MALDIVES

BARRIER ANALYSIS AND ENABLING FRAMEWORK REPORT

MITIGATION

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TECHNOLOGY NEEDS ASSESSMENT REPORT

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EXECUTIVE SUMMARY

Maldives TNA report was completed in May 2022 and the second stage of TNA process is to identify the barriers hindering the acquisition and diffusion of the prioritized technologies and to develop enabling framework to overcome the identified barriers. Maldives TNA report identified electricity consumption and generation, waste management and transport sector as key sectors for climate change mitigation since these are the key sectors which contribute to highest GHG emissions from the country. In the TNA report the following technologies were prioritized for barrier analysis;

Electricity Generation and Consumption Sector

- Roof Top Solar PV with Energy Storage System including battery.
- Floating Solar Platforms

Waste Management Sector

- Waste to Energy Facilities (WTE) in Regional Waste Management Centres

Transport Sector

- Electric buses, vehicles, and motorbikes (EVs)

In this second TNA report, barriers hindering the transfer and diffusion of prioritized mitigation technologies for three sectors have been identified, and measures to overcome the barriers and facilitate the transfer, adoption and diffusion of these technologies are explained.

To facilitate the identification of root causes of the main barriers, expert working groups for energy and waste sectors were taken through exercises on creating Market Mapping, Problem Tree (PT) and Objective Tree (OT) for each of the energy and waste technologies. The outcome of these exercises is provided in the annexes.

The whole process of technology barrier identification was drawn from various literature reviews, stakeholder meetings, stakeholder bilateral meetings, mitigation expert working group and respective technology experts. Mitigation consultant also seek reference to the TNA barrier analysis guideline, resources, information, and templates provided by specialists of UNEP Climate Change Centre during and after regional capacity building workshops.

Electricity Generation and Consumption Sector

Roof top Solar PV with Energy Storage System including Battery: This technology is considered as either a consumer good or capital good depending on the scale of the PV installation. In the residential and private sector, it is considered as a consumer good while large scale installation from donor funded project its considered as a capital good.

The main barrier facing update of this technology is high capital cost and limited availability of roof space and land area in Maldives. Furthermore, lack of financial institutions to finance large scale PV installation and limited availability of US dollars for importation of PV system is identified as barrier.

The main enabling measures identified for the technology include waiver of the import duty for spare parts and different components of the Rooftop Solar PV systems, enhancing implementation of Net-metering regulation and introduction of a national feed-in-tariff (FIT) mechanism and de-risking the commercial banks by Government of Maldives (GoM) to decrease the interest rates for Green Loan initiatives by the commercial banks.

Floating Solar Platform: Similar to the Rooftop Solar PV installation, Floating Solar Platforms are considered as both consumer and capital goods depending on the scale of PV installation.

The key barriers identified for this technology include limited lagoon space for installation of Floating Solar Platforms, lack of skilled technicians, and high maintenance costs associated with corrosion due to proximity to the marine water.

Some of the enabling measures for the Floating Solar Platform technology include collaboration with Maldives National University (MNU) and Maldives Polytechnic to develop short-term vocational training programs for technicians working on PV installation and maintenance.

Waste Management Sector

WTE facilities in Regional Waste Management Centre: This technology is considered as a capital good due to the high investment cost involved.

The main barriers identified for this technology include high investment required for construction and also operation of the WTE facilities. In addition, lack of trained staff for the operation of WTE facilities is considered as a significant barrier for Maldives.

Some of enabling measures include mobilization of private sector finance for WTE facilities and training of Waste Management Corporation (WAMCO) staff for operation of WTE facilities.

Transport Sector

Electric Vehicles (EVs): EVs are considered as consumer goods. The key barriers identified for the EVs include lack of infrastructure such as charging stations for the EV in Maldives and lack of awareness among the stakeholders regarding potential of EVs.

Some of the enabling measures identified include the establishment of charging stations in populous islands like Hulhumale' and Addu city and carrying out advocacy and awareness programs on EVs.

LIST OF ABBREVIATION

ARISE	Accelerating Renewable Energy Integration and Sustainable Energy
ASURE	Accelerating Sustainable System Development Using Renewable Energy
DBO	Design Build and Operate
EIA	Environmental Impact Assessment
EMS	Energy Management System
FENAKA	Fenaka Corporation Limited
FIT	Feed-in-tariff
ICE	Internal Combustion Engine
MNU	Maldives National University
MoT	Ministry of Tourism
MSL	Mean Sea Level
MSW	Municipal Solid Waste
MTCC	Maldives Transport and Contracting Company Limited
NDC	Nationally Determined Contribution
POISED	Preparing Outer Islands for Sustainable Energy Development
PV	Photovoltaics
RE	Renewable Energy
STELCO	State Electric Company Limited
TNA	Technology Needs Assessment
WAMCO	Waste Management Corporation
WTE	Waste to Energy

CHAPTER 1 – ELECTRICITY GENERATION AND CONSUMPTION SECTOR

This chapter will describe the barrier analysis and enabling framework for the two technologies which has been prioritized in the Maldives TNA report for Electricity Generation and consumption sector.

1.1 Preliminary targets for technology transfer and diffusion

Energy sector is one of the key sectors for climate change mitigation in Maldives. Energy sector is the main contributor to the GHG emissions in the Maldives due to high dependence on the fossil fuels for electricity generation. The main strategies outlined in the Maldives Nationally Determined Contribution (NDC) for energy sector mitigation action include the following;

- Increase of electricity production by renewable energy (RE) with storage and grid stabilization. Efforts would be made to increase installed RE share to 15%, by the year 2030 which includes the public and private sector.[1]

At present the total installed capacity for renewable energy systems in the country is 21.5 MW.[2] This account to approximately 7% of the total installed capacity of the Maldives. However, the Maldives as a significant potential to utilize solar energy for production of electricity given that Solar radiation is in the order of 1,200 kWh/m2/year in the country.[3] Currently, solar PV projects is being successfully implemented in the country. Solar PV panels are installed on roofs of diesel power houses, schools, seawater desalination plants, pump stations of sewerage systems and public buildings like mosques and hospitals. These installed PV panels are connected to the existing electricity grid of the island via Energy Management Systems (EMS) that enhances regulation of the power supply.

In addition, the National Strategic Action Plan (2019 – 2023) has identified some RE targets which the Government of Maldives (GoM) aspires to achieve. They include;

- By 2023, at least 80% of mosques utilize renewable energy for air conditioning;
- By 2023, share of renewable energy in the national energy mix increased by 20% compared to 2018 levels
- By 2023, at least 10MW of solar PV is installed under net metering regulation.

[1] Ministry of Environment (2020), "Updated Nationally Determined Contribution (NDC)"
[2] Asian Development Bank (2020), "Road Map for the Energy Sector 2020-2030"
[3] ibid

- By 2023, renewable energy storage capacity is increased to 30MWh.
- By 2023, 30% of energy consumption for water and sewerage facilities across the Maldives will be met with renewable energy.

However, these targets are yet to be achieved due to economic recession because of COVID-19 pandemic. Furthermore, as a follow-up on the National Strategic Action Plan (2019 – 2023) GoM has endorsed a Maldives Recovery and Resilience Plan 2019-2023 which include the following provisions regarding the RE in terms of Electricity Generation and Consumption;

- Rollout renewable energy projects to meet increasing energy demands, by maximizing solar power energy generation and adopting energy efficiency policies and strategies with a specific focus on meeting the 2030 net-zero targets.

The Maldives TNA report – Climate Change Mitigation has prioritized two technologies which are inline with the aforementioned plans of GoM. The following Table 1 are the prioritized technology and preliminary target for transfer and diffusion;

Table 1: Preliminary target for transfer and diffusion for prioritized technologies in electricity production and consumption sector

Technology	Preliminary Target for transfer and diffusion
Roof top Solar Photovoltaics (PV) with Energy Storage System including Battery	Roof top Solar Photovoltaics (PV) with Energy Storage System including Battery installed to all residential islands in the Maldives.
Floating Solar Platforms	25% of tourist resorts operational in the country install floating solar platforms.

1.2 Roof top Solar Photovoltaics (PV) with Energy Storage System including Battery

1.2.1 General Description

Roof top Solar PV with Energy Storage System including battery consist of Solar PV Modules, Invertor, Utility Power and Meter and Charge Controller. The following Figure 1 illustrates a typical Roof top Solar PV with Energy Storage System including battery storage.

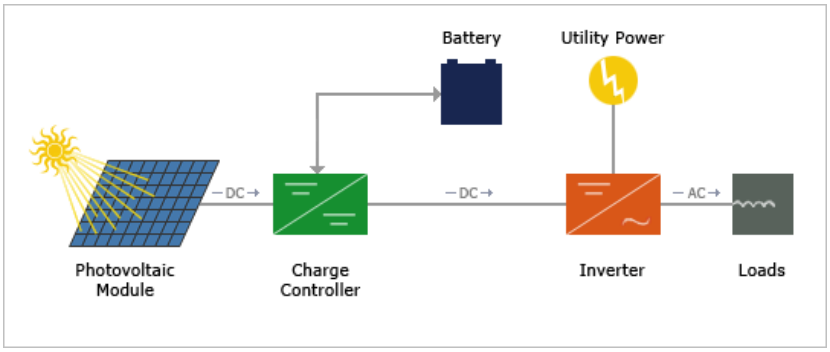


Figure 1: Components of a Roof top solar PV with Energy Storage System (Adapted from Synergy Enviro Engineers (India) Private Limited, 2016)

The following are the main components of a Roof Top Solar PV with Energy Storage System:

PV Modules: PV cells are the basic unit which converts the sunlight to energy. A PV module consists of PV cells arranged in frames to form a module. A PV module is constructed by connecting PV cells in series for high voltage and in parallel for high current. By connecting series of PV modules, a PV array is formed.

Inverter: Inverters convert Direct current (DC power) into standard Alternating Current (AC power) which can be used for the household appliances, synchronizing with utility power whenever the electrical grid is distributing electricity.

Battery: Battery stores any excess energy produced by PV modules and delivers it back when in demand.

Utility Power and Meter: At nighttime, and if the demand exceeds the power produced from Solar PV during the day, electricity is provided through utility power source. The utility meter would spin backwards when solar power production exceeds house demand. This allows you to credit any excess electricity in the future utility bills.

Charge Controller: it avoids overcharging the battery and prolongs the life of the PV system.

1.2.2 Status of Technology in Maldives

Solar PV energy is an indigenous resource with the most immediate exploitation possibilities in Maldives. Solar radiation is in the order of 1,200 kWh/m2/year, which is considered good for any solar PV project.

The solar PV project is being successfully implemented in hybrid systems in several inhabited islands through donor financed projects. PV panels are installed on the roofs of diesel power plants, schools, water desalination plants, sewage plants, and public buildings. PV panels are connected to diesel power plants through an energy management system (EMS) that enhances the regulation of power supply. This hybrid configuration can offer short pay back times when compared to current prices of electricity produced by diesel generation sets. Rooftop solar PV is also being installed in the country, under net metering.

There are 3 major donor financed projects which is currently implemented in Maldives which focuses on installation of Solar Photovoltaic. They include the following;

- The Accelerating Renewable Energy Integration and Sustainable Energy (ARISE) project;
- Preparing Outer Islands for Sustainable Energy Development (POISED) project.
- Accelerating Sustainable System Development Using Renewable Energy (ASURE) Project.

The ARISE project is funded by World Bank Group while POISED and ASURE projects are funded by Asian Development Bank (ADB). All these projects involve installation of Solar PV systems of different types and scale across Maldives.

1.2.3 Technology Category and Market Characteristics

The technologies are categorized based on both the type of pf goods and services they belong to or contribute to and the markets or non-markets in which they are transferred and diffused rather than according to their technical properties. This is to facilitate the barrier analysis process and reporting based on the barrier analysis.[4] Roof top solar PV with Energy Storage System was identified by Electricity Generation and Consumption Sector Working Group as a a consumer and capital goods. When purchased by the private or business sector on a small scale for installation on their rooftops to reduce electricity bills, this technology is referred to as a consumer goods, whereas bigger scale solar PV arrays installed on Government and commercial building rooftops merely to support the grid are considered to be capital goods. The following Table 2 provides information on the categorization of goods and market characteristics.

[4] Ivan Nygaard, U. E. (2015). Overcoming Barriers to the Transfer and Diffusion of Climate Technologies: Second Edition. Copenhagen: UNEP DTU Partnership

Table 2: Classification of Roof Top Solar with Energy Storage System including battery and floating solar platforms

Technologies	Category	Description	Market Characteristics
Roof Top Solar with Energy Storage System including Battery (AND) Floating Solar platforms	Consumer Goods	Goods specifically intended for the mass market; households, businesses and institutions.	• a high number of potential consumers • interaction with existing markets and requiring distribution, maintenance and installer networks in the supply chain • large and complicated supply chains with many actors, including producers, assemblers, importers, wholesalers, retailers and end consumers • barriers may exist in all steps in the supply chain • demand depends on consumer awareness and preferences and on commercial marketing and promotional efforts
	Capital Goods	Machinery and equipment used in the production of goods, e.g. consumer goods or electricity.	• a limited number of potential sites/ consumers • relatively large capital investment • simpler market chain, i.e. few or no existing technology providers • demand is profit-driven and depends on • demand for the products the capital goods are used to make

1.2.4 Identification of Barriers for Roof Top Solar with Energy Storage Systems including Battery

In order to identify the barriers for the Roof Top Solar with Energy Storage System including Battery, a working group session for the Electricity Generation and Consumption Sector was conducted on 15th March 2023. The composition and attendees of this working group meeting is included in Annex 02 of this

report. The stakeholders were given the opportunity to have a facilitated discussion regarding the existing barriers for the technology diffusion in the Maldives. The following barrier categories were given for the classification of the identified barriers. They include;

- Economic and Financial
- Market condition
- Legal and Regulatory
- Institutional and organization capacity
- Human skills
- Information and awareness
- Social, cultural and behavioral
- Technical
- Others

The long list of barriers listed by consultant and shared with stakeholder for the facilitated discussion in the working group meeting include the following;

- Lack of availability of roof space for PV installations
- Physical conditions of the roof space.
- High investment cost
- Unavailability of Material for PV installation
- Lack of skilled technicians
- Instability of the existing electricity grids
- Lack of financial resources for large scale PV installation

The stakeholder working group was asked to identify any additional barriers and classify the long list of barriers and any additional barriers identified during the facilitation discussions. The following Table 3 are the main barriers identified by the stakeholders and their respective classifications.

Table 3: Identification of barriers for Roof Top Solar PV with Energy Storage System including Batteries

Barriers	Economic and Financial	Legal and Regulatory	Market Condition	Institutional and organizational capacity	Human Skills	Information and Awareness	Social, Cultural and Behavioral	Technical	Others
Lack of availability of roof space		✔							✔
Physical conditions of the roofs								✔	
Current installed capacity in some islands is higher than the demand								✔	
High Capital Investment	✔								
Impact on Aesthetics in Tourism Sector							✔		
Unavailability of Material for PV installation			✔						
Lack of US Dollars for importing	✔								

Instability of the existing grid								✔	
Lack of financial resources for large scale PV installation	✔								

1.2.5 Prioritization of the identified barriers

In order to prioritize the identified barrier, each participant of the working group was asked to assign a score between 0 to 5 with higher score for the more significant barriers. The following Table 4 provides the results of the prioritization of identified barriers.

Table 4: Ranking of Identified Barriers based on their significance.

Identified Barrier	Average Assigned Score (0 to 5)	Rank
Lack of availability of roof space	4.25	1
Physical conditions of the roofs	3.25	5
Current installed capacity in some islands is higher than the demand	4.25	1
High Capital Investment	3.75	3
Impact on Aesthetics in Tourism Sector	3.5	4
Unavailability of Material for PV installation	4	2
Lack of US Dollars for importing	3.5	4
Instability of the existing grid	3.5	4
Lack of financial resources to finance large scale PV installation	4.25	1

Based on the prioritization exercise the following are the list of identified barriers based on their level of significance according to the stakeholders of the electricity generation and consumption working group. The following Table 5 provides information on the ranking and barrier categories of identified barrier.

Table 5: Prioritized ranking for the identified barrier and their corresponding categories

Rank	Identified Barrier	Barrier Category
1	Lack of availability of roof space	Other
	Current installed capacity in some islands is higher than the demand	Technical

	Lack of financial resources for large scale Rooftop Solar PV installation	Economic and Financial
2	Unavailability of Material for PV installation	Market Condition
3	High Capital Investment	Economic and Financial
4	Impact on Aesthetics in Tourism Sector	Social, Cultural and Behavioral
	Lack of US Dollars for importing	Economic and Financial
	Instability of the existing grid	Technical
5	Physical conditions of the roofs	Technical

1.2.6 Screening of Prioritized Barriers

The screening of the barriers identified above was carried out by the same Electricity Generation and Consumption working group and the outcome of this discussion and information gathered is produced in the market mapping, problem tree and solution tree. The following Figure 2 is the market mapping for Roof Top Solar PV with Battery technology.

The end-users of solar PV systems in Maldives are Residential PV users, Tourist Facilities and Donor Funded Projects and utility companies. Importers of PV, local retailers, and installation companies along with foreign contractors are the main importers of Solar PV systems to Maldives. There are no manufacturers of Solar PV systems in the Maldives. Local retailers carry out installation works, and they import solar PVs in most cases. They provide installation services to residential users and tourist facilities across Maldives. Foreign contractors implement large scale installation of solar PV systems for donor funded projects. In addition, contractor finance is utilized for large scale installation and their investments are repaid through power purchase agreements with utility companies.

Some of the incentives for enhancing diffusion of the technology include import duty exceptions, upgrading the existing electricity grids so that they assimilate the electricity generated by solar PV systems. In addition, the introduction of green loan schemes by commercial banks has enabled residential users to access finance for small scale solar PV installation.

Some of the key barriers identified include lack of US dollars which is required for importation of solar PV systems, lack of adequate roof space for solar PV installation works and where roof space is available the physical condition of the roof unfavorable for installation works. Furthermore, the instability of the existing

electricity grid is a key barrier for penetration of solar PV systems in Maldives. The Figure 2 is a market mapping for the roof top solar with battery technology.

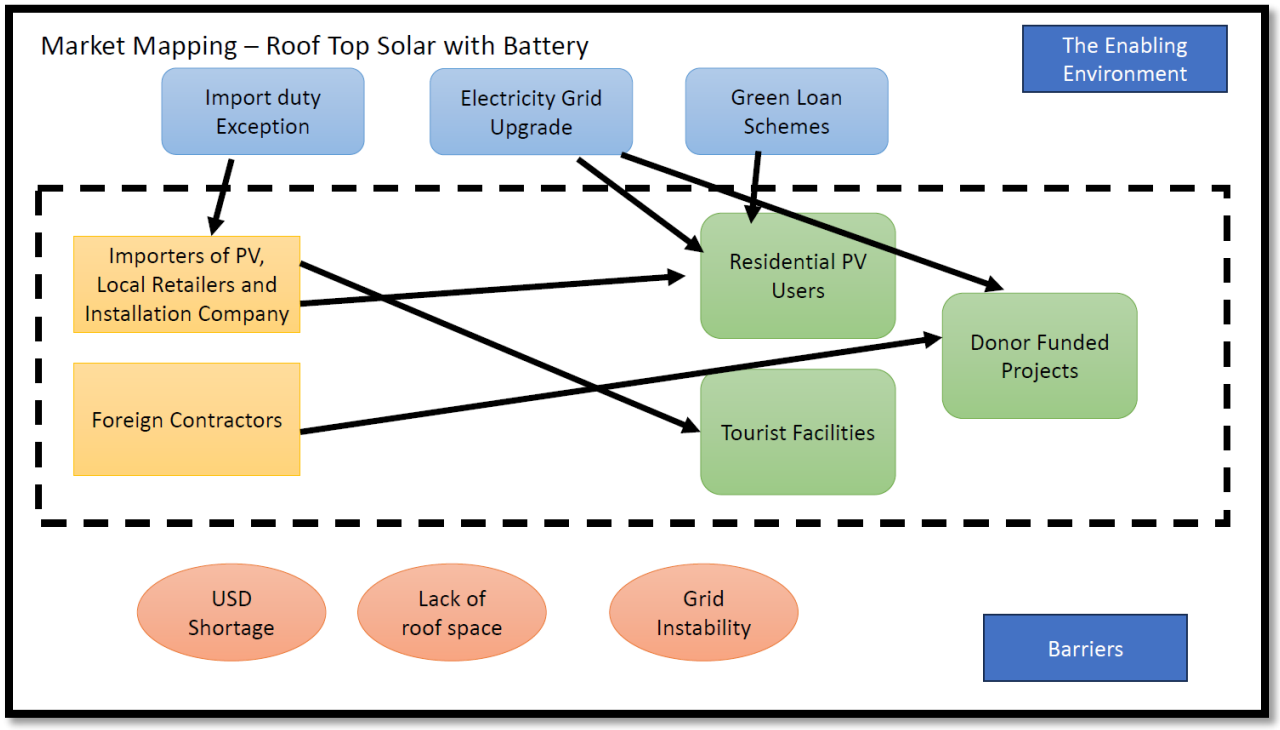


Figure 2: Market Mapping for Roof Top Solar with Battery

The following Figure 3 and Figure 4 are the problem tree and solution tree respectively for the Rooftop solar PV with EMS.

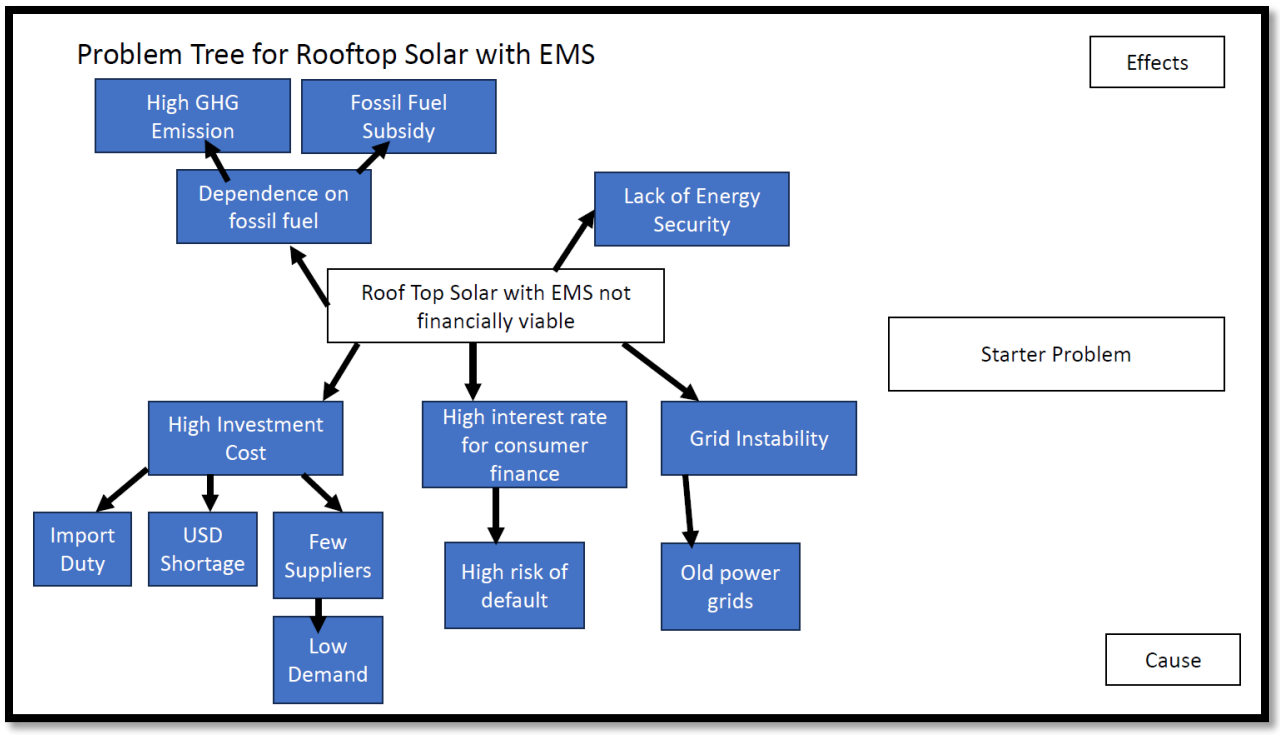


Figure 3: The problem tree for Rooftop Solar with EMS including battery technology

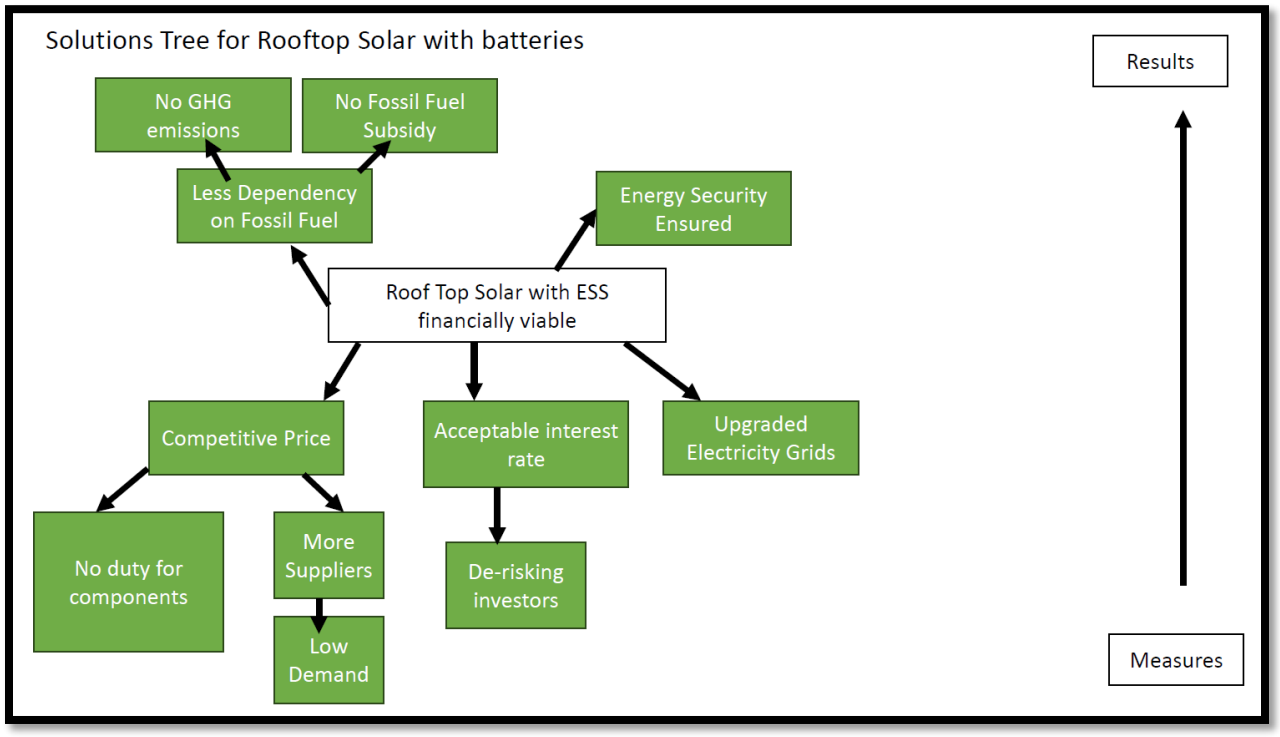


Figure 4: The solutions tree for Rooftop Solar with batteries technology

1.2.6.1 Economic and Financial Barriers

High Capital Investment: For the private sector, the cost of importing roof top solar PV system is high even though import duty rate for Solar PV modules is 0% the spare parts including the batteries, invertors and other components are subjected to 20% import duty rates. Furthermore, the cost of shipping is very high since most of these Solar PVs and spare parts are coming from China, Japan and India. In addition, the port charges are also high in Maldives.

Lack of financial resources to finance large scale PV installation: Even though, commercial banks of Maldives provide finance for green initiative such as installation of solar PV system these schemes are relatively in small scale and very limited effort from commercial banks to promote these as their financial products. In addition, the high interest rates of these kinds of green loans make it unattractive for the individual residential customers.

Lack of US Dollars for importing: Maldives faces shortage of US dollar required for importation of commodities despite of foreign currency revenues from tourism sector. Even though, the official exchange rate of USD is 15.42 MVR per USD, it is extremely difficult to for import businesses to purchase USD at this rate in order to import all commodities including Solar PVs and different components.

1.2.6.2 Non-financial Barriers

Technical

- **Current installed capacity in some islands is higher than the demand:** Due to inadequate planning some of the islands has been installed with PV systems which produce excess electricity than the demand of the island and there are no battery systems to store this surplus electricity generated.
- **Instability of the existing grid:** Many of the electricity grids in the country require upgrading and is unavailable to integrate the electricity produced by Solar PV systems. However, in some projects, particularly donor funded projects energy management systems has been used to maintain the stability of the grid despite integration of RE.
- **Physical conditions of the roofs:** Many roof areas in the Maldives, particularly in small island are unusable for PV installation due to old age of the roof and some roofs are still made of asbestos material which makes it a health hazard for PV installations workers.

Market Conditions

- **Unavailability of Material for PV installation:** There are limited no. of suppliers and companies which install PV systems in Maldives. Hence, there are significant shortages of material required for PV installation as well as different components of Roof Top Solar PV systems.

Social, Cultural and Behavioral

- **Impact on Aesthetics in Tourism Sector:** Some tourist resort of Maldives does not prefer Solar PV panels since it has aesthetic impacts of the tourist resorts.

Other

- **Lack of availability of roof space:** Due to small nature of the islands and lack of space generally the roof space for PV installations is limited in the Maldives. Furthermore, many households in small island practice rainwater harvesting which require roof space.

1.2.7 Economic and Financial Measures

The following economic and financial measures and non-financial mechanisms were identified in consultation with stakeholders in the Electricity Generation and Consumption working group and these measures are based on the solution tree and root causes identified in the problem tree (See Figure 03 and 04).

- Waiver of the import duty for the spare parts and different components of the Rooftop Solar PV system including batteries.
- Enhance implementation of Net-metering regulation and introduction of a national feed-in-tariff (FIT) mechanism.
- De-risk the commercial banks by GoM to decrease the interest rates for Green Loan initiatives by the commercial banks.

1.2.8 Non-financial Mechanism

Technical

- **Current installed capacity in some islands is higher than the demand:** Proper feasibility studies need to be conducted prior to any PV installation works and investing on Energy Storage Systems along with roof top Solar PV installation.

- **Instability of the existing grid:** Upgrading the existing electricity network grid in the islands and utilization of a battery to stabilize the Roof Top Solar PV system.
- **Physical conditions of the roofs:** Focus the installation on the new buildings, investing in upgrading the roofs as part of the PV installation works.

Market Conditions

- **Unavailability of Material for PV installation:** Conduct forums for supplier of Rooftop solar PV systems and material required for PV installation so that required network is established to overcome any logistical challenges.

Social, Cultural and Behavioral

- **Impact on Aesthetics in Tourism Sector:** Currently, the Ministry of Tourism (MoT) is working on a National Green Label Certification. Utilization of the RE for resort power generation can be included as a significant criterion for Green Label Certification which will incentivize tourist sector to utilize RE technologies such as rooftop solar PV.

1.3 Floating Solar Platforms

1.3.1 General Description

Floating Solar Platforms have similar components as Roof Top Solar systems, however they are deployed in a water body particularly in lakes and shallow lagoon areas. These are platforms moored in the sea with mounted PV arrays on top. These PV floating platforms are connected to the island's grid using a submarine cable. These platforms must be placed in areas close to the islands and with low wave activity to ensure their operations withstand. Effects of salinity over the solar panels must also be considered in the design. The following Figure 5 are photographs of floating solar platforms deployed in a tourist resort in Maldives.

Figure 5: Floating Solar Platforms deployed in a tourist resort in Maldives (Photo credit: Swimsol Maldives)

1.3.2 Status of Technology in Maldives

In Maldives, currently there are international and local companies which provide installation services of floating solar platforms in tourist resorts. A significant number of tourist resorts has deployed floating solar platforms within their lagoon areas. In addition, 10MW solar PV platforms are planned to be installed in the Addu City under the World Bank finance ARISE project.

1.3.3 Technology Category and Market Characteristics

Similar to Roof top Solar PV installation, Floating solar platforms was identified by Electricity Generation and Consumption working group as a consumer and capital goods. When purchased by the tourism sector

on a small scale for installation on their lagoon area, this technology is referred to as a consumer good. However, bigger scale floating solar platforms established under donor financed projects the technology is considered to be a capital good. Detailed information on the categorization of the goods and market characteristics has been given in Table 2 of this report.

1.3.4 Identification of Barriers for Floating Solar Platforms

In order to identify the barriers for the Floating Solar Platforms, a working group session for the Electricity Generation and Consumption Sector was conducted on 15th March 2023. The composition and attendees of this working group meeting is included in Annex 02 of this report. The stakeholders were given the opportunity to have a facilitated discussion regarding the existing barriers for the technology diffusion in the Maldives. The following barrier categories were given for the classification of the identified barriers. They include;

- Economic and Financial
- Market condition
- Legal and Regulatory
- Institutional and organization capacity
- Human skills
- Information and awareness
- Social, cultural and behavioral
- Technical
- Others

The long list of barriers listed by consultant and shared with stakeholder for the facilitated discussion in the working group meeting include the following;

- Environmental condition of the lagoons.
- Boundary restrictions on lagoon utilization
- High investment cost
- Lack of technical knowledge and information on the environmental conditions
- Lack of skilled technicians
- High capital and maintenance cost
- Lack of financial resources for large scale PV installation

The stakeholder working group was asked to identify any additional barriers and classify the long list of barriers and any additional barriers identified during the facilitation discussions. The following Table 5 are the main barriers identified by the stakeholders and their respective classifications.

Table 6: Identification of barriers for Floating Solar Platforms

Barriers	Economic and Financial	Legal and Regulatory	Market Condition	Institutional and organizational capacity	Human Skills	Information and Awareness	Social, Cultural and Behavioral	Technical	Others
Boundary restriction to use lagoon space		✔							
Extra charges for sea space	✔								
Environmental Condition of the lagoon									✔
Lack of Technical Information regarding the environmental conditions								✔	
Limited Skilled Technicians					✔				
High Capital and Maintenance Cost	✔								
Lack of US Dollars for importing	✔								
Lack of financial resources for large scale PV installation	✔								

1.3.5 Prioritization of the identified barriers

In order to prioritize the identified barrier, each participant of the working group was asked to assign a score between 0 to 5 with higher score for the more significant barriers. The following Table 6 provides the results of the prioritization of identified barriers.

Table 7: Ranking of Identified Barriers based on their significance.

Identified Barrier	Average Assigned Score (0 to 5)	Rank
Boundary restriction to use lagoon space	4.75	1
Extra charges for sea space	3.5	4
Environmental Condition of the lagoon	3.5	4
Lack of Technical Information regarding the environmental conditions	3.25	5
Limited Skilled Technicians	3.75	3
High Capital and Maintenance Cost	4.5	2
Lack of US Dollars for importing	3.5	4
Lack of financial resources for large scale PV installation	3.5	4

Based on the prioritization exercise the following are the list of identified barrier based on their level of significance according the stakeholders of the electricity generation and consumption working group.

Table 8: Ranking of identified barrier and their corresponding barrier category

Rank	Identified Barrier	Barrier Category
1	Boundary restriction to use lagoon space	Legal and Regulatory
2	High Capital and Maintenance Cost	Economic and Financial
3	Limited Skilled Technicians	Human Skills
4	Extra charges for sea space	Legal and Regulatory
	Environmental Condition of the lagoon	Others

	Lack of US Dollars for importing	Economic and Financial
	Lack of financial resources for large scale PV installation	Economic and Financial
5	Lack of Technical Information regarding the environmental conditions	Technical

1.3.6 Screening of Prioritized Barriers

The screening of the barriers identified above was carried out by the same Electricity Generation and Consumption working group and the outcome of this discussion and information gathered is produced in the market mapping, problem tree and solution tree. The following Figure 6 is the market mapping for Floating Solar Platforms.

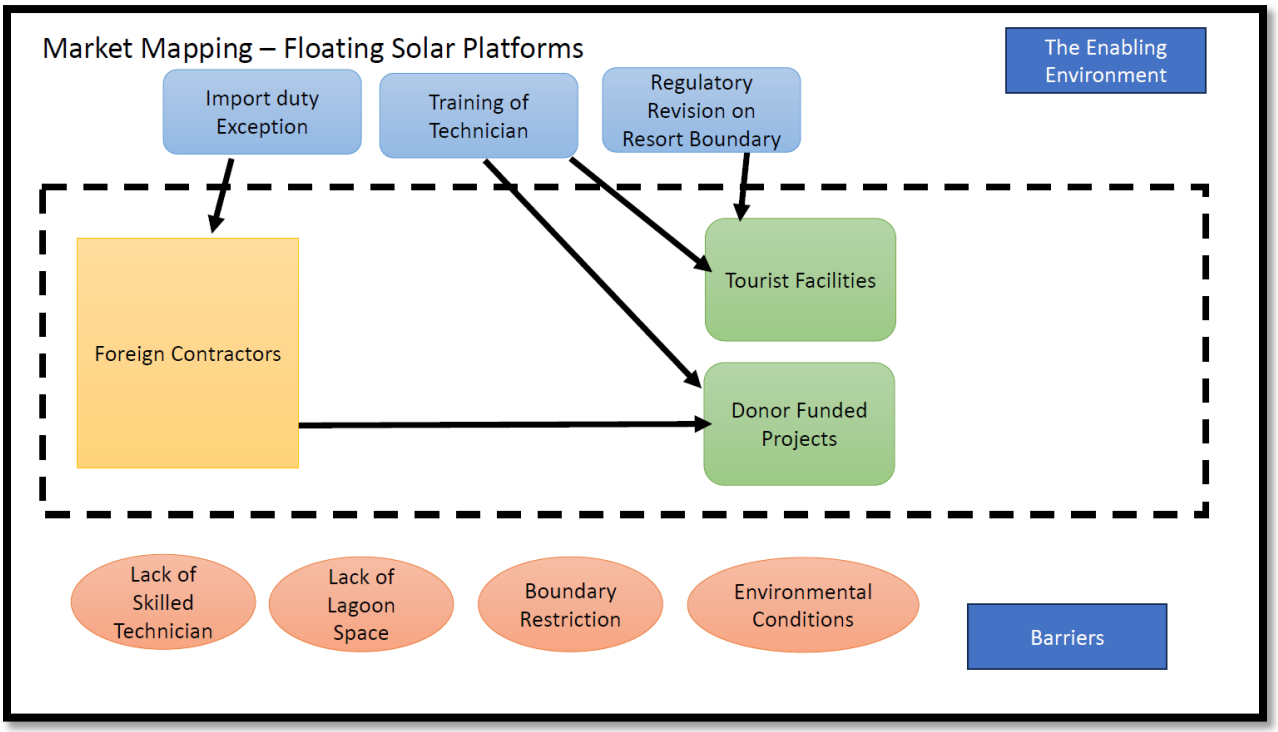


Figure 6: Market Mapping for Floating Solar PV systems

The main actors in Floating Solar Platform technology are Foreign Contractors, Tourism Facilities and Donor Funded projects in the Maldives. Foreign contractors install floating solar platforms in tourist facilities. In some instances, donor funded projects are installing floating solar in residential islands.

Some of the barriers identified for the floating solar platforms include lack of skilled technicians, lack of lagoon space for installation of floating solar platforms, boundary restrictions and unfavorable environmental conditions.

The main incentives to address the previously identified barriers include exemption of import duty for the floating solar platforms, training of local technicians for installation works and regulatory revisions to prevent the boundary restrictions which hinder floating solar platform installation in tourism sector. The following Figure 7 and Figure 8 are the problem tree and solution tree respectively for the Floating Solar Platforms.

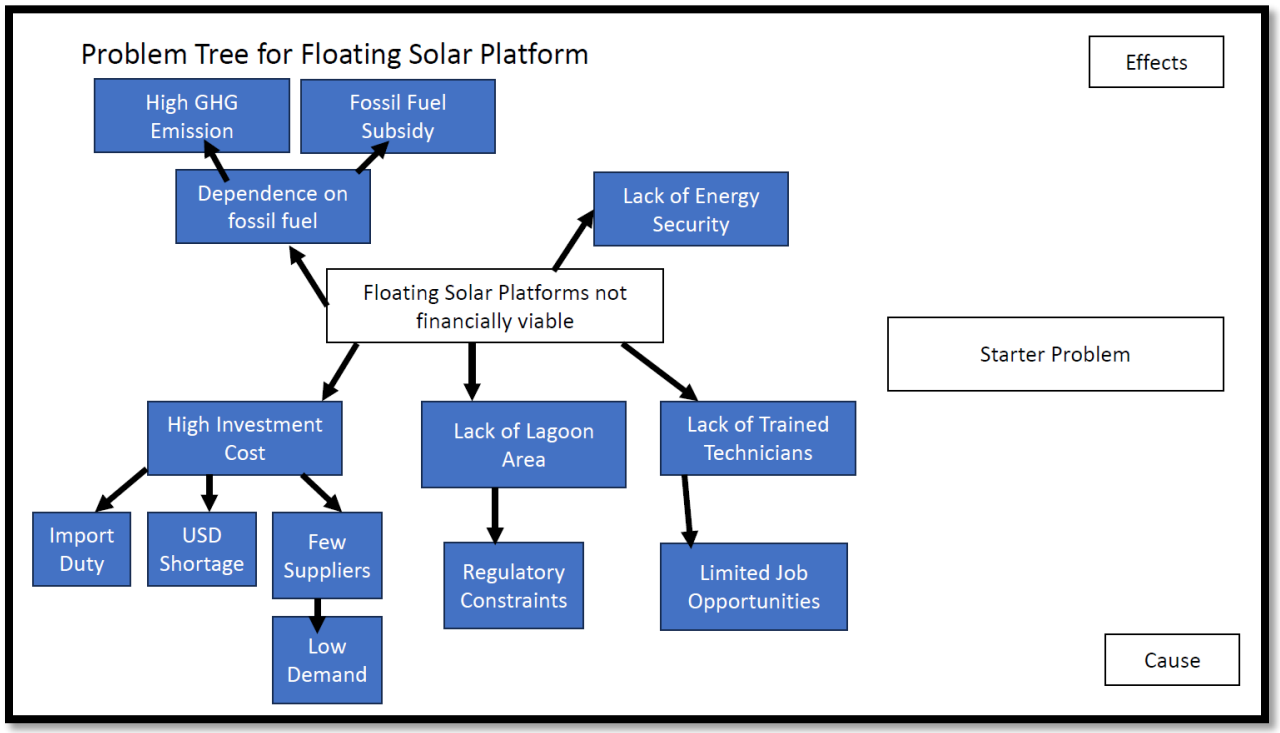


Figure 7: The problem tree for Floating Solar Platform Technology

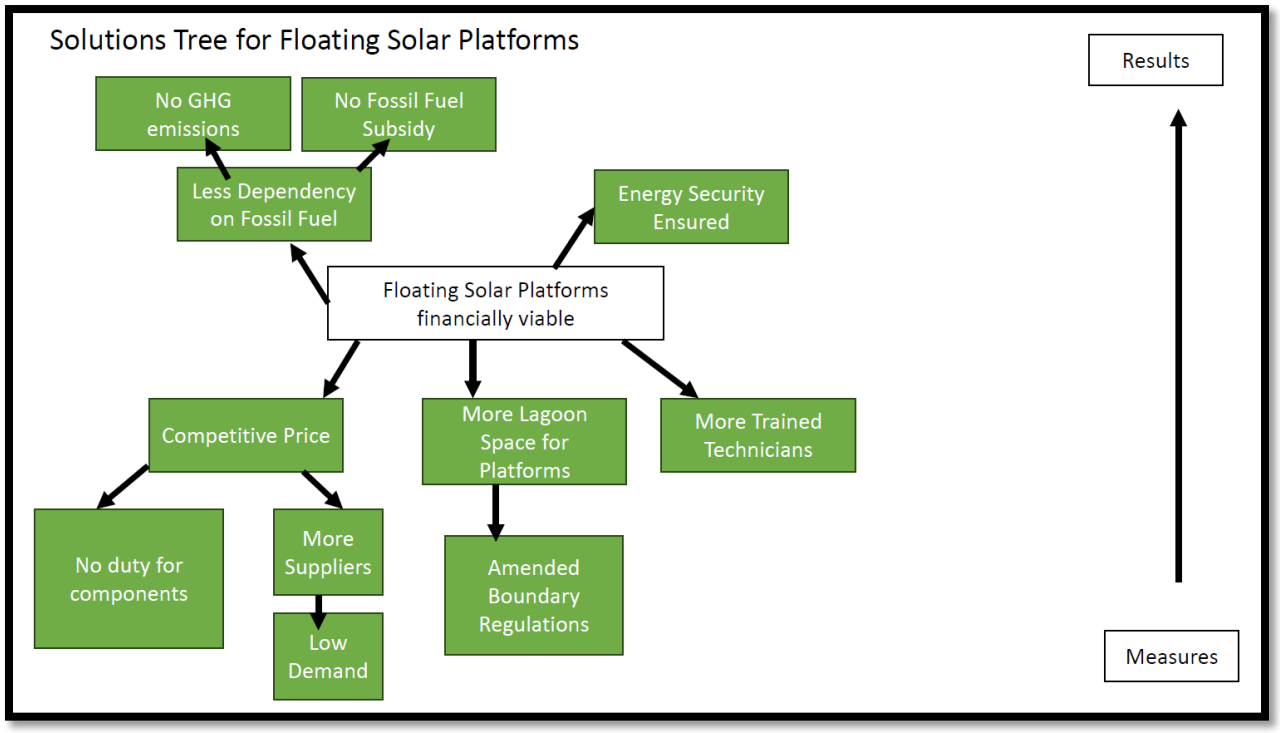


Figure 8: Solution Tree for the Floating Solar Platform Technology

1.3.6.1Economic and Financial Barriers

High Capital and Maintenance Cost: Similar barriers regarding importation of spare parts and components of the floating solar platforms. In addition, high investments are required for components such as submarine cables which is an additional requirement for the floating solar platforms in comparison with the roof top solar PV systems. Furthermore, the platforms and anchoring buoys are additional components which need to be procured for installation of solar floating platforms.

Lack of financial institution to finance large scale PV installation: This barrier is similar to the Roof Top Solar PV with Energy Storage system including battery technology (See Section 1.2.6.1).

Lack of US Dollars for importing: This barrier is similar to the Roof Top Solar PV with Energy Storage system including battery technology (See Section 1.2.6.1).

1.3.6.2 Non-financial Barriers

Legal and Regulatory

- **Boundary restriction to use lagoon space:** this barrier is particularly relevant for tourism sector installations. According to the Boundary Regulation (2012/R-7)[5] and Amendment (2016/R-94)[6] under the Tourism Act of Maldives (Law No. 2/99)[7], the boundary of a tourist resort is as follows;
    - If a boundary has already been identified in the Lease Agreement, the boundary of the lagoon surrounding the island shall be as outlined in the Lease Agreement.
    - If a boundary has not been identified in the Lease Agreement, the lagoon of the island extends more than 500m from the vegetation line of the island, the boundary shall be 500m into the lagoon from the vegetation line of the island.
    - If the reef is less than 500m from the vegetation line of the island, then the boundary shall be up to the outer reef from the vegetation line of the island.
    - If another island is found greater than 500m within the same lagoon, the boundary of the resort island shall be 500m from vegetation line of the resort island.
    - If another island is found in less than 1000m within the same lagoon, the boundary shall be the middle point between the vegetation of the resort island and the other island
    - If there are more than one islands within the same lagoon, a no development buffer of 100m shall be established from the outer boundary.
    - If an island is reclaimed within a lagoon, the boundary shall still remain as the original boundary outlined for the resort.
    - If a developer wishes to develop tourist facilities up to 2000m from the resort, the Ministry of Tourism has the authority to decide so with certain conditions.

Due to these regulatory restrictions of the boundary of the tourist resort, there is limited usable space within the lagoons of tourist resorts which can be used for installation of floating solar platforms.

- **Extra charges for sea space:** Due to boundary restrictions of tourist resorts, extra charges are incurred to rent lagoon space from neighboring islands within the same lagoon area.

Technical

[5] Ministry of Tourism (2012) “Regulation on Tourism Facilities Boundary”
[6] Ministry of Tourism (2016) “Amendment to the regulation on Tourism Facilities Boundary”
[7] Ministry of Tourism (1999) “Maldives Tourism Act”

- **Lack of Technical Information regarding the environmental conditions:** There are limited studies conducted to determine the wind, wave conditions and tidal information in tourist resorts. Only an Environmental Impact Assessment (EIA) and addendum to these EIA reports are available for some reports. However, these EIA reports rely on tertiary data sources to predict wave conditions and tidal information are often proxy data from nearest airport islands. Very few reports conducted wave modelling exercise. Hence, it is difficult predict the wave and tidal conditions of the location where the floating solar platforms are deployed.

Human Skills

- **Limited Skilled Technicians:** Maldives lack human resources particularly skilled technicians for installation of floating solar platforms and integration of these solar platforms to the existing electricity grids in tourist resorts.

Other

- **Environmental Condition of the lagoon:** The wind, wave condition and tidal ranges of the lagoon environment make it difficult to install and maintain the floating solar platform.

1.3.7 Economic and Financial Measures

The following economic and financial measures and non-financial mechanisms were identified in consultation with stakeholders in the Electricity Generation and Consumption working group and these measures are based on the solution tree and root causes identified in the problem tree (See Figure 06 and 07).

- Waiver of the import duty for the spare parts and different components of the Floating solar platform

1.3.8 Non-financial Mechanism

Legal and Regulatory

- **Boundary restriction to use lagoon space:** Revision of the boundary regulation to accommodate at least 500 m from the shoreline at Mean Sea Level (MSL) rather than the vegetation line. However, this can be a sensitive issue since there are large no. of tourist resorts in the Maldives and could impact livelihoods of residents living in nearby islands to these tourist resorts.
- **Extra charges for sea space:** Collaboration with local island councils to share the electricity generated from Floating Solar Platforms so that the extra charges for space can be waivered.

Technical

- **Lack of Technical Information regarding the environmental conditions:** Improve the EIA process to collect empirical data for wind, wave, and tidal information so that these reports can be utilized for feasibility studies for floating solar platforms.

Human Skills

- **Limited Skilled Technicians:** Collaboration with Maldives National University (MNU) and Maldives Polytechnic to conduct vocational trainings to produce skilled technicians required for PV installation works.

Other

- **Environmental Condition of the lagoon:** Proper feasibility studies should be conducted which are informed from wave, wind, and tidal data for the project location so that environmental conditions of the proposed location can be determined prior to installation of floating solar platforms.

1.3.9 Interlinkages between Barriers Identified

This section of the report discusses the barrier common to Roof Top Solar with Energy Storage System and Floating Solar Platform. These two prioritized technologies in Electricity Generation and Consumption Sector serve the common goal in providing an alternative source of energy that can be fed into electricity grid and this reducing the fossil fuel dependency for electricity generation.

A review of the barriers shows a concern for high capital costs, lack of USD for importation of the Solar PV modules, spare parts and components of the system including batteries. Furthermore, lack of financial institutions like commercial banks which finance large scale Solar PV installation project is identified as common barriers for both prioritized technologies.

1.3.10 Enabling Framework for overcoming the barrier for Electricity Generation and Consumption Sector

The most significant barrier identified for both technologies are mostly economic and financial or technical. The high capital cost and lack of financial institutions to finance large scale PV installation barrier need to be overcome through policy interventions such as de-risking the financial institutions so that they could lend more finance on Solar PV projects. Furthermore, some of the key barriers like lack of roof space for PV installation and lack of lagoon space for floating solar could not be overcome due to the geographical nature of the islands.

CHAPTER TWO- WASTE MANAGEMENT SECTOR

This chapter of the report will provide information on the barrier analysis on the technology prioritized for waste management sector in the Maldives TNA report.

2.1 Preliminary targets for technology transfer and diffusion

Waste sector is key sectors with potential for implementation of climate change mitigation projects in Maldives. Waste sector is the second main contributor to the GHG emission in Maldives due to current practices of open burning of waste.[8] The main strategies outlined in the Maldives' NDC for waste sector mitigation include the following;

- Waste to energy. The planned installation of 8 MW in Thilafushi and 1.5 MW in Addu City will be completed. These systems will be optimized for grid connection and electricity production.

At present there are 2 Waste to energy systems planned to be developed in Regional Waste Management Centres namely in Addu City at southern part of Maldives and K. Thilafushi at the Greater Male' Region. These two projects are donor funded projects. These two projects align the National Strategic Action Plan 2019-2023. The National Strategic Action Plan (2019 – 2023) has identified the following targets for climate change mitigation in the waste management centre;

- By 2023, open burning of waste is minimized by 50% in all inhabited islands;

The Maldives TNA report – Climate Change Mitigation has prioritized technology which is in line with the aforementioned plans of GoM. These technologies include;

Table 9: Preliminary target for transfer and diffusion for prioritized technologies in waste management sector

Technology	Preliminary Target for transfer and diffusion
Waste to Energy Facilities in Regional Waste Management Facilities	To establish Waste to Energy Facilities in all the regional waste management facilities

[8] Ministry of Environment (2019), "Initial Biennial Update Report to UNFCCC".

2.2 Waste to Energy Facilities in Regional Waste Management Facilities

2.2.1 General Description

A waste to energy (WTE) facility that combusts waste to produce electricity. The traditional waste-to-energy process uses steam to turn a turbine to generate electricity. The steam is generated by burning the municipal solid waste (MSW). It is thus similar to conventional thermal power generation, but replaces traditional fuels (gas, coal) with waste. The Figure 9 shows a diagram showing different processes involved in Waste to Energy Facilities.

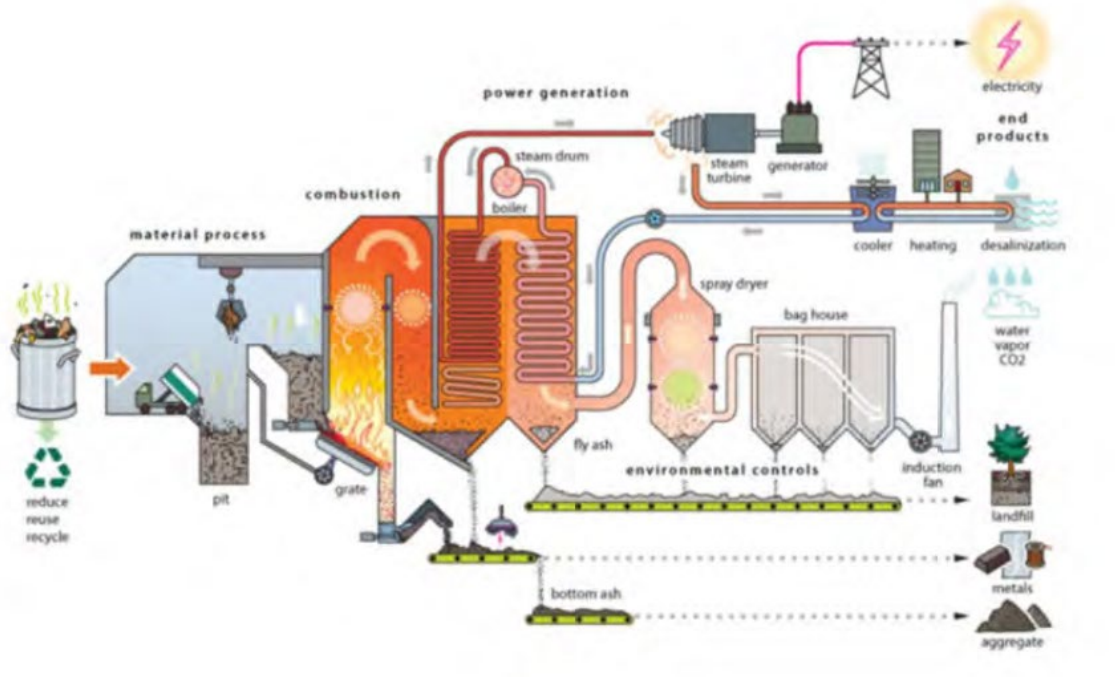


Figure 9: Schematic diagram of a Typical WTE plant (Source: Asian Development Bank (2019))

The WTE facilities are considered to be environmentally friendly however, the facilities produce ash in the form of fly ash and bottom ash. Fly ash is considered as air pollutants and there are environmental control mechanisms such as scrubber utilized to minimize the impacts of the air pollutants. The bottom ash is used for different purposes such as preparation of aggregate for road construction projects.

2.2.2 Status of Technology in Maldives

Two WTE plants are planned one for Greater Male' Region and one for southern most atoll of the Maldives.

- 8MW waste to energy plant to be installed at Thilafushi as solution for regional waste management.

- 1.5MW waste to energy plant installed at Addu City as solution for regional waste management.

The WTE in the southernmost atoll of the Maldives (Addu City) will be operational in near future as construction works has been almost completed. The following Figure 10 is photograph of the WTE plant under construction in Addu City.

Figure 10: The WTE currently being constructed in Addu City (Photo credit: Author of this report)

2.2.3 Technology Category and Market Characteristics

WTE facilities were classified as capital goods by the Waste Management Sector working group due to the large-scale nature of the construction and high investment required for the WTE facility. The following Table 7 provides information on the categorization of goods and market characteristics.

Table 10: Classification of WTE facilities at Regional Waste Management Facilities

Technology	Category	Description	Market Characteristics
WTE facilities at Regional Waste Management Centres	Capital Goods	Machinery and equipment used in the production of goods, e.g. consumer goods or electricity.	• a limited number of potential sites/ consumers • relatively large capital investment • simpler market chain, i.e. few or no existing technology providers • demand is profit-driven and depends on • demand for the products the capital goods are used to make

2.2.4 Identification of Barriers for Floating Solar Platforms

In order to identify the barriers for the WTE facilities in Regional Waste Management Centres, a working group session for the Waste Management Sector was conducted on 03rd May 2023. The composition and attendees of this working group meeting is included in Annex 02 of this report. The stakeholders were given the opportunity to have a facilitated discussion regarding the existing barriers for the technology diffusion in the Maldives. The following barrier categories were given for the classification of the identified barriers. They include;

- Economic and Financial
- Market condition
- Legal and Regulatory
- Institutional and organization capacity
- Human skills
- Information and awareness
- Social, cultural and behavioral
- Technical
- Others

The long list of barriers listed by consultant and shared with stakeholder for the facilitated discussion in the working group meeting include the following;

- High Investment cost
- Lack of Regulatory Framework for WTE facilities
- High Operations and Maintenance cost
- Lack of trained Human Capital
- Land Constraints for WTE facilities
- Limited Experience in implementation of WTE facilities

The stakeholder working group was asked to identify any additional barriers and classify the long list of barriers and any additional barriers identified during the facilitation discussions. The following Table 8 are the main barriers identified by the stakeholders and their respective classifications.

Table 11: Identification of barriers for WTE Facilities in Regional Waste Management Centres

Barriers	Economic and Financial	Legal and Regulatory	Market Condition	Institutional and organizational capacity	Human Skills	Information and Awareness	Social, Cultural and Behavioral	Technical	Others
High Investment Cost	✔								
Lack of trained Human Capital					✔				
Lack of Regulatory Framework for WTE facilities		✔							
Limited Experience in implementation of WTE facilities								✔	
High Operational Cost	✔								
High Capital Required for Maintenance	✔								
Land Constraints for WTE facilities									✔

Lack of means for Management of By-products			✔						

2.2.5 Prioritization of the identified barriers

In order to prioritize the identified barrier, each participant of the working group was asked to assign a score between 0 to 5 with higher score for the more significant barriers. The following Table 9 provides the results of the prioritization of identified barriers.

Table 12: Ranking of Identified Barriers based on their significance.

Identified Barrier	Average Assigned Score (0 to 5)	Rank
High Investment Cost	4.8	1
Lack of trained Human Capital	4.8	1
Lack of Regulatory Framework for WTE facilities	4.8	1
Limited Experience in implementation of WTE facilities	4.2	4
High Operational Cost	4.6	2
High Capital Required for Maintenance	4.4	3
Land Constraints for WTE facilities	4.4	3
Lack of means for Management of By-products	3.4	5

Based on the prioritization exercise the following are the list of identified barriers based on their level of significance according to the stakeholders of the waste management sector working group. The following Table 10 provide information on the ranking and type of the barriers identified for WTE facilities.

Table 13: Ranking and Type of Barriers Identified for WTE facilities at Regional Waste Management facilities

Rank	Identified Barrier	Barrier Category
1	High Investment Cost	Economic and Financial
1	Lack of trained Human Capital	Human Skills
1	Lack of Regulatory Framework for WTE facilities	Legal and Regulatory
2	High Operational Cost	Economic and Financial

3	High Capital Required for Maintenance	Economic and Financial
3	Land Constraints for WTE facilities	Other
4	Limited Experience in implementation of WTE facilities	Technical
5	Lack of means for Management of By-products	Technical

2.2.6 Screening of Prioritized Barriers

The screening of the barriers identified above was carried out by the same Waste Management Sector working group and the outcome of this discussion and information gathered is produced in the market mapping, problem tree and solution tree tables. The following Figure 11 is the market mapping for the Waste to Energy Facilities in Regional Waste Management Centres.

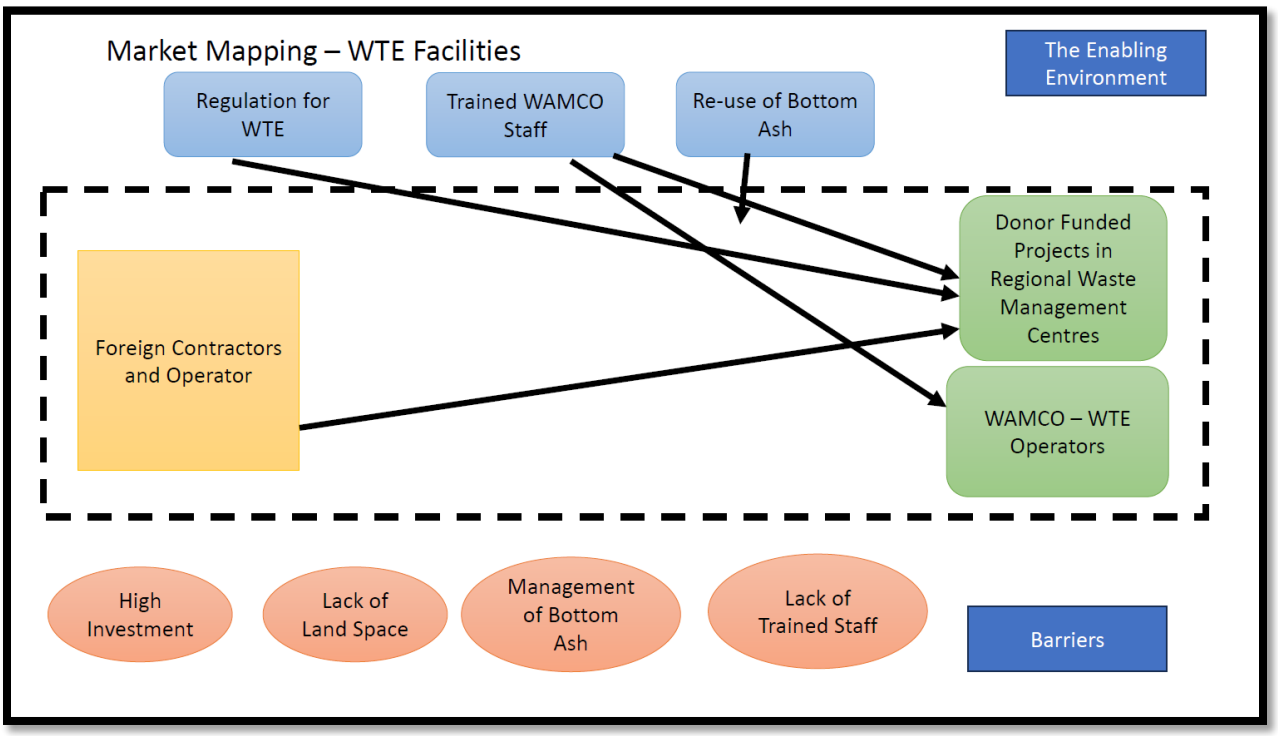


Figure 11: Market Mapping for Waste to Energy Facilities in Regional Waste Management Centres

The main actors in Waste to Energy Facilities in Regional Waste Management Centres are foreign contractors and operators, donor funded projects in regional waste management centres and Waste Management Corporation (WAMCO) which is the operators of Waste to Energy Facilities.

Some key barriers identified include high investment required for establishment of waste to energy facilities, lack of land space for the waste to energy facilities, lack of trained staff for the operational aspects of waste to energy facilities and management of the by-products of waste to energy facilities such as bottom ash.

Some measures to address the above-identified barriers include development of regulations dealing with waste to energy facilities, training of WAMCO staff for the operation of Waste to energy facilities and finding avenues for re-using of by-products from waste to energy facilities such as bottom ash.

The following Figure 12 and Figure 13 are the problem tree and solution tree for the waste to energy facilities.

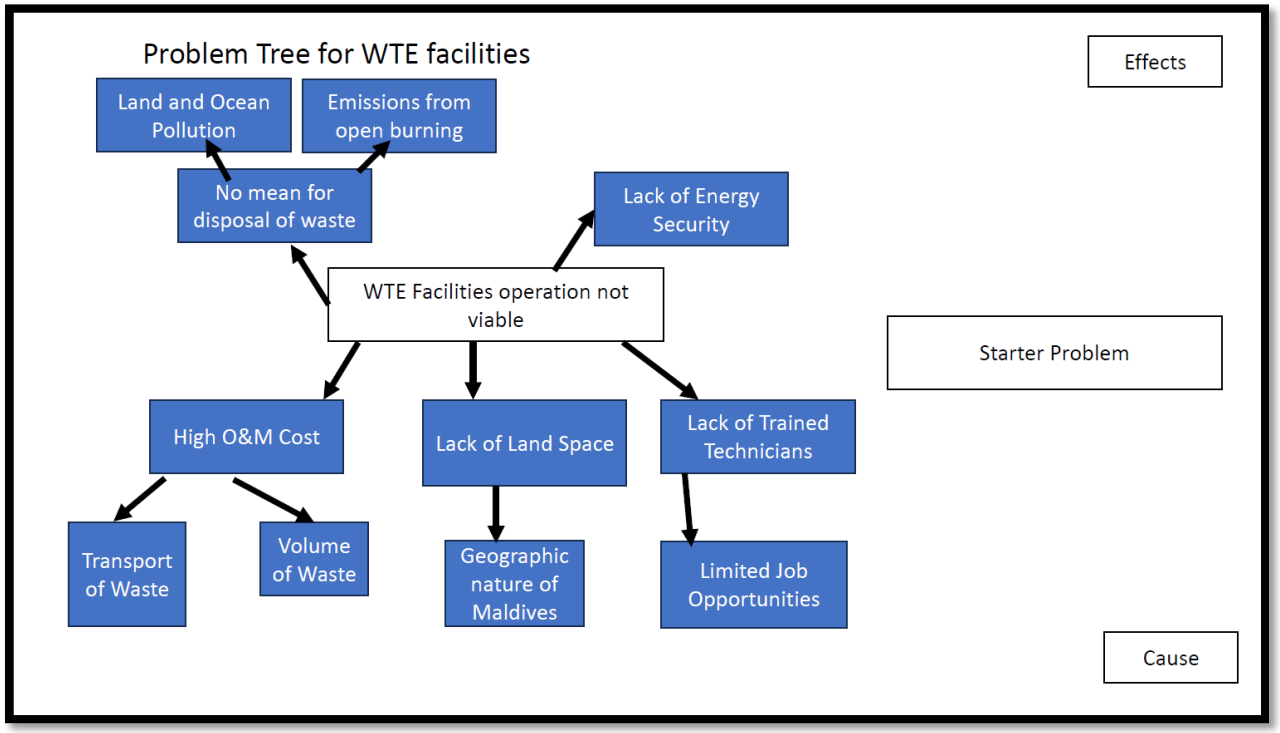


Figure 12: The problem tree for Waste to Energy Facilities in Regional Waste Management Centres

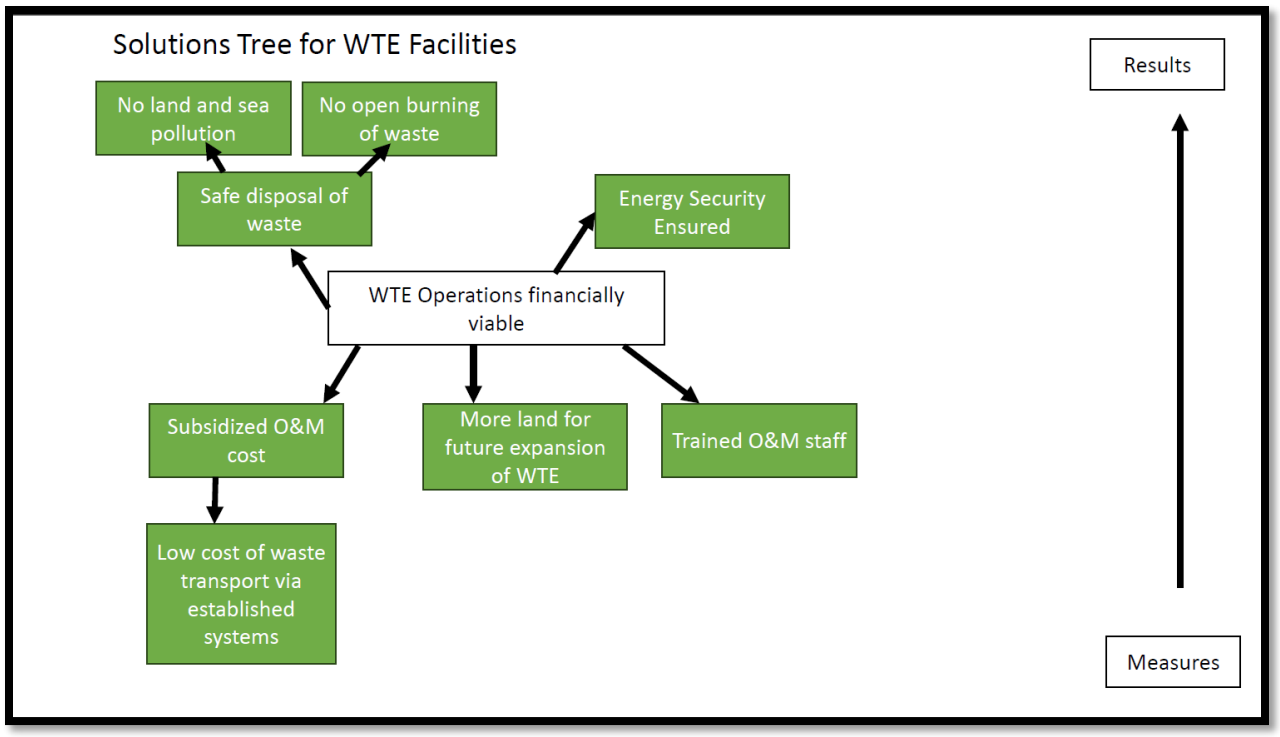


Figure 13: The Solution Tree for the Waste to Energy Facilities in Regional Waste Management Centres

2.2.6.1 Economic and Financial Barriers

High Capital Cost: Since WTE facilities are capital goods these facilities require large initial investment for establishing. These facilities are currently built under donor financed projects which are either grants or loans from Multilateral Banks such as World Bank Group or ADB.

High Operational Cost: WTE requires a certain volume of waste for successful operation hence, transport of the waste generated from different islands is essential for successful running of WTE facilities. This transport of waste is essential since this waste cannot be managed within the island which they were generated in many cases. However, due to scattered nature of the islands of Maldives transport of these waste is extremely costly.

High Capital Required for Maintenance: As mentioned above the transport of waste from islands to the Regional Waste Management Facilities will incur operational cost and the vessels required for the transport of the waste will require significant upfront capital cost for maintenance and operation of WTE facilities. Furthermore, investments should be made on training the staff required for the day to day operation of WTE facilities. Currently, the WTE facilities are built under Design, Build and Operate (DBO) contracts which will make sure that the contractor will be responsible for operating the WTE facilities for certain period of time and eventually they need to build capacity of Waste Management Corporation (WAMCO) who will take over operations from the contractor after 10 years of operations.

2.2.6.2 Non-financial Barriers

Human Skills

- **Lack of trained Human Capital:** The operation of WTE facilities will require technical expertise in different fields which is currently lacking in the Maldives. It is expected that the operators will bring in expertise from abroad for initial operation of the WTE facilities while building capacity of the WAMCO staff who will eventually be responsible for operation of WTE facilities.

Legal and Regulatory

- **Lack of Regulatory Framework for WTE facilities:** Since WTE facilities are developed for the first time in Maldives, there is limited provision regarding regulatory aspects such as emission standards to be met or segregation of waste to make it ready for incineration at WTE facilities. Limited provisions are in the Waste Management Act (2022) or any waste management

regulations formulated under Environmental Protection and Preservation Act (1993) regarding WTE facilities.

Technical

- **Limited Experience in implementation of WTE facilities:** As mentioned above, WTE facilities are being established for the first time in Maldives, there are no local expertise to operate a WTE facilities. This is expected to lead to heavy reliance on experts from abroad for successful operation of the WTE facilities.
- **Lack of means for Management of By-products:** Even though some incinerators has been operated in Maldives, the management of bottom ash has been a big challenge for Maldives. Since, bottom ash is considered as a hazardous waste it cannot be disposed through the channels for disposal of MSW. Furthermore, there is no experience in utilization of these bottom ash to produce other useful products for construction industries. However, under ADB technical assistance studies have been conducted to develop potential products which can be produced by using the bottom ash from WTE facilities.

Other

- **Land Constraints for WTE facilities:** WTE facilities require a large land area due to different operations undertaken within the premises. However, due to land scarcity of Maldives it is difficult to allocate large plots of land for these facilities.

2.2.7 Economic and Financial Measures

The following economic and financial measures and non-financial mechanisms were identified in consultation with stakeholders in the Waste Management Sector working group and these measures are based on the solution tree and root causes identified in the problem tree (See Figure 12 and 13).

- Mobilization of private sector finance for WTE facilities and other waste management projects is essential through successful demonstration of these donor funded projects.

2.2.8 Non-financial Mechanism

Human Skills

- **Lack of trained Human Capital:** It is important to train the staff of WAMCO on operation of WTE facilities so that the WTE facilities can be operated successfully even after completion of contractor's operating period.

Legal and Regulatory

- **Lack of Regulatory Framework for WTE facilities:** A regulation on operation and regulatory standards such as emission and pollution control standards need to be developed under the umbrella of Waste Management Act (2022).

Technical

- **Lack of means for Management of By-products:** The findings of the studies for management of bottom ash of incinerators should be shared with various stakeholders and awareness amongst the stakeholders should be created regarding potential re-use of these bottom ash. Provide incentives for industries which utilize bottom ash.

2.2.9 Enabling Framework for Waste Management Sector

In order to overcome the barriers identified for the WTE facilities, the on-going projects of WTE need to be successfully implemented. In addition, a regulation which deals with WTE facilities needs to be formulated. Furthermore, building human resource capital in terms of staff operating the WTE facilities. Last, during the operation of WTE facilities it is important to incentives industries which utilize bottom ash generated from WTE facilities.

CHAPTER THREE: TRANSPORT SECTOR

This chapter of the report will provide information on the barrier analysis on the technology prioritized for transport sector in the Maldives TNA report.

3.1 Preliminary targets for technology transfer and diffusion

The transport sector is a sector where climate change mitigation initiates were not implemented in the past. However, transport sector contributes to the national GHE emissions significantly. Most of the vehicles, vessels used in Maldives rely on fossil fuel such as petrol and diesel. Hence, there is immense potential for climate change mitigation activities in the Transport sector. The main strategies outline in the Maldives's NDC for transport sector mitigation include;

- Establishment of vehicle/vessels emissions standard and establishment of efficient transport management system and promotion of hybrid-vehicles.

The National Strategic Action Plan (2019 – 2023) include the following strategy regarding emission reduction from transport sector;

- Enable the transportation industry to adopt vehicles that use renewable energy

In line with Maldives NDC and SAP 2019 – 2023, the Maldives TNA report has prioritized the following two technologies for transport sector;

- Electric buses, vehicles, and motorbikes.
- Hybrid Solar Boats

However, during the stakeholder consultation for Barrier analysis of these technologies in the transport sector working group it was decided to focus only on Electric buses, vehicles and motorbikes (E-vehicles) since Hybrid Solar Boats do not have potential in environmental conditions prevailing in Maldives. Hybrid Solar Boats are ideal for river and lake transportation where there are no wave and tidal influence. Furthermore, Hybrid Solar Boats does not meet the speed requirements which is essential for tourism and other commuter transport trips in Maldives.

The preliminary target for transfer and diffusion of E-vehicles in Maldives the following is to increase the share of E-vehicles to 20% of all the land-based vehicles operational in the Maldives.

3.2 Electric Vehicles (EV)

3.2.1 General Description

Electric vehicle is a vehicle which uses one or more electric motors for propulsion. In many cases these electric motors are powered by rechargeable battery packs. EVs have several advantages compared to conventional vehicles which includes the following;

- EVs are more energy efficient: EVs convert over 77% of the electrical energy from the grid to power at the wheels. Conventional gasoline vehicles only convert about 12%–30% of the energy stored in gasoline to power at the wheels.
- EVs are considered to be more environmentally friendly since they do not emit air pollutants such as Sulphur dioxide, Nitrous oxide, Carbon monoxide and Particulate Matter. However, the power plant which is used for power the EVs may emit air pollutants. Nevertheless, electricity produced by solar power, wind power or nuclear power will not emit any air pollutants.
- Electric motors provide quiet, smooth operation and stronger acceleration and require less maintenance than internal combustion engines (ICEs).

There are some disadvantages of EVs in comparison with conventional vehicles. They include the following:

- EVs have a shorter driving range than most conventional vehicles—although EV driving ranges are improving. Most EVs can travel more than 100 miles on a charge, and some can travel in excess of 200 or 300 miles depending on the model.
- Fully recharging the battery pack can take 3 to 12 hours. Even a "fast charge" to 80% capacity can take 30 min.

3.2.2 Status of Technology in Maldives

There are 131,000 land use vehicles registered in the Maldives. Out of which only 4% of vehicles are EVs and most of these constitute of tricycles and e-bicycles.[9] Despite having customs duty advantages up to 150% for imported electric motorcycles and cars over conventional fossil fuel-based vehicles, very limited EV penetration has been observed in islands like Male', Hulhumale and Addu city.

[9] World Bank Group (2020) "Accelerating the electric vehicles transition in Maldives".

Despite having customs duties advantages of up to 150% for imported electric motorcycles and cars over their fossil fuel counterparts, islands like Male, Hulhumale, Addu etc. have witnessed limited EV penetration among their resident populations.

3.2.3 Technology Category and Market Characteristics

EVs were classified as consumer goods by the Transport sector working group since EVs are intended for the mass market. The following Table 11 provides information on the categorization of goods and market characteristics.

Table 14: Classification of Electric Vehicles

Technology	**Category**	**Description**	**Market Characteristics**
Electric Vehicles (EVs)	Consumer Goods	Goods specifically intended for the mass market; households, businesses and institutions.	• a high number of potential consumers • interaction with existing markets and requiring distribution, maintenance and installer networks in the supply chain • large and complicated supply chains with many actors, including producers, assemblers, importers, wholesalers, retailers and end consumers. • barriers may exist in all steps in the supply chain. • demand depends on consumer awareness and preferences and on commercial marketing and promotional efforts.

3.2.4 Identification of Barriers for Floating Solar Platforms

In order to identify the barriers for the EVs a working group session for the Transport Sector was conducted on 03rd May 2023. The composition and attendees of this working group meeting is included in Annex 02 of this report. The stakeholders were given the opportunity to have a facilitated discussion regarding the

existing barriers for the technology diffusion in the Maldives. The following barrier categories were given for the classification of the identified barriers. They include;

- Economic and Financial
- Market condition
- Legal and Regulatory
- Institutional and organization capacity
- Human skills
- Information and awareness
- Social, cultural and behavioral
- Technical
- Others

The following Table 12 are the main barriers identified by the stakeholders and their respective classifications.

Table 15: Identification of barriers for Electric Vehicles

Barriers	**Economic and Financial**	**Legal and Regulatory**	**Market Condition**	**Institutional and organizational capacity**	**Human Skills**	**Information and Awareness**	**Social, Cultural and Behavioral**	**Technical**	**Others**
Legal and Administrative Barriers		✔							
Lack of Awareness and Advocacy efforts						✔			
Lack of trained mechanics					✔				
Lack of EV infrastructure like charging stations				✔					
High Capital Cost	✔								
Communication gap between in line ministries				✔					
Highly Subsidized fossil fuel							✔		
Legacy conventional waste and lack of means for battery disposal									✔

3.2.5 Prioritization of the identified barriers

In order to prioritize the identified barrier, each participant of the working group was asked to assign a score between 0 to 5 with higher score for the more significant barriers. The following Table 13 provides the results of the prioritization of identified barriers.

Table 16: Ranking of Identified Barriers based on their significance.

Identified Barrier	Average Assigned Score (0 to 5)	Rank
Legal and Administrative Barriers	4.71	1
Lack of Awareness and Advocacy efforts	3.43	6
Lack of trained mechanics	3.71	5
Lack of EV infrastructure like charging stations	4.71	2
High Capital Cost	4.29	3
Communication gap between in line ministries	3.29	7
Highly Subsidized fossil fuel	3.29	7
Legacy conventional waste and lack of means for battery disposal	3.86	4

Based on the prioritization exercise the following are the list of identified barriers based on their level of significance according to the stakeholders of the waste management sector working group. The Table 14 provides the ranking and barrier category for the identified barriers for EVs.

Table 17: Ranking and Type of Barriers Identified for Electric Vehicles

Rank	Identified Barrier	Barrier Category
1	Legal and Administrative Barriers	Legal and Regulatory
2	Lack of EV infrastructure like charging stations	Institutional and organizational capacity
3	High Capital Cost	Economic and Financial

4	Legacy conventional waste and lack of means for battery disposal	Other
5	Lack of trained mechanics	Human Skills
6	Lack of Awareness and Advocacy efforts	Information and Awareness
7	Communication gap between in line ministries	Institutional and organizational capacity
	Highly Subsidized fossil fuel	Social, Cultural and Behavioral

3.2.6 Screening of Prioritized Barriers

The screening of the barriers identified above was carried out by the same Transport Sector working group and the outcome of this discussion and information gathered is produced in the market mapping, problem tree and solution tree tables. The following Figure 14 is the market mapping for E-vehicles in the Maldives.

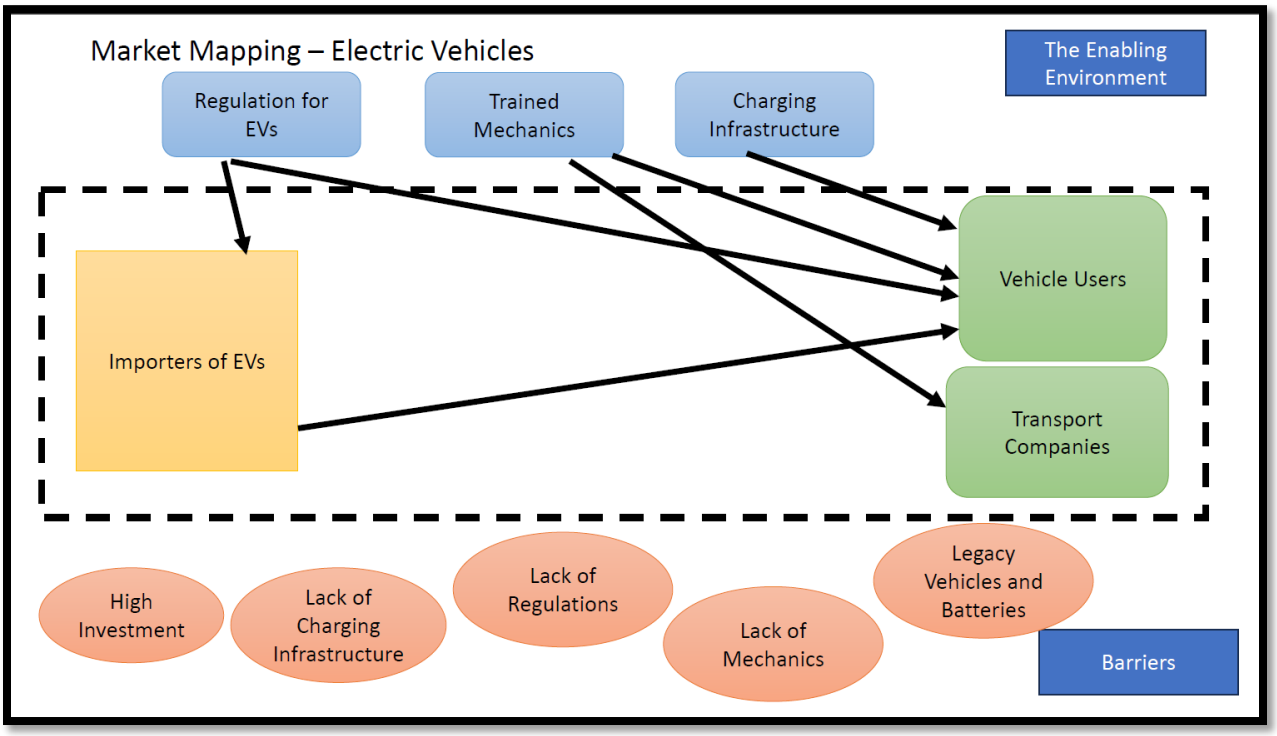


Figure 14: Market Mapping for E-vehicles

The main actors for E-vehicles in the Maldives include importers of E-vehicles, end-users of vehicles and transport companies which are mostly state-owned enterprises like Maldives Transport and Contracting Company (MTCC).

The main barriers for transfer and diffusion of the E-vehicles include high investment cost, lack of charging infrastructure in the country, lack of regulations which deals with E-vehicles, lack of trained mechanics for maintenance of E-vehicles and means of disposal for conventional redundant vehicles and batteries.

The main incentives which can be utilized to increase the diffusion of E-vehicles include a regulation which deals with different aspects of E-vehicles, training programmes for mechanics for maintenance of E-vehicles and developing infrastructure required for charging of E-vehicles.

The following Figure 15 and Figure 16 are the problem tree and solution trees for the E-vehicles.

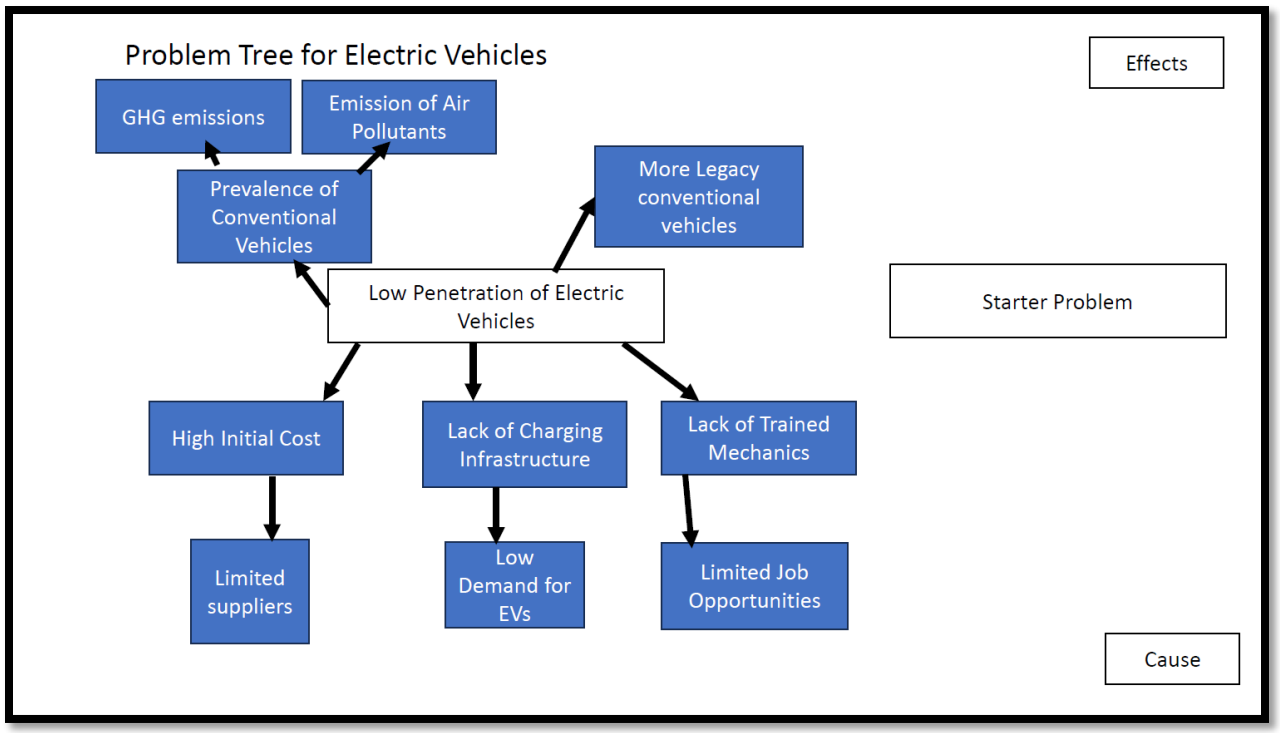


Figure 15: The problem tree for the Electric Vehicles

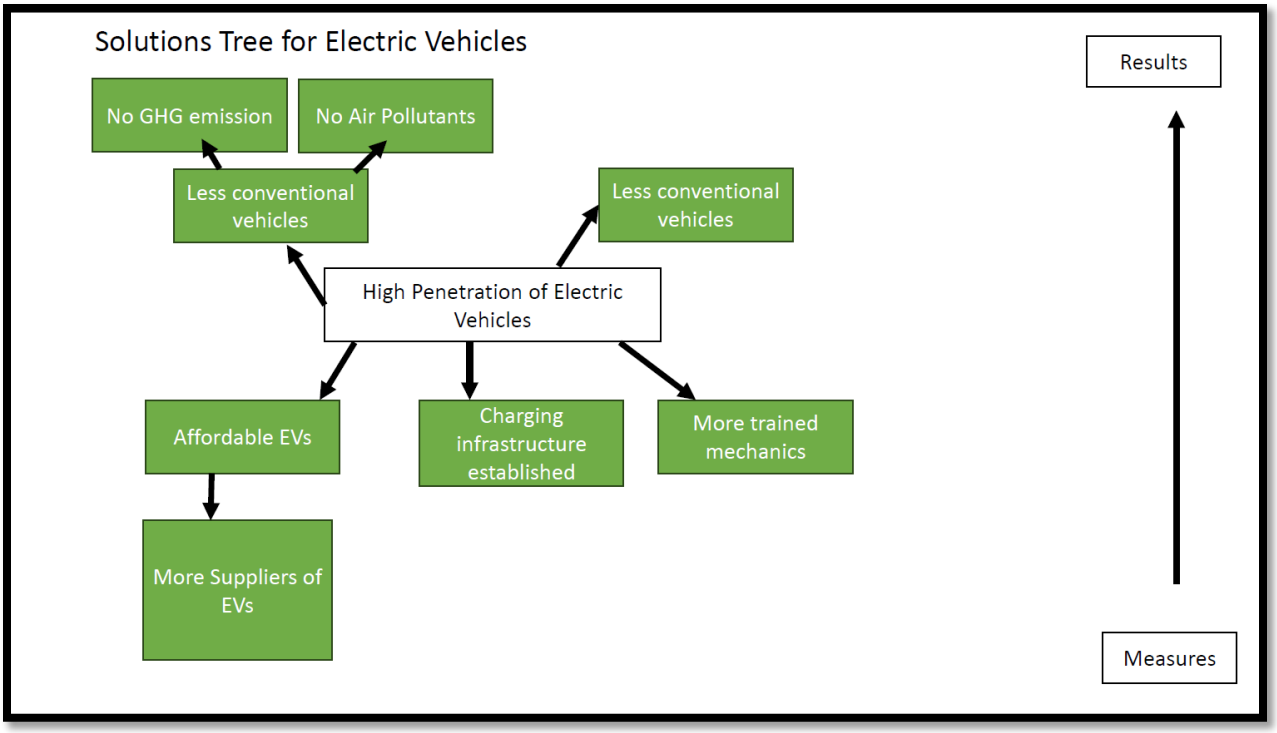


Figure 16: The solution tree for the Electric Vehicles

3.2.6.1 Economic and Financial Barriers

High Capital Cost: In comparison with conventional vehicles, EVs require high capital cost. Currently average price of EVs is approximately 20% higher than the price of a conventional vehicle. Furthermore, there are very limited installment schemes to own a EV however, there are many installment schemes for conventional vehicles particularly motorcycles offered by commercial banks and suppliers of vehicles in Maldives.

3.2.6.2 Non-financial Barriers

Human Skills

- **Lack of Trained Mechanics:** There are very few trained mechanics who has experience and qualification for maintenance of EVs. Most of these trained mechanics are expatriate workers.

Legal and Regulatory

- **Legal and Administrative Barriers:** There are no clear definition on the mandates for regulation or policy making regarding the import, operation, emission standards and maintenance requirement of EVs in the Maldives. The existing transport regulations has some provisions such

as lower duty rates for EVs and Hybrid vehicles, however regulations regarding EVs are yet to be formulated.

Institutional and Organization Capacity

- **Lack of EV infrastructure like charging stations:** There are only one charging stations available for the public for charging the EVs. It is located in Hulhumale'. The remaining EVs need to be charged in owners' private garages or on the roadside.
- **Communication gap between in line ministries:** The policy making, and regulatory mandate of transport sector include EVs is on Ministry of Transport and Transport Authority. However, due to recent amendments to the Local Government Act (2011), the island and city councils are given some mandates such as revenue generated from vehicle fees are currently collected by island and city council. There are overlapping mandates between the local councils and Ministry of Transport which need to be rectified. Furthermore, the mandate for land use planning is currently given to island and city council. Hence, it is important to have inclusive stakeholder consultations when allocating land area for parking or for charging infrastructure.

Social, Cultural and Behavioral

- **Highly Subsidized fossil fuel:** The highly subsidized fossil fuel makes operation of conventional vehicle relatively cheaper for the owners. Petrol and Diesel subsidies accounts for a significant portion of the Gross Domestic Product (GDP) of the Maldives. The cheaper fossil fuel incentive vehicle owners to choose conventional vehicles rather than EVs.

Information and Awareness

- **Lack of Awareness and Advocacy efforts:** Even though hybrid vehicles and EVs have lower import duty rates, public are not aware regarding these incentives. Furthermore, very few advocacy programs are held by vehicle suppliers who rather promote conventional vehicles which cost significantly less capital cost.

Other

- **Legacy conventional waste and lack of means for battery disposal:** As Maldives have limited resources to manage hazardous waste produced within the country. The legacy vehicles and disposal of used batteries from EVs is a key constraint. Currently, the legacy vehicles are dumped to roads in Hulhumale or Male' city or sold for scrap metal. There are no private companies which

do recycling or disposal of used batteries. However, few companies re-export them to countries like India and South Korea.

3.2.7 Economic and Financial Measures

The following economic and financial measures and non-financial mechanisms were identified in consultation with stakeholders in the Transport Sector working group and these measures are based on the solution tree and root causes identified in the problem tree (See Figure 15 and 16).

- Incentive the private sector vehicle suppliers and commercial banks to introduce installment schemes for EVs.

3.2.8 Non-financial Mechanism

Human Skills

- **Lack of Trained Mechanics:** In collaboration with MNU and Maldives Polytechnics vocational education courses can be conducted for repair and maintenance of EVs.

Legal and Regulatory

- **Legal and Administrative Barriers:** Formulation of Regulation on importing, maintenance, and emission standards for EVs.

Institutional and Organization Capacity

- **Lack of EV infrastructure like charging stations:** Establishment of Charging Stations in the Parking spaces especially in Hulhumale' Phase 1 and Phase 2.
- **Communication gap between in line ministries:** Clear definition of mandates of local council and central government ministries.

Information and Awareness

- **Lack of Awareness and Advocacy efforts:** Conduct awareness campaigns regarding promotion of EVs for both vehicle owners, commercial banks, and vehicle suppliers.

Other

- **Legacy conventional waste and lack of means for battery disposal:** Improve the port infrastructure so that more companies will work on re-exporting the batteries and scrap metals.

3.2.9 Enabling Framework for Transport Sector

Creating awareness among the local suppliers and commercial scale regarding the potential of EV vehicles through advocacy campaigns for EVs is crucial to overcome the barriers identified. A regulation which deals with EVs in terms of importing, maintenance, and emission standards is also important. The cost important measure to overcome the barriers for penetration of EVs in Maldives is establishment of charging infrastructure required for EVs in most populous islands like Hulhumale' and Addu City.

CHAPTER FOUR: CONCLUSION

Some of the identified barriers are similar in all the technologies identified for different sectors. They include high investment cost, lack of trained personnel, lack of regulatory frameworks. Some of the technologies such as floating solar platforms have unique barriers such as environmental conditions. In addition, rooftop solar with EMS including battery technology has significant barriers of lack of roof space and physical condition of the roofs. The transport sector technology of Electric vehicles has a lack of charging infrastructure as a barrier. The waste to energy facilities for the waste management sector has significant barrier due to lack of available land for the construction of waste to energy facilities.

Some of enabling measures include capacity building measures such as training of mechanics for maintenance of E-vehicles, training of staff for operation of Waste to Energy Facilities and capacity building of technicians for deployment of floating solar platforms.

The regulatory and institutional barriers need to be addressed with urgency and many regulations which deal with deployment, maintenance and operation of these prioritized technologies needs to be developed.

Some of the identified barriers require advocacy and awareness campaigns to overcome. These advocacy campaigns need to be developed and implemented in collaboration with Civil Society Organizations for far-reaching impacts.

Reference List

Asian Development Bank (2020) “A Brighter Future for Maldives Powered by Renewables Road Map for the Energy Sector 2020–2030”.

Asian Development Bank (2019) “Environmental Impact Assessment for MLD: Greater Malé Waste-to-Energy Project – Waste to Energy Plant”.

Ivan Nygaard, U. E. (2015). Overcoming Barriers to the Transfer and Diffusion of Climate Technologies: Second Edition. Copenhagen: UNEP DTU Partnership

Ministry of Tourism (1999) “Maldives Tourism Act”, Male’, Maldives.

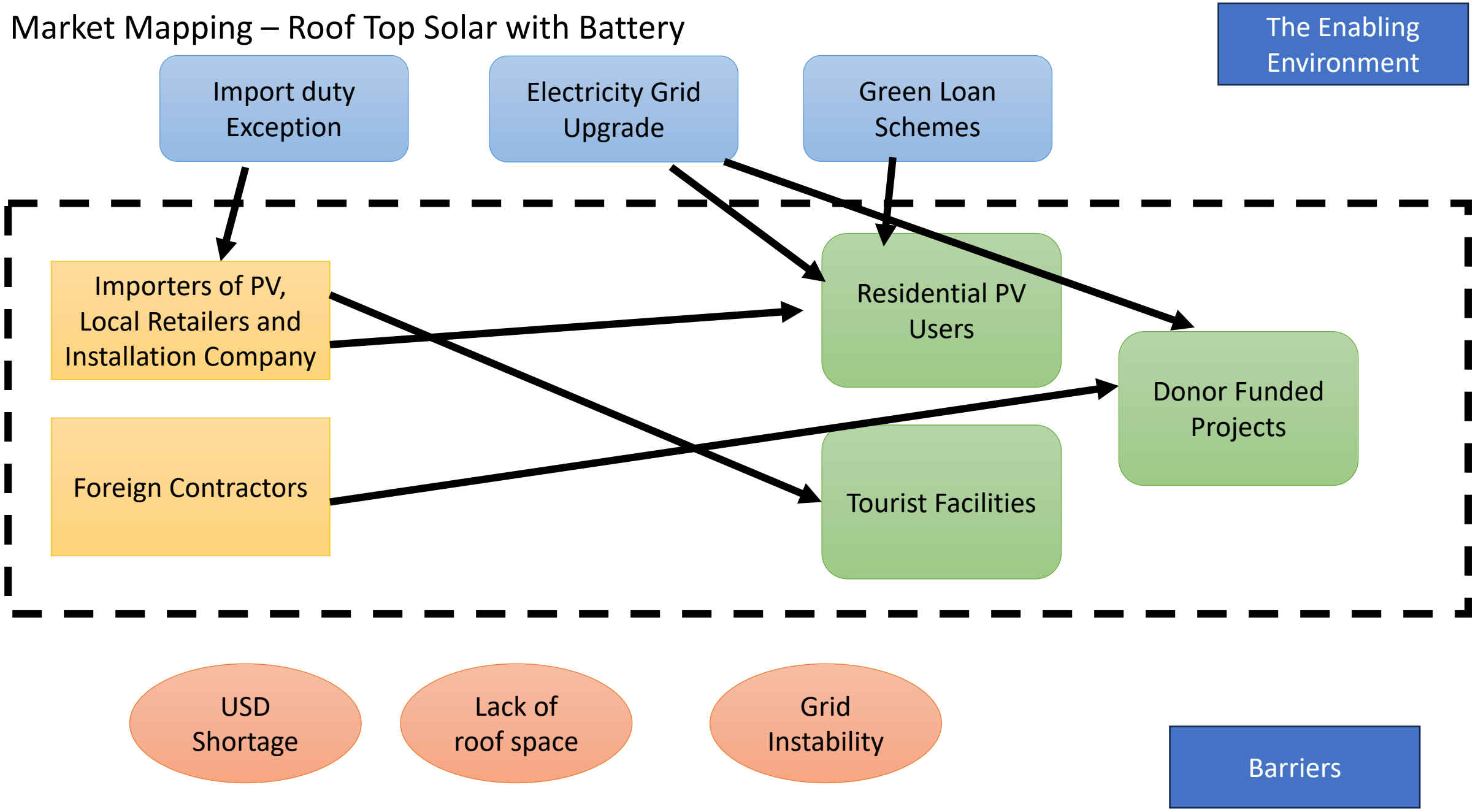
Ministry of Tourism (2012) “Tourism Facility Boundary Regulation”, Male’, Maldives.

Ministry of Tourism (2012) “Amendment to Tourism Facility Boundary Regulation”, Male’, Maldives.

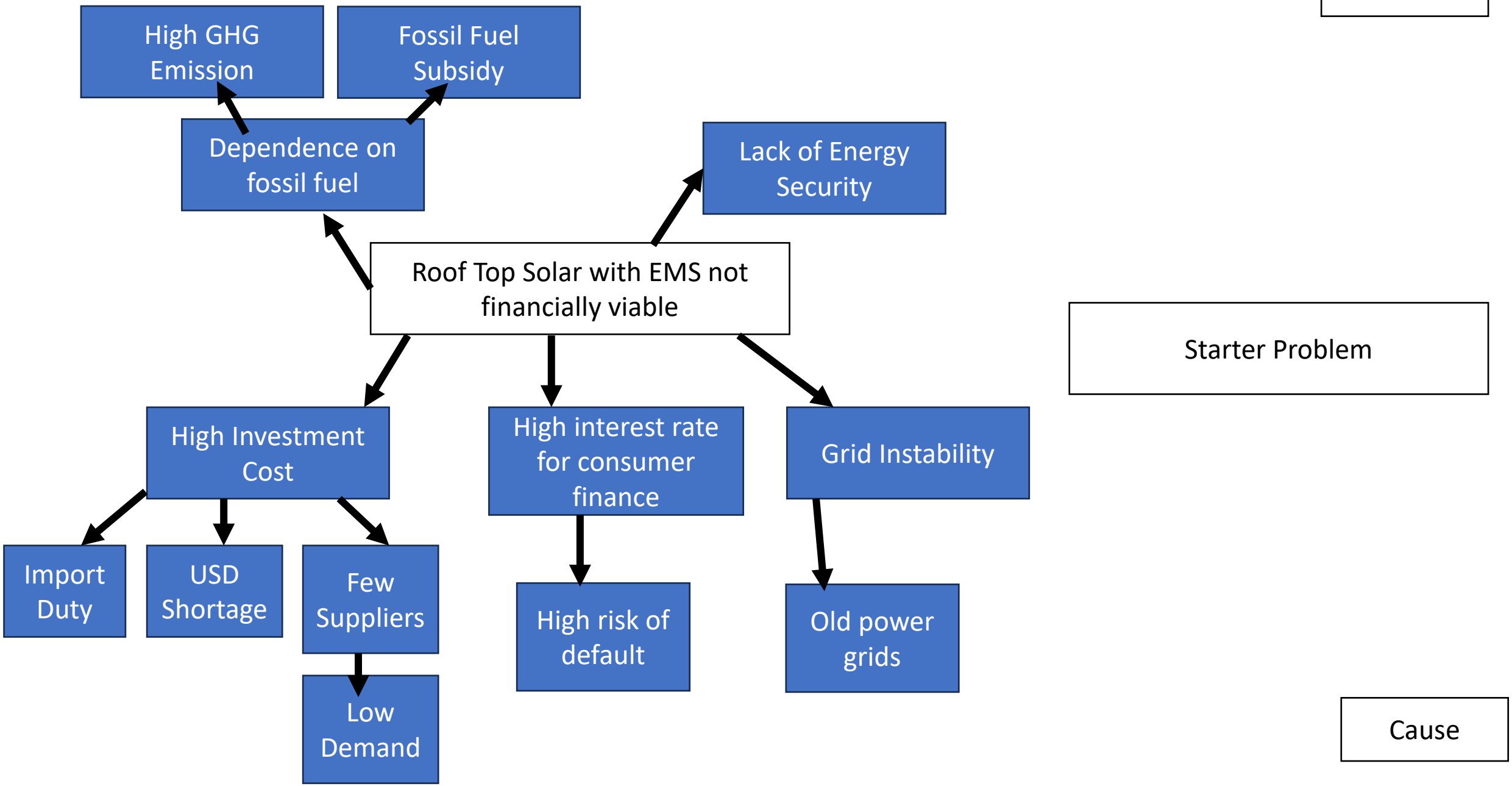
World Bank Group (2020) “Accelerating the electric vehicles transition in Maldives” Survey Report.

Annex 1: Electricity Consumption and Generation Sector – Market Mapping, Problem and Solution Trees

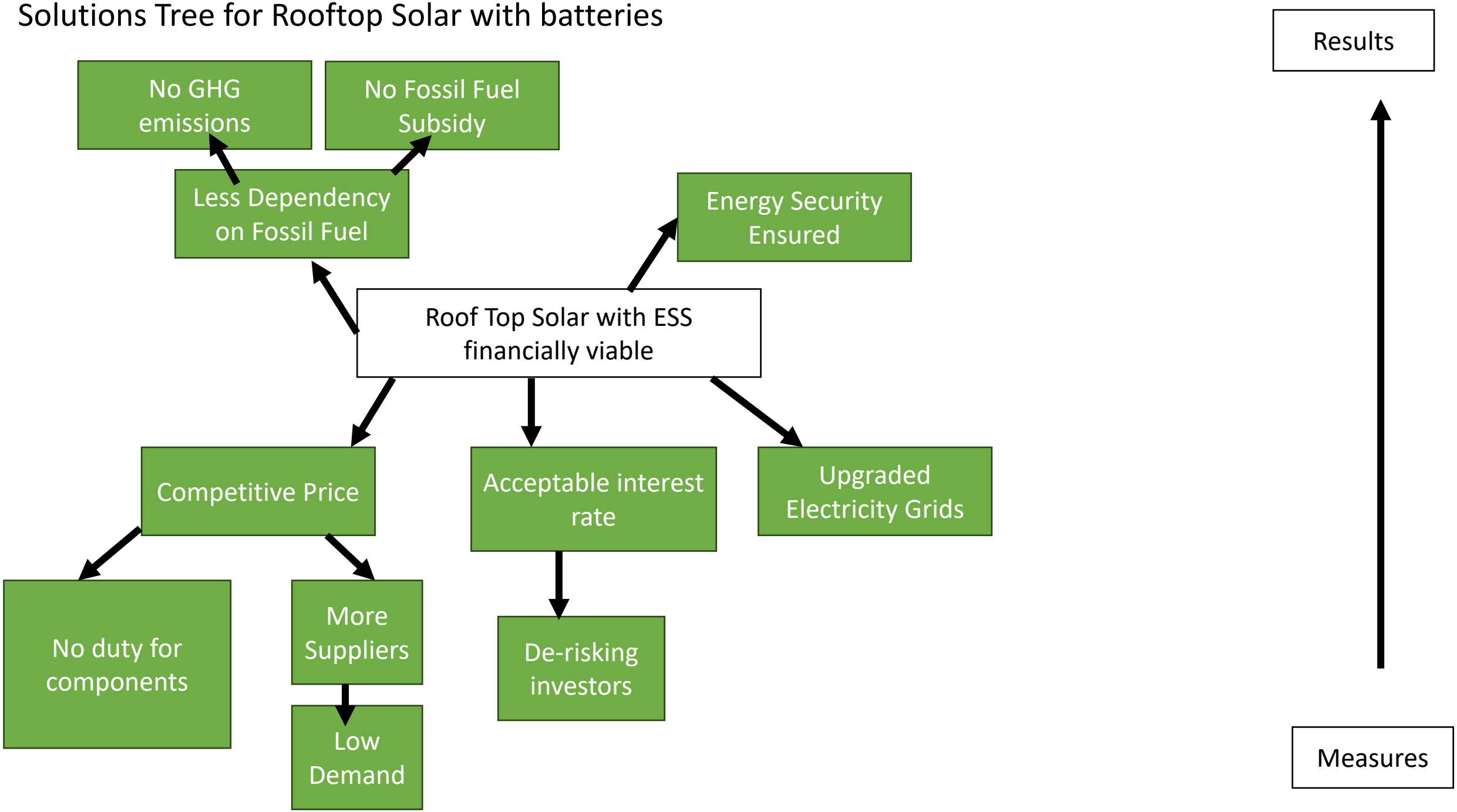
Market Mapping – Roof Top Solar with Battery



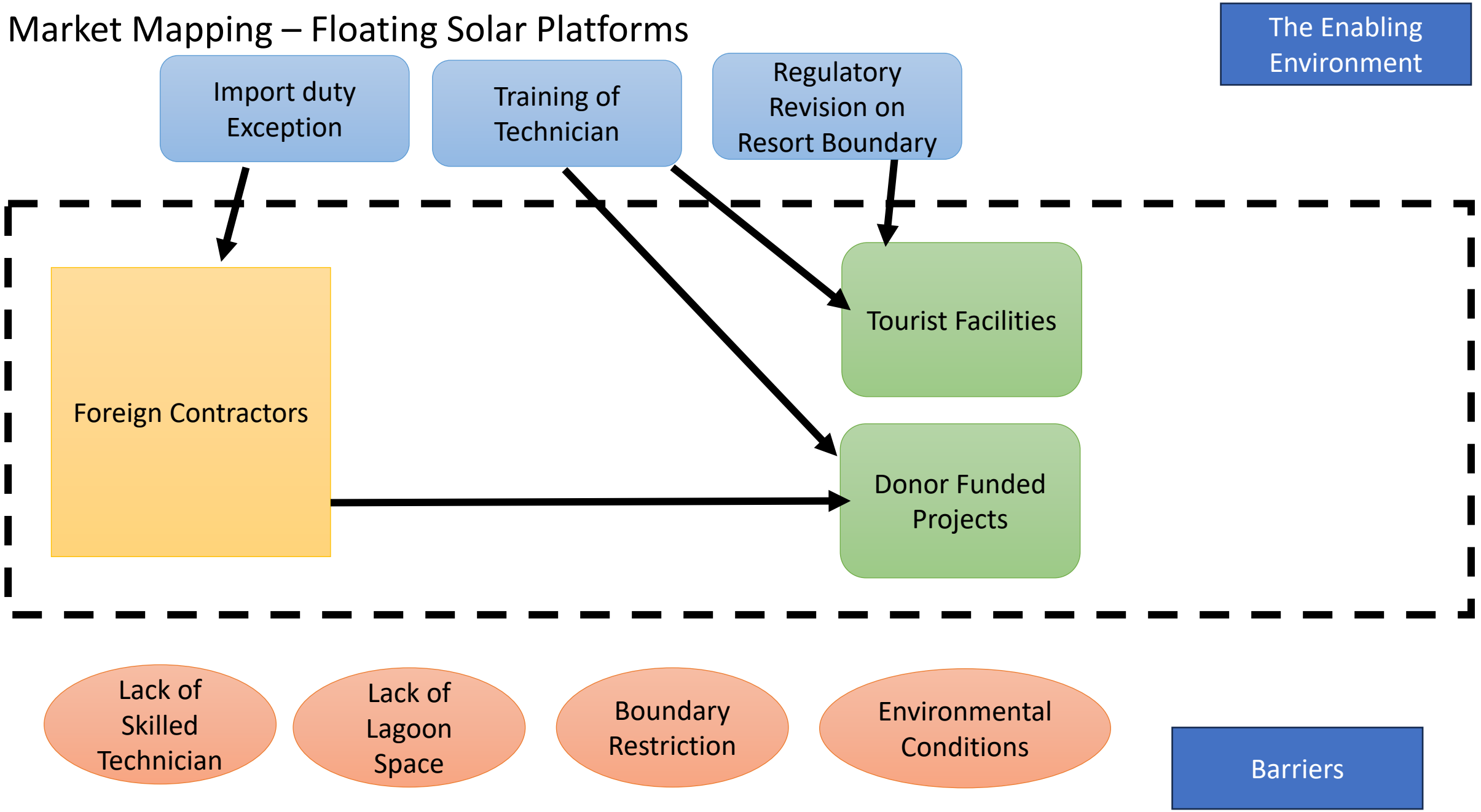
Problem Tree for Rooftop Solar with batteries



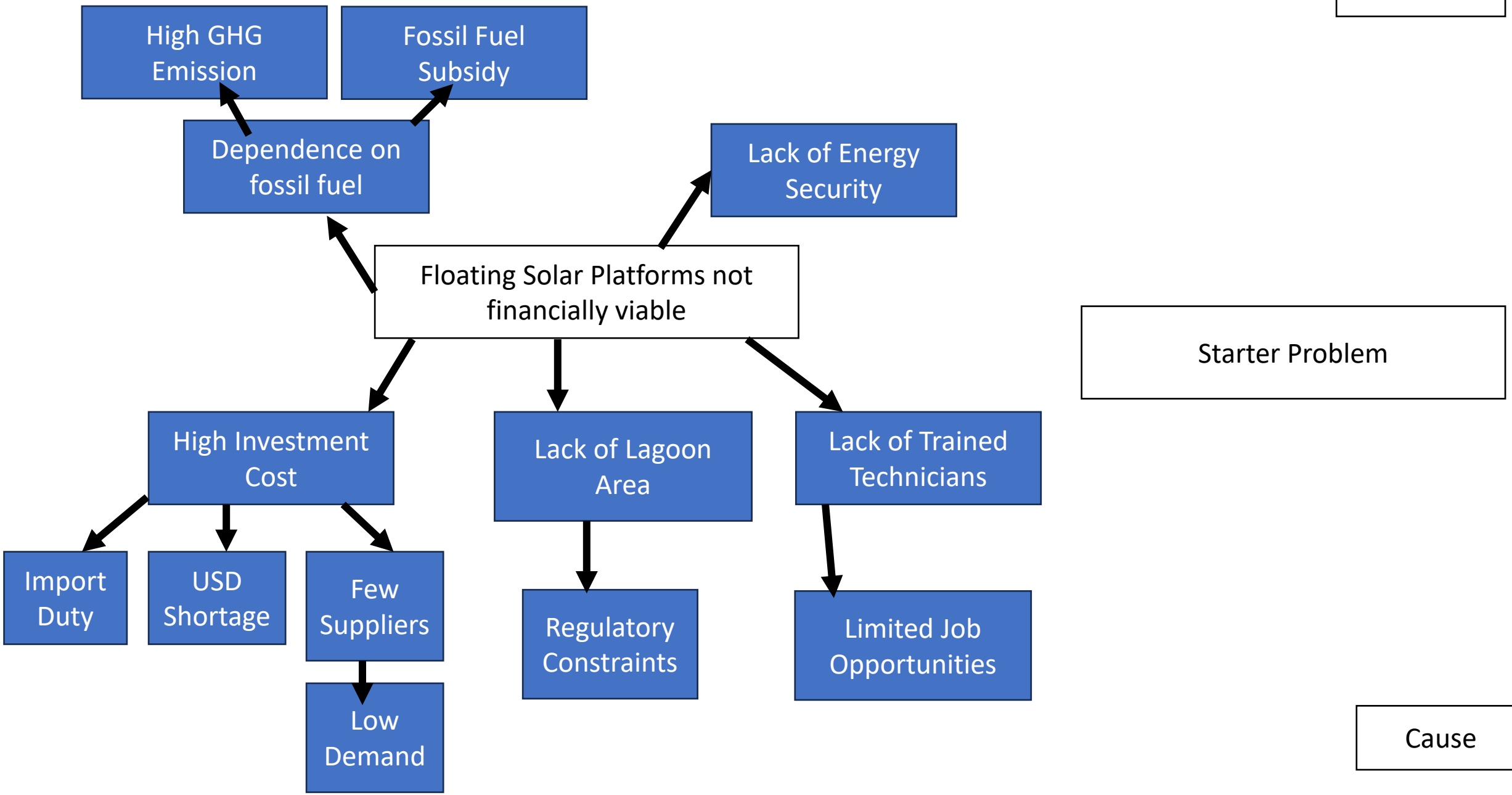
Solutions Tree for Rooftop Solar with batteries



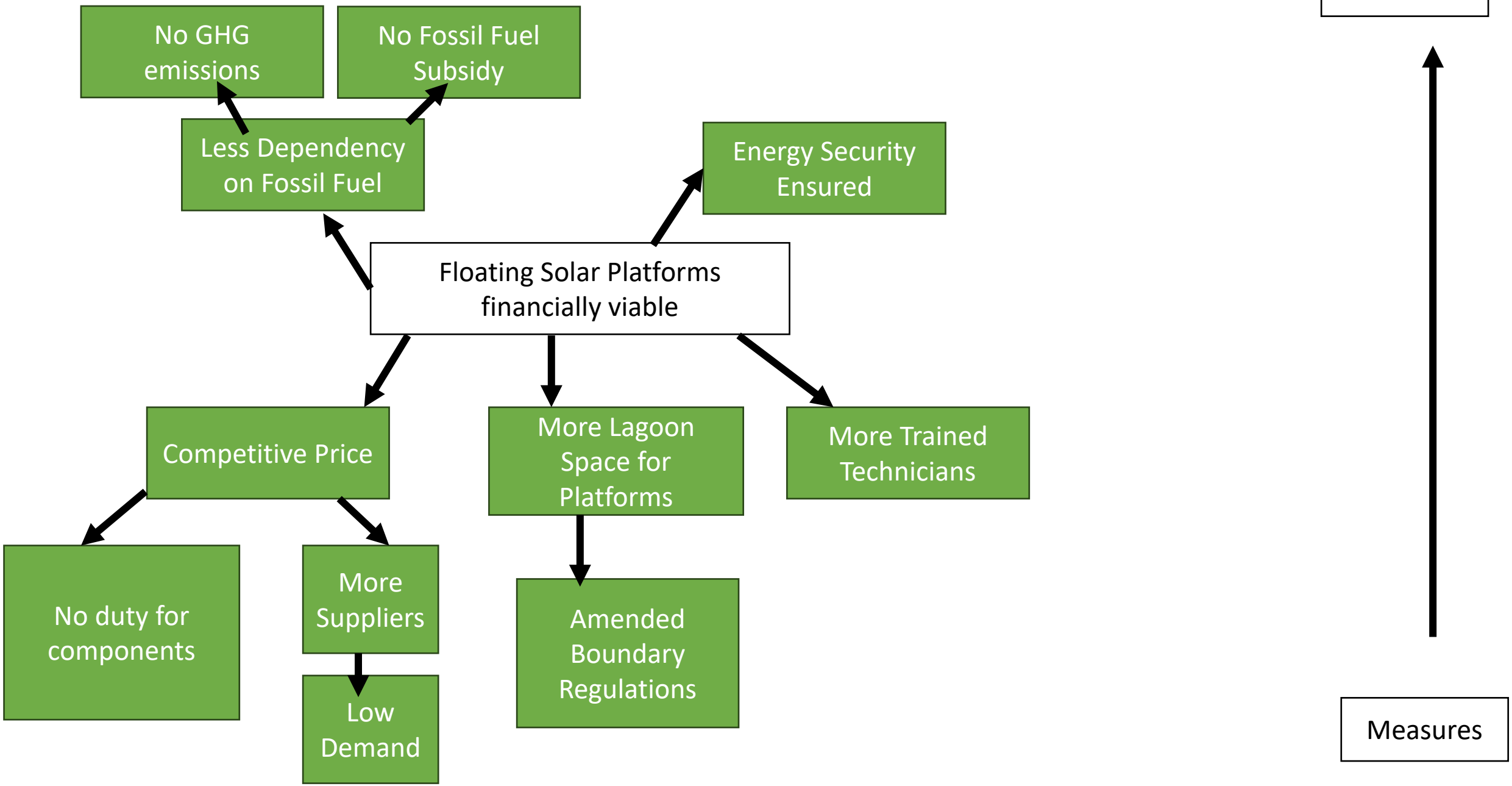
Market Mapping – Floating Solar Platforms



Problem Tree for Floating Solar Platform

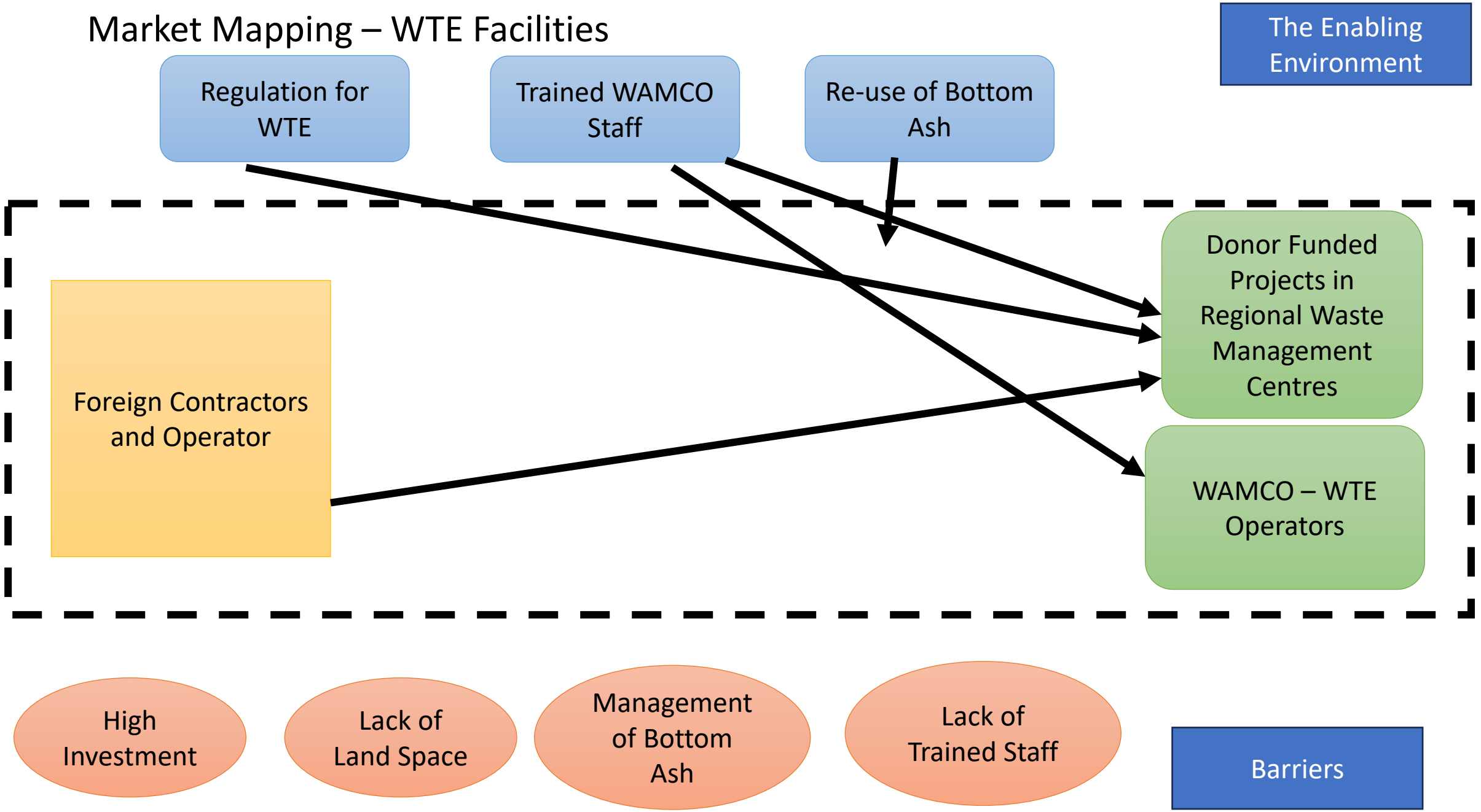


Solutions Tree for Floating Solar Platforms

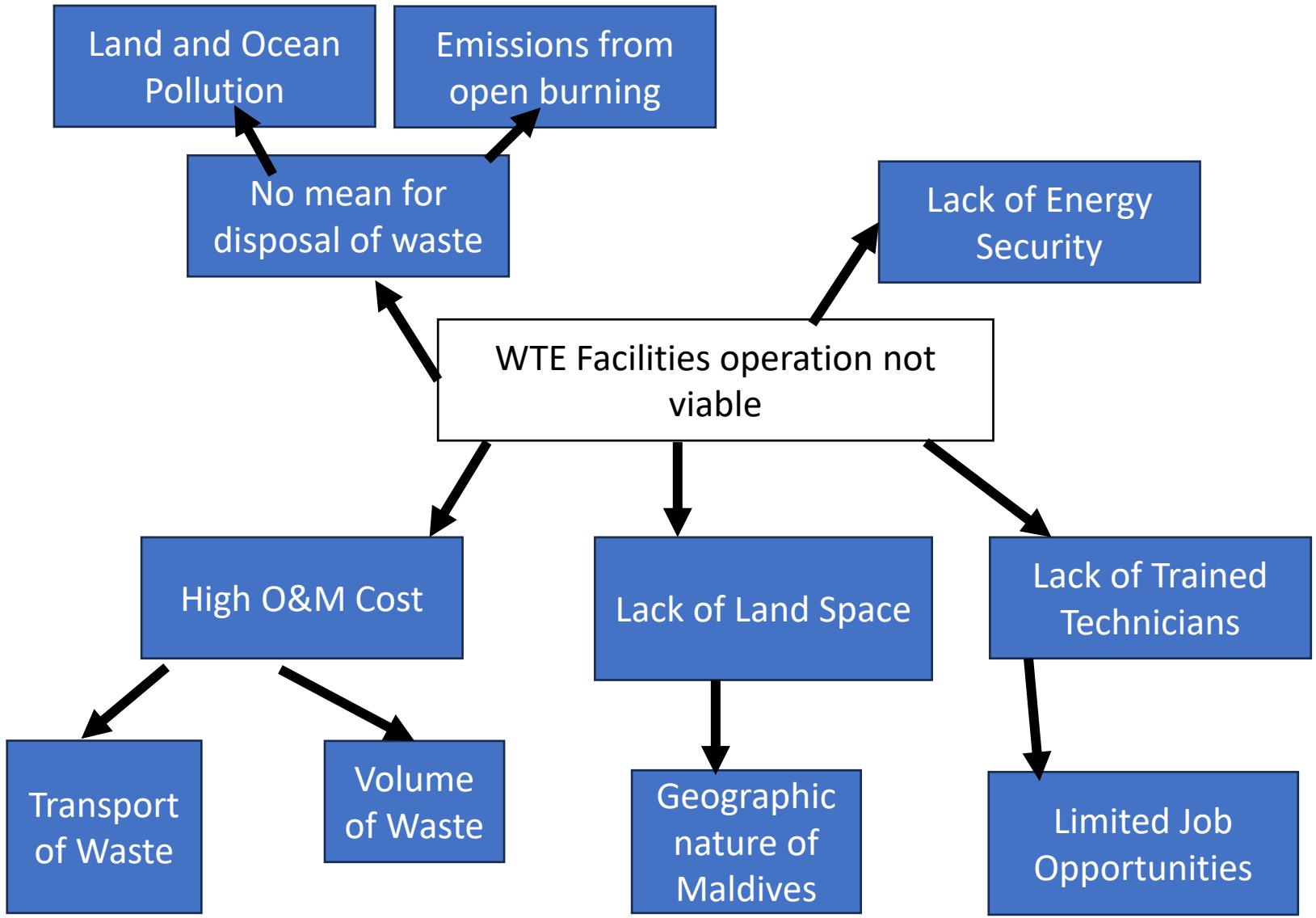


Annex 2 – Waste Management Sector Market Mapping, Problem and Solution Trees

Market Mapping – WTE Facilities



Problem Tree for WTE facilities

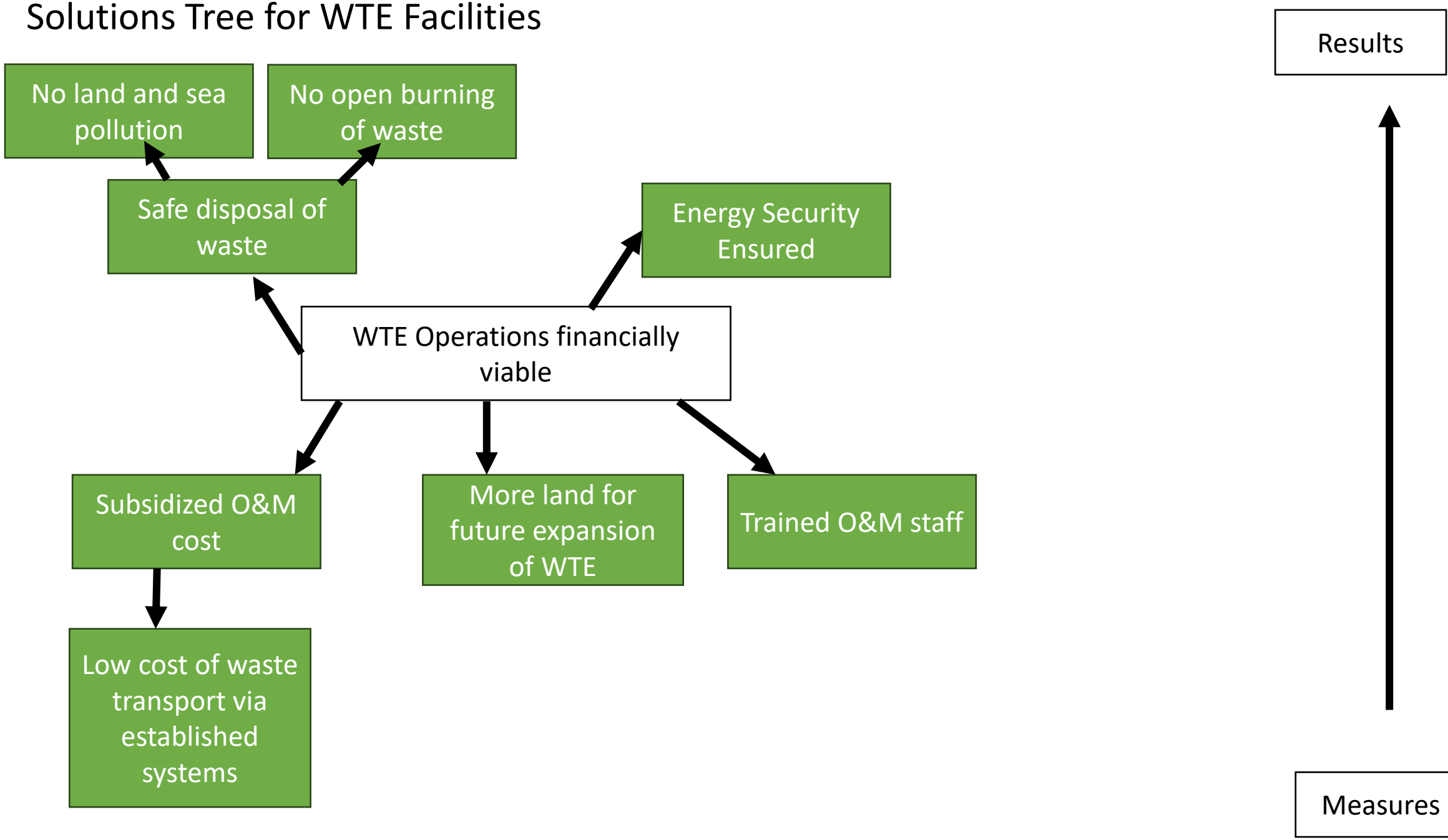


Effects

Starter Problem

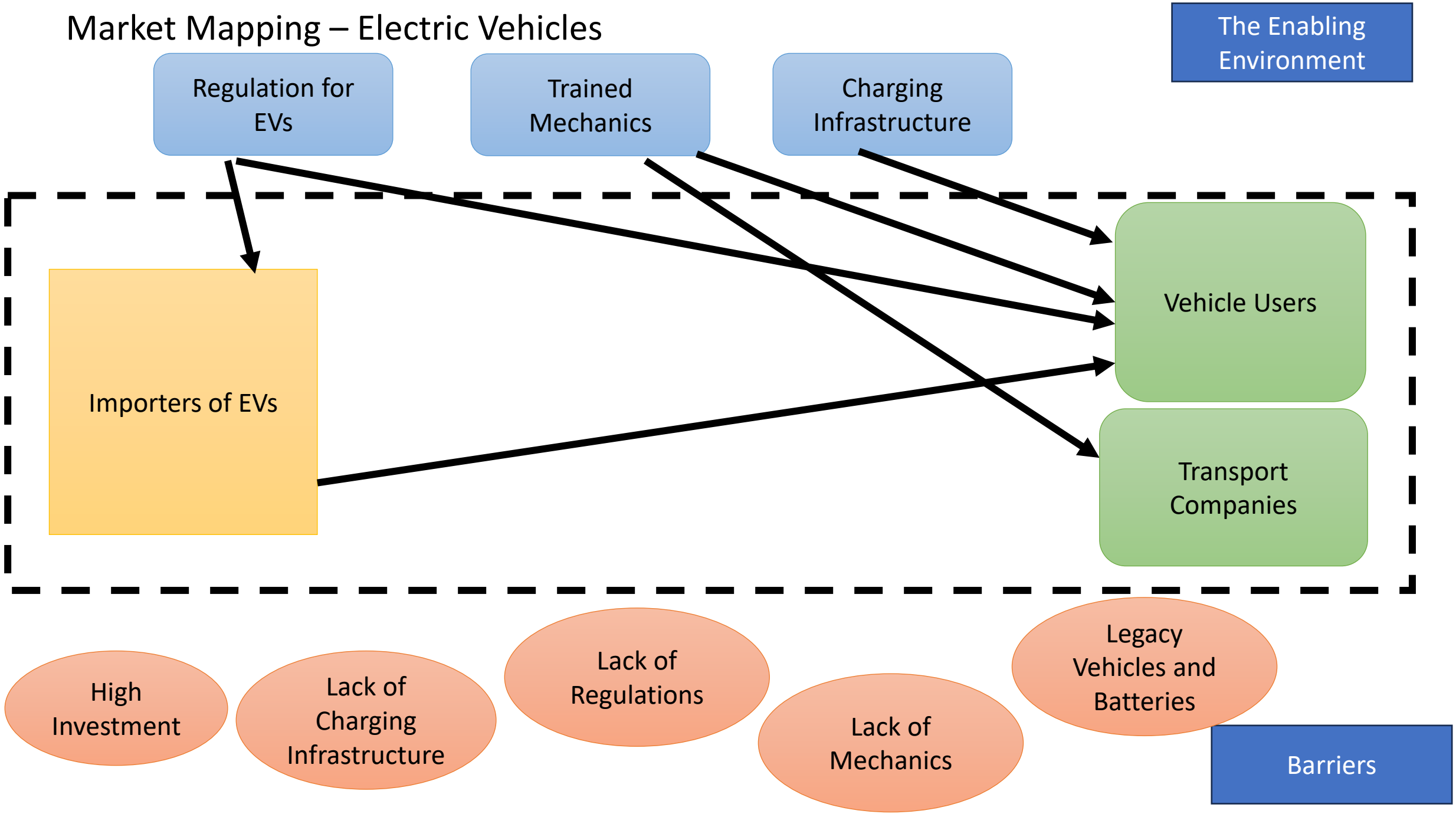
Cause

Solutions Tree for WTE Facilities

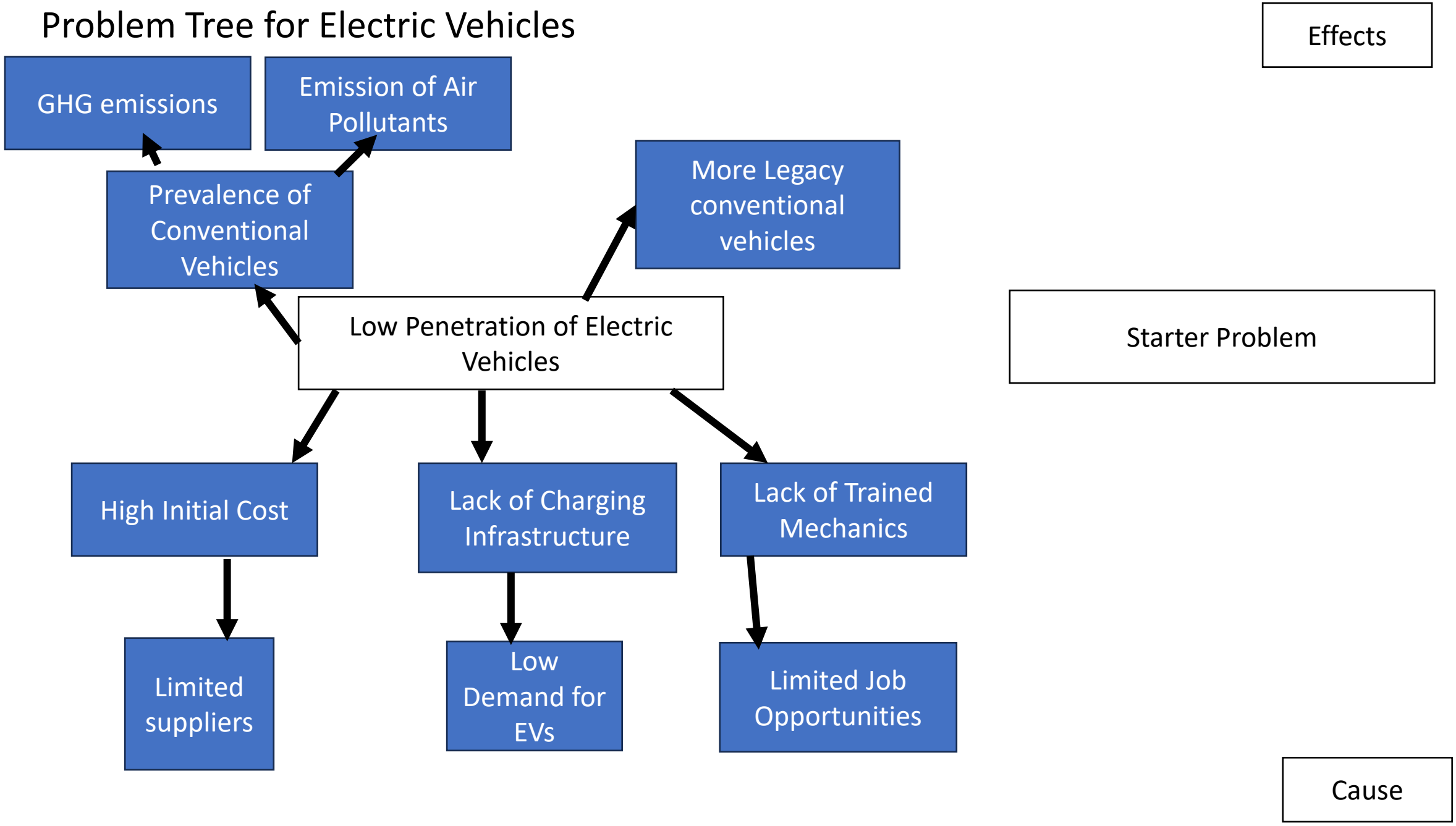


Annex 3 – Transport Sector Market Mapping, Problem and Solution Trees

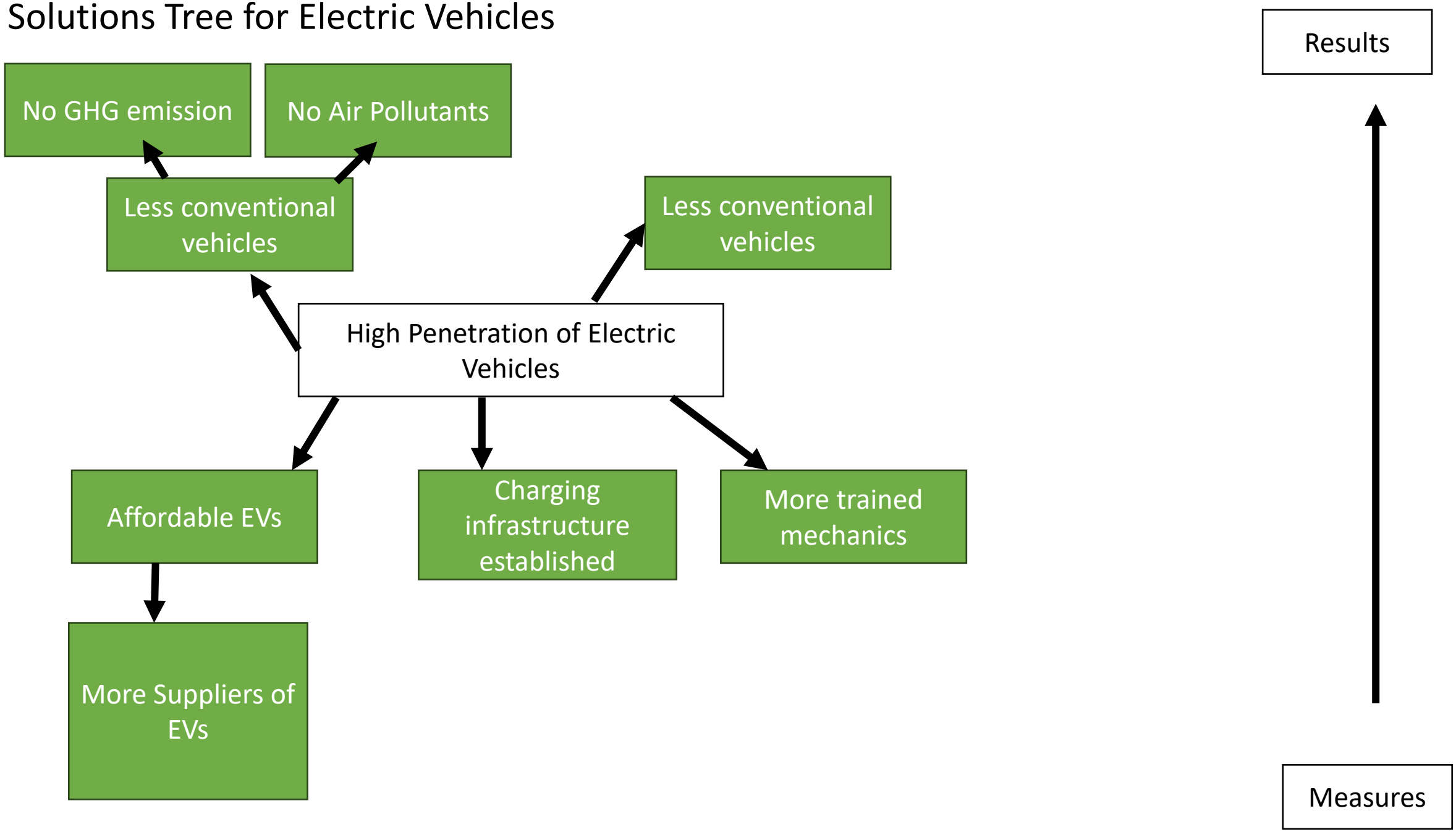
Market Mapping – Electric Vehicles



Problem Tree for Electric Vehicles



Solutions Tree for Electric Vehicles



Annex 4 – Sectorial Working Groups
Electricity Generation and Consumption Sector

Name	Designation	Organization
Thomas Siebenbrunner	Head of Marketing	Swimsol
Verena Wiesbauer	Environmental Expert	Swimsol
Dr. Furugaan Ibrahim	Research and Development manager	Male Water and Sewerage Company (MWSC)
Rizna Rasheed	Assistant Engineer	Energy Department, Ministry of Environment, Climate Change and Technology
Dhanish Mohamed Ali	Program Officer	Energy Department, Ministry of Environment, Climate Change and Technology
Ahmed Azleem	Director	Fenaka Corporation Limited
Abdulla Nasith	Director	Fenaka Corporation Limited
Akram Waheed	Senior Energy Specialist (Engineer)	ARISE Project
Mohamed Faizaan Faiz	Assistant Engineer	State Electric Company Limited (STELCO)
Mohamed Auzam	Project Coordinator	Avi Technology Pvt Ltd
Hamna Zadhy	Assistant Engineer	Avi Technology Pvt Ltd
Mohamed Azan Abdulla	Environmental Analyst	Climate Change Department, Ministry of Environment, Climate Change and Technology

Waste Management Sector

Name	Designation	Organization
Ismail Ajmal	Senior Environment Analyst	Waste Management and Pollution Control Department, Ministry of Environment, Climate Change and Technology
Mohamed Shumais	Sector Expert	Geo-tech Maldives
Ahmed Azim	Communication Specialist	ADB WTE project
Mohamed Afraz	Engineer	MCEP Project
Zabeen	Assistant Manager	WAMCO
Mohamed Akram	Research and Development Officer	WAMCO

Transport Sector

Name	Designation	Organization
Ali Solih	Minister of State	Minister of Transport and Civil Aviation
Hussain Nazeer	Director	Minister of Transport and Civil Aviation
Hassaan Abdul Muhsin	Environment Analyst	URBANCO
Aminath Athifa	National Technical Coordinator	Integrated, Sustainable Low Emission Transport Project, Ministry of Environment, Climate Change and Technology
Ahmed Ibrahim	Treasurer	Maldives Boating Association
Ahmed Salaam		Maldives Transport and Contracting Company (MTCC)
Abdul Wahid		Maldives Transport and Contracting Company (MTCC)
Hamman Mohamed		Maldives Transport and Contracting Company (MTCC)

Ahmed Simad		URBANCO