDINGS AND ANALYSIS

This chapter presents the results from the team's brainstorm and market research as follows.

1. Assessment Tools of the Feasibility Analysis Based on SWOT Analysis and Business Model Canvas

2. Energy Industry and Competitor Analysis

3. Recommendations on Business Development Strategy

4.1 Assessment Tools of the Feasibility Analysis Based on SWOT Analysis and Business Model Canvas

HelioRec is a new tech startup founded in April 2018 with an innovative idea and engineering expertise in offshore solar power plant. The startup saw the opportunity in the solar energy market to design a floating structure made of recycled plastic waste. To extract this idea into production, it is essential to conduct an internal and external environment analysis to study the feasibility in entering the market. The TSM team used two analysis tools: 1) SWOT analysis to identify the competitive advantages and market attractiveness and 2) business model canvas to quickly and easily improve all aspects in the value chain in order to adjust its value proposition and develop its strategic planning.

The TSM team selected the first tool, which is SWOT analysis, as shown in Figure 4.1. Later, HelioRec can include this analysis into its business plan.

4.1.1 SWOT Analysis

The key objective is to discover and explore strengths and opportunities, to spot the weaknesses, and to eliminate or manage threats. Strengths and weaknesses represent the internal positive and negative aspects affecting on the business.

Opportunities and threats, however, present the external positive and negative elements. Hence, the SWOT analysis of HelioRec is conducted in order to further understand the features and overall situation. Figure 4.1 illustrates the strengths, weaknesses, opportunities and threats of the company.

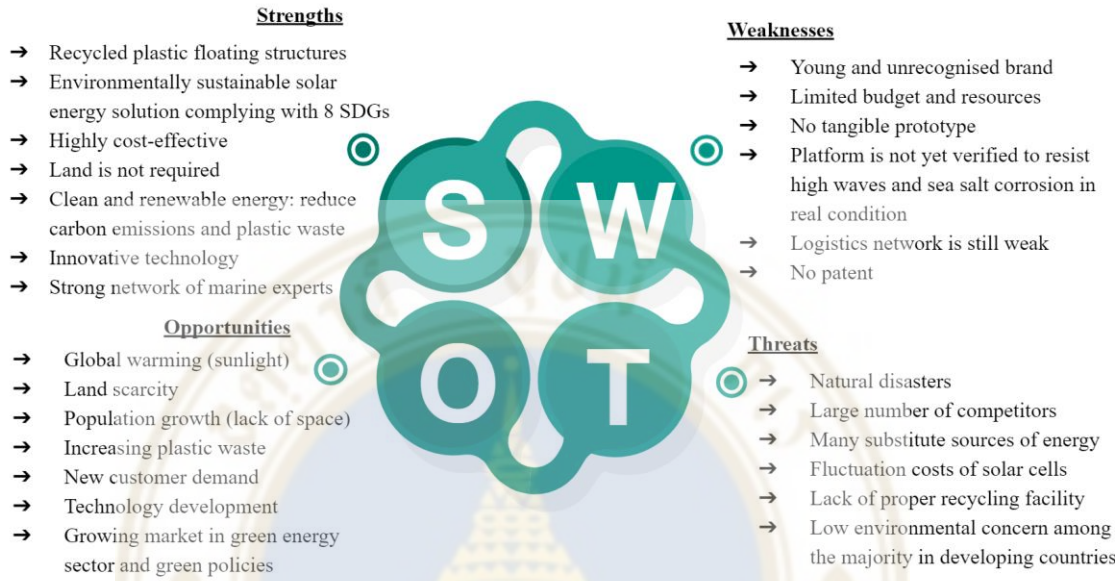


Figure 4.1 SWOT Analysis of HelioRec

Source: Own Illustration

Based on the SWOT analysis, the TSM team identified all the factors considering further actions to be done such as building the brand awareness or a solid business plan.

4.1.1.1 Strengths

The TSM team identified numerous strengths that favor starting up a solar energy company such as HelioRec. Firstly, there is no similar floating solar power plant made of recycled plastic waste in the market yet. This strength lessens global environmental concern to solve the devastated plastic waste in a circular economy (Veolia, 2018). Notably, HelioRec (2019) is complied with eight out of 17 Sustainable Development Goals (SDGs) of the UN. The goals are as follows.

Goal 7: *Affordable and Clean Energy* by adding the clean-energy floating solar power plant to the total share of renewable energy

Goal 9: *Industry, Innovation, and Infrastructure* by fostering innovative and sustainable industrialization to recycle the disposal plastic waste

Goal 11: *Sustainable Cities and Communities* by managing the plastic waste by recycling it into platforms to reduce plastic waste pollution and lower carbon footprint to the communities

Goal 12: *Responsible Production and Consumption* by recycling high-density polyethylene (HDPE) or single-use plastic to manufacture as the plant platform

Goal 13: *Climate Action* by producing clean solar energy, mitigating greenhouse gases from the plastic pollution and the rising global warming temperature

Goal 14: *Life Below Water* by converting the plastic waste into a productive recycling and preserving the sea lives under the floating power plant

Goal 15: *Life on Land* by installing solar panels on the sea surface so that land can be utilized for other purposes

Goal 17: *Partnerships for the Goals* by collaborating with both developed and developing countries to combat with the climate change, land scarcity and plastic pollution

By recycling the plastic waste, HelioRec would have low production costs from buying recycled plastic in granules as raw materials. Plastic granules are small particles recycled from shredded plastic waste. Besides, these indestructible and light materials are highly cost-effective which can save time and cost of deployment. In addition, the power plant does not occupy the land space. This is a perfect option for space-constraint coastal countries and remote locations. The power plant is designed to be as easy to install as possible with integrated cooling scheme to increase efficiency. In addition, it is a new idea of balancing between the plastic recycling and the solar energy industry that no other competitor has done before. The last key strength is the strong network of technical experts in solar engineering and ocean energy as well as sustainability agencies that HelioRec has throughout the years.

4.1.1.2 Weaknesses

One of the weaknesses of HelioRec is brand awareness since it is still new and unrecognized in the industry. It needs to increasingly promote itself to the market via events, motivational speech, or website. Additionally, there are limited budget and resources for the CEO to create the pilot project by herself or with her development team. Developing such a type of project involves a certain level of financial means and more experts in this field than just R&D or technology simulation.

As mentioned earlier, there is no similar invention at the moment. This forms an issue in customer awareness as they do not have prior knowledge or experience of this type of floating structures and how it can benefit the environment. Hence, it may require a lot of effort and expertise to educate customers. In addition, the floating platform itself is not yet verified to resist high waves in the sea and sea water corrosion as there is no tangible prototype yet. This may decrease the company's credibility in the investors' viewpoint.

4.1.1.3 Opportunities

As the world today is embracing more of renewables as substitute energy with low carbon footprint, it provides HelioRec opportunities as green-tech business to innovate new idea to the solar industry. One of the main opportunities is land scarcity in both populated areas and islands with space constraint. Floating solar power plant does not require land space unlike on ground solar or wind power plant. Moreover, population growth indicates that more space will be utilized to accommodate these people and thus land might not be sufficient in the future.

Today, renewables become potential alternatives which support the increasing electricity demand in many areas. As technologies are more affordable, people are more willing to invest in a low carbon footprint power generation. Accordingly, there will be new customer demand and innovative technology supporting HelioRec to continue their product development. Another opportunity for HelioRec is that there are numerous green policies supported by governments in many countries, i.e., feed-in-tariff for solar PV projects in Malaysia (SEDA, n.d.). As people are increasingly aware of the impact of global warming, it is a good chance for HelioRec to introduce its innovative solution to solve the concern

sustainably. Additionally, it can also broaden the offerings for customers by adding new features such as mobile application to keep track of energy generation.

4.1.1.4 Threats

One of the biggest threats for HelioRec is there is a large number of competitors and those who can imitate this idea. Big companies like Sungrow and Ciel et Terre can be the greatest threat as they most likely have more resources, less funding issues and an existing customer base. Moreover, there are many substitute sources of energy for consumers to choose from such as fossil fuels or wind power which can be competitive. Another significant threat is what most revolutionary entrepreneurs face that is the unknown demand in the market. Market feasibility analysis should be conducted particularly on the target market to forecast and estimate the demands. Even so, the total of actual demands may not be correctly forecasted especially for new ideas.

Fluctuation costs of solar cells are various in many countries and HelioRec cannot control the price of this factor as they only produce the platform, thus it could be another threat for HelioRec. This includes the lack of proper recycling facility to produce the granules of recycled plastics as raw materials. Also, as mentioned earlier, the demand in the market is unclear, thus the profit could be unpredictable as well.

Another threat is the majority in developing countries has low environmental concern on plastic pollution. According to Jambeck et al. (2015), Asia has the highest share of mismanaged plastic waste (Appendix B).

4.1.1.5 Unique Selling Points

Derived from the SWOT analysis, the TSM team brainstormed three key unique selling points for HelioRec in order to introduce or pitch the idea to investors as follows;

- *Innovation*
  - First-ever platform made of granules of used plastic materials or recycled plastic waste
  - Simulated wave resistant: able to deploy in the sea with high waves

