The Republic of The Union of Myanmar

Barrier Analysis and Enabling Framework Report for Climate Change Mitigation

April 2021

Myanmar Barrier Analysis and Enabling Framework Report – Climate Change Mitigation

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DISCLAIMER

Foreword

The adoption of climate technologies is key to reducing greenhouse gas emission while improving the competitiveness of major economic and industrial sectors, and thereby promoting low-carbon and green growth in Myanmar.

Recognizing these circumstances, the Republic of the Union of Myanmar has implemented the third phase of the "Technology Needs Assessment (TNA)" project whose objective is to promote investments in technology transfer and to improve access to environmentally sound technologies (EST) that are relevant for achievement of Myanmar's climate change adaptation and mitigation targets. Myanmar developed a national NDC in 2015 to confirm its commitment to climate change mitigation especially in the forestry and energy sector, and to adapt to the devastating effects of climate change in agriculture, forestry, water, infrastructure, and so forth.

This "Barrier Analysis and Enabling Framework Report" was coordinated by the Ministry of Natural Resources and Environmental Conservation (MONREC) through the Climate Change Division of Environmental Conservation Department (ECD), with the help of national consultants and local experts. MONREC acknowledges that the TNA project is funded by the Global Environmental Facility (GEF). The project is implemented by the United Nations Environment Programme (UNEP) through the UNEP DTU Partnership (UDP) with technical support from the Asian Institute of Technology (AIT) for the Asian Countries.

This analysis utilized a standardized methodology, in which ECD facilitated stakeholders' consultation meetings, and the consultant conducted a series of bilateral meetings, field visits, and user interviews to identify barriers hindering development and adoption of the technologies' market supply-chain, and proposing enabling frameworks necessary to overcome identified barriers. Therefore, all of the identified barriers were identified from a bottom-up approach to reflect the situation of technologies as prioritized by key stakeholders within Myanmar. I am honored to provide a foreword to the second report of the TNA Project.

I am happy to present this report to a wide range of stakeholders such as decision-makers, policymakers, potential investors, technology developers, scientists and researchers. I have high confidence that this report can be one of the solutions to achieving the government's commitment towards addressing the climate change-related issues, and to improve our county economic, environmental and social development goals by eliminating identify barriers. Additionally, this report is an alarm for us to take necessary steps to streamline policies, legislation, etc. to help transfer and diffusion of technologies prioritized.

Union Minister

Ministry of Natural Resources and Environmental Conservation

The Government of the Republic of the Union of Myanmar

Acknowledgement

The report on Barrier Analysis and Enabling Framework for Climate Change Mitigation for priority climate change mitigation technologies under the TNA Project in Myanmar was developed in consultation with various national experts and personnel from relevant ministries, sectors, institutions, and factories.

The outcomes of the TNA Project will contribute to the achievement of the country sustainable development goals, as well as efforts to realize the vision of Myanmar's Climate Change Policy, which is to promote a climate-resilient, low-carbon society that is sustainable, prosperous and inclusive, for the wellbeing of present and future generation". On this occasion, the Environmental Conservation Department would like to thank the Ministry of Natural Resources and Environmental Conservation for facilitating the administrative and legal procedures of the report and project development.

We hereby would like to express the sincerest gratitude to His Excellency Union Minister of MONREC, for his strong encouragement and leadership, as well as his continuous precious suggestions and guidance in the whole period of the project's process.

Our heartfelt gratitude goes to GEF, which financed the project, and to UNEP and the UNEP DTU Partnership which implement the project in collaboration with AIT for their support, valuable comments, and helpful technical inputs for the project.

We extend our special thanks to various experts, stakeholders, and factories for giving their scarce time for bilateral meetings and field visits to identify barriers in ground situations. Also, we acknowledge the important guidance made by all members of the National TNA Project Steering Committee of the Myanmar TNA Project.

Finally, we would like to thank the active and efficient participation of all national stakeholders from technical working groups which drove the project to success.

Last but not least, I would like to express my sincere appreciation to the national consultant, the national TNA team, and the staff of the Climate Change Division for their continuous efforts to develop the Barrier Analysis and Enabling Framework Report.

Director General

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Executive Summary

This is Report II of the Technology Needs Assessment (TNA) Project which is called Barriers Analysis and Enabling Framework Report after selecting prioritize technologies for the country in Report I which is called the Technology Needs Assessment Report. According to Report I, Energy and Industrial Sector are selected to be two priority sectors for climate change mitigation. Having selected potential prioritized technologies in each sector for adoption, the second step of the TNA process involved with barriers analysis that is conducted to identify challenges for deployment and diffusion of priority technologies and proposing enabling framework to overcome these barriers for successful transfer and diffusion of selected technologies interventions. This barrier analysis and enabling framework report is developed by applying the guidance from: 'Overcoming barriers to the transfer and diffusion of climate technologies 2nd edition' which provide a process that emphasizes country-driven participatory approach and stakeholder consultation.

The preliminary objectives for the barrier analysis for Energy and Industrial Sectors are premised on the relevant objectives from the National Electrification Plan (NEP), the NDC and National Energy Efficiency and Conservation Policy, Strategy, and Roadmap for Myanmar. TNA therefore will support addressing the country's targets and goals in part. Regarding this, the process of barrier analysis and proposing an enabling framework for the Energy Sector will support to increase the use of solar mini-grid systems, LED household lighting and LPG stoves to reduce greenhouse gas emission from electricity generation and energy consumption in the residential sector, and energy efficiency improvement and increase energy saving in the residential sector. In Industrial Sector, the process of barrier analysis and proposing enabling framework will address the increased utilization of variable speed driver, energy-efficient boiler and solar dryer to mitigate the GHG emission and to enhance energy efficiency by reducing energy consumption without compromising the production of the Industrial Sector. Additionally, cost-benefit analyses are conducted for all proposed technologies to examine as an economic benefit and environmental benefit of each technology.

Results of Barrier Analysis and Enabling Framework for technology specific for Energy Sector are:

(i) Solar Mini-grid

The barriers identified hindering the deployment of solar mini-grid are (a) High interest cost, (b) Insufficient subsidy or support for mini-grid developers, (c) Lack of mini-grid regulation and cooperation between off-grid and grid concessions, (d) Inadequate renewable energy policy, strategy and action plan, (e) Limited demand for productive activities in rural areas, (f) Lack of grid interconnection system, (g) Insufficient capacity of township-level staffs on solar mini-grid and (h) Inadequate public knowledge on solar mini-grid system's capabilities.

The enabling framework for the deployment of solar mini-grid are (a) Creating bank loan guarantee process by line ministries, (b) Engage with the international funding agency, (c) Develop attractive business model with appropriate incentives for developers and investors, (d) Develop mini-grid regulation and create cooperation channel between off-grid and grid concessions, (e) Develop renewable energy policy, strategy and its action plan, (f) Create the development of technology transfer program to increase productive use demand, (g) Develop a regulatory framework to enable grid interconnection system, (h) Develop capacity building programs for staffs and (i) Create information and awareness program for off-grid areas.

(ii) LED

The barriers identified hindering the deployment of LED are (a) High initial cost because of import taxes, (b) Lack of financial support, (c) Lack of economic feasible data, (d) Lack of legal, regulatory and enforcement framework for lighting, (e) Insufficient coordination between line ministries, (f) Lack of standard and labelling, (g) Lack of quality control, (h) Limited market information and awareness, and inadequate knowledge about e-waste and (i) Insufficient ability to foresee potential benefit due to household income.

The enabling framework for the deployment of LED are (a) Consider to create tax incentives for importation, (b) Create subsidy program for customers, (c) Conduct economic and financial feasibility study and disseminate the study result to the public, (d) Develop sufficient legal, regulatory and enforcement framework, (e) Enhance coordination between line ministries, (f) Develop standard and labelling, (g) Develop quality control system and establish testing laboratory, (h) Promote public awareness and (i) Conduct awareness raising.

(iii) Substitution of firewood with efficient fuel (LPG) at household level for cooking

The barriers identified hindering the deployment of LPG are (a) High importation taxes on LPG, (b) Lack of subsidy, (c) Weakness of LPG Law, (d) Inadequacy cooperation between key stakeholders, (e) Insufficient human capacity and resources for inspection, (f) Insufficient infrastructure, (g) Lack of local gas tank (cylinder) manufacturing, (h) Insufficient information about LPG and (i) Safety issue: Afraid of the explosion.

The enabling framework for the deployment of LPG are (a) Consider to reduce taxes for importation of LPG, (b) Create subsidy program for fuel switching, (c) Develop LPG Law, (d) Enhance cooperation between key stakeholders, (e) Conduct technical training for inspection, (f) Develop a standard for the gas tank and open last mile retailer shops, (g) Transfer cylinder manufacturing technology to the country, (h) Promoting public awareness and (i) Conducting knowledge sharing sessions and promoting public awareness.

Results of Barrier Analysis and Enabling Framework for technology specific for Industrial Sector are:

(i) Efficient Electric Motor (Using the variable speed driver (VSD))

The barriers identified hindering the deployment of VSD are (a) High taxes and import duty, (b) Insufficient financial resources and subsidies, (c) Financial variability not examined, (d) Lack of legal regulatory framework and lack of enforcement, (e) Lack of capacity in the existing institution because of insufficient time and prioritized other responsibility by engaged departments, (f) Lack of standards and codes, (g) Poor Operation & Maintenance, (h) Insufficient Research and Development (R&D) and lack of curriculum development for practical training and (i) Inadequate knowledge and compliance on energy management system of decision-makers in factories.

The enabling framework for deployment of VSD are (a) Regulation on the exemption of tax and import duty of machinery, appliances, and goods for energy-efficient and climate technologies, (b) Provision of financial and banking services for energy efficiency projects, and providing financial incentives to industries under appropriate financial mechanism, (c) Study on the potential of CDM-PoA/ internationally supported NAMA concept in Energy Efficiency and Conservation Projects for electrical appliances, (d) Create economic feasibility assessment activities in different industry sub-categories which are using VSD system, (e) Establish energy efficiency law and develop appropriate regulatory mechanism for enforcement, (f) Capacity development in existing institution, (g) Develop

proper standards and codes, (h) Establish a factory level O&M management system with registered after-sale services providers and maintenance services providers, (i) Develop R&D activities, (j) Develop a curriculum for step-by-step practical training courses and (k) Technology transfer of energy management system.

(ii) Energy Efficient Boiler

The barriers identified hindering the deployment of energy-efficient boiler are (a) High capital cost due to taxes and custom duty, (b) Weak access to financial resources, (c) Lack of economic feasibility assessment, (d) Lack of specific regulatory framework on boiler efficiency, (e) Insufficient human resource and limited capacity for boiler inspection in existing institutions, (f) Weak O&M, (g) Lack of efficiency standards for boilers, (h) Lack of Research and Development (R&D) and (i) Lack of awareness and compliance by decision-makers in factories regarding energy management system.

The enabling framework for deployment of energy-efficient boiler are (a) Regulation on the exemption of tax and import duty of boilers and its related accessories for energy efficient and climate technologies, (b) Provision of financial mechanisms and incentives, (c) Study on the potential of CDM-PoA/ internationally supported NAMA concept in Energy Efficiency and Conservation Projects for energy-efficient boiler and fuel switching technologies in boilers, (d) Create economic feasibility assessment activities in different industry sub-categories which are using boilers, (e) Establish energy efficiency law including specific section for boiler and review current regulation to update for energy efficiency improvement, (f) Institutional strengthen by providing training, (g) Establish critical mass of locally trained personnel and establish training programs for technical and operators, (h) Develop minimum energy efficiency standard, (i) Develop Industrial based R&D activities and (j) Technology transfer of energy management system.

(iii) Solar Dryer

The barriers identified hindering the deployment of the solar dryer are (a) Lack of tax exemption, (b) Insufficient subsidy program and Improper financial resources, (c) Lack of economic feasibility assessment, (d) Absence of legal and policy framework and lack of enforcement, (e) Lack of standard on materials, (f) Insufficient skilled manpower and absence of technology transfer, (g) Lack of technical capacity by farmers, (h) Insufficient awareness and information and (i) Insufficient awareness on energy management system from decision-makers in factories

The enabling framework for the deployment of the solar dryer are (a) Develop either tax exemption or reducing tax mechanism to encourage the use of renewable technology in the industrial sector, (b) Establish subsidy programs and provision of financial and baking services, (c) Create economic feasibility assessment activities, (d) Formulate enabling policy, legal and regulatory framework for solar driers, (e) Set up a quality control system, (f) Establish technical education, adequate training and technology transfer programs, (g) Capacity development program for farmers, (h) Create information and awareness campaigns and (i) Technology transfer of energy management system.

National GHG emission could be reduced obviously by implementing these technologies, and the country could achieve climate resilience and move toward a low-carbon growth pathway as well as contribute to the efforts of global warming reduction.

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List of Abbreviations

AC	Alternative Current
ADB	Asian Development Bank
AFD	Agence Française de Développement
AIT	Asian Institute of Technology
ASEAN	Association of Southeast Asian Nations
BCA	Benefit-Cost Analysis
BCR	Benefit-Cost Ratio
Capax	Capital expenditure
CBA	Cost-benefit Analysis
CDM-PoA	Clean Development Mechanism – Program of Activity
CER	Certified Emission Reductions
CFL	Compact Fluorescent Lamp
CH_4	Methane
CO_2	Carbon Dioxide
CH_4	Methane
DC	Direct Current
DRD	Department of Rural Development
DRI	Department of Research and Innovation
EEB	Energy Efficient Boiler
EE&C	Energy Efficiency and Conservation
ESCO	Energy Service Company
FTA	Foreign Trade Agreement
GDP	Gross Domestic Product
GERES	Group for Environment, Renewable Energy and Solidarity
GHG	Greenhouse Gas
GLS	General Lighting Service
GWh	Giga Watt Hour

HH	Household
INGO	International Non-Governmental Organization
IRR	Internal Rate of Return
JCM	The Joint Crediting Mechanism
ktoe	Kilo Tons of Oil Equivalent
kW	Kilo Watt
LDC	Least Developed Country
LED	Light-emitting Diode
LEP	Light-emitting Polymer
LPG	Liquefied Petroleum Gas
MMK	Myanmar Kyat
MPE	Myanmar Petrochemical Enterprise
mtoe	Million tonnes of oil equivalent
MW	Mega Watt
MWh	Mega Watt Hour
NDC	Nationally Determined Contribution
NEP	National Electrification Plan
NGO	Non-governmental Organization
NPV	Net Present Value
OLED	Organic Light-Emitting Diode
O&M	Operation and Maintenance
PPP	Public Private Partnership
PV	Photovoltaic
RBF	Responsible Business Fund
RE	Renewable Energy
R&D	Research and Development
SME	Small and Medium Enterprise

SSL	Solid-state Lighting
TNA	Technology Needs Assessment
T&D	Transmission and Distribution
TV	Television
UNIDO	United Nations Industrial Development Organization
UPRD	Upper Respiratory Diseases
USD	US Dollar
USEPA	United State Environmental Protection Agency
UV	Ultraviolet
VSD	Variable Speed Drive
W	Watt
Wh	Watt hour
W_p	Watt Peak
WWF	World Wildlife Fund

Chapter 1 Energy Sector

1.1 Preliminary targets for technology transfer and diffusion

Electricity generation in Myanmar is dominant by hydropower with 9,743.85 GWh per year which is around 54% of the total generation in 2016 followed by gas-fired electricity generation with 7,537.79 GWh per year which is around 42% of the total generation mix, the steam turbine which uses natural gas as a fuel with 514.64 GWh per year, etc. Detail electricity generation mix is shown in Table 1. Among different electricity users, the residential sector is the most significant electricity consumer in the country with 7,572.60 GWh per year which is 42% of total electricity consumption in 2016. Table 2 shows the final electricity consumption of the different sectors from 2010 to 2016.