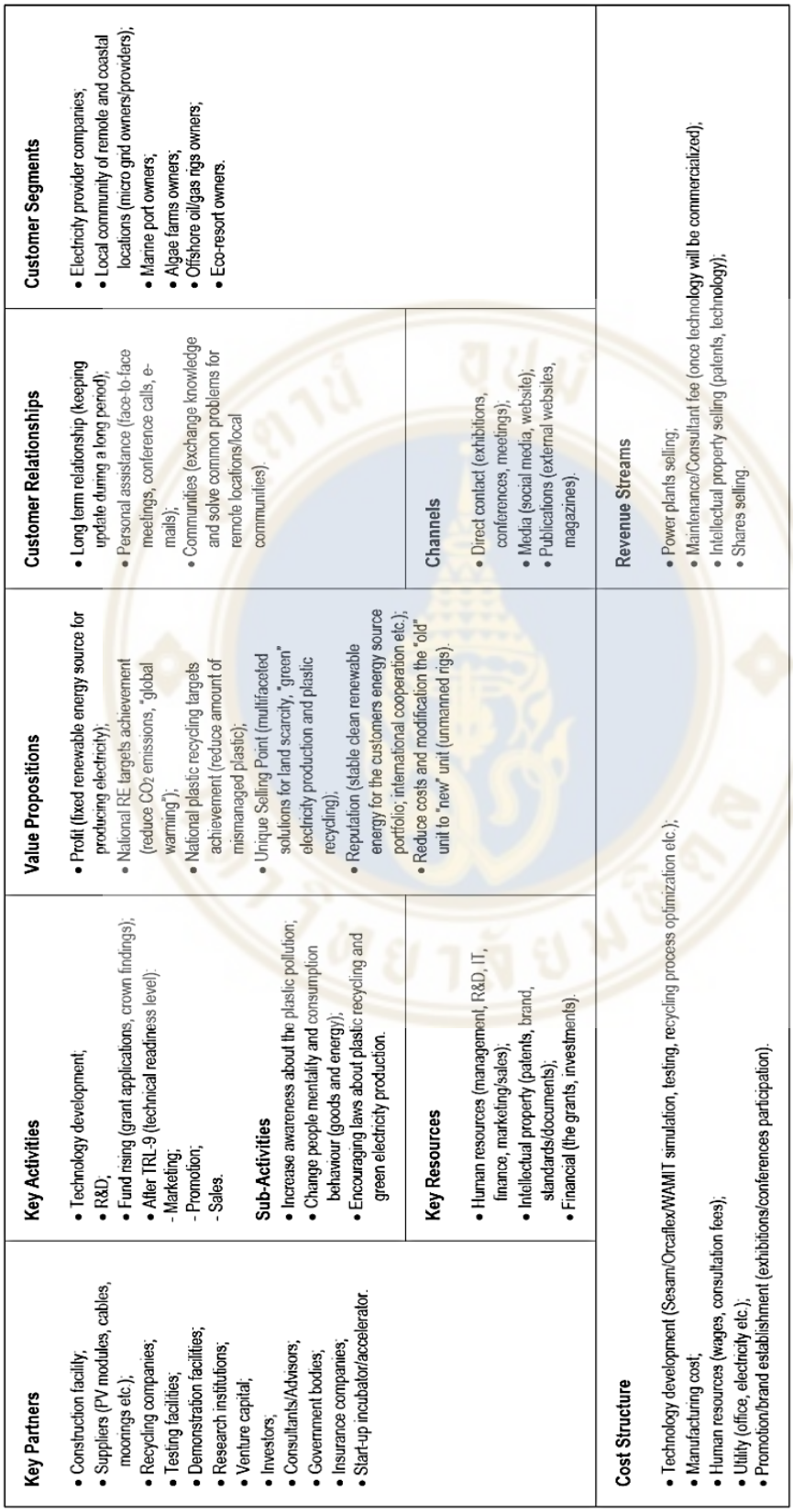
  - Air-flow cooling technology to prevent system from overheating
- *Sustainability*
  - Providing clean energy while reducing greenhouse gas emissions and plastic waste, especially in highly populated coastal countries
  - Huge social impacts
  - Complying with eight SDGs
  - Improving the quality of life globally
- *Cost-efficiency*
  - Land is not required
  - Fast deployment
  - Scalable modular system with stackable platform

4.1.2 Business Model Canvas

The second tool is the business model canvas (Table 4.1), which describes how the company creates, delivers and captures values. The canvas comprises of nine categories of the company's activities from producing the product to post-delivering. From the canvas, HelioRec can gain a better view of its value propositions which will be helpful in business pitching and the success of the future business.

Table 4.1 HelioRec's Business Model Canvas

Source: Own Data



4.1.2.1 Key Partners

HelioRec designs and construct the floaters using recycled materials from recycling companies. Suppliers will provide PV modules, cables, mooring lines, etc. to construct the platform. Facilities relating to research, testing, demonstration, and construction are needed for project viability. Experienced advisors in this field would most likely be one of the key partners. For funding partners, investors are essential partners to a profitable project delivery. In addition, government bodies and insurance companies will be involved in starting up the project as well. For instance, local government can direct and affirm the intent between the company and the investor as well as discussing the government support policy. Other possible partners are startup incubators or accelerators that aid new startups to grow and develop the business by providing services such as management training or events.

4.1.2.2 Key Activities

The primary purpose for the project is to acquire funds to develop the solar technology that can be deployed in the sea. Currently, HelioRec is financed its feasibility project by the CEO herself. The company needs to obtain more funds in order to develop the pilot project. The CEO aims to attract potential investors to finance the whole project so that the company itself can focus on R&D and technology development. Meanwhile, HelioRec will also raise funds from applying for grants and participating in award ceremony in energy and sustainability platforms to progressively support the current R&D process. The key goal is to execute the project and reach the TRL tier nine. After that, marketing, promotion and sales will be implemented. The secondary purpose is to carry sub-activities that are to increase awareness of plastic pollution and change people's mentality and behavior by educating and demonstrating them that plastic waste can be recycled to produce green electricity.

4.1.2.3 Key Resources

HelioRec still has limited human resources and financial resources to start up the project. At the moment, most of the personnel are volunteers from different fields. The CEO might need to hire full-time personnel once the project is initiated. Financial support such as investments and grants is essential to continue

the project. In addition, intellectual property can be a valuable resource for the company.

4.1.2.4 Value Propositions

The core value of the company is to be profitable and with good reputation. It plans to achieve the national renewable energy goal to mitigate carbon footprint as well as plastic recycling program. At the same time, it will reduce the negative anthropogenic impacts on the planet. Green energy industry expands continuously, the main idea is to offer the multifaceted solution and allow customers to meet their preferences.

4.1.2.5 Customer Relationships

The goal is to create a long-lasting relationship and to build a strong network with customers. Good customer relations often bring commitment from both parties. To maintain relationships, customer service and satisfaction are crucial to HelioRec. Hence, it aims to provide personal assistance and update on the project regularly. It would also create a community whereby people can exchange knowledge and share opinions.

4.1.2.6 Channels

The preferred choices of channel are both direct and indirect contact with the prospects. For the direct contact, HelioRec will attend all relevant exhibitions and conferences regarding renewable energy and sustainability. By attending these events, HelioRec will be able to expand its networks and promote the brand awareness. For the indirect contact of brand advertising, the Internet or social media is the main channel. HelioRec developed a company's website, Facebook, LinkedIn, etc. Additionally, HelioRec builds its audience through online publications on external websites such as Youtube.com, Medium.com and Oceannews.com. Advertisements through these channels will be helpful in this digital era to create customer awareness. Interested investors can directly contact the CEO of HelioRec via telephone, email, and website for further discussion on the investment. For the after sales service, HelioRec will provide the team of operation and maintenance assigned to the project.

4.1.2.7 Customer Segments

Customers can be divided into two groups: public and private customers. Public energy seekers consist of governments, national energy provider, etc. Private sectors are businesses or individuals who need additional offshore electricity generation or those who believe in the same values with HelioRec such as SDG's farmers, multinational companies concerning environmental footprint, etc.

4.1.2.8 Cost Structure

The costs will involve technology development program, e.g., virtual simulation and recycling process, manufacturing, utility, human resources, insurances and advertising of the brand. From the table, the cost structure is also scanned although the business idea is still in an early stage. As such, the financial estimates are not yet included in this study until further business planning by HelioRec. Consequently, the calculations are left out in this paper.

4.1.2.9 Revenue Streams

The revenue stream, therefore, will include power plants selling, maintenance and consultant fees after commercialized. The selling of intellectual property and shares is also taken into consideration. Still, there is a chance that HelioRec may not gain profits in the first stage since the costs will be concentrated on developing a viable power plant.

4.2 Energy Industry and Competitor Analysis

The TSM team created two tables of comparison analysis: industry and competitors respectively. Various parameters are applied in the analysis.

4.2.1 Energy Industry Analysis

Energy industry analysis was conducted in order to compare all available energy sources in the industry with HelioRec both renewables and non-renewables. From the global report of REN21 (2019), it shows that more electricity has been generated from different power generating sources for the past years. In 2018, especially, the market share of the renewables capacity is increasing up to 33% of the global total installed electricity generating capacity. Though the share of renewables is rising, it does not stop the non-renewables from production. In fact, renewables have become additional electricity generation to supply the upward demand for electricity.

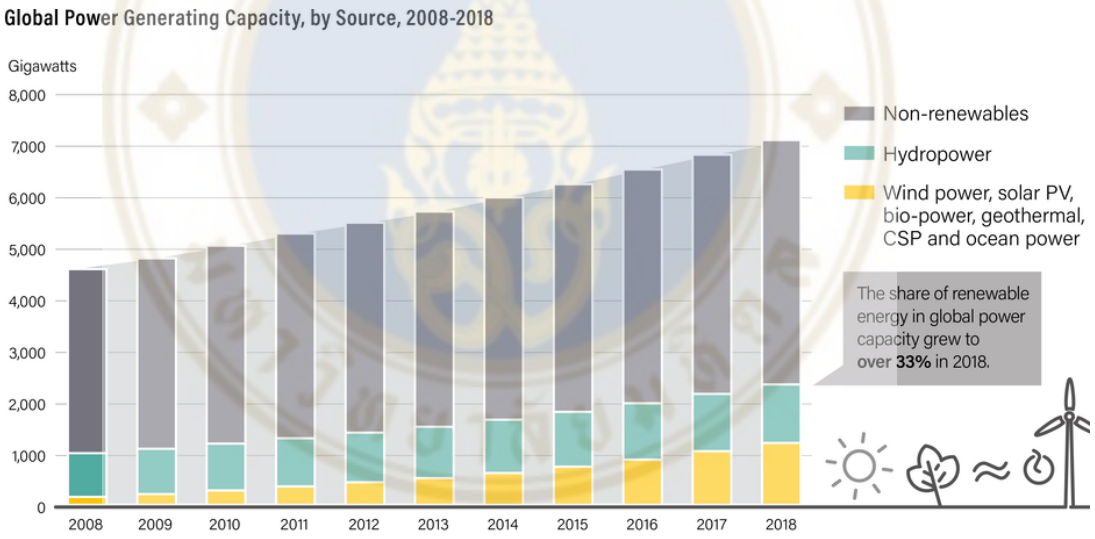


Figure 4.2 Global Power Generating Capacity, by Source, 2008-2018
Source: REN21 (2019)

The TSM team categorized sources of electricity generation into 14 types. However, only some parameters are applied to analyze and compare the characteristics of each energy source to the HelioRec's offshore solar one. The comparison of energy sources including both renewables and non-renewables shows some critical differences. The team highlighted certain factors that show competitive advantages of HelioRec for potential investors.

Table 4.2 Energy Industry Analysis

Source: Own Data

Source of Energy/ Parameters	Offshore Solar	Onshore Solar	Offshore Wind	Onshore Wind
Source of Fuel	Local renewables	Local renewables	Local renewables	Local renewables
Accessibility	Yes : mainly in the ocean, islands, remote places, lakes, coast and gulf	Yes : mainly in China, India, the U.S., South Europe, Africa and Australia	Yes : mainly in Canada, the U.S., Russia, North Europe	Yes : mainly in Canada, Argentina, the U.S., Russia, North Europe
Predictable Energy Supply	Unpredictable, depends on the sun exposure and water conditions	Unpredictable, depends on the sun exposure	Unpredictable, depends on the wind of each zone	Unpredictable, depends on the wind of each zone
Land Required	No	Yes	No	Yes
Generation	Intermitent	Intermitent	Intermitent	Intermitent
Affected by Typical Weather	Yes	Yes	Yes	Yes
Affected by Storms/Hurricanes	Yes	Yes	Yes	Yes
Carbon Footprint during Life Cycle Assessment (LCA) (TonnesCO2e/GWh)	85 (but HelioRec can reduce even lower due to recycled plastic waste)	85	26	26
Emissions of Toxic of the Power Plant	Low, depends on floating structure: PV production has emissions but **waste recycled platforms overcome this issue**, better than steel/HDPE	Low, but PV production has high emissions	Medium, blades and structure's materials have high pollution index	Medium, blades and structure's materials have high pollution index
Global Average LCOE USD/MWh (unsubsidized) *as of Jan 19	$67/MWh (ranging from ~29.9-104/MWh) (site-dependant)	$85/MWh	$127/MWh	$56/MWh
Sources of Average LCOE Euro/MWh	https://www.researchgate.net/publication/322364592_Economic_viability_assessment_of_floating_photovoltaic_energy	https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/Jan/IRENA_2017_Power_Costs_2018.pdf		
Applicable for Subsidies/Tax Advantages, FiT, Green Certificate	Subsidies, Best investment conditions in: China, Japan, US, UK, India, Taiwan	Subsidies, Best investment conditions in: China, Japan, US, UK, Germany	Subsidies, Best investment conditions in: China, Germany, the U.S., Brazil, India	Subsidies, Best investment conditions in: China, Germany, the U.S., Brazil, India
References	https://www.worldbank.org/en/topic/energy/publication/where-sun-meets-water	https://www.irena.org/publications/2019/May/Renewable-power-generation-costs-in-2018	https://www.pnas.org/content/106/27/10933	https://www.pnas.org/content/106/27/10933
Picture				

Table 4.2 Energy Industry Analysis (cont.)

Source: Own Data

Source of Energy/ Parameters	Hydro	Wave	Tidal	Geothermal
Source of Fuel	Local renewables	Local renewables	Local renewables	Local renewables
Accessibility	Yes : mainly in the U.S., North Europe, Canada, South East Asia, China	Yes : mainly in West Europe, India, the U.S., China, Canada	Yes, successfully in use by Canada, China, Russia, UK, France, and South Korea	For big plants, better near the "ring of fire" (high volcanic and earthquake activities)
Predictable Energy Supply	Predictable at long-term	Unpredictable, depends on the waves and tide	Yes	Yes
Land Required	Yes	No	No	Small area
Generation	Controllable	Intermitent	Constant	Constant
Affected by Typical Weather	Yes, high temperature can evaporate water	Yes	No	No
Affected by Storms/Hurricanes	No	Yes	Yes	No
Carbon Footprint during Life Cycle Assessment (LCA) (TonnesCO2e/GWh)	26	29	29	122
Emissions of Toxic of the Power Plant	Medium, barrages kill and modify biodiversity	Low, production of the installation comes with high pollution, disturbs marine biodiversity	Medium, barrages and stream generators kill and disrupt spawning of marine ecosystems	No
Global Average LCOE USD/MWh (unsubsidized) *as of Jan 19	$74/MWh	$268/MWh	$215/MWh	$72/MWh
Sources of Average LCOE Euro/MWh	https://www.eia.gov/outlooks/aeo/pdf/electricity_generation.pdf	https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/Jan/IRENA_2017_Power_Costs_2018.pdf	https://www.researchgate.net/publication/282579414_Evaluation_and_comparison_of_the_levelized_cost_of_tidal_wave_and_offshore_wind_energy	https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/May/IRENA_Renewable-Power-Generations-Costs-in-2018.pdf
Applicable for Subsidies/Tax Advantages, FiT, Green Certificate	Subsidies, Best investment conditions in: China, Brazil, Canada, the U.S., Turkey, India	Subsidies, Best investment conditions in: India, China, the U.S.	Subsidies, Best investment conditions in: China, Russia, Australia	Tax credits in the U.S. (30%), France and others developing countries, FiT applicable
References	https://www.renewableenergyworld.com/hydropower/tech.html	https://www.boem.gov/Ocean-Wave-Energy/	https://www.researchgate.net/publication/282579414_Evaluation_and_comparison_of_the_levelized_cost_of_tidal_wave_and_offshore_wind_energy	https://www.brighthubengineering.com/power-plants/34715-what-are-the-best-locations-for-geothermal-powerplants/
Picture				

Table 4.2 Energy Industry Analysis (cont.)

Source: Own Data

Source of Energy/ Parameters	Biomass	OTEC	Nuclear
Source of Fuel	Mostly imported renewables	Local renewables	Non-renewables (uranium source is not infinite on earth)
Accessibility	Yes, mostly used in developing countries (Brazil, Portugal, India, Netherlands, UK, Canada, China, Finland, Poland)	Tropical oceans (big lake with warm water)	Require space, no earthquake area, and countries that allow nuclear
Predictable Energy Supply	Yes	Yes	Yes
Land Required	Small area	Small area	Buffer zone required
Generation	Constant	Constant	Constant
Affected by Typical Weather	No	No	No
Affected by Storms/Hurricanes	No	No	No
Carbon Footprint during Life Cycle Assessment (LCA) (TonnesCO2e/GWh)	45	38.5	39
Emissions of Toxic of the Power Plant	Medium, Limits annual 1.42 tonnes/MWh (Global BACT policy)	No	Medium, no CO2 but problematic waste & high risk exposure/accident
Global Average LCOE USD/MWh (unsubsidized) *as of Jan 19	$62/MWh	$140/MWh	$90/MWh
Sources of Average LCOE Euro/MWh	https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/May/IRENA_Renewable-Power-Generations-Costs-in-2018.pdf	https://setis.ec.Europa.eu/system/files/tpoandoee_input_act1and2_ocean.pdf and https://www.nrel.gov/docs/legosti/old/3594.pdf	
Applicable for Subsidies/Tax Advantages, FiT, Green Certificate	FiT applicable, many certifications scheme, tax credit	Subsidies (tax credits and research funding)	Tax credits (up to 6000 MW)
References	https://corporate.vattenfall.com/about-energy/renewable-energy-sources/biomass/how-it-works/	http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.666.8262&rep=rep1&type=pdf	https://www.nei.org/advocacy/build-new-reactors/nuclear-production-tax-credit
Picture			

Table 4.2 Energy Industry Analysis (cont.)

Source: Own Data

Source of Energy/ Parameters	Coal	Gas	Oil
Source of Fuel	Non-renewables (Natural resource)	Non-renewables (Natural resource)	Non-renewables (Natural resource)
Accessibility	Yes, accessible coal in the ground especially in the U.S., China, India, and North America	Yes, mostly in the U.S., Russia, North America, and Europe.	Yes, accessible oil in the ground and sea especially in U.S., the Middle East and northern Africa
Predictable Energy Supply	Yes	Yes	Yes
Land Required	Yes	Yes	On land: Yes; On sea: Yes (extract oil from sea)
Generation	Constant	Constant	Constant
Affected by Typical Weather	No	No	No
Affected by Storms/Hurricanes	No	No	No
Carbon Footprint during Life Cycle Assessment (LCA) (TonnesCO2e/GWh)	888	499	733
Emissions of Toxic of the Power Plant	High, GHG causing acid rain, Mercury airborne toxins and pollutants, radioactive materials e.g. coal ash (toxic heavy metals)	Medium, GHG, toxic gases including the methane and carbon monoxide; polluted air, soil and groundwater	High, GHG, oil spills toxic smell and chemicals (acrylic oil) and bypass products
Global Average LCOE USD/MWh (unsubsidized) *as of Jan 19	$66/MWh	$57.5/MWh	$110/MWh
Sources of Average LCOE Euro/MWh	https://drive.google.com/drive/u/0/folders/1Jjhgvho_lz0IUrsn1n0N2ONJ-vo7ZXU7	https://www.lazard.com/perspective/levelized-cost-of-energy-and-levelized-cost-of-storage-2018/	https://www.greentechmedia.com/articles/read/irena-renewable-energy-competitive-fossil-fuels-2020#gs.gP7rOpjU
Applicable for Subsidies/Tax Advantages, FiT, Green Certificate	Carbon tax, emission tax and energy tax depending on countries' policy(Clean Air Act) In the U.S., clean coal facilities are "subsidized"	Highest gas taxes are mostly found in Europe and North America, while highest subsidies are found in oil-rich countries like in the Middle East and northern Africa	Biggest tax-contributor, direct tax to consumers. Most governments only allow subsidy for independent producers
References	http://www.nera.com/content/dam/nera/upload/NERA-Energy-Revenue-and-Expenditure-May-2018.pdf	https://www.eia.gov/energyexplained/index.php?page=natural_gas_home	https://www.eia.gov/energyexplained/index.php?page=coal_where
Picture			

Table 4.2 exhibits that each energy source has its pros and cons. For the renewables, they are easily accessible and applicable for subsidies than the non-renewable ones. Of all these renewables, hydropower has been accounted for 60% of the electricity generation, followed by wind energy (21%), solar PV (9%) and biomass (8%) (REN21, 2019). The growing capacity of renewable energy share predicts the positive market feasibility for the years to come. However, renewables still cannot compete with the non-renewables in attaining the bigger share. The main reasons are their constant electricity generation, predictable energy supply, and invulnerability to any weather condition. In addition, fossil fuels have a strong growth in total electricity production and unwavering investment due to the low prices. This encourages higher demand while challenging the markets of renewable power.

Fortunately, according to IRENA (2019), the trend towards renewable energy drives the overall costs of installing the renewable power plant to be competitive with the non-renewables. Not only they become cheaper for installation, they are also help to reduce the electricity cost and toxic emissions to the environment. Among these renewables, offshore solar PV can be viable over most energy sources. For instance, no land occupancy, more scalable installation (than land-based plants) and low toxic emission. One key feature to tell which source of energy is attractive to install a power plant is by observing the LCOE. The TSM team examined the global average LCOEs in USD/MWh with unsubsidized cost to compare the average costs of electricity generation of each energy source over its lifetime (Figure 4.3).

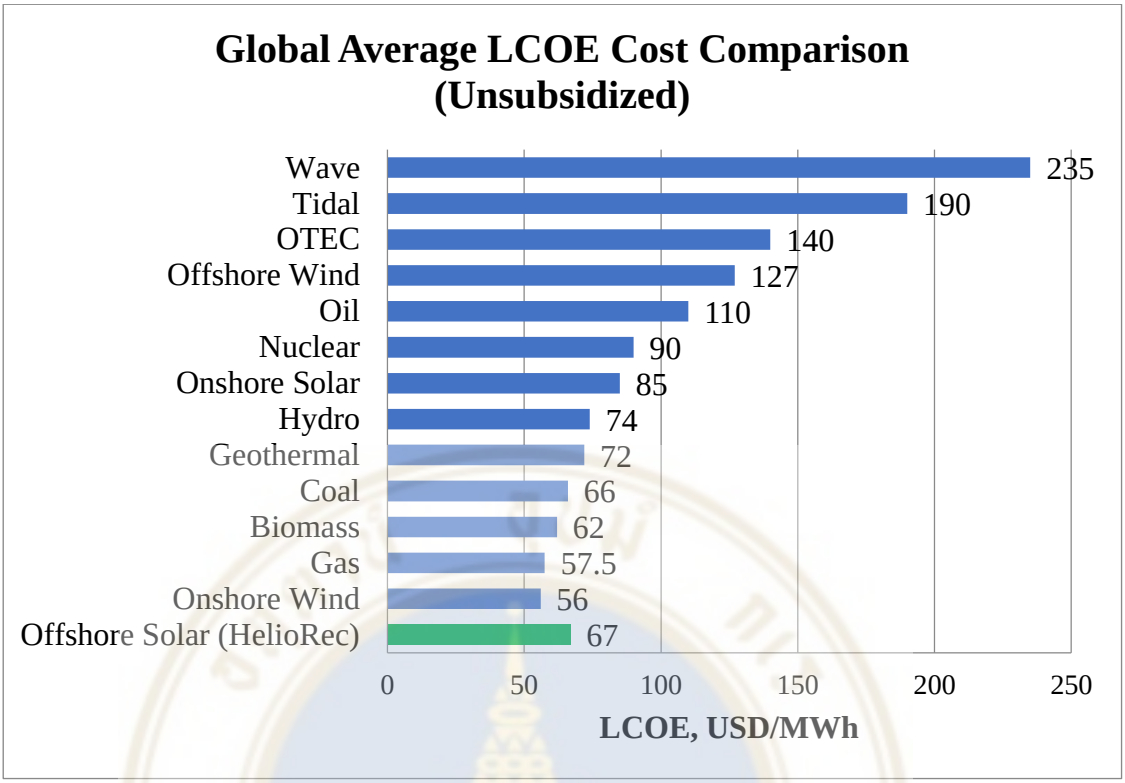


Figure 4.3 Global Average LCOE Cost Comparison

Source: Own Data

From the figure, it shows how various types of energy source used to generate electricity measure up against each other. The lowest cost of electricity per megawatts is the onshore wind and gas, which is around 56 USD/MWh and 57.5 USD/MWh respectively. The highest cost of electricity is the wave energy which costs around 235 USD/MWh. From the chart, coal, biomass and offshore solar power are seen to be the next lowest costs of electricity at the range of 60-70 USD/MWh. Evidently, these stated renewables can combat against the non-renewables like gas and coal power. For solar on land, the global average cost of electricity is around 85 USD/MWh. The reason behind the cheaper cost of offshore solar is largely because of the cooling effect of the water below that enhances solar cells' efficiency by up to 22 percent (Bennington-Castro, 2019). Therefore, solar and wind technologies are considered to be the best accessible sources of energy for everyone due to a larger production in most countries (BNEF, 2018), not only for business purposes but also for household consumption (IEA, 2019a).

With a rising in production of wind and solar energy-related components, electricity costs have become more economical. For instance, increasing demand for developed solar technology helps to produce cheaper materials (PV modules, inverters, batteries, etc.). Even though onshore wind, gas, biomass and coal have competitive advantage on cheaper cost of electricity, the limitation is that they must be installed on the ground. Hence, offshore solar and offshore wind are better alternatives that can be deployed in the sea and no land is required. Since the LCOE of offshore wind is at 127 USD/MWh which is doubled the cost of offshore solar; hence, offshore solar is a better option for investment.

In the meantime, the offshore solar technology of HelioRec aims to reduce the LCOE to differentiate and compete with competitors in the energy industry. To win this war, HelioRec needs to design a better cost-effective floating platform for its future commercial project and to gain competitive advantage to attract future investors.

4.2.2 Competitor Analysis

To gain a better understanding of the competitiveness in the offshore solar energy market, HelioRec's competitors are examined. Currently, HelioRec does not have direct competitors with exactly the same solution of offshore solar power plant made of recycled plastic platform. Therefore, in this analysis, floating solar power plants **in the sea** will be considered as most possible direct competitors.

The common benefits of all offshore solar power plants are saving of land space and better efficiency from water cooling effect, which helps to generate more electricity than ground-mounted systems. Table 4.3 presents 16 companies providing an offshore solar power generation with various parameters applied.

Table 4.3 Competitor Analysis

Source: Own Data

Company/ Parameters	HelioRec	Ciel et Terre	SUNGROW	FloatPac Solar	SPG Solar	Solaris Synergy	Takiron Engineering	LG CNS
Country	France	France	China	Australia	USA	USA	Japan	Korea
Company Registration	2018	2006 (2011 first floating solar power plant)	1997	1984	2008. Company is closed	2014	2015	2015
Country of Project Establishment	N/A	Worldwide	China, India, Australia	Mainly Australia	USA	Israel	Japan	Korea
Closed/ Open Water/Sea	Open water, high wave	Close water, lake, High wave	Close water, lake, low wave	Close water, lake, high wave and/or hurricanes	Close water, lake, low wave	Close water, lake, low wave	Close water, lake, low wave	Close water, lake, low wave
TRL	3	9	9	7	9	9	9	9
Patent	No	Yes - US9132889B2 , US9849945B2	Yes, for sun reflection system - CN207321192U	No, only Trademark on the system, and patent on part of the system	Yes - US20080029148A1	Yes - US20160006391A1	Yes - JP2012210961A	No
Cooling System	Air-flow	No	No	Yes	Medium	Yes	No	No
Total installed capacity, MWh	0	110	150	0	0.4	0.05	3	9
Installation Duration	Fast Assembled on shore, released into the water by jet ski	Fast Assembled on shore, to be later released into the water	Fast Assembled on shore, to be later released into the water	Long	Long	Long	Long	Long

Table 4.3 Competitor Analysis (cont.)

Source: Own Data

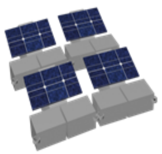
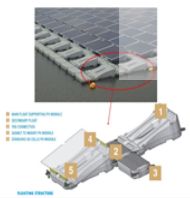
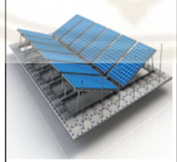
Company/ Parameters	HelioRec	Ciel et Terre	SUNGROW	FloatPac Solar	SPG Solar	Solaris Synergy	Takiron Engineering	LG CNS
Stackable/Not stackable	Stackable	Not stackable	Not stackable	Not stackable	Not stackable	Not stackable	Not stackable	Not stackable
Environment	High Floaters from recycled plastic waste, recycled after use, evaporation reduction	Medium All materials can be recycled after use, slower algae growth, no excavation work	Medium Weather resistant materials, spray NF3 on the PV panel for recycling, recycled waste packaging	Medium Reducing carbon emissions by using recyclable cells, rot and mould resistant	N/A	Medium (Company environment policy)	Medium (Company environment policy)	Medium (Company environment policy)
Life Cycle Assessment (LCA) (e.g. Steel, Aluminum, or HDPE)	Recycled HDPE plastic	Virgin HDPE plastic	Virgin PP plastic corrosion-resistant materials	Virgin HDPE plastic and aluminum	Metal and rubber	N/A	Synthetic resin - Virgin HDPE plastic	Metal
Social Impact	High (LCA, upcycling to reduce plastic waste & social campaigns)	Low	Medium (Annual corporate social responsibility report)	Low	Low	Low	Medium (Annual corporate social responsibility report)	Low
Software Support	*Mobile application (additional service)	No	No	No	No	No	No	No
References	https://heliorec.com/	https://www.ciel-et-terre.net/	https://en.sungrowpower.com/	https://floatpac.com/	https://farniente.com/napa-wine-estate/sustainability/	http://www.solaris-synergy.com/Advantages.html	https://tech.nikkeibp.co.jp/dm/atclen/news_en/15mk/032201221/?ST=msbe	https://www.lgcns.com/Views/News/NewsDetail?SERIAL_NO=1560
Picture					https://www.youtube.com/watch?time_continue=93&v=zG6w4lXnyMw			

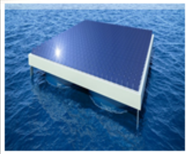
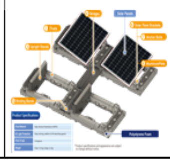
Table 4.3 Competitor Analysis (cont.)

Source: Own Data

Company/ Parameters	Sun Float	Oceans of Energy	HydroPV	Swimsol	TU Wien (HelioFloat)	Sumitomo Mitsui Construction	Ibiden Engineering	West Group & Kyoraku
Country	Netherlands	Netherland	Netherland	Austria	Austria	Japan	Japan	Japan
Company Registration	2016	2017	2017	2014	2016	1887	1912	1917
Country of Project Establishment	Netherlands	Netherlands - Project of 21 000 sq meters plant will be finished in 2021	Netherlands	Maldives	NA	Japan	Japan	Japan
Closed/ Open Water/Sea	Close water, lake, low wave	Open water, high wave	Close water, lake, low wave	Open water but on low wave	Close Water, lake, low wave	Close Water, lake, low wave	Close Water, lake, low wave	Close Water, lake, low wave
TRL	9	7	6	9	5	9	9	9
Patent	No	No	Yes, for cooling system	Yes - EP3237277B1	Yes - patented pressure based skirt system which is connected through a light weight structure	Yes - JP2016068934A	Yes - JP2017065350A	Yes - US20170085214 A1
Cooling System	Yes	N/A	Yes (with specific metal)	Medium	N/A No floating projects yet, they focus on developing platforms	No	No	No
Total installed capacity, MWh	0.5	0	N/A	0.54	0	2.6	2	3.8
Installation Duration	Long	Long	Fast Assembled on shore, to be later released into the water	Long System components pre-assembled in Austria but installation directly on-site	Long	Fast On-site and simple to install by minimum of 2 people using bolts and brackets	Fast Assembled on shore, to be later released into the water	Fast Assembled on shore, to be later released into the water

Table 4.3 Competitor Analysis (cont.)

Source: Own Data

Company/ Parameters	Sun Float	Oceans of Energy	HydroPV	Swimsol	TU Wien (HelioFloat)	Sumitomo Mitsui Construction	Ibiden Engineering	West Group & Kyoraku
Stackable/Not stackable	Not stackable	Not stackable	N/A	Not stackable	Not stackable	Not stackable, but compact shape and lightweight	Not Stackable	Not Stackable
Environment	Medium (Company environment policy)	Medium In phase of evaluating the floater's consequences on the environment with marine experts	Medium (Company environment policy)	Medium (Company environment policy)	Medium (Company environment policy)	Medium (Company environment policy)	Medium (Company environment policy)	Medium (Company environment policy)
Life Cycle Assessment (LCA) (e.g. Steel, Aluminum, or HDPE)	Aluminum	Metal	Metal	Virgin HDPE plastic and steel	Plastic PU	Virgin HDPE plastic	Virgin HDPE plastic Floaters are filled with polystyrene foam	Virgin HDPE plastic
Social Impact	Low	Low	Low	Low	Low	Low	Medium (Annual corporate social responsibility report)	Low
Software Support	No	No	No	No	No	No	No	No
References	http://www.sunfloat.com	https://oceansofenergy.blue/press-release-1-new-consortium-builds-first-offshore/	http://www.hydropv.eu/	https://swimsol.com/	https://www.tuwien.ac.at/fileadmin/t/tuwien/downloads/Publishing_Texte/Marokko2016_HELIOFLOAT_platform_EN.pdf	http://pv-float.com/english/ and https://tech.nikkeibp.co.jp/dm/atclen/news_en/15mk/081902303/?ST=msbe	https://tech.nikkeibp.co.jp/dm/atclen/news_en/15mk/051401330/?ST=msbe&P=2	https://www.krk.co.jp/en_attention/minamo_solar_system/
Picture		https://www.youtube.com/watch?v=xrXOLgrifd0						

With an increasing competition in the solar energy market, it is required to oversee the existing competitors with offshore solar technology both in the sea and on closed water bodies. From the tables, most of the offshore plants can only be deployed in a closed water body with low wave such as lake, dam and reservoir. Among them, Swimsol and Oceans of Energy are two companies who can deploy in an open water body with high wave. So far, Swimsol is the first company who could install the project on the sea surface.

Furthermore, HelioRec is the only company that offers a solution of stackable and lightweight floaters that helps minimize the transportation cost and fast deployment. Significantly, the company highly concerns about the life cycle of plastic materials (Appendix E) and the fact that these disposable plastics can harm the environment. Therefore, HelioRec will recycle the plastic waste manufactured for the floaters and reprocess them again into plastic granules after use. By using the recycled plastic waste, the company absolutely differentiates itself from all current competitors.

4.3 Recommendations on Business Development Strategy

After the internal and external environment analysis, the TSM team provided recommendations for HelioRec to develop its business strategy, which would be useful for its future business plan.

Derived from the competitor analysis table, Figure 4.4 compares HelioRec with the existed offshore solar power plants that are already installed by the competitors along with their TRL scale. The tool signifies the global standard measurement for benchmarking. HelioRec will be able to monitor and plan on the technology progress of the project from one level to the next. The level is marked to identify the current position of technology readiness for each company.

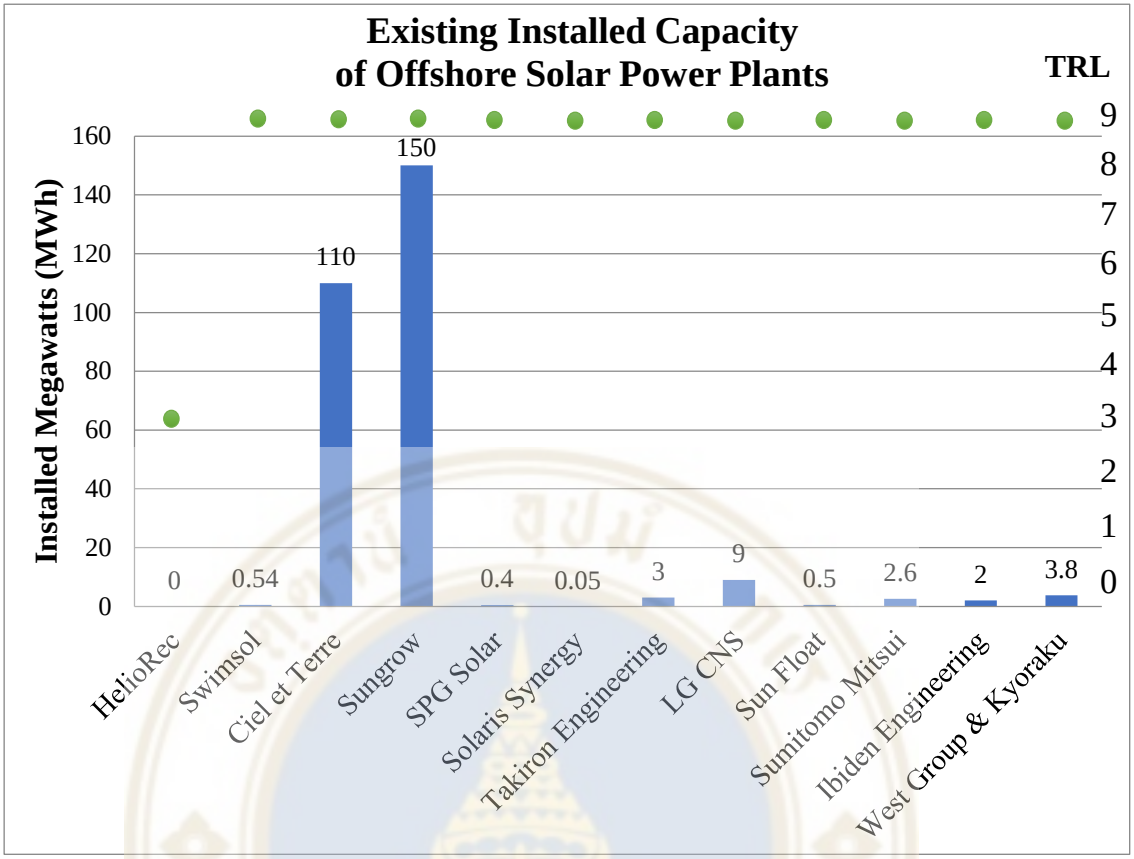


Figure 4.4 Existing Installed Capacity of Offshore Solar Power Plants

Source: Own Data

The TSM team applied the TRL scale to identify HelioRec's current position and what it has to do to achieve the next level. As the chart above illustrates, listed companies (except for HelioRec) are commercialized offshore solar power-plant developers from worldwide with TRL tier nine level (installed product). On the right axis, it shows that HelioRec has TRL only at level three (research to prove feasibility of idea) and no pilot project is yet installed. From the chart, there is only one direct competitor of HelioRec who successfully installed the offshore solar power plant in the sea which is Swimsol with 0.54 MWh installed capacity. The rest of the companies with TRL tier nine listed only deployed on a closed water body. Among them, Sungrow and Ciel et Terre have the most installed capacity of 150 MWh and 110 MWh respectively. Therefore, HelioRec needs to find funds to achieve level four to five by proving of concept in a software simulation, testing in the laboratory, and building the prototype. To achieve level six to nine, it needs to validate the prototype and to deploy in a real sea condition.

To summarize the results of this study, HelioRec has potential to become a viable offshore solar energy business and compete with current competitors in the solar energy market. From the research, the solar energy market is attractive and continue to grow year by year. HelioRec has its unique selling point as a sustainable solution to fight against plastic pollution, which is completely different from other competitors. However, there is a drawback on people's lack of experience with an offshore solar power plant. It is difficult to know how well the power plant would perform in the long run. Also, it is unclear whether how the installation would have impact on local aquatic ecosystem. Hence, it might be challenging to convince the investors to see the untapped potential of this new innovation.

The TSM team suggested HelioRec to follow the following checklist of action items.

1) Assessing financial feasibility in order to prepare a business plan to attract potential investors.
2) Testing wave tank and determining the target country
3) Select the target country with a criteria of concentrated plastic waste and proper recycling facility to produce the floaters at a cheaper cost. Conduct the PESTEL market analysis. The team suggested that coastal China and India are attractive solar energy marget to enter which fall into our criteria (Appendices B and C). Also, there are opportunities for market expansion into other countries in Asia as well.
4) Reducing carbon footprint by keeping Life Cycle Assessment (LCA) of the process as low as possible. This way, HelioRec will be able to decrease ecological impacts throughout the life cycle of the power plant. Moreover, the TSM team suggests creating a mobile application to track carbon footprint from suppliers to installation of the power plant (Appendix H). For instance, manufacturing of cables, anchors and floater as well as transportation of materials.
5) Applying for the patent in the target country where the first project will be installed. For example, patent on stacking design, airflow system, or moulded construction.
6) Installing a pilot project (>50 kWh)

7) Considering AI/ML in real sea condition to differentiate from all competitors
   - Artificial Intelligent (AI): to predict water quality and to provide recommendations on the water quality improvement
   - Machine Learning (ML): to store local climate and energy data and weather conditions within installed areas
8) Promoting the brand awareness on social media, websites, events and partnerships
9) Achieving the Sustainable Development Goals (SDGs) with certification. The SDG Impact Accelerator hosted by the UN recruits startups with sustainable innovation annually. Successful startups will get the certificate endorsed by the UN and, most importantly, is funded for the full-scale project. Detail is provided on this following link. https://www.sdgia.org/10-startups-to-continue-on-into-the-acceleration-period-announced/
10) Developing a sun tracking system with self angle regulation for more efficiency (to solve sun irradiance issue)

4.3.1 Suggestion on Potential Buyers

The TSM team brainstormed regarding HelioRec's potential buyers and analyzed which factors the floating solar power plant will benefit to these buyers. HelioRec targets both public and private buyers ranging from utility provider companies to local communities of remote and coastal locations. The customer, for example, can generate revenues by selling electricity to consumers, getting subsidy or FiT from the government and, in that case of the unmanned oil rigs, will be able to generate revenues from ecologically responsible tourism. To possibly attract these investors, HelioRec will need to create a business plan which includes a preliminary project's calculation at the specific site. The financial proposal will be needed in the next phrase in order to estimate the total costs of the project and how this investment can be profitable for the buyers.

The team then identified ten categories of potential buyers whom HelioRec should approach. The specific benefits for each category are also introduced.

4.3.1.1 Remote Locations and Islands

- Self-reliance and independent from the global energy system
- “Run it your way” concept
- Closer source of energy (no massive transportation installation needed)
- Maintain biodiversity and aquatic ecosystem (source of food)

4.3.1.2 National Energy Providers

- Investing in the green energy, investing in the future of the industry
- Floating solar harnesses electricity from the sun, which is the most accessible source of energy to generate electricity for remote areas.
- Localized source of energy with less supervision.
- Technology based on circular economy: recycling the planet’s waste to build the floaters
- Reduce transportation costs
- Become energy independent and avoid political pressures

4.3.1.3 Disaster Relief Authority

- Viable alternative for emergency circumstances to generate electricity where main utility or other sources cannot
- Fastly deployed in case of emergency
- Add value to the land of sensitive areas
- Plastic waste management
- Sensibilize people with pollution, actual health of the planet, some disasters are the results of human acts
- Help warning people of the upcoming disasters (additional service: mobile application)

4.3.1.4 Winery and SDG-Oriented Farmers

- High efficiency, innovative, and sustainable power generation to substitute or support more electricity power as needed
- Unique and ethically green image
- Reduce carbon footprint and local plastic waste
- Make use of the scarce land or land that can grow more plants
- Build organic trust bond between company, employees and customers

4.3.1.5 Coastal Hotels and Resorts Owners

- Highly efficient with less costly
- Space or Land is not required
- Sustainability and eco-friendly is a way to customer communication of a green image
- Reduce carbon emission intensity
- Reduce plastic waste such as plastic bottles, straws, and plastic containers

4.3.1.6 Multinational Companies

- Become an eco-friendly company
- Follow the "energy transition" trend.
- Decrease the company's environmental footprint
- Pioneer on floating solar: the "source of the future"
- Become the most innovative company as it invests in the most innovative solar energy technology while recognising a circular economy

4.3.1.7 Energy Companies

- Invest in renewable energy as an alternative source of energy
- Follow the "energy transition" era
- Technology based on circular economy
- Win-win solution for the company and the planet

- Combine two energy sources to increase efficiency and lower costs, thus more profitability
- Risk repartition
- Improve the green image

4.3.1.8 Wind Farms

- Combine two sources of energy
- Increase efficiency
- Risk repartition
- Strengthen the green image
- Plastic waste management

4.3.1.9 Offshore Plants (Algae, Hydrogen and Desalination)

- Produce own electricity
- Increase efficiency
- Increase profits
- Risk repartition
- Strengthen the green image
- Plastic waste management
- Cost savings

4.3.1.10 Solar PV Manufacturers

- Increase profits
- New market and improve brand image in solar energy market
- Risk repartition
- Strengthen the green image
- Plastic waste management
- New innovative approach and/or product development

4.3.2 Suggestion on Building the Brand Awareness

The TSM team proposes HelioRec a practical implementation to increase brand awareness among potential buyers. Brand awareness is significant because HelioRec is new to the solar energy market and people are not aware of the brand's existence. In order to promote and distinguish HelioRec's solution from other competitors, the team suggests four steps as follows.

1) *Raise awareness*: to convince prospects that HelioRec has a solution that they might need through both direct and indirect channels.
   For instance, the team created ten types of brochure, customized email templates for each buyer category and sent them emails or messages via LinkedIn.
2) *Increase reach*: to search for companies with similar values whose customers are likely to prospect HelioRec's product.
   For example, Red Cross, Unisef, the United Nations, etc.
3) *Partnering*: to convince partners to recommend the product to their customers or acquaintances (networking, energy or sustainability events, impact funds, etc.).
4) *Increase credibility*: to increase visibility as an award-winning startup and the expert in ocean energy to boost public relations for a long-term growth and good reputation.

CHAPTER V
CONCLUSION AND RECOMMENDATIONS

This chapter provides conclusion and recommendations for possible future research. The purpose of this study is to conduct the business analysis, explore existing energy sources and assess the market attractiveness as well as to provide recommendations to HelioRec on strategic planning.

5.1 Conclusion and Discussions

To achieve the research objectives, the TSM team analyzed HelioRec's competitive advantages, explored the existing energy sources available in the energy market, evaluated the market attractiveness and provided some practical recommendations for HelioRec to implement.

Renewable energy market has prospective opportunity for HelioRec to enter and improve its technology capabilities and calibration. The solar energy market is growing rapidly worldwide and shows significant cost reduction along the supply chain. As the solar technology matures, costs will continue to drop with an incremental innovation.

The team assessed the market attractiveness and analyzed HelioRec as a business using SWOT framework and business model canvas. To conclude the results of this research, HelioRec has a potential to become a real business and compete in the growing solar energy market. The business analysis presents various kinds of strengths, weaknesses, opportunities and threats. From the SWOT analysis, HelioRec processes more positive aspects than the negative ones. HelioRec has a strong competitive advantage of being an eco-friendly offshore solar power plant, which platform is manufactured from recycled plastic waste. The innovation is a multi-faceted solution that addresses three global problems at once: green electricity with low greenhouse gas emissions, mismanaged plastic waste, and land scarcity. Hence,

the TSM team agreed that the idea of recycling plastic waste into valuable floating structure is intelligent. An offshore solar power plant, especially with a subsidy, can benefit and yield some profits to businesses and private buyers to reduce the overall electricity cost and serve the greater electricity demand.

Comparing the LCOEs of various energy sources, offshore solar is considered less expensive than offshore wind and other ocean-located power plants. In addition, HelioRec could reduce costs of raw materials by using recycled plastic as floaters and designing a better cost-effective floating platform to lower the LCOE. This way, it would minimize initial costs and yield more profits than competitors. which will eventually help to attract more investors. Furthermore, it is important for a startup like HelioRec to monitor its project's progress to a market launch by using the TRL assessment to stay on course and continue to develop to the next level.

This feasibility study provides necessary description of how HeliRec could use the competitive advantages to market its product and attract the potential investors. Thus, it helps the company to prepare for entering the solar energy market. By knowing its competitors and environment, HelioRec can differentiate itself, stays innovative and continuously improves the technology to be a sustainable solution.

For managerial inference, the TSM team provided the recommendations to HelioRec regarding the business development strategy. The team proposed the checklist of what they need to achieve, identify ten categories of potential buyers, and four steps of building brand awareness and engagement. HelioRec could implement this strategic plan to further develop its business proposal.

5.2 Limitations of the Study

Even though HelioRec has some experts in renewables engineering and product development, they are still new to business environment and energy industry. Therefore, there are many limitations found in this study as follows.

1) HelioRec is a small startup and has limited resources and information to share to the TSM team. Also, there is a lack of a robust track record of the global

floating solar panel industry. The limited information created difficulties for the TSM team when analyzing the company's capabilities.

2) HelioRec did not have any full-time employee, except for the CEO, which was somehow difficult for her to prioritize and multitask.

3) The communication between HelioRec and the TSM team was not quite clear. The energy industry was new to the team members; hence, the team needed ample time to find the correct information and direction.

4) HelioRec did not have any strategic business plan or preferred method of promoting the brand. When the TSM team proposed the business development strategy and how to approach each potential buyer's category, the team will never know the result whether it is working or not.

5) Many companies in the same industry were not willing to provide useful information and their expertise through the phone interview and emailing.

6) The LCOE costs are varied depending on many factors such as location of the power plant, inflation, discount rate, etc. The calculation is largely site-specific.

5.3 Future work

Due to several limitations of this study, more actions should be taken in this particular topic as follows.

1) Financial difficulty is the main obstacle for HelioRec. The company needs to create a robust business plan which includes every aspect of the project. For example, construction process, organizational structure, and financial strategy. HelioRec should learn more about business development, seek consultancy from business experts within its networks, or recruit a full-time business graduate before pitching to the investors.

2) HelioRec should actively attend events on renewable energy and sustainability topics whenever possible. Many of the investors are likely to be there and it is a good opportunity to introduce the business.

5.4 Recommendations

As a small startup business, the practical recommendations for HelioRec are divided into two phrases, a short-term goal within one year and a long-term goal that is three years or above. For the short-term goal, HelioRec should focus on promoting its business to be recognized in the market. The company has significant unique selling points which make it stand out from the competitors. To optimize advertising costs, HelioRec can utilize social media channel to increase publicity and communicate with the prospects.

Next, HelioRec should select the target country where the plastic waste is concentrated and has a proper recycling facility to produce the floaters with optimum cost. It is recommended that HelioRec visits the site and local suppliers before begins project initiation. It is vital for the company to be familiar with the target country's regulations and green policies as they will be greatly beneficial to HelioRec's project and will lead to a high probability of success.

In the long-run, HelioRec will need to use the market development strategy for the company's growth. As an evolution in solar technology is led by the falling price of solar modules, it is advised that HelioRec expands into new markets where there are lots of buyers and high electricity demand such as China, India and Japan. This way, it can increase the numbers of offshore solar power plant to be more accessible and affordable.

Finally, to enable the trend of solar energy, HelioRec should improve the reliability of solar power generation to be constant, predictable energy supply and resistant to severe weather. This initiative will distinguish HelioRec among the energy competitors. As a result, it will help to reduce the overall plastic waste contributing to the circular economy while producing a green electricity and saving land space.

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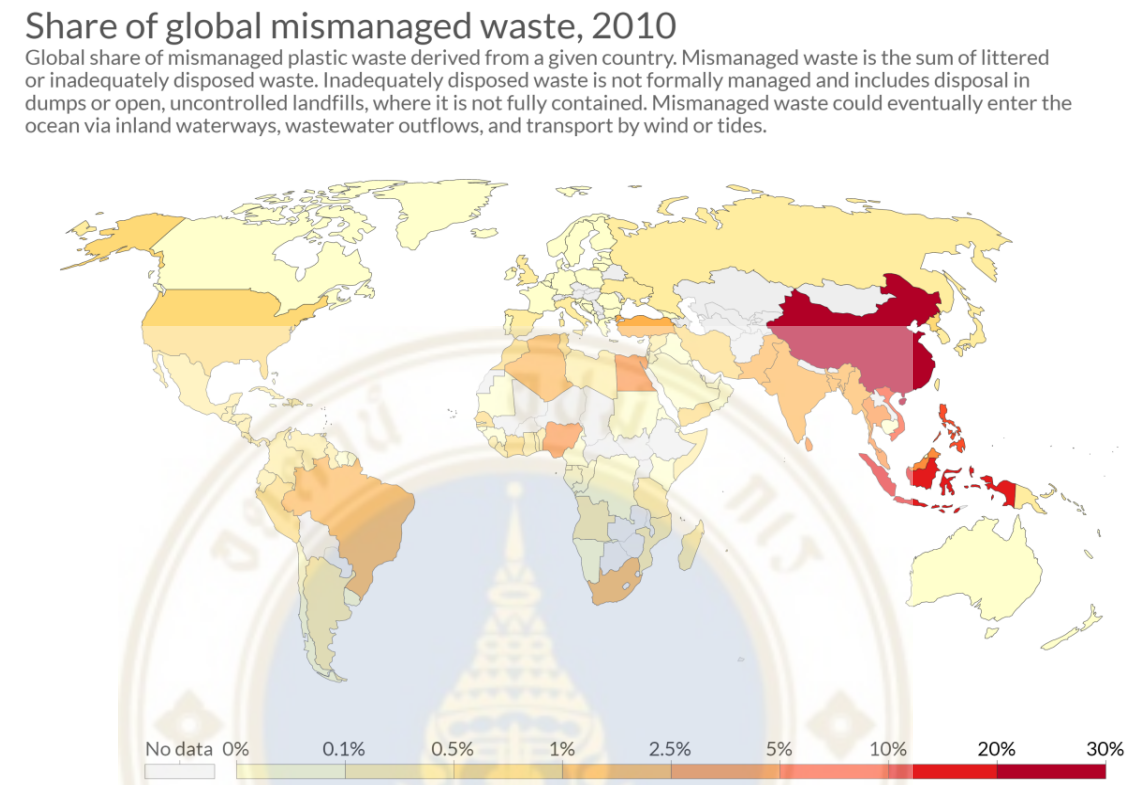
APPENDICES

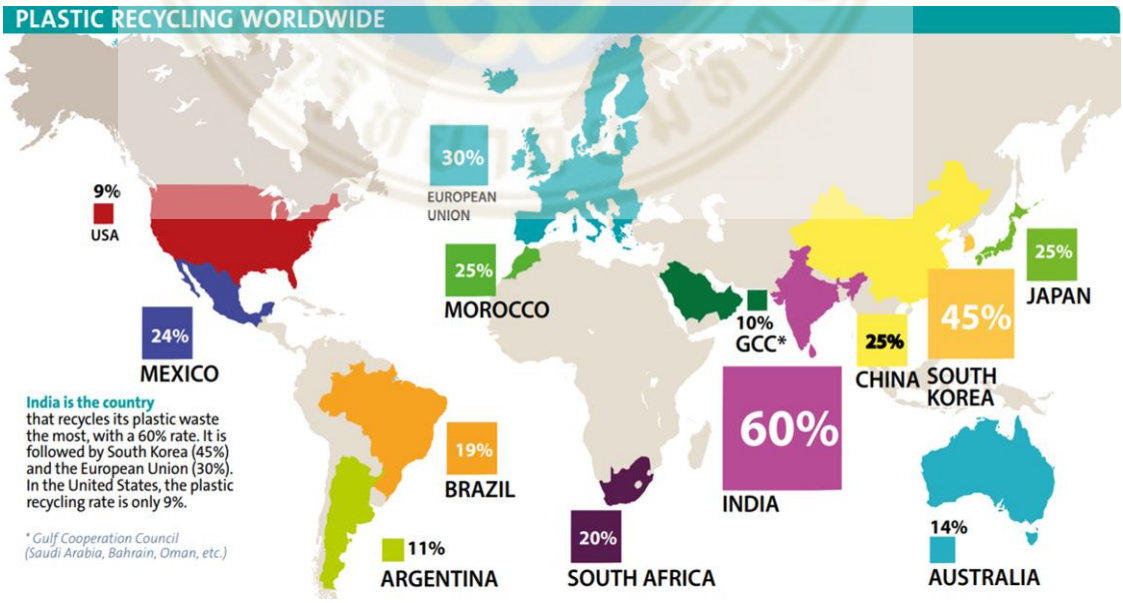
Appendix A: 17 Sustainable Development Goals (SDGs)

Source: UNDP (n.d.)

Appendix B: Share of Global Mismanaged Waste and Plastic Recycling Worldwide

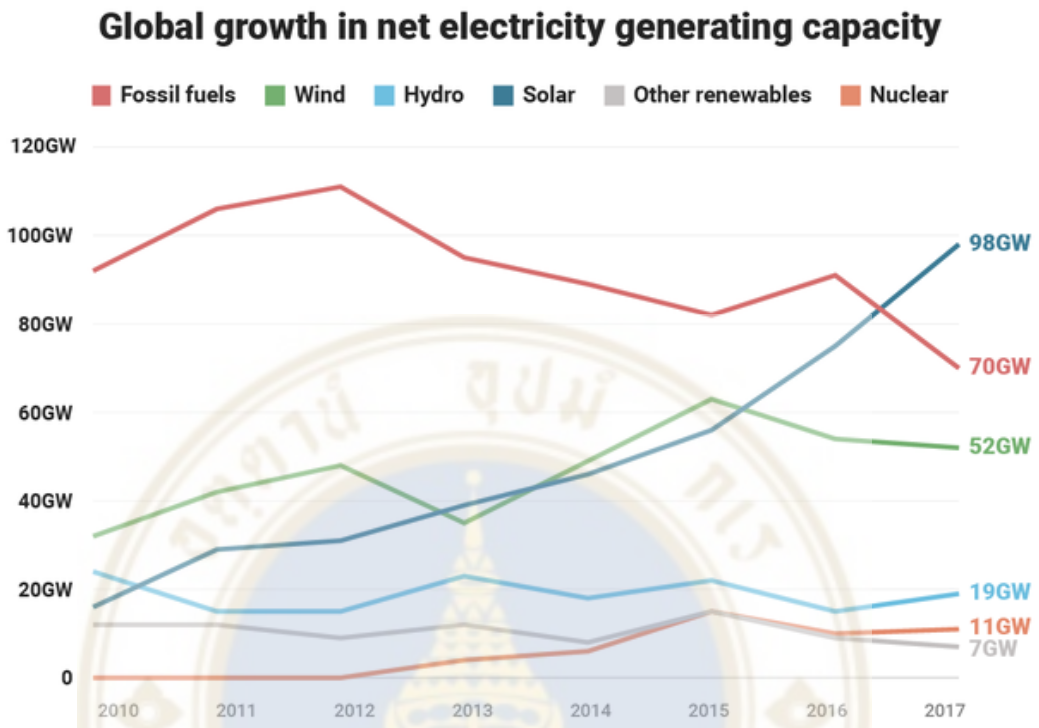


Source: Jambeck et al. (2015)

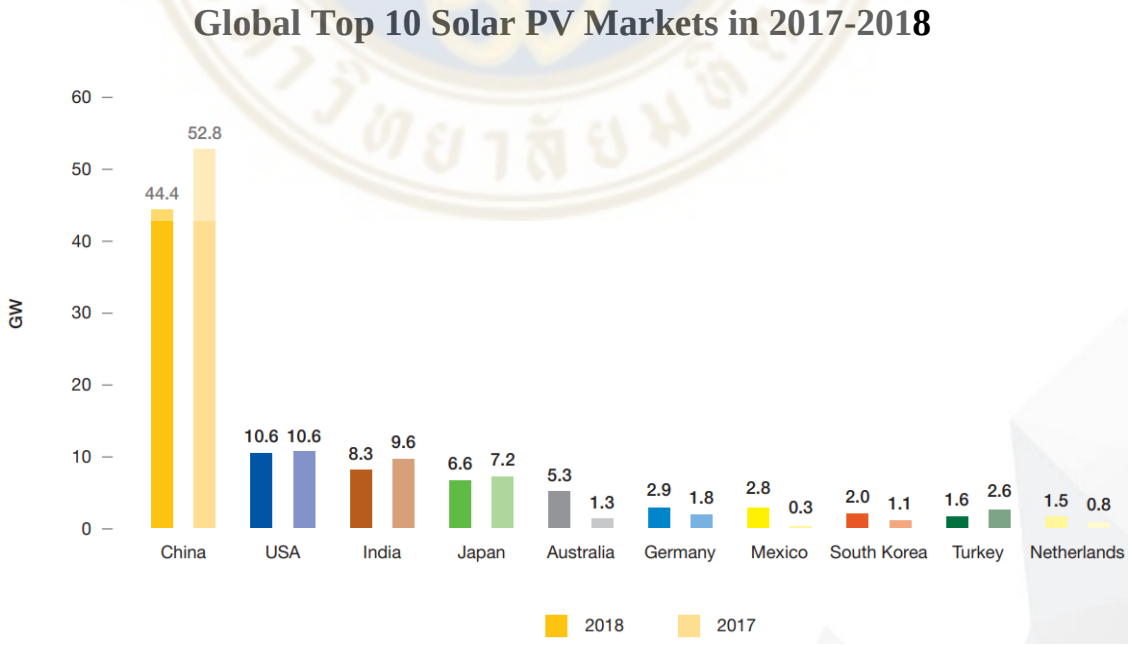


Source: Veolia (2018)

Appendix C: Global Growth in Net Electricity Generating Capacity and Global Top 10 Solar PV Markets in 2017-2018

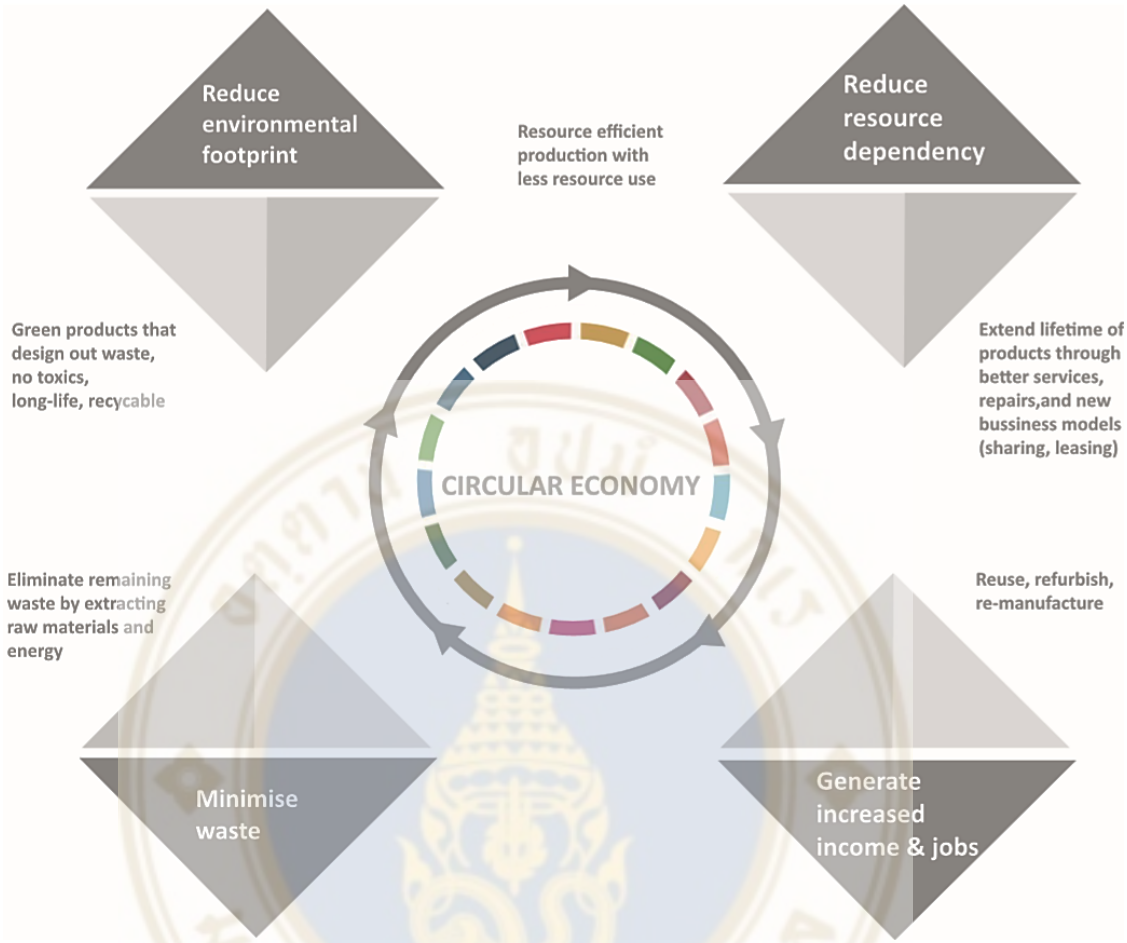


Source: Business Insider (2018)



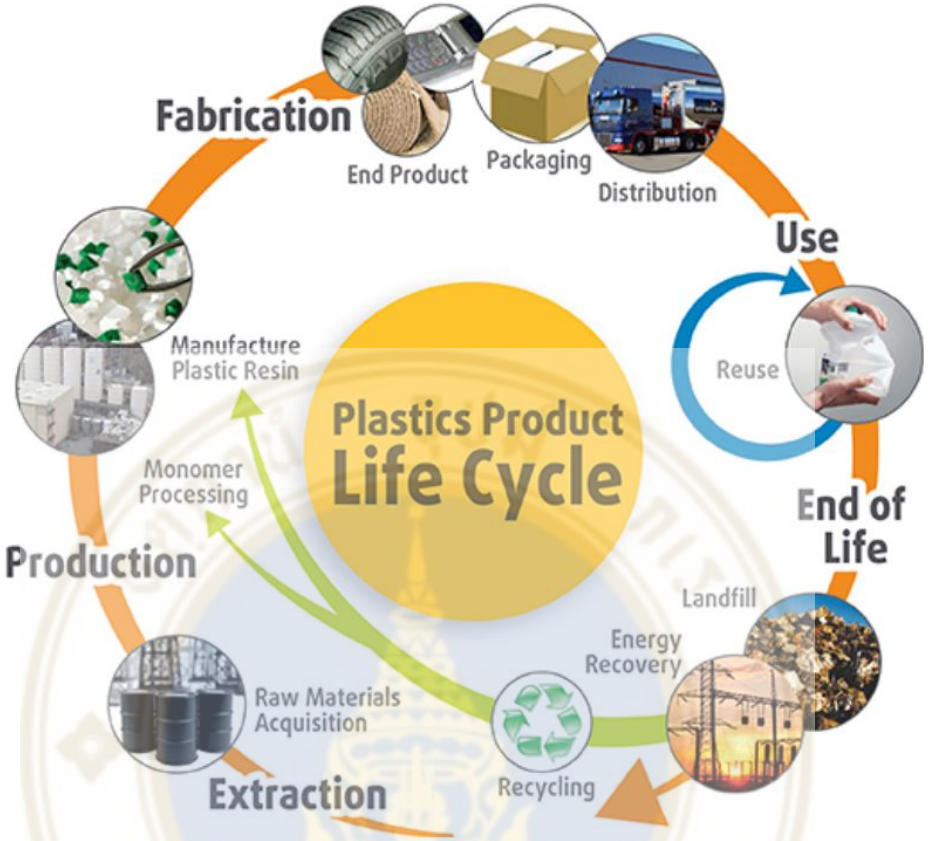
Source: SolarPower Europe (2019)

Appendix D: The Circular Economy



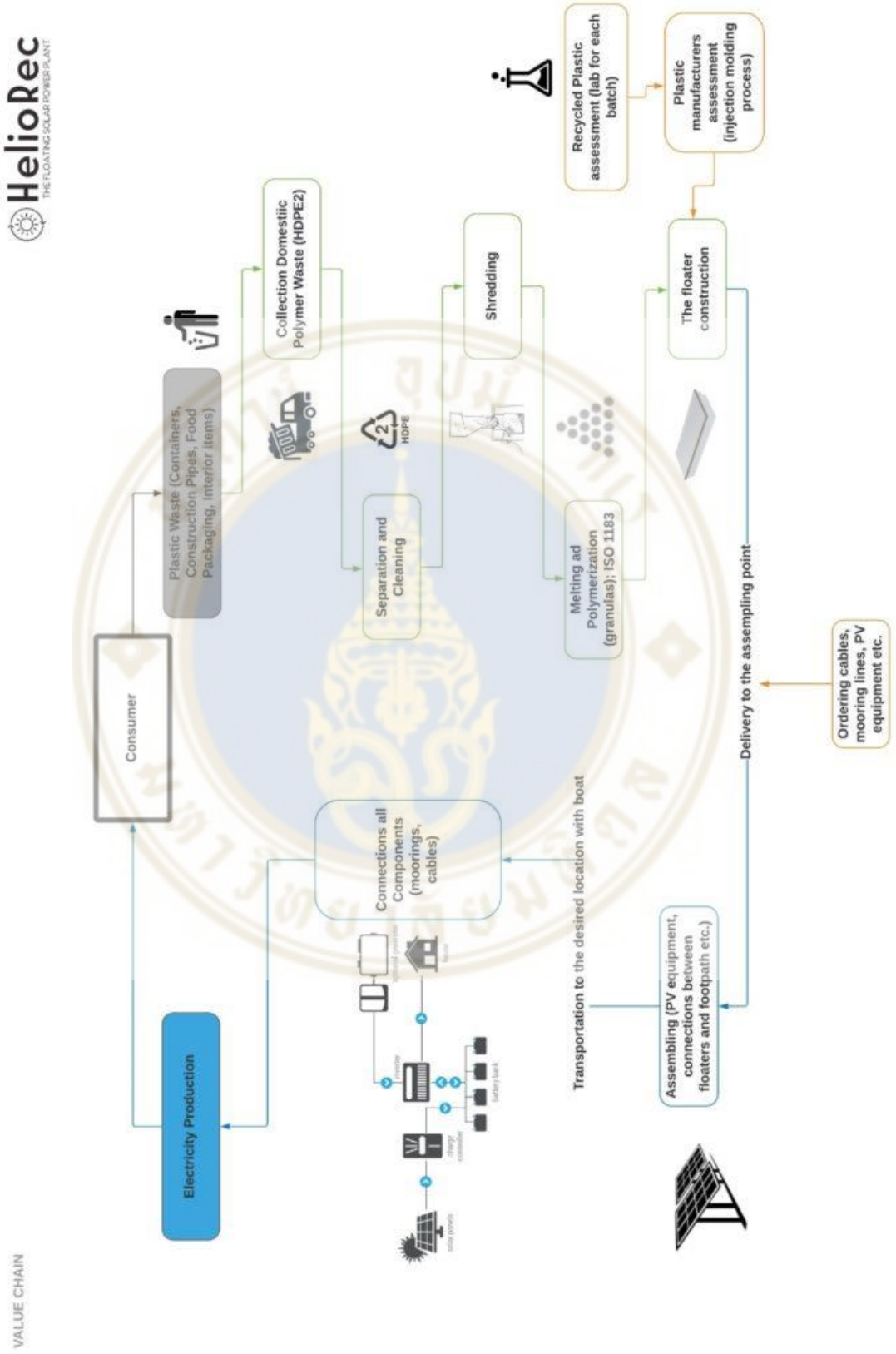
Source: UNIDO (2017)

Appendix E: The Plastics Product Life Cycle



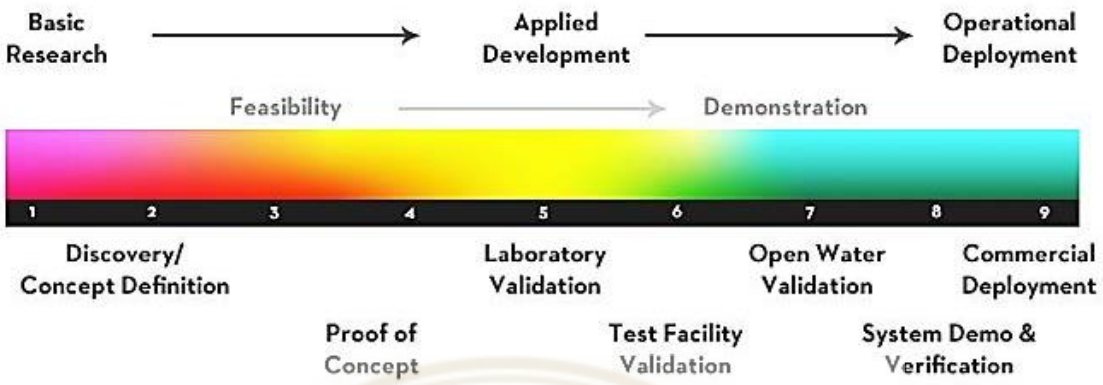
Source: Chen; Pelton & Smith (2015)

Appendix F: HelioRec's Value Chain



Source: HelioRec (2018)

Appendix G: Technology Readiness Levels (TRL)



Source: Own Data

Appendix H: Mobile Application to Track Carbon Footprint as an Added Service

Source: Own Illustration