Table 1: Electricity generation by primary energy resource in Myanmar (GWh)

YEAR	HYDRO	Steam	DIESEL	GAS	COAL	RE	TOTAL
2010	6,188.53	278.18	32.66	1,733.84	391.47	0.04	8,624.72
2011	7,544.07	438.11	38.33	2,118.02	311.66	4.32	10,454.51
2012	7,766.24	505.59	50.63	2,377.39	265.05	4.32	10,969.22
2013	8,778.11	433.25	60.76	2,794.30	135.66	4.32	12,206.40
2014	8,828.85	216.01	64.89	4,977.03	69.53	19.66	14,175.97
2015	9,398.98	284.98	55.23	6,232.77	-	12.2	15,984.16
2016	9,743.85	514.64	61.12	7,537.79	9.59	10.74	17,877.73

Steam = Gas is the fuel for steam turbine

RE = Photovoltaic electricity, wind turbine and micro-hydro

Source: (OGPD, 2019)

Table 2: Final electricity consumption by sectors in Myanmar (GWh)

Year	Own use	Residential	Industrial	Commercial and public services	Others
2010	120	2,653.34	2,286.76	1,306.38	65.60
2011	132.54	3,377.84	2,710.92	1,531.05	80.74
2012	196.43	2,680.91	3,848.42	1,642.58	86.28

2013	174.00	3,763.78	4,060.97	1,692.36	99.77
2014	151.81	4,112.84	5,275.78	1,754.58	131.42
2015	154.26	6,674.66	4,120.77	2,506.08	106.78
2016	127.00	7,572.60	4,650.90	3,023.27	117.81

Own use = Power consumption by power plants

Source: (OGPD, 2019)

Electricity generation is gradually increasing year by year which can be seen in Table 1 due to the increasing demand for electricity by different consumers. Based on Myanmar Energy Master Plan, final energy consumption is expected around 25 mtoe in 2030 in the case of the high growth rate of final energy consumption and 21.9 mtoe as a medium growth rate. Therefore, the government is trying to generate more electricity aiming to 2030. At present, about 50 percent of the population in Myanmar has access to electricity from the national grid (President Office, 2019). The Government has a commitment to achieve 100 percent electrification by 2030 according to The Myanmar National Electrification Plan (NEP) (Castalia Strategic Advisors, 2014) which will require a double of the current pace. Many areas may not receive electricity for at least 10 years, even if Myanmar can achieve its ambitious rural electrification grid extension scale-up targets (Greacen, 2015).

In line with Myanmar NDC in 2015, rural electrification through renewable energy is one of the key commitments which are to increase access to clean sources of electricity amongst communities and households currently without access to an electric power grid system. The indicative goal is that rural electrification could be achieved by using at least 30% of renewable energy (such as mini-hydropower, biomass, solar, wind, and solar mini-grid technologies) to generate electricity supplies (MOECAF, 2012). This NDC on the electricity sector guide by the National Energy Policy and the Myanmar Energy Master Plan 2015.

In parallel with the electricity generation target in Myanmar, the country has an energy-saving goal for targeting two end-use sectors which are namely electricity and biomass for 2030 as well. According to National Energy Efficiency and Conservation Policy, Strategy, and Roadmap for Myanmar, the policy target for 2030 is 20% electricity saving in all sectors and 7% biomass saving in the residential sector. Of this, the residential sector is expected to save 7.8% of electricity in 2030 (MOI, 2015).

Myanmar, as an LDC, has obvious limitations in financial, technical, and capacity resources. Therefore, this period (2020-2030) is a transition period to take measures of the country's efforts for its commitment to the international community. As a consequence, the specific targets for technology transfer and diffusion in the TNA project are difficult to develop, and relevant stakeholders admit that setting specific targets is inaccessible at this moment since the specific roadmap for each selected technology has not been identified yet apart from the solar mini-grid. Therefore, the preliminary target for technologies transfer and diffusion of the TNA project is that the prioritized technologies in TNA Project are expected to support to achieve the country's targets in some circumstances. The

solar mini-grid will support to fulfill to achieve the rural electrification plan instead of relying on grid electricity. On the other hand, replacing incandescent lamps and fluorescent lamps with LED will support to gain energy saving in the residential sector to contribute the country target for 2030 while the substitution of fuelwood with efficient fuel (LPG) at the Household Level for cooking will support to reduce of biomass consumption in the household sector to contribute the National Energy Efficiency and Conservation Policy, Strategy, and Roadmap for Myanmar's target.

As mentioned above, TNA therefore will support addressing the country's targets and goals in part. Regarding this, the process of barrier analysis and proposing an enabling framework will support increasing the use of solar mini-grid systems, LED, and LPG stoves to reduce greenhouse gas emission from electricity generation and energy consumption in the residential sector, and energy efficiency improvement and increase energy saving in the residential sector. The prioritized technologies which are selected in the TNA report for barrier analysis and enabling framework for energy section is shown in Table 3, and technologies are categorized based on their market characteristic. According to the TNA guidebook, technologies are not categorized based on their technical properties. However, they are categorized according to their types of goods and services where they belong or contribute to **(Nygaard & Hansen, 2015)**. Based on this, only solar mini-grid is categorized into both consumer and capital goods because some solar mini-grid systems in countries are operated by their own capital from some stakeholders while other systems are operating under NEP. Since LED and LPG stoves are specifically intended for the mass market as like as households, these are therefore categorized under consumer goods.

Table 3: Selected technologies for Energy Sector with their respective category

No	Prioritized technologies	Category
1.	Solar Mini-Grid	Consumer and Capital Good
2.	Replacing incandescent lamps and fluorescent lamps with LED	Consumer Good
3.	Substitution of Fuelwood with efficient fuel (LPG) at Household Level for cooking	Consumer Good

1.2 Barrier analysis and possible enabling measures for Solar Mini-Grid

1.2.1 General description of Solar Mini-Grid

Solar photovoltaic systems use sunlight to generate electricity directly. Solar mini-grid consists of three main subsystems which are very common for the renewable mini-grid system and is presented below **(ADB(a), 2017)**:

1) Generation – There are four main components in the generation systems which are the power sources (solar panels), batteries, charge controllers, and inverters which are described below. In some case, some solar mini-grid site uses diesel Genset for power backup solution especially when sunlight cannot be harnessed to generate electricity for night time. These determine the amount of electricity that can be produced by the system.

2) Distribution - This subsystem is the core of delivering the electricity to the end-users through a grid that covers the whole community. The grid can be chosen either DC or AC based on the system model. Moreover, single-phase or three-phase can be chosen to deliver to the end-users.

3) Consumption – Generally, this is the final site of the system. This site includes all the equipment not only meter connection equipment such as meter boxes, power limiters, electric sockets but also appliances at the end-users' side (e.g. – lightings, fans, TVs, phone chargers, etc.).

According to Developing Renewable Energy Mini-Grids in Myanmar Report in 2017, the following table 4 presents the main components of the system.

Table 4: The main components of solar mini grid

Generation	(i) Solar panels – Low voltage direct current (DC) is generated by solar panels which should be placed with the South facing inclination position to capture maximum sunlight. In Myanmar, this is typically at an angle of 15–25 degrees. The panel installation should consider that minimal shading throughout the day should be allowed onto the planes. (ii) Batteries – Deep-cycle type batteries specifically designed for the photovoltaic system are recommended to use in solar mini-grid. Even though these types of batteries are more expensive than other types of batteries (e.g. – car batteries), their lifetime is longer. Therefore, cost-effective is more in the long term. Typically, these parts are the weakest in the system, so adequate maintenance is required. However, batteries replacement should be done in a certain year. (iii) Charge controller - Overcharging and deep discharging of the batteries are prevented by the charge controller. (iv) Inverter - As usual, this component converts low-voltage DC power to higher-voltage alternating current (AC) power. In a larger system, two or more inverters should be used. However, DC power small mini-grids do not require this element.
Distribution and	Balance-of-system components are;

Consumption	• Mounting racks – To fix at the right angle, solar panels are attached at the mounting racks on the ground. Corrosion-resistant materials should be used to make racks. • System housing – The batteries and electric equipment envelop in a weatherproof metal house. A concrete powerhouse may be constructed for larger systems instead of the metal house. • Wires and conduits – To minimize voltage drop and line loss, adequate size is needed to use for the connection. • Circuit protection – Fuses and circuit breakers are included in this component to prevent damage to the system. Note that all wires connected to batteries need circuit protection. • Earth grounding – This is safety equipment to protect lightning and to prevent shocks and ground faults. • Consumer loads – Generally, these are the end used appliances such as lighting, TVs, fans, phone chargers, fridges.

Source: (ADB(a), 2017)

Some advantages of solar mini-grid are presented below:

- Due to the electricity access in rural areas, there are a lot of gender benefits such as reduce drudgery time, income generation, as well as health and safety improvements.
- Since off-grid areas can access electricity due to mini-grid, the people from these areas can generate their household incomes more than before by doing value-added business activities against their traditional business activities
- Agricultural production can improve since people from off-grid area can use electricity for productive use of energy.
- New employment opportunities can facilitate and create by the system as well as the establishment of cottage industries can be supported. Therefore, increasing the working hours is a benefit for people as well.
- The solar mini-grid can replace fossil fuel power generation, so the country reduces the expenditure of conventional energy and can reserve the country's future energy needs.
- Since solar energy is clean energy, the solar mini-grid system can provide better health conditions and significantly reduces the risk of fire when the use of candles and kerosene lamps are phased out in the household.
- The students can obtain learning opportunities in the evening also.
- Since the system can replace fossil fuel consumption, it helps in reducing national-level GHG emissions. Therefore, it helps to contribute to achieving the targets of the international

commitments of the country. Moreover, it can help in reducing local air pollution and noise pollution.

- Through Clean Development Mechanism projects, Certified Emission Reductions (CER) can claim since the system is a source of clean energy. Thus, it can be a source of additional income.

1.2.2 Identification of barriers for Solar Mini-Grid

First of all, key barriers to Solar Mini-Grid identify through literature reviews and field visits to some solar mini-grid sites. The purposes of field visits are to identify the difference between before and after mini-grid in the village such as business activities, household income and electricity access and to identify the potential barriers of current mini-grid to address for following mini-grid implementation. From these activities, general barriers were identified which is called long list of barriers. The long list of barriers is presented in Annex V. Then, the consultant joined the solar mini-grid developer roundtable event which was held by AFD on 22nd January 2020 in Yangon for their feasibility study to discuss hidden barriers such as regulatory challenges, financial challenges, and needs, technical challenges, the supply chain in Myanmar. After that, bilateral meeting and email exchange which has a purpose of identification and ensuring the pre-selected barriers as the identified barriers with two solar mini-grid developers are following to ensure the identified barriers which get from previous activities. Once the consultant collects the necessary information, the problem tree, and market map which are in Annex I are developed for using root-cause analysis. Finally, all identified barriers by the consultant are presented in a stakeholder consultation meeting with the Energy Sector Working Group (Stakeholders list is in Annex IV), and technical working group validated the identified barriers as a result of barrier analysis. During the barrier analysis, specific barrier for gender perspective did not find out since there are women lead solar mini-grid companies and women are already involving in the village electrification committee for implementation of mini-gird in off-grid areas.

In Myanmar, the manufacturing of solar-related products is almost negligible. The solar panels are imported by solar mini-grid developers, and then assembled locally. Regarding the other parts of the solar mini-grid system, the charge controller, and converter which converts solar Direct Current (DC) to Alternate Current (AC) electricity are imported as well. Also, deep discharge batteries for solar PV systems are imported. The off-grid solar PV market is growing up fast in rural areas since 2017 due to National Electrification Plan which is mentioned in Section 1.1. As a key player in the market for solar mini-grid, the mini-grid developers or the importers who import all components of the system have a crucial, and they encounter many financial, institutional, policy barriers, etc.

The overall process of barrier identification bases on the consultant's knowledge and information from key informants, field visits, and stakeholder consultation. These (step-by-step process) includes among others:

a. A desk study and literature review

b. Field visit to existing solar mini-grid sites

c. Solar mini-grid developer roundtable event

d. Bilateral meeting and email exchange

e. Guidance from TNA guidebook

f. Market mapping tool

g. Stakeholder consultation workshop

The major barriers in the wide diffusion of solar mini-grids are categorized under economic and financial and non-financial barriers.

Table 5: Identified barriers for solar mini-grid

Category	Barrier Dimension	Main Barriers
Economic and Financial Barriers	Cost	(a) High-interest cost (b) Insufficient subsidy or support for mini-grid developers
Non- Financial Barriers	Policy, legal and regulatory	(c) Lack of mini-grid regulation and cooperation between off-grid and grid concessions (d) Inadequate renewable energy policy, strategy and action plan
	Technical	(e) Limited demand for productive activities in rural areas (f) Lack of grid interconnection system
	Institutional and organizational capacity	(g) Insufficient capacity of township level staffs on solar mini-grid
	Information and awareness	(h) Inadequate public knowledge on solar mini-grid system's capabilities

1.2.2.1 Economic and financial barriers for Solar Mini-Grid

High Capital Cost barriers

(a) High Interest Cost

Since renewable energy project financing is very new for local commercial banks, they generally do not have the capacity or experiences for financing on such kind of projects, especially in rural electrification projects. Therefore, they are generally looking at the project cash flow as security. Moreover, the physical assets are required by local banks as collateral. Also, the interest rate for the loan is 13% per year and the loan is limited up to 3 years (Htaik, 2020). This interest rate which is 13% was confirmed during the roundtable event and bilateral meeting with Talent & Technology Company and an additional 2% charge for service fee and commission fee. Moreover, the process for a loan request is not simple for project developers. Due to high payback period which is more than 5 years, accessing financial resources is difficult for solar mini-grid projects from commercial banks.

(b) Insufficient subsidy or support for mini-grid developers

Under the National Electrification Project, the Myanmar government has taken a loan of 400 million USD from the World Bank. The loan has two main elements: (1) Grid extension - 300 million USD which is for procurement of goods and services to extend the national grid (2) Off-grid component - 80 million USD which is for off-grid electrification through solar home systems, village-level mini-grids, electrification of health clinics, and public street lights. The balance of the loan (USD 20 million) is for technical assistance and project management (The Asia Foundation, 2019). The off-grid component of the current phase of the NEP is directly financed by the Government of Myanmar (DRD) which is 60% of the capital cost. The other 40% of the capital cost is contributed by the village and solar mini-grid developer equally. According to NEP, a total of 649,198 households in 9, 874 villages will be expected to be electrified. To achieve 100% rural electrification, this amount of loan is insufficient to electrify all off-grid areas, and this WB loan will be running out soon since NEP starts from 2016. In the meantime, any other schemes like WB's schemes have not been identified yet. Therefore, without accessing partial subsidy in solar mini-grid project cannot achieve to fulfill NEP's target since the capital cost is quite high.

1.2.2.2 Non-financial barriers

Policy, legal and regulatory barriers

(c) Lack of mini-grid regulation and cooperation between off-grid and grid concessions

There is uncertainty between mini-grid developers because the cooperation between off-grid and grid concessions is not in place. Therefore, there is a difficulty to know that it is possible to become an IPP if the grid comes to the off-grid area in the next 5 or 10 years. As a consequence, this results in uncertainty around long-term ownership of the mini-grid assets. Currently, developers agree that mini-grid assets that are under the national electrification project are required to be handed over to the village electrification committee after 8 or 10 years of operation according to the mini-grid guideline which is developed by DRD.

(d) Inadequate renewable energy policy, strategy and action plan

In the meantime, the county does not have an adequate renewable energy policy with clear strategies and action plans for each line ministry. It results in the delaying and restricting progress not only in solar mini-grid projects but also in renewable energy project development and commercialization. Therefore, having renewable energy policy, strategy, and action plans in the country can lead to move forward the country's renewable energy sector in a sustainable manner and to attract both local and international investors to invest in the renewable energy sector. Therefore, renewable energy policy and its action plan can be a guideline for the country to implement renewable energy projects and commercialization.

Technical barrier

(e) Limited demand for productive activities in rural areas

As mentioned above, most solar mini-grid systems in Myanmar are hybrid systems (solar and diesel). Therefore, daytime loads are in excess very often because almost all of the solar mini-grid electrify villages have more household demand rather than productive use demand. Since Myanmar is an agriculture-based country, there are a lot of opportunities to create value-added agricultural products around the country. Currently, very few amounts of productive use of energy are in place, which is not more than 5 or 10 businesses in one village. Among these businesses, almost all of the businesses do not consume more than 5 kW per day according to field visits, and these businesses are very fundamental businesses that have no value-added technology which are rice hullers, portable welding machines, small carpentry businesses, refrigerator for selling soft drinks, etc. Therefore, a minimum of 60 or 70 kW is always excess in the daytime after the batteries are fully charged for night time. Increasing the demand for productive use in rural areas is therefore very attractive for project developers which can reduce the time of the payback period of the system since consuming daytime load from productive use activities can gain the system revenue.

(f) Lack of grid interconnection system

Since solar mini-grid produce electricity by using sunlight during the day, it is not available at night without storage. The storages, batteries have the highest share of the system cost. Nowadays in Myanmar, most of the solar mini-grid systems are hybrid systems. Therefore, power is excess in the day time. If the grid interconnection system is in place, the system allows the project developers to feed the excess power into the grid when it arrives near to the off-grid area since the country has a plan to extend the national grid to the off-grid area by 2030. Then, project developers can gain extra benefits by selling extra power to the grid, and the worry of project developers at the uncertainty of grid arrival to the off-grid area could be addressed. Therefore, this system is very attractive due and can contribute to reducing the burden of the cost of batteries. Moreover, the village electrification committee and the village can generate more income when they receive a handover from the developer after the operation years. Consequently, provision for this system can significantly lead to a reduction of capital cost and to be financially viable.

Institutional and organizational barrier

(g) Insufficient capacity of township level staffs and village electrification committee on solar mini-grid

The implementation of the solar mini-grid projects is done at the township level DRD office when the projects get approval from DRD headquarters in Naypyidaw. Therefore, township DRD offices have a responsibility to support the village electrification committee in terms of operation and maintenance after receiving a handover of solar mini-grid assets from developers after the operation period of developers. Therefore, the sustainability of the systems is depending on township level staff and village electrification committees. Since this technology is new for rural areas, people from there have limited capacity for doing operation and maintenance. Hence, capacity building for operation and maintenance is necessary for staff from the DRD township level office and people from village electrification committees.

Information and awareness barrier

(h) Inadequate public knowledge on solar mini-grid system's capabilities

The public awareness of solar mini-grid is just for electricity generation to use for home appliances as a benefit of the system. People are not aware of the system's capabilities to use other than household consumption. Therefore, electricity demand for business activities is very low. The results in lower-income generation in off-grid areas, and the payback period for project developers are higher as well.

1.2.3 Identified measures for Solar Mini-Grid

The measures for overcoming barriers for the solar mini-grid system were initially identified by the TNA consultant's experiences, field visit, and interviews with project developers in the field. These supplement the desk study in the literature in the country and other countries' experiences. As a result, the logical problem analysis support to shift from problems to a solution. The measures were grouped and evaluated during the online stakeholder consultation meeting and by requesting additional comments from line ministries.

1.2.3.1 Economic and financial measures for Solar Mini-Grid

(a) Barrier: High Interest Cost
(a) Measure: Reducing the rate of interest

The high-interest rate can be reduced by the support of the government for the project developers' side and the local banking sector side. To reduce the interest rate, the government may guarantee banking loans or cooperate with local banks by using a project contract instead of collateral. Currently, the total interest rate at the bank is 15% which is a 13% interest rate plus a 1% service fee and a 1% commission fee. According to the mini-grid developers' roundtable event which is held by AFD, most developers agree that a 7% interest rate is doable for them since there is low electricity demand in the mini-grid area. Therefore, the government should also negotiate with the banking sector to reduce the rate of interest.

(b) Barrier: Insufficient subsidy or support for mini-grid developers
(b) Measure: Engage with international funding agencies

The government should provide subsidies by seeking international environmental programs and other aids that already have such initiatives. An example of the current situation (Loan from the World Bank), the government provides a 60% subsidy for the mini-grid project developers to implement a mini-grid project in the off-grid area to achieve the target of NEP. In the meantime, some international funding agencies, like AFD are preparing to offer some amount of loan. Therefore, the government should negotiate quickly and efficiently with such kind of funding agencies to take a concession loan to support the development of the rural electrification sector before running out of the current fund. This lead to secure the loan for the country. As a consequence, electrifying rural areas by using solar mini-grid systems and other renewable energy mini-grid systems can be running continuously to achieve NEP's target.

1.2.3.2 Non-financial measures for solar mini-grid

Measures for Policy, legal and regulatory barriers

(c) Barrier: Lack of mini-grid regulation and cooperation between off-grid and grid concessions
(c) Measure: Develop mini-grid regulation and adequate cooperation between off-grid and grid concessions

The cooperation between off-grid developers and grid concessions is very crucial because this can reduce the uncertainty between mini-grid developers by developing an officially regulatory framework about IPP for the rural electrification sector. As a consequence, developers have the possibility to become an IPP once the national grid comes to off-grid areas. This would result in increased security to the banks who lend money to developers to develop projects. Also, project developers can choose either to become an IPP or to handover mini-grid assets to the village electrification committee after a certain operation period. This cooperation guideline should be added to mini-grid regulation. Developing this new regulation and framework can take time but more financing can be secured if this can be developed at the earliest.

(d) Barrier: Inadequate renewable energy policy, strategy and its action plan
(d) Measure: Develop renewable energy policy, strategy and its action plan

Developing renewable energy policy with clear strategy and proper action plan takes longer time and when it would be available is also uncertain. Due to the long time it takes to draft and to publish a policy, the level of work that can be linked to existing related laws depends on the priorities of the work to be done and identification of relevant preliminary targets for long term. The parts that need to be drafted should be differentiated, and the clear targets should be included as well. Therefore, having strong policy with clear strategy, and proper action plans can support the renewable energy sector to move forward quickly and efficiently. Also, the coordination and cooperation among stakeholders and various ministers could be improved since policy has clear action plans for every related line ministries. Moreover, interested investors can directly invest in the area where the country prioritises or where investors are interested in. The sooner it gets done, the sooner the benefit can be

gained within the country. Therefore, the energy regulator should consider developing this official document at the earliest convenience.

Measure for technical barrier

(e) Barrier: Limited demand for productive activities in rural areas
(e) Measure: Stimulate productive use demand

The government may seek support either from INGO or from the Department of Agriculture to assess the energy requirement of the most important agriculture and food value chain in the rural area of Myanmar. This is to develop financially viable business models. Three or four business models that can be replicable and acceptable should develop and identify based on the situation of the rural agricultural value chain and rural people's needs. These models could support not only to improve rural agriculture and food businesses but also to gain revenue from solar mini-grid. In the meantime, Smart Power Myanmar is initiating to do the study on identifying potential agricultural-related businesses to stimulate the productive use demand. According to the stakeholder consultation meeting, DRD has coordination with Smart Power Myanmar. Therefore, this measure could achieve when the study finished. Consequently, interested investors (maybe people from solar mini-grid electrify villages or people from outside of the village) could invest in these businesses, and these results increase the demand for productive use.

(f) Barrier: Lack of grid interconnection system
(f) Measure: Develop a regulatory framework to enable grid interconnection and access grid interconnection technology

To uptake of solar mini-grid system, net metering provision is necessary to attract project developers because this is a billing mechanism that allows developers who generate electricity by using solar mini-grid to feed excess power to the national grid. Therefore, the project rate of return can be faster. Also, the villages which own the mini-grid system after the operation year of the developer can gain benefit from this system especially village income generation by selling extra electricity. The rules of grid interconnection can vary from one country to another. The energy regulator should consider the development of the grid interconnection policy and system to improve the country’s energy security because this policy can use not only for solar mini-grid systems but also for every electricity generation project by using renewable energy. Therefore, the country needs to develop a regulatory framework to enable grid interconnection and to access grid interconnection technology.

Measure for institutional and organizational barrier

(g) Barrier: Insufficient capacity of township-level staffs on solar mini-grid
(g) Measure: Providing capacity building

In Myanmar, most of the capacity building program are held in city where headquarter is located. Therefore, most of the participants from government are from headquarters. In solar mini-grid case, the project implementation is done with township level office, so the staffs from township level should increase their capacity on solar mini-grid operation and maintenance to support village after the operation year of project developer. Therefore, training program for staffs from government agencies should be considered to develop for capacity improvement on solar mini-grid system and

its operation and maintenance. This results the sustainability of the system for long time after receiving a handover of system assets from project developer.

Measure for information and awareness barrier

(h) Barrier: Inadequate public knowledge on solar PV system's capabilities
(h) Measure: Conduct workshops and roadshows on solar mini-grid to inform its capabilities for business activities

DRD should facilitate the workshops and roadshows to increase the knowledge of the people on solar mini-grid capabilities, and some business activities which can do with electricity from solar mini-grid such as producing agricultural relating products, fishery products. The businesses should be financially viable, and these should consume excess daytime loads in mini-grid areas.

1.2.4 Cost-Benefit Analysis of Solar Mini-Grid

A lot of demonstration solar mini-grid projects were implemented by ADB before 2018. Moreover, financial analysis were prepared by ADB in 2017 to inform the financial feasibility of the solar mini-grid system to stakeholders, investors, project developers, funding agencies, etc. In their financial analysis, they consider five main financial factors which are project costs, financial contributions, service fees, connection fees, and fees for operation and maintenance. In their calculation, two-level of tariff rate were considered, which is 500 MMK/ kWh for the first 100 Wh on any given day, and 1,500 MMK/ kWh for additional use. The tariff rate for enterprise is 1,500 MMK/kWh as well. They consider that the project developer provides 30,000 USD, and batteries will be replaced after 5 years of operation. Other project costs are from 60% grant funds and 20% community contribution. The total system installed cost is 150,000 USD for 200 households which is 9 USD/ W. The system design data is given in table 6.

Table 6: System design data of ADB demonstration project

Overall conversion efficiency	70%
Daily charging required (Wh)	75,000
Peak sun hour (h)	4.5
Suggested PV array (Wp)	16,667
Days of autonomy (@ 50% max DOD)	2
Battery capacity (AH @ 24V)	12,500

Source: (ADB(a), 2017)

Their estimated daily load per household is 100 Wh/day with three 5 W LEDs per household which account to use for 6 h/day each and one 5V 5W USB charger which is expected to be used for 2 h/day as a basic load estimation. Additional loads are twenty 10 W streetlights for using 6 h/day and 5 commercial users who may use 500 Wh/day each. Therefore, the total additional loads' estimation is 52,500 Wh/day. Also, there is a three-level of expected household demand.

Table 7: Estimated households demand

Household Demand	Quantity	Wh/HH/day	Wh/day
Total HH	200		
Basic consumers (50%)	100	100	10,000
Medium consumers (30%)	60	200	12,000
High consumers (20%)	40	400	16,000

Source: (ADB(a), 2017)

With these input parameters, this solar mini-grid system could generate 9,683 USD as a net profit after one year. Therefore, the payback period of the project is 5.9 years with 27% IRR.

1.3 Barrier analysis and possible enabling measures for LED

1.3.1 General description of LED

Generally, there are two types of lighting requirements - indoor lights and outdoor lights - that household needs. LEDs, Compact Fluorescent Lamps (CFLs), and Fluorescent Tubes are suitable technologies for both indoor and outdoor lighting requirements. In Myanmar, many different types of lighting appliances are used based on market availability and household income. In domestic usage, Incandescent Bulbs (GLS), Linear Fluorescent Lamp, and Compact Fluorescent Lamp (CFL) are very common, while LEDs are not very popular in the country.

LED is a two-lead semiconductor light source. LEDs transmit light in a particular direction, so these are called “directional light sources” in contrast to incandescent and CFL which transmit light and heat in every direction.

There are various types of LED bulbs such as solid-state lighting (SSL), organic light-emitting diodes (OLEDs), and light-emitting polymers (LEPs). Light is emitted by LED in a narrow spectral band as mention above but white light can be produced when phosphor material, a yellowish material, that can convert light color to a familiar “white” light used in homes is used to cover or combine with different color LEDs (including amber, red, green, and blue) (U.S. EPA ENERGY STAR Program, 2019). Therefore, these kinds of bulbs can be used in the daily life of offices and houses. Compared to other types of light bulbs, LED bulbs are more efficient, durable, and longer-lasting. LED consumes about 90% less energy than an incandescent bulb while CFL consumes around 75% less energy than incandescent bulb (Alt, 2020).

There are a lot of benefits from LED lighting system applications that can contribute to the country’s social, economic, and environmental development priorities. Regarding the social development

priorities of the country, households get direct benefits through the installation of LED which results in energy saving that leads to reduce household energy bill, increase the livelihood of the population, improve indoor comfort by accessing higher luminous efficacy. This technology contributes to the country's energy security supply which is the level of economic development priorities of the country because of the reduction of households' energy consumption. Moreover, the country's economic sector can revive due to the development of a new manufacturing sector. Regarding the environmental development of the country, government strategy can be fulfilled by providing environmentally sound energy supply through the application of LED technology. Since this technology can diffuse all over the country, the effective population that can benefit is quite high. Therefore, a huge amount of emissions can be reduced by this application.

Depending on the price of bulbs, quality and manufacturer, the cost for the application of LEDs system is varied. According to the LED market of Yangon in November 2019, the price of 18 W LED downlight (built-in type, Opple Brand) is around 10,000 Kyats which is equivalent to around 7 USD (assume 1 USD = 1,400 Kyats). This high initial cost is one of the main disadvantages for this technology diffusion. However, this technology is proven and available in Myanmar. Its market can be considerably increased if the enabling environment is in place (awareness, financial incentive, policy, and regulation, etc.).

1.3.2 Identification of barriers for LED

Firstly, the desk study reviewed the LED technology market situation in Myanmar, and the long list of barriers which is in Annex V is identified. Then, identification of barriers for LED technology which is the market goods is done by using the market mapping technique. There are three main parts of the market map. The top part describes the enabling environment while the central part is showing the supply chain of the market and the bottom part is illustrating the support services that support the supply chain's overall functioning. Through the interview with two LED shops and one construction company, the collected barriers were identified as the important elements for each section of the market map. Then, users' perspectives were collected to combine the information with information that obtains from the previous step. Therefore, logical problem analysis could be done by a combination of the above processes. Then, barriers in Table 8 as a list of key barriers are presented during the stakeholder consultation meeting for validation. As a final step, the draft report was shared with Energy Sector Working Group after doing stakeholder consultation meeting to review the report to collect the additional information.

The manufacturing of LED bulbs is almost negligible in Myanmar. Various types of LED products are imported by importers or suppliers, and then they distribute to the wholesalers or supermarkets. Again, wholesalers distribute to retailers who sell LED products to customers. In some cases, suppliers have their shop to sell directly to the customers. Also, wholesalers sell directly to the customers. Since suppliers are the key player in the market, they face financial barriers, policy barriers, technical barriers to distributing to the market.

The step-by-step process of barrier identification is based on combination of consultant's knowledge, key informant interviews and stakeholder consultation. Following are overall process of barriers identification:

a. A desk study and literature review
b. Market mapping tool
c. Key informant interviews
d. Collection of users' perspective
e. Logical Problem analysis
f. Guidance from TNA guidebook
g. Stakeholder consultation workshop

The major barriers in the wide diffusion of LED technology are categorized under economic and financial and non-financial barriers.

Table 8: Identified barriers for LED technology

Category	Barrier Dimension	Main Barriers
Economic and financial barriers	Cost	(a) High initial cost because of tax and import duty (b) Lack of financial support (c) Lack of economic feasible data
Non-financial barriers	Policy, legal and regulatory	(d) Lack of legal, regulatory and enforcement framework for lighting
	Institutional and organizational capacity	(e) Limited coordination capacity of existing organizations
	Technical	(f) Lack of (minimum) performance standard and labelling (g) Lack of quality control and assurance
	Information and awareness	(h) Limited market information and awareness, and inadequate knowledge about e-waste
	Social and culture	(i) Insufficient ability to foresee potential benefit due to household income

1.3.2.1 Economic and financial barriers for LED

High cost of capital barriers

(a) High initial cost because of tax and import duty

Normally, more efficient products are relatively higher in price than normal products. In Myanmar, the root causes of high prices of the product are lack of manufacturing, (less) size of the market, and import taxes. Currently, there is no tax exemption from the current tax law for energy-efficient appliances. Therefore, these appliances are levied import duty and tax during importation and during selling such as custom duty and commercial tax. However, the rate of import duties is different for importation from non-FTA countries and from FTA countries. Recent tax policy plus the size of the market is a factor that is preventing wholesalers and retailers to offer LEDs at an affordable price.

(b) Lack of financial support

The proposed technology is market-driven products since LED is categorized into consumer goods, unlike renewable energy projects and large energy efficiency projects. Moreover, hire purchase or credit schemes cannot be accessed by people unlike for other electric appliances such as a refrigerator, TV, air-conditioner, washing machine. Therefore, house owners need to buy this appliance with their own money.

(c) Lack of economic feasible data

LED is just starting to be popular in Myanmar especially in the urban area, but there is no data that is telling the economic feasibility of this technology. Since this technology is relatively more expensive than CFL and incandescent bulb, and this technology is not easily accessible for households, from the perspective of people this is financially unfeasible, and so, they are generally reluctant to invest on this technology.

1.3.2.2 Non-financial barriers for LED

Policy, legal and regulatory

(d) Lack of legal, regulatory and enforcement framework for lighting

Even though Myanmar has Energy Efficiency Policy, Strategy, and Roadmap as a draft, there is still a gap for energy-efficient lighting systems. This is one of the fundamental barriers to diffuse this proposed technology well in the country. Without a legal and regulatory framework, there is no compliance guideline to follow to ensure the sustainability of the technology. For example, inferior quality lighting products such as low-quality products, no certification products and low standard products can be entered into a country since there is no entry requirement as a legal and regulatory framework. Moreover, the country could face difficulty to control and prevent the entry of the low efficient products since legal enforcement is not in place.

Institutional and organizational capacity barrier

(e) Limited coordination capacity of existing organizations

There is a weak institutional basis of relevant institutions and agencies, including local authorities. This is because of the poor access to technical capacity and the poor coordination of activities among relevant organizations. For example, coordination between the energy efficiency and conservation department and custom department is lacking to review the custom duty to update for energy-efficient appliances, because these organizations have a limited capacity in terms of human resource and

technical capacity. Therefore, limited coordination capacity of existing organizations could be noticed as one of the barriers for impeding the diffusion of the technology.

Technical barriers

(f) Lack of (minimum) energy performance standard and labelling

Not only LED but also other lighting and electric appliances have lack of standard and labelling. Most imported LED products in the market are labeled in foreign languages especially with English, Thai, and Chinese. Therefore, most consumers have a difficulty to understand well the description of the products. As a result, improper application can be seen in some instances. In the case of LED standard, Myanmar does not have the country's own standard for electric appliances. Lacking standards could lead to import lower efficiency products since there is no benchmark to follow for importation. Therefore, importers cannot follow the minimum standard to meet the country's efficiency level. Consequently, low-quality products are in the market, and people cannot use these products correctly. Moreover, consumers cannot see the potential benefit of the LED when they decide to buy lighting products.

(g) Lack of quality control and assurance

The issue of quality is directly linked to lacking quality control systems in the country to check the quality and performance that are stated in the product manual. For example, LED lamps claim that the lifetime of LED is 10,000 hours (this may be vary based on the product brand and quality), and the price tag is based on this and its rated luminous flux. However, in practice, this claim cannot be verified in the country. According to the market map, the country cannot test the quality of LED because of lack of testing centers. As a result, low-quality products are imported into the country since these are cheaper than better quality products.

Information and awareness barrier

(h) Limited market information and awareness, and inadequate knowledge about e-waste

Most of the people in Myanmar especially in the rural area are far away to access the latest information or update information on this proposed technology because these cannot see in the public domain. Most information about this technology is advertised in the supermarket in city areas and the website which is owned by electrical appliances selling companies. Therefore, people are not aware of this technology very much. Moreover, most people in Myanmar just throw away LED waste into the dustbin without considering the problems of e-wastes and the negative impacts of electrical appliances wastes. Therefore, a vast amount of LED wastes is expected in the future. As a consequence, environmental contamination would be increased because of unawareness regarding disposal of LED waste.

Social and culture barrier

(i) Insufficient ability to foresee potential benefit due to household income

Myanmar poverty rate is 24.8% in 2017 (ADB, 2020), and 70% of the population are living in rural areas. Moreover, only 50% of households have access to grid electricity. The combination of the poverty rate and low electricity access rate is limiting the market size of Myanmar. Moreover, some users choose the lamps and lighting systems based on the design rather than considering the cost and

energy saving in some situations. Additionally, the English term "LED" might be difficult to pronounce for most of the Myanmar people and might have difficulties for asking and buying. However, this barrier is directly linked with the poverty situation and market information while most people do not want to invest in LED because of the higher price, which may be 5 times higher than an incandescent bulb and 3 times higher than a fluorescent lamp, rather than seeing the benefits of LED such as energy bill saving, longer lifetime, better quality. Therefore, people are normally not interested in buying more efficient electric appliances because they think that these appliances are just higher in price and people sometimes need to adjust to their household income.

1.3.3 Identified measures for LED

The measures for overcoming barriers to promote LED technology are initially identified by the TNA consultant's experiences, field visit, and interviews with project developers in the field. These are supplemented by reviewing existing literature in the country and other countries' experiences. As a result, the logical problem analysis support to shift from problems to a solution. The measures are grouped and evaluated during the online stakeholder consultation meeting. Moreover, measures are finalized by requesting extra comments from line ministries for further input.

1.3.3.1 Economic and financial measures for LED

Measures for high cost of capital barrier

(a) Barrier: High initial cost because of tax and import duty
(a) Measure: Consider to create tax incentives for importation

Even though electricity generation projects are exempted from some taxes, residential energy efficiency projects are not included in the list of tax exemption. Currently, LED suppliers are levied 5% commercial tax during importation and different amount of import duty based on the countries. Therefore, the market price of LED is already increased in the local market as a price compensation of tax. For example, the actual price of LED is around 7.1 USD but the market price is 7.5 USD while retailers or suppliers add on 5% commercial tax on their products to sell in the market. To reduce the capital cost of LED, the government should consider creating tax incentives for importing LED to support the diffusion of technology by reducing or eliminating commercial tax on the LED. As a consequence, people will access this proposed technology more than before due to price reduction, so the affordable price can be offered in the market.

(b) Barrier: Lack of financial support
(b) Measure: Create subsidy program for customers

There are two options to support customers and importers to successfully penetrate the proposed technology in the country. First, the government could allocate the budget to distribute LEDs in the targeted area of the country like the budget for the Dry Zone Greening Department to distribute improved fuelwood cookstoves in very remote areas of Dry Zone. This program distributes cookstoves to people free of charge. However, the program for LED should not follow that program because the sense of ownership of the products can disappear when people get products free. Moreover, people will be reluctant to buy to replace the products with their own money once the product is broken. Therefore, the program should be market-based. For example, the government

should subsidize some amount of the product cost for customers. This can be done with cooperation with suppliers.

Second, is that the government could seek support from donor agencies to access funding or loan to promote this technology. Then, this funding or loan can be considered to provide funds on concessionary terms (for instance - low-interest rate loan) to the suppliers or companies to distribute the proposed technology. Such funding should be going through either the government treasury or commercial banks.

(c) Barrier: Lack of economic feasible data
(c) Measure: Conduct economic and financial feasibility study and disseminate the study result to the public

This is suggested that the relevant ministry such as the Energy efficiency and conservation department should conduct an economic and financial feasibility study of this proposed technology. Then, this study results should be available to the public and decision-makers by disseminating the study result. Competent national personnel should conduct this study for ensuring the results. To conduct the study, the government could reserve the budget or engage INGOs who already have the initiative on promoting an efficient lighting system.

1.3.3.2 Non-financial measures for LED

Measure for policy, legal and regulatory barrier

(d) Barrier: Lack of legal, regulatory and enforcement framework for lighting
(d) Measure: Develop sufficient legal, regulatory and enforcement framework

Adoption of the Energy Efficiency and Conservation Law and the Energy Conservation Guideline is essential to enhance the use of energy efficient lighting in both residential and commercial buildings. To encourage the efficient use of energy in the residential and commercial sector, energy efficiency legal and regulatory framework should be developed for lighting, and this framework should be a part of the Energy Conservation Guideline. The framework should include the entry requirements of the products which are legislation which is describing a certain set of conditions for lighting that should be met before importation to the country, registration scheme, and verification program which is a program for testing the product parameters. Moreover, the enforcement framework which is a legal framework that is stating for importers and suppliers to comply with national legislation should also be developed to support the strengthening of the legal and regulatory framework.

Measure for institutional and organizational barrier

(e) Barrier: Limited coordination capacity in existing organizations
(e) Measure: Enhance coordination between line ministries

In this regard, the measure focuses more on coordination between line ministries for LED technology diffusion in the country. This includes cooperation between Energy Efficiency and Conservation Department and Departments who have responsibilities to collect taxes and import duties to review current tax policy to create an enabling environment for technology importation. Moreover, collaboration with the Department of Research and Innovation should be carried out to develop a national standard and labelling system for lighting. Additionally, existing institutions and

organizations have a limited capacity of cooperation for developing appropriate policy, legal, procedural matters and technical matters. Therefore, the capacity required to fulfil should be considered as well since this is one of the barriers facing any organization.

Measure for technical barriers

(f) Barrier: Lack of (minimum) standard and labelling
(f) Measure: Develop standard and labelling

Energy standards and labelling are essential for not only LED but also all-electric appliances to meet the minimum energy efficiency standard of the country and to encourage consumers to consider the pros and cons of the electric products before buying any appliances or items. Therefore, it is recommended that the national minimum performance standard for LED should be developed by the government. Moreover, all labels should be in Burmese languages since labelling is a tool to provide advantages and disadvantages of the products to consumers. An example from Thailand, many of the products from Thailand have an energy label which is commonly seen on refrigerators, TV, washing machines, etc. with their local language. These can be seen as well in Myanmar since most appliances are imported from Thailand. Thailand's energy labelling system provides to achieve the country energy-saving targets as well as GHG emission reduction.

(g) Barrier: Lack of quality control and assurance
(g) Measure: Develop quality control system and establish testing laboratory

To ensure the quality of the products, an appropriate testing mechanism should be in place. An appropriate methodology is required to develop to test samples of LED under more stringent conditions with the view to judge the estimated rated luminous flux and the lifetime of LED. As a consequence, the testing institution should be introduced to carry out the testing and issue the certification for quality based on the test results. Therefore, the testing center is needed to establish the soonest. Stakeholders think that this service should be provided to control the quality of LEDs. Moreover, consumers may want support to provide quality assurance on the product performance from state institutions due to high payable price.

Information and awareness barrier

(h) Barrier: Limited market information and awareness, and inadequate knowledge about e-waste
(h) Measure: Promote public awareness

As LED is a market-driven product, public awareness is important to diffuse the technology well. To promote public awareness, a promotion campaign should be considered to do in a crowded area such as a supermarket, local market. Moreover, the media campaign is also an effective way of product marketing and promotion by using radio, TV, social network, etc. Additionally, the public event can be facilitated in some days like World Environment Day. Also, the information on the technology can be spread through awareness-raising materials like posters, pamphlets, brochures, billboards, etc. These activates could be done through cooperation with private sectors to promote the products. During the promotion of public awareness, there should have information of the different variety of LEDs in the market (e.g – color, design and shape), localized term of LED to be enabled to understand

easily by local people, and the benefit of using LED such as energy bill saving, reduce energy consumption and improve living condition through getting more lumens from the LED.

Concerning waste management, the government should introduce a systematic waste throw-away plan to people including how to throw-away trashes and electrical waste, how to separate wastes, etc.

Social and culture barrier

(i) Unchanged behaviour of seeing only on initial price
(i) Measure: Conduct awareness raising

There is a very common behaviour that can be seen in Myanmar which is always seeing only on initial price rather than seeing the benefits of using the product. This is very normal in Myanmar because of the poverty rate and limited information. This can be eliminated through conducting public awareness-raising campaigns. Therefore, the measure for this barrier is the same as the measure for limited market information and awareness barrier. Together with an awareness-raising programs, appropriate practices or ways to convince users should be considered to include in the program for ensuring the implementation of this technology over time.

1.3.4 Cost-Benefit Analysis of LED

To see technology economic viability, Cost-Benefit Analysis (CBA) was conducted for LED technology while CBA is a technique to access monetary costs and benefits of technology implementation over a while. NPV of costs and benefits are calculated in this analysis.

Table 9: Costs and Benefits included in CBA of LED Program for 0.5 million households

Total implementing cost of LED Program	Total benefit of LED Program
- Developing Minimum energy performance standard and labeling - Staff cost for 4 years program - Market Monitoring, verification and enforcement for 4 years - Awareness raising and demonstration project for 4 years - Hiring experts for assessment and analysis - Testing Center - Training for Testing Center - LED subsidy for one time during program years (50%) - HH buying new LED for replacement	Social Benefits - Total households' electricity saving bill - Total avoided replacement cost of lighting fixtures due to LED Economic Benefits - Avoided capital investment for electricity generation Environmental Benefit - Total emission reduction cost

The following assumptions are used to conduct CBA for LED intervention:

- 5 lightings from each household are assumed for the calculation. The ownership rates of lightings are 100 % rate for compact fluorescent lamp tubes and around 39% rate for an incandescent lamp according to a field survey in 2014 (Htet, 2015).
- LED 18 W Opple Downlight which is around 7.5 USD and 11 W Philips LED stick which is around 4.4 USD are considered as the same with 40 W 4 ft Fluorescent Lamp Tube which is around 2.8 USD and 90 W incandescent lamp which is around 0.7 USD based on price list from the retailer.
- It is assumed that every household uses lighting for 5 hours daily starting from 18:30 to 23:30.
- The assumption for the tariff rate is 0.036 USD/ unit which is equivalent to 50 MMK/ unit. This cost is considered as a flat rate even though the tariff rate is varied based on the total consumption unit per month starting from 35 MMK/unit to 125 MMK/unit.
- The money exchange rate is 1400 MMK / USD.
- The total discount rate is assumed at 10%.
- The grid emission factor is taken as 0.32 ton CO_2 / MWh (ADB(b), 2017).
  To calculate avoided electricity generation, below assumptions are made
    - T&D Losses = 30%,
    - System Load Factor = 81%
    - Capax of gas turbine (F-type) = 486 USD/kW **(NEMC, 2015)**
- The social cost of carbon from USEPA (per ton) for CO_2 is 36 USD/ ton **(Rivoal & Haselip, 2017)**.
- The assumption of lighting life span is relatively favored to the actual lifetime of lighting application while mention the life span on the package is different in reality. The life span of LED which is described on the package of LED is 30,000 hours for 18 W Downlight LED and 15,000 hours for 11 W LED stick. Based on the mention life span, these LEDs could be used for more than 16 years. However, replacement time for LED is considered every 5 years, and individual household needs to invest their investment.

Cost assessment: The total implementation cost of LED intervention at Year-1 is presented in Table 10. Throughout the program period, a one-time subsidy is provided with 50% for each household. The total cost of this intervention is around 8.6 million USD.

Table 10: Total implementation cost of the LED program at first year

No	Items	Cost in Year 1 (USD)
1.	Developing Minimum energy performance standard and labelling	12,500
2.	Staff cost for 4 years program	60,000
3.	Market Monitoring, verification and enforcement for 4 years	250,000
4.	Awareness raising and demonstration project for 4 years	250,000
5.	Hiring experts for assessment and analysis	16,667

6.	Testing Center	50,000
7.	Training for Testing Center	5,000
8.	LED subsidy for one time during program years (50%)	7,972,222
	Total Cost	8,616,389

Benefit assessment: Apart from total HH electricity-saving bill benefits, other benefits are not accounted for in the first year of the program as they generally do not show immediately. However, the total benefit in year 5 is 11,626,358 USD since another investment to replace the old LED is accounted for. Avoided CO_2 emission reduction due to replacement with LED is estimated as around 64,807 tons CO_2/ year. Overall benefits are shown in table 11.

Table 11: Annual total benefits of program

No	Description	Cost (USD)
1.	Total HH electricity saving bill	2,485,024
2.	Total avoided replacement cost of lighting fixtures due to LED	5,038,690
3.	Avoided Capital investment for electricity generation	6,808,284
4.	Total emission reduction cost (CO_2)	2,333,051
	Total benefit	16,665,049

The program yields a net benefit of 16,070,882 USD after one year. In a 10 year period (Table 12) this intervention generates 59,224,821 USD of NPV with a 1.55 benefit-cost ratio and IRR is 224%. Even in a shorter period, NPV shows a positive value which is 28,088,864 USD for 5 years of the intervention period. The benefit-cost ratio (BCR) of 5 years program is 1.19 with 223% of IRR. Therefore, the program is economically viable.

Table 12: Cost overview of 10 years and 5 years LED intervention

	NPV	Discount benefits	Discount costs	BCR	IRR
10 years program	59,224,821	59,224,821	38,154,873	1.55	224%
5 years program	28,088,864	28,088,864	23,659,924	1.19	223%

1.4 Barrier analysis and possible enabling measures for Substitution of Fuelwood with Efficient Fuel (LPG) at Household Level for Cooking

1.4.1 General description of Substitution of Fuelwood with Efficient Fuel (LPG) at Household Level for Cooking

Liquefied petroleum gas, LPG, has a high energy per unit volume and is convenient to use. Its calorific value per unit volume is about 2.5 times larger than that of natural gas (methane). It is used for road transport, cooking, heating, refrigeration, air conditioning, and spray cans. It is a portable source of energy used for remote and leisure applications in cooking and transport in developing countries. LPG is manufactured during the refining of crude oil (40%) or from natural gas during extraction (60%). LPG is a hydrocarbon fuel comprised of propane and/or butane and used for heating, cooking, and transport (autogas) in developing markets. It is compressed into a liquid for storage in cylinders and can be easily imported and distributed without complex piped natural gas distribution systems. Currently, LPG is widely used in the county but it is not dominant in the cooking sector. Fuel switching from fuelwood to LPG could be a clean source of energy for cooking.

In Myanmar, LPG is stored in cylinders by using Manual, Containerized Filling, and Automatic Filling Carrousels. Portable cartridge, 4 kg, 7kg, 15 kg, and 25 kg Cylinders are used in households. Myanma Petrochemical Enterprise distributes its own 25 kg Butane & 50 kg Propane cylinders. Myanmar LPG Market has various types & brands of LPG cylinder. It is connected with a hosepipe to the gas stove. These are system components of LPG stoves such as cylinders, connection hoses, regulators, and cooking stoves. Single Burner gas stove and Double Burner gas stove are applied commonly to use in households.

The reliability of LPG cookstoves is generally considered high as the technology is mature and applied widely across the world and even in Myanmar as well. According to the LPG plan, the Myanmar LPG market has a huge potential for expansion and it provides a clean and cost-effective alternative fuel for cooking purposes, particularly in household levels. Demand for LPG in Myanmar has been growing at 15-20% per annum for the past five years based on the year 2017 (Myint, 2018). This growth is driven mainly by the population switching from traditional fuel to LPG as their preferred energy source for cooking. Currently, only 12% of Myanmar's population is using LPG and there is still considerable room for the growth in demand to continue for the next five to ten years.

Many benefits can gain by using an LPG cookstove instead of a fuelwood stove. Users will get direct benefits through using the LPG cookstove. Firstly, users will have a clean kitchen environment since smoke from LPG is much lesser than a fuelwood stove. Therefore, the indoor air quality of users' homes will be improved. Then, cooking time is faster with LPG, so users will have extra time to do other home activities. Moreover, fuel collecting time for cooking can be saved. Since indoor air quality of homes is improved, respiratory system problems which cause because of smoke and other pollutants will be reduced. Consequently, this proposed technology contributes to achieving national social development priorities. In terms of economic development priorities, both users and countries could have direct benefits. On the users' side, they can do extra income generation activities since cooking time with LPG can save nearly 4 hours compared to cooking with biomass (Rivoal & Haselip, 2017). On the country's side, the country will get a direct benefit by selling its own LPG

from MPE for the household cooking sector. Regards to environmental development priorities, the deforestation rate could be reduced by avoiding cutting trees for firewood and charcoal production. Moreover, national-level GHG emission can reduce since emission from the household cooking sector is significantly reduced avoiding the use of fuelwood and charcoal for cooking, and the deforestation rates are decreased.

1.4.2 Identification of barriers for Substitution of Fuelwood with Efficient Fuel (LPG) at Household Level for Cooking

The literature review is the very initial step of collecting information for barrier analysis to identify the long list of barriers which is in Annex V. The collected information is transformed into a market map since the LPG cookstove is consumer-driven products. Moreover, a logical problem tree is developed to analyze the root cause of barriers. Then, elements in the market map are identified by conducting a bilateral meeting with MPE. After the meeting, the market map and logical problem trees are modified, and potential barriers can identify. As mentioned for previous technologies, the market map has three main sections. The top section is the enabling framework section. The core section of the market map is called the supply chain which is the middle section of the market map while support services are described in the bottom section. Through interviews with users and phone meetings with working group members from MPE, the collected main barriers are categorized into two different groups which are financial barriers and non-financial barriers. Then, the main barriers are cascade down seven different sub barriers for barrier analysis. These barriers are discussed in the stakeholder consultation meeting with Energy Sector Working Group to identify as key barriers for validation.

As the market map reveals, LPG is produced in the country by MPE and also imported from Thailand. However, there is no cylinder manufacturing for the gas tank inside the country. All empty cylinders which are used in the MPE production area and filling stations are imported. In this technology, MPE is the main regulator body for the whole market to issue different kinds of LPG licenses such as retailer licenses, importation licenses, and storage licenses. MPE itself has its barriers to promote the technology. Moreover, every actor in the supply chain of LPG faces different barriers individually.

The overall barriers identification is done by applying the following processes. This is completed by a combination of consultant's knowledge, key informant interviews, and stakeholder consultation.

a. A desk study and literature review
b. Bilateral meeting
c. Market mapping tool
d. Logical Problem analysis
e. Key informant interviews
f. Collection of users' perspective
g. Guidance from TNA guidebook
h. Stakeholder consultation workshop

The major barriers in the wide diffusion of substitution of fuelwood with efficient fuel (LPG) at household level for cooking are categorized under economic and financial and non-financial barriers.

Table 13: Identified barriers for substitution of fuelwood with efficient fuel (LPG) at household level for cooking

Category	Barrier Dimension	Main Barriers
Economic and financial barriers	Cost	(a) High capital cost due to taxes and import duty (b) Lack of subsidy
Non-financial barriers	Policy, legal and regulatory	(c) Weakness of LPG Law
	Institutional and organizational capacity	(d) Inadequate cooperation between key stakeholders (e) Insufficient human capacity and resources for inspection
	Technical	(f) Insufficient infrastructure (g) Lack of local gas tank (cylinder) manufacturing
	Information and awareness	(h) Insufficient information about LPG
	Social and culture	(g) Safety issue: Afraid of the explosion

1.4.2.1 Economic and financial barriers for Substitution of Fuelwood with Efficient Fuel (LPG) at Household Level for Cooking

High capital cost barriers

(a) High capital cost due to taxes and import duty

LPG businesses are not listed in the tax exemption list of Myanmar. Currently, the LPG cost of capital is therefore high due to 2% advanced tax, 3% customs duty, and 5% commercial tax for LPG importation. Moreover, transportation charges are added to the capital cost because of border trade. In total, 10% of taxes are levied by the government on LPG businesses. However, the rate of import duty is different for importation from non-FTA countries and from FTA countries. As a consequence, the cost of buying LPG is high in the market since LPG users are paying the cost beyond the actual cost of LPG (fuel) and related accessories for the stove.

(b) Lack of subsidy

Since this proposed technology is market-driven products (consumer goods), consumers are not entitled to access to hire purchase or credit schemes, unlike other valuable home appliances. Moreover, both government and private sectors are not currently showing interest to provide subsidies for the household to encourage using LPG as cooking fuel. Therefore, the lack of subsidy is one of the bottlenecks to promote the use of LPG in the household cooking sector.

1.4.2.2 Non-financial barriers for Substitution of Fuelwood with Efficient Fuel (LPG) at Household Level for Cooking

Policy, legal and regulatory barrier

(c) Weakness of LPG Law

MPE is the regulatory body of the LPG business. Currently, MPE issues different types of LPG licenses such as retailer license, warehouse license, and importation license to operate the LPG business in the country. Even though the country has such kind of regulations are available for LPG business, LPG Law is still absent to guide the whole sector to move forward successfully. Therefore, this barrier is hindering to development LPG market.

Institutional and organizational barriers

(d) Inadequacy cooperation between key stakeholders

In 2018, the government initiated the development of public-private partnerships for the development of LPG importation capacity, and a target of LPG distribution is one million households in 2020 (Ko, 2018).However, the target is not met according to a bilateral meeting with MPE. Moreover, no monitoring institution is in place to check the milestone. That target is not met due to insufficient cooperation between the regulator body and implementation body which may be from the LPG community. On the other hand, insufficient cooperation between line ministries can be seen. For example, there is no initiative from line ministries to review tax policies together for LPG importation.

(e) Insufficient human capacity and resources for inspection

As mentioned previously, MPE is a regulatory body of LPG business in the country. MPE normally make only one-time inspection per year for the safety of gas tank in retailer shops, storage areas and filling stations once business persons come to extend their business licenses. Due to limited human resources and capacities, MPE cannot be done regular inspection (for example – quarterly inspection). Consequently, the risk may increase at filling stations, storage areas, and retailer shops.

Technical barriers

(f) Insufficient infrastructure

First of all, the country has a weakness in LPG transportation. Normally, LPG is transported by bowser (tank lorry), tank trailer, and barge up to the designated places and cylinders as well up to the rural area. The standard for bowser (tank lorry) is not adequate. Moreover, the standard for cylinders is absence and ownership of cylinders as well in some places. These lead to the slow transportation of LPG to reach rural areas. What is more, last-mile retailers are lacking in very remote areas even

though MPE issues retailer license. As a result, LPG market penetration in a very remote area is quite low.

(g) Lack of local gas tank (cylinder) manufacturing

The Market map reveals that local manufacturing of gas tank (cylinders) and stoves are absent. All accessories are imported from Thailand, China, India, and Japan. Due to the weakness of technology transfer, lack of local gas tank manufacturing is hindering to promote LPG cookstoves in the rural area. Moreover, most of the local companies are not interested in investing in the manufacturing of gas tanks due to the narrow market.

Information and awareness barrier

(h) Insufficient information about LPG

Currently, several promotion and marketing activities can only be seen in city areas compared to the rural area. Even in the city area, effective advertisement is very less since most retailer shops just distribute leaflets near their shops. Also, sufficient information and awareness as like as advantages of using LPG such as time-saving, air quality, clean environment, reduce health impacts are absent in their leaflet. They are just an advertisement for the price of LPG and information about their shop. Therefore, people not only in the urban area but also in rural areas do not receive sufficient information about LPG. As a consequence, people are not well attracted to use LPG around the country. On the other hand, some people especially from rural areas are unaware of the negative impacts of firewoods and charcoals on the environment and human health compared to benefit of LPG and LPG stove.

Social and culture barrier

(i) Safety issues: Afraid of the explosion

This barrier is in-line with many studies which are indicating that social and culture barrier is hindering the diffusion of cookstoves against traditional stoves while user perspective on traditional fuelwood stove is better in safety and can give better taste than other types of cookstoves. In the case of LPG stoves, most people in Myanmar are afraid of using LPG stoves because they think that LPG is easily flammable and it is very easy to explode. Therefore, very few users can be seen outside of urban areas. On the other hand, it is easier to access to firewood than LPG at some village level, and many people think that firewood is safer than LPG.

1.4.3 Identified measures for Substitution of Fuelwood with Efficient Fuel (LPG) at Household Level for Cooking

The measures for overcoming barriers for the LPG technology are initially identified by the TNA consultant's own experiences, his field visit, and his interviews with project developers in the field. These are supplemented by the desk study in the literature in the country and other countries' experiences. As a result, the logical problem analysis support to shift from problems to a solution. The measures are grouped and evaluated during the online stakeholder consultation meeting and by requesting extra comments from line ministries.

1.4.3.1 Economic and financial measures for Substitution of Fuelwood with Efficient Fuel (LPG) at Household Level for Cooking

Measure for high capital cost barriers

(a) Barrier: High capital cost due to taxes
(a) Measure: Consider to reduce taxes for importation

In the domestic cooking sector, the LPG cookstove has a high initial cost compared to traditional cookstoves. The price of the LPG cookstove starting from 15,000 MMK while the traditional cookstove price is around 3,000 MMK. These prices can vary place to place, so the LPG cookstove is nearly 5 times more expensive than a fuelwood stove. Therefore, it is suggested that the government should consider reducing taxes for importation or to exempt some taxes for certain years to promote the use of LPG cookstoves around Myanmar. Moreover, the government should consider this measure as the invitation of the investment for the sustainable development of the LPG market and businesses.

(b) Barrier: Lack of subsidy
(b) Measure: Create subsidy programme for fuel switching

The government may seek support from international funding agencies to create a subsidy program. For example, Myanmar is eligible to apply the Green Climate Fund with the support of the country's NDC to offset the emission from the household cooking sector. Once the government receives funding, the government could develop its strategy to distribute LPG or the government could adopt the strategy from Indonesia as well which is based on the cylinder recirculation model. In that model, households only need to exchange their empty cylinder with a full one which is at the government subsidy rate. At the initial stage, a free LPG "starter pack" which is including a 3-kg cylinder, single-burner stove, rubber hose, and regulator is distributed to households and small businesses. The value of the starter pack is around 33 USD (Thoday, Benjamin, Gan, & Puzzolo, 2018). On the other hand, the government may offer a company or NGO that is interesting to promote the LPG cookstove program in the country by participating in the voluntary carbon market to buy carbon credits. Therefore, government strategy is very essential to provide subsidy for household-level customers, and the government should prevent becoming long-term subsidies and unmanageable financial burdens by slowly conversion into the market pricing system after providing targeted subsidies for low-income households (Clean Cooking Alliance, 2019). In the absence of sufficient financial resources and subsidies, plans should be made to attract foreign investment for the necessary funds and subsidies

1.4.3.2 Non-financial measures for Substitution of Fuelwood with Efficient Fuel (LPG) at Household Level for Cooking

Measure for policy, legal and regulatory barrier

(c) Barrier: Weakness of LPG Law
(c) Measure: Develop LPG Law

According to information from MPE, MPE has an initiative for developing LPG Law. The law is in the drafting stage, and it is expected to be published very soon which may be either in 2020 or in

2021. Therefore, the barrier will be addressed once it is published by MPE. Due to the length of time it takes to draft a law, it is important to prioritize the work to be done by the energy master plan, and the parts that need to be treated as important for LPG market development should be differentiated clearly in the law.

Measure for institutional and organizational barriers

(d) Barrier: Inadequacy cooperation between key stakeholders
(d) Measure: Enhance cooperation between key stakeholders

It is suggested that MPE should initiate to discuss to review current tax policy for LPG with the cooperation with relevant ministries. As a result, there will be an outcome for LPG business in terms of tax reduction or tax exemption. Moreover, the regulatory body and private sector should be engaged more than before to promote LPG markets for wide penetration in the country. For example, a pilot project or economic feasibility assessment of LPG cookstove distribution in a rural area could be done through a public-private partnership.

(e) Barrier: Insufficient human capacity and resources for inspection
(e) Measure: Conduct technical training for inspection

Before introducing this proposed technology, the regulatory body should be ready for human resources and capacities for inspecting to ensure safety and avoid leakage of gas at various working places of license holders such as retailer shops, filling stations, warehouses before transporting to consumers. Therefore, regular technical and health and safety inspection should be done by MPE. As a consequence, developing training programs for staff from not only headquarters but also local offices are necessary to get enough exposure for inspection. Then, these trained staff should be assigned to make inspections quarterly.

Measure for technical barriers

(f) Barrier: Insufficient infrastructure
(f) Measure: Develop quality control and standard for gas tank and open last mile retailer shops

For better LPG cylinders transportation with better safety, it is suggested that quality control and standard for the gas tank to guarantee the safety of the cylinders (e.g thickness, lifespan, materials, storage guideline, sealing, etc.) should be developed by MPE. MPE should limit the total capacity of cylinders (for example – must not exceed 9 kg) when the car is used for transporting cylinders. That limit can be varied based on the size of the car. Also, the number of cylinders should be limited for transportation from retailer shops and filling stations. To stimulate to increase the use of LPG cookstove in rural areas, MPE is recommended that some state own retailer shops should be opened at the last mile. On the other hand, MPE could issue more retail licenses for retailers from a very remote rural area.

(g) Barrier: Lack of local gas tank (cylinder) manufacturing
(g) Measure: Transfer cylinder manufacturing technology to the country

The cost of LPG is raised due to cylinder importation to use in the country. If the cylinder can be produced within the country, the price of LPG for the household cooking sector could be decreased.

Therefore, the government should engage in cylinder manufacturing companies to access technology and training. After receiving technology and training, these should be able to transfer to the country. Then, MPE shares the information for those who interest to invest in cylinders manufacturing. MPE should give favor for interested people to manufacture to access tax incentives or tax holidays for manufacturing.

Measure for information and awareness barrier

(h) Barrier: Insufficient information about LPG
(h) Measure: Promoting public awareness

For consumer goods, public awareness of products is playing a major role in achieving successful market penetration. Therefore, most people are needed to access enough information about LPG which is including the benefits of using LPG (cooking time-saving, less pollution easy to use, etc.), LPG accessible areas or shops, etc. To combat the barriers of limited awareness of people, MPE and the LPG community should facilitate promotion campaigns in selected areas. Moreover, TV and media advertisements, billboard advertisements, and social media advertising as awareness-raising channels are useful to enhance public knowledge and awareness. Together with the awareness program, there should is a need to find a strategy to implement the use of LPG over time. Moreover, educating on the negative impacts of unsustainable use of firewood and charcoal should be added ~~in~~ to the awareness program.

Measure for social and culture barrier

(i) Barrier: Afraid of explosion
(i) Measure: Conducting knowledge sharing sessions and promoting public awareness

LPG penetration is required because household cooking behavior is often influenced by aspirations for modernity, affordability, accessibility, and health benefits. Governments in collaboration with the LPG community should support effective public awareness campaigns on LPG benefits and safety. Promotion campaigns should be tailored to the local context via TV and media knowledge sharing programs, Billboard advertisement, social media knowledge sharing program, radio knowledge sharing programs, and LPG stove demonstration at promotion areas. Educational campaigns are sometimes useful. Especially health and environmental benefits should be underlined to target groups. The correct utilization should be advocated to avoid accidents.

1.4.4 Cost-Benefit Analysis of Substitution of Fuelwood with Efficient Fuel (LPG) at Household Level for Cooking

The same formula which is described in section 1.3.4 is used for conducting CBA for LPG intervention. Below table is mentioned the various input for CBA for 1 million households.

Table 14: Costs and Benefits included in CBA of LPG Program for 1 million households

Total implementing cost of LPG Program	Total benefit of LPG Program
- Total LPG starter packs - Marketing and promotion - Inspection Training for officials - Cost of retailer shop - Total refill cost for 1,000,00 HH for 3 years with subsidy rate - User manual for 1,000,000 HH - Training for 10 retailer shops - Staffing cost for 4 years program	Social Benefits - Total avoided cost of people who suffer UPRD per year (40% HH) Economic Benefits - Benefit of cooking time saving (4 hr doing income generation by 40% of HH) - Income generation by avoiding fuelwood collection per total HH per year (20% of HH) - Total fuelwood cost saving for 1,000,000 HH Environmental Benefit - Total emission reduction cost

In this CBA, following assumptions are considered;

- In the calculation, the household size is considered as 5 in line with GERES's Kitchen Performance Test.
- Only 40% of households are doing income generation activities during cooking time-saving. Cooking time-saving of the LPG stove is 4 hours compared to the fuelwood stove (Rivoal & Haselip, 2017). The daily labor rate is based on the rate from Myanmar Labor Law which is 4,800 MMK per day (600 MMK/ h).
- One time (4 hours) of one person fuel collection per year (24 times) is accounted here but several times might be carried out by several individuals in households with various time spending.
- Daily fuelwood consumption is 1.3542 kg per a.eq in one household according to GERES's Kitchen Performance Test (Upadhyay, 2018).
- This is assumed that the cost of fuelwood is 200 MMK per 1.3542 kg but the weight may be varying since the firewood in the market is selling with the local unit which is called the bundle. The actual cost of one bundle of the local market in Meikhtila is 200 MMK in November 2019 according to an interview with a firewood seller.
- In this scenario, health benefits are highly conservative. For example, it is assumed that people from 40% of household may need to go to the hospital for 8 times annually because of upper respiratory disease.
- Apart from LPG starter pack cost, other costs for program implementation are assumed.
- The total monthly gas refill weight is expected to be 4 kg/ HH. However, the weight may be changed or more when the household has guests and some donations for monks.
- The money exchange rate is 1400 MMK / USD.

- The total discount rate is assumed at 10%.

Cost assessment: Table 15 gives the total implementation cost of the program for Year 1. LPG starter pack is 22 USD/ HH including a 4 kg full of the gas tank, nozzle, and pot rest. The total monthly gas refill cost is with a 50% subsidy for 1 million households.

Table 15: Total implementation cost of the program at first year

No	Items	Cost (USD)
1	Total starter pack	22,000,000
2	Marketing and promotion	22,857
3	Inspection Training for officials	7,143
4	Cost of retailer shop	142,857
5	Total refill cost for 1,000,000 HH for 3 years	15,714,286
6	User manual for 1,000,000 HH	7,142,857
7	Training for 20 retailer shops	3,571
8	Staffing cost for 4 years program	72,000
	Total Cost	**43,677,000**

Benefit assessment: During the first year of the program, the environmental benefit is not accounted for as they do not show immediately (Rivoal & Haselip, 2017) but the social benefit (health benefit) is accounted for from the second half of the first year of the program. Avoided CO_2 and CH_4 emission per year by using LPG stoves is calculated as around 708,519 tons and around 2,270 tons respectively. Here, the CO_2 emission factor is 63,100 kg/TJ and CH_4 emission factor is 5 kg/TJ for LPG while 112,000 kg/TJ is for CO_2 and 300 kg/TJ is for CH_4 in fuelwood stoves. Table 16 presents the total benefits of LPG stoves in 1 year.

Table 16: Annual total benefits of the program after the first year

No	Benefits	Cost (USD)
1.	Total avoided cost of people who suffer UPRD per year (40% HH)	9,142,857
2.	Benefit of cooking time saving (4 hr doing income generation by 40% of HH)	8,228,571
3.	Income generation by avoiding fuelwood collection per total HH per year (20% of HH)	8,228,571
4.	Total fuelwood cost saving for 1, 000, 000 HH	1,428,571
	Total emission reduction cost	27,028,571

After year 1, the program yields about 21,704,258 USD net benefits. After 10 years, the NPV of LPG intervention is around 164,500,169 USD of benefits at a 10% discount rate (Table 17). Also, positive NPV can obtain even with a shorter program time of 5 years. NPV after 5 years generates around 87,839,075 USD of benefits at a 10% discount rate. The benefit-cost ratio (BCR) after 10 years is 2.014 and the IRR rate is 121%. BCR which is 1.085 is generated when the program runs for 5 years. IRR for 5 years program is 119%.

Table 17: Cost overview of 10 years and 5 years LPG intervention

	NPV	**Discount benefits**	**Discount costs**	**BCR**	**IRR**
10 years program	164,500,169	166,293,910	82,586,408	2.014	121%
5 years program	87,839,075	89,632,816	82,586,408	1.085	119%

1.5 Linkages of the barriers identified

Most of the barriers are similar to each other even though technologies' nature is different from one another. These barriers are specified as common barriers. These linked barriers are mentioned below.

1. High capital cost due to import tax

High capital cost due to import tax and lack of or insufficient financial support and subsidy are the most significant common barrier to all technologies in the Energy Sector. Since most of the equipment is imported, custom duty is levied on every equipment and the rate of customs duty is varies based on the countries of origin. Apart from custom duty, a 5% commercial tax is levied on every technology as well.

2. Lack of/ Insufficient financial support and subsidy

The insufficient subsidy is mainly concerning solar mini-grid technology because the country has a big financial gap to achieve NEP's target in 2030. Currently, DRD is providing subsidy for solar mini-grid with the support of funding agencies. However, this subsidy program could be ended when the budget is running out. In the case of LED technology and LPG technology, the country has no subsidy program to promote the diffusion of these technologies. Due to lack of subsidy, consumers need to invest their own money to apply these technologies at home.

3. Lack of / Insufficient policy, legal and regulatory framework

This is another common barrier for all technologies although the nature of the policy framework is varying from one another. Since the country does not have sufficient Renewable Energy Policy, Mini-grid regulation, Energy Efficiency Regulation for electrical appliances, and LPG Law, the pathway of more diffusion of these technologies are in the bottleneck. For example, developers are generally reluctant to invest more in solar mini-grid due to lack of cooperation between on-grid and off-grid concession which may be linked to insufficient renewable energy policy and lack of mini-grid regulation. In the case of LED, the benchmark for entry requirement is absence due to insufficient

energy efficiency legal and regulation framework for electrical appliances. This leads to diffuse poor-quality products in the country market in terms of energy efficiency, durability, etc. Regarding LPG technology, the market of the LPG in the country is monopolized by some companies that are financially strong due to the weakness of LPG Law.

4. Insufficient coordination between key stakeholders or line ministries

This barrier applies to LED and LPG technologies, and it is hindering technology diffusion and improvement of energy efficiency in the Residential Sector. Regarding LED technology, coordination between key ministries for technology implementation and for levying import tax is absences. This is an obstacle to create an enabling environment for the LED market. As a consequence, users are paying the high initial cost to apply this technology in their home without having participation in the technology promotion period in the country and accessing information of advantages from the demonstration project which is a promotion and testing program for LED technology. In the case of LPG technology, the regulator body and implementation body who might be from the LPG community do not have sufficient coordination for setting up a public-private partnership to distribute LPG cookstoves as a demonstration project for rural household according to fulfill the target of 1 million households in 2020.

5. Insufficient capacity in key institutions

This is also a common barrier for Solar mini-grid and LPG technology but the nature of the barrier is different. As mention in section 1.2.2.2, there is a capacity limitation in DRD township level staff to guide the village electrification committee for operation and maintenance of the solar mini-grid system after receiving a handover of solar mini-grid assets from developers after the operation period of developers. Regarding LPG technology, the proper inspection could not be done at filling stations, storage areas, retailer shops due to poor capacity of staff, and insufficient human resources in regulatory bodies. Therefore, a one-time inspection can be done until now when the license holder comes to MPE to extend the license period.

6. Limited market information

This barrier is hindering penetrating the local market especially outside of the main city areas of each State and Region. Since LED and LPG technology are consumer goods, public awareness is very essential to diffuse these technologies well. However, the market information of these technologies cannot be accessed by people easily because people cannot be able to see this information in the public domain. Currently, the advertisement of these technologies cannot be able to see widely even in the city area although people from city areas can access information from supermarkets and some retail shops. Therefore, people who are living outside of the city area are far away to access the latest information about technologies. They can only see some information about LED technology only in social media of LED retail shops but LPG technology is not.

1.6 Enabling framework for overcoming the barriers in the Energy Sector

The common barriers are already identified in the previous section. These common barriers are broad categories into (1) High capital cost due to import tax, (2) Lack of/ Insufficient financial support and subsidy, (3) Lack of / Insufficient policy, legal and regulatory framework, (4) Insufficient coordination between key stakeholders or line ministries, (5) Insufficient capacity in the key institution and (6) Limited market information. The table 18 proposes an enabling framework for common barriers. Moreover, technology specific enabling frameworks are presented in Table 19, 20 and 21 to overcome the technology specific barriers.

Table 18: Common barriers and proposed enabling framework for Energy Sector

No	Common barriers	Enabling framework	Technology
1.	High capital cost due to import tax	(i) Facilitate tax reduction or tax removing scheme on importation of technologies in respect of Energy Efficiency Projects	LED, LPG
2.	Lack of/ Insufficient financial support and subsidy	(ii) Engage with international funding agencies for solar mini-grid (iii) Create subsidy program for Energy Efficiency in residential sector	Solar, LED, LPG
3.	Lack of / Insufficient policy, legal and regulatory framework	(iv) Develop appropriate policy and regulation framework to promote mitigation technologies	Solar, LED, LPG
4.	Insufficient coordination between key stakeholders or line ministries	(v) Set up appropriate coordination channel within key stakeholders	LED, LPG
5.	Insufficient capacity in key institution	(vi) Provide technical training to staffs	Solar, LPG
6.	Limited market information	(vii) Create awareness campaign through various media	LED, LPG

Enabling framework for common barriers in detail:

1. **Facilitate tax reduction or tax removing scheme on the importation of technologies in respect of Energy Efficiency Projects**

Providing enabling financial framework and import tax reduction will be an effective measure to overcome the barrier of high capital cost due to import tax. LED and LPG technology suppliers can be provided either a tax holiday or tax reduction plan for a limited period during the technology promotion time of applying energy-efficient products in the household. Any revenue loss will be compensated to the government by indirect saving through national-level energy saving and energy security improvement. Moreover, GHG emissions from energy consumption can be reduced.

2. **Engage with international funding agencies for solar mini-grid**

The government should provide subsidies by seeking support from international funding agencies that already have such initiatives. The government can take a current experience with the World Bank to provide a certain amount of subsidy to implement a mini-grid project in the off-grid area. By using the experience of the current rural electrification project, the government should negotiate quickly and efficiently with international funding agencies to take concession loans to support the development of the rural electrification sector before running out of the current fund. This lead to secure the loan for the country. As a consequence, electrifying rural areas by using the solar mini-grid system and other renewable energy mini-grid system can be running without intermittently to achieve NEP's target. At the same time, the government should consider reducing the amount of subsidy rate from 60% to a certain amount of subsidy to manage the budget more sustainable manner.

3. **Create a subsidy program for Energy Efficiency in the residential sector**

There are two options to support customers and importers to successfully penetrate LED and LPG technology in the country. First, the government could allocate the specific budget to distribute LED and LPG technologies in the targeted area of the country as like the budget of the Dry Zone Greening Department to distribute improved fuelwood cookstoves (A1 cookstoves) in a very remote area of Dry Zone. That program distributes cookstoves to people free of charge. However, the program for LED and LPG should not follow the same procedures of that program because the sense of ownership on the products can be disappeared when people always get an appliance free. Moreover, people will be reluctant to buy to replace the appliance with their own money once the appliance is broken. Therefore, the program should be a market-based program. For example, the government should subsidize a certain amount of money for the technology cost for customers for a certain year of the subsidy program. For instance, the government should provide a 50% subsidy for customers to buy LED products within 2 years of the subsidy program for the Lighting Efficiency Program which is a designated period of the program. As an example of LPG technology, the government could provide a free LPG starter pack to users at the beginning of the Household Cooking Sector Fuel Substituting Program, then the program should offer to refill the gas with government subsidy rate. This can be done with the cooperation with suppliers as like as setting up the public-private partnership project.

Second is that the government could seek support from donor agencies to access funding or loan to promote this technology. Then, this funding or loan can be considered to provide funds on

concessionary terms (for instance - low-interest rate loan) to the suppliers or companies to distribute the proposed technology at a lower price than before (for example - 50% less price). Such funding should be going through either the government treasury or commercial banks.

4. Develop appropriate policy and regulatory framework to promote mitigation technologies

(i) Develop mini-grid regulation

The cooperation between off-grid and grid concessions is very crucial because this can release the uncertainty between mini-grid developers by developing an officially regulatory framework about IPP for the rural electrification sector. As a consequence, developers can become an IPP once the national grid comes to off-grid areas. This would result in increased security to the banks who lend them money to developers to develop the project. Also, project developers can choose either to become an IPP or to handover mini-grid assets to the village electrification committee after a certain operation period. Therefore, developing mini-grid regulations could create to release an uncertainty situation for developers in the rural electrification program. Developing this new regulation and framework can take time but more financing can be secured if this can develop at the soonest.

(ii) Establish an appropriate regulatory mechanism for lighting and LPG Law to promote mitigation technologies for household-level energy efficiency improvement

Establishing an appropriate regulatory framework together with an effective implementation mechanism will be an effective instrument to promote mitigation technologies. Moreover, that legal and regulatory framework should ensure to be continuous improvement of energy efficiency in lighting. Therefore, it is suggested that entry requirements, registration schemes, verification programs, and enforcement frameworks for lighting should be developed as soon as possible.

On the other hand, it is recommended that draft LPG Law should be finalized at the soonest. Consequently, an uninterrupted supply of LPG is expected to promote fuel switching programs in household-level cooking sector energy efficiency improvement. Moreover, the LPG community will have overall guidance to promote this mitigation technology.

5. Set up appropriate coordination channel within key stakeholders

It is recommended to streamline the effective coordination channel within key stakeholders to ensure the effective implementation of energy efficiency programs for lighting and fuel switching programs from fuelwood to LPG to promote the adoption of GHG mitigation technologies at the household level. For example, Energy Efficiency and Conservation Department should coordinate with Custom Department to review the custom duty regulation for the importation of LED technology to promote lighting energy efficiency at the household level through the reduction of import duty. In the case of LPG, the regulatory body should engage with the LPG community who is interested to do a pilot project of LPG cookstove distribution in the household sector to promote the fuel-switching program from firewood to LPG through a public-private partnership program.

6. Provide technical training to officials

It is recommended that officials from DRD Township Offices should be provided technical training for operation and maintenance to support the village electrification committee. MPE is suggested that human resources and technical capacities should be ready for doing inspection regularly. Therefore,

technical training for inspection should be conducted for officials prior to the vast diffusion of LPG technology. As a consequence, the diffusion of technologies will be more sustainable.

7. Create an awareness campaign through various media

As LED and LPG technologies are market-driven products, public awareness is important to diffuse technologies well. To promote public awareness, a promotion campaign should be considered to do in a crowded area such as a supermarket, local market. Moreover, the media campaign is also an effective way of product marketing and promotion by using radio, TV, social network, etc. Additionally, the public event can be facilitated in some days like World Environment Day. Also, the information on the technology can be spread through awareness-raising materials like posters, pamphlets, brochures, billboards, etc. These activates could be done through during the energy efficiency program for lighting and fuel switching from firewood to LPG or cooperation with private sectors to promote technologies.

Enabling Framework for each technology:

Table 19: Enabling Framework for Solar Mini-grid

Category	Barrier Dimension	Main barriers	Enabling Framework
Economic and Financial Barriers	Cost	(a) High interest cost (b) Insufficient subsidy or support for mini-grid developers	(a) Creating bank loan guarantee process by line ministry (b) Engage with international funding agency (c) Develop attractive business model with appropriate incentives for developers and investors
Non-Financial Barriers	Policy, legal and regulatory	(c) Lack of mini-grid regulation and cooperation between off grid and grid concessions (d) Inadequate renewable energy policy, strategy and action plan	(d) Develop mini-grid regulation and Create cooperation channel between off-gird and grid concessions (e) Develop renewable energy policy, strategy and its action plan
	Technical	(e) Limited demand for productive activities in rural areas (f) Lack of grid interconnection system	(f) Create the development of technology transfer program to increase productive use demand (g) Develop a regulatory framework to enable grid interconnection system

	Institutional and organizational capacity	(g) Insufficient capacity of township level staffs on solar mini-grid	(h) Develop capacity building programs for staffs
	Information and awareness	(h) Inadequate public knowledge on solar mini-grid system's capabilities	(i) Create information and awareness program for off-grid area

Table 20: Enabling Framework for LED

Category	Barrier Dimension	Main Barriers	Enabling Framework
Economic and financial barriers	Cost	(a) High initial cost because of tax and import duty (b) Lack of financial support (c) Lack of economic feasible data	(a) Regulation to create tax incentives or import duty reduction scheme for importation (b) Create subsidy program for customers (c) Develop economic and financial feasibility study activity to encourage green financing scheme
Non-financial barriers	Policy, legal and regulatory	(d) Lack of legal, regulatory and enforcement framework for lighting	(d) Develop sufficient legal, regulatory and enforcement framework
	Institutional and organizational capacity	(e) Limited coordination capacity of existing organizations	(e) Create official coordination channel between line ministries
	Technical	(f) Lack of (minimum) energy performance standard and labelling (g) Lack of quality control and assurance	(f) Develop standard and labelling (g) Develop quality control system, establish testing laboratory and create university curriculum for ensuring pool of experts
	Information and awareness	(h) Limited market information and awareness, and inadequate knowledge about e-waste	(h) Create public awareness raising program

	Social and culture	(i) Insufficient ability to foresee potential benefit due to household income	

Table 21: Enabling Framework for substitution of fuelwood with efficient fuel (LPG) at household level for cooking

Category	Barrier Dimension	Main Barriers	Enabling Framework
Economic and financial barriers	Cost	(a) High capital cost due to taxes and import duty (b) Lack of subsidy	(a) Consider to reduce taxes for importation (b) Create subsidy programme for fuel switching
Non-financial barriers	Policy, legal and regulatory	(c) Weakness of LPG Law	(d) Develop LPG Law
	Institutional and organizational capacity	(e) Inadequacy cooperation between key stakeholders (f) Insufficient human capacity and resources for inspection	(c) Create Public Private Partnership to develop cooperation between key stakeholders and LPG market (d) Create technical training programs for inspection
	Technical	(g) Insufficient infrastructure (h) Lack of local gas tank (cylinder) manufacturing	(e) Develop quality control and standard for gas tank and open last mile retailer shops (f) Create technology transfer program for cylinder manufacturing
	Information and awareness	(i) Insufficient information about LPG	(g) Create public awareness programs
	Social and culture	(j) Safety issue: Afraid of explosion	

Chapter 2 Industrial Sector

2.1 Preliminary targets for technology transfer and diffusion

An energy consumption survey was conducted for industries, and there were 175 sample industries (around 20 samples per each sub-sector) under 13 major industry sub-sectors. According to the survey results, the total calculated energy consumption in Industrial Sector is 1,387 ktoe, and the significant fuel consumed by the industry sector is electricity with 542 ktoe followed by biomass (368 ktoe), oil (365 ktoe), diesel (348 ktoe), etc. As shown in Figure 1, the industrial sector electricity consumption is the second-highest in the country.

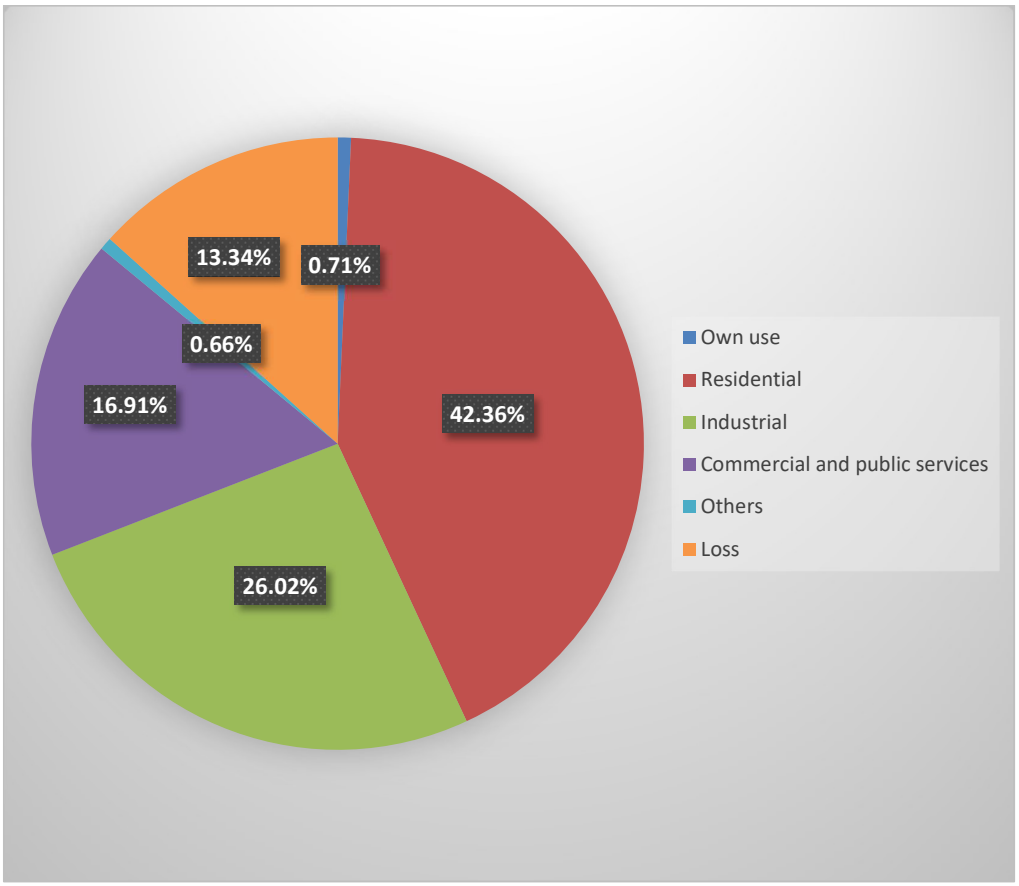

Figure 1: Electricity consumption by different sectors in Myanmar in 2016

Source: (OGPD, 2019)

Since the government is aware that electricity is one of the major sources of energy in the industrial sector, National Energy Efficiency and Conservation Policy, Strategy, and Roadmap for Myanmar has been established to enhance energy efficiency in the industrial sector. As mentioned in section 1.1, the overall electricity-saving target of the policy is 20%, of which 6.63% is for the target of the Industrial Sector. In line with this policy, the target for NDC is adopted for energy efficiency in the Industrial Sector. To reduce GHG emission in the rapidly booming industrial sector, the indicative goal for energy efficiency in the industrial sector in NDC is to support to realize for 20% reducing

potential electricity consumption by 2030 of the total projected electricity consumption (MOECAF, 2015).

To be able to achieve the above target, TNA will be a bridge as a supporting framework for implementing energy efficiency improvement activities in the Industrial Sector. Therefore, the process of barrier analysis and proposing an enabling framework will address the increased utilization of variable speed driver, energy-efficient boiler and solar dryer in the Industrial Sector to mitigate the GHG emission and to enhance energy efficiency by reducing energy consumption without compromising the production in the industries. From the stakeholder consultation meeting, stakeholders confirm that only private industries are focused on this barrier analysis and proposing an enabling framework.

The selected technologies from the TNA report are shown in the table 22 according to their relevant market category. All selected technologies are categorised under capital goods since these technologies are intended to be used in the production process of the Industrial Sector with only a few buyers who need these technologies.

Table 22: Technology category of Industrial Sector

No	Prioritize technologies	Category
1.	Efficient Electric Motor (Using the Variable Speed Driver (VSD))	Consumer Good
2.	Energy-Efficient Boiler	Consumer Good
3.	Solar Dryer	Consumer Good

2.2 Barrier analysis and possible enabling measures for Efficient Electric Motor (Using the variable speed driver (VSD))

2.2.1 General description of Efficient Electric Motor (Using the variable speed driver (VSD))

Myanmar has significant potential in its industrial and commercial activities for substantial savings in energy consumption. The potential savings estimated are 45% for the iron and steel industry, 65% for pulp and paper, and 35% for sugar mills due to their high electrical and thermal demands (ADB, 2016). By installing efficient electric motors (using variable speed drivers) to provide the required end-use energy, efficient electric motors can greatly increase the facility's operational efficiency and decrease energy costs.

In the industrial sector, electric motors are one of the workhorses to drive sector productivity. Throughout the world, a lot of industrial electric motors are sold every day since these are reliable and inexpensive but these are constant speed, motor drivers. These cannot adjust the suitable speed

of the application since these machines are coupled with mechanical devices such as clutch, gear, belt, and pulley. Therefore, the traditional machines are inefficient because of mechanical wear which leads to frictional and iron losses during the condition of high-speed motor running and energy consumption which is high energy losses due to friction (Merwe, Motiontronix, Hoogendoorn, & Industries, 2005). Moreover, these traditional machines need considerable space because these often require maintenance based on the usage and environment. Up to 60% of energy can be possibly saved based on the application using the speed control, and high energy saving can also be achievable with fans and pumps because these are very common in most of the industries (MoERE, 2012).

A device used in electromechanical drives is called a variable speed drive or a variable speed control system to control a motor's rotational speed (CLR, 2020). By adjusting the input frequency and voltage to the motor, this can control the speed and torque of an AC motor to suit the application. Since the system is electronic, it controls the motor's speed during the operation of the motor in a precise and constant manner. Therefore, energy loss is much lower than the mechanical speed controller, and the system is also compact. However, this kind of system needs a stable power supply to be free in its trouble operation. Otherwise, the motor cannot run efficiently by using the capacity of VSD and the motor would run with its own characteristic and power supply. This leads to being highly ineffective and inefficient. Other technologies are provided by various manufactures to perform motor operational improvement to be able to obtain energy-saving and for operating system optimization.

High energy saving can be obtained by using variable speed drives in motor-driven pumps and fans in closed loops. In air-conditioning systems, VSD systems can control pumps and fans which have a function of controlling the temperature and flow by reducing on/off cycles and providing a more stable indoor temperature. In air compressors and horizontal conveyors which are constant torque loads, a stable operating system with modulation can be achieved through an adjustable speed control instead of using on/off cycles. In the case of tea withering process in a tea manufacturing factory, the energy-saving can also be achieved by reducing the operating speed of the pump up to 80% which does not affect most of the processes until the requirement of the high precision speed because pumps generally running intermittent operation at full speed (MoERE, 2012).

This technology can contribute to achieving the country's development priorities for social, economic, and environment. As regards social development priorities, industries access direct benefits through the application of the VSD system. These results in the reduction of electricity consumption and noise pollution, so industries can save electricity bills and enhance the working environment of the factory. Consequently, the county's energy security can be increased through avoided electricity generation for the industrial sector where a huge amount of electricity saving occurs. Therefore, such a benefit can contribute to the country economic development priorities. Since industries reduce electricity consumption, the emission from electricity generation is reduced. Therefore, environmental priorities are contributed through the reduction of national GHG emissions by using this technology.

2.2.2 Identification of barriers for Energy Efficient Motor (Using the variable speed driver (VSD))

The barriers which are called the long list of barriers in Annex V for energy-efficient motors (using the variable speed driver (VSD)) are identified through literature review and field visits to five factories, which include two tea curing factories and three rice vermicelli factories. These factories use electricity for operating motors. Then, a bilateral meeting with the expert was conducted by the consultant to identify more possible barriers, and then the stakeholder consultation meeting determines that for this technology, this barrier is the key barrier by analyzing casual relation using root cause analysis through problem tree and market mapping which are included in Annex II.

As mentioned above, the major barriers of the VSD system to diffuse in the country are identified through several steps. The analysis of market mapping reveals that associated equipment of the VSD system is imported, so the manufacturing of motor associated products is almost negligible. However, some ESCOs can install such kind of application in industries. Since the equipment is imported into the country, the suppliers or importers and ESCOs who are the main actors of the market face most of the identified barriers. Also, factory owners are important as technology is capital goods. The step-by-step barriers identification process is below, and the identified barriers are validated in stakeholder consultation workshop as show in table 23.

i. A desk study and literature review
ii. Field visit
iii. Market mapping tool
iv. Guidance from TNA guidebook
v. Logical Problem analysis
vi. Bilateral meeting
vii. Stakeholder consultation workshop

Table 23: Identified barriers for energy efficient motor (using variable speed driver (VSD))

Barriers Category	Barrier Dimension	Main Barriers
Economic and Financial Barriers	Cost	(a) High taxes and import duty (b) Insufficient financial resources and subsidies (c) Financial variability not examined
Non- Financial Barriers	Policy, legal and regulatory	(d) Lack of legal regulatory framework and lack of enforcement
	Institutional and organizational capacity	(e) Lack of capacity in the existing institution because of insufficient

		time and prioritized other responsibility by engaged departments
	Technical	(f) Lack of standards and codes (g) Poor O&M
	Human skill	(h) Insufficient Research and Development (R&D) and lack of curriculum for practical training
	Information and awareness	(i) Inadequate knowledge and compliance on energy management system of the decision-makers in factories

2.2.2.1 Economic and financial barriers

Cost barriers

(a) High tax and import duty

In Myanmar, the price of normal motors, energy-efficient motors, and its related accessories varies based on the application in respective factories. The cost may start from around 30,000 MMK for 186.5 W (0.25 hp) to 50 million MMK for more or less around 74.6 kW (100 hp). Therefore, the high capital cost is the main barrier to this technology. Even though electricity generation projects by using renewable energy get tax exemption in some circumstances, there is no such kind of regulatory framework for technologies and equipment for energy efficiency improvement in the Industrial Sector. Therefore, the cost can further increase due to a 5% commercial tax during importation and some amount of customs duty which is based on country of origin even if the capital assets of the factory can be depreciated. These lead to an increase in the cost of the capital of technology. However, import duty can be decreased when suppliers import their products from the country with FTA with Myanmar.

(b) Insufficient financial resources and subsidies

Insufficient financial resources and subsidies are other key barriers that lead to increasing the capital cost of the technology. Generally, commercial banks are reluctant to provide concessional loans either to invest in new technologies or to invest in upgrading existing technologies. Normally, they charge around 10% interest rate of loan as a minimum for demand loan, and the maximum amount

of loan interest rate is around 16% which is limited to 3 years. However, the collateral is needed as a security to get a loan. The loan amount can be varied totally depend on the value of the collateral. Moreover, banks always look at the cash flow of the factory. Additionally, the country does not have enough funds or budget for energy efficiency and conservation program for the Industrial Sector. Due to insufficient financial resources and subsidies, technology development in Industrial Sector is a key barrier.

(c) Financial viability not examined

An Energy-efficient motor (using variable speed drive system) is not examined for financial viability. To carry out this kind of assessment needs either funding or investment while there is no internal budget for doing a financial assessment of this technology. Therefore, some private sector, especially local factories are not aware of the financial benefit of this technology because there is no reference information about technology in terms of financial and energy efficiency level.

2.2.2.2 Non-financial barriers

Policy, legal and regulatory barriers

(d) Lack of legal regulatory framework and lack of enforcement

With the support of ADB, Myanmar published Energy Efficiency and Conservation Policy, Strategy, and Roadmap in 2015. Even though the document has an energy-saving target and strategy to initiative energy efficiency and conservation concept for the Industrial Sector, it is not mandatory to use energy-efficient appliances and machines in the Industrial Sector. Moreover, energy efficiency law is absent in Myanmar. Therefore, energy managers are not employed in most industries since there is no regulation to assign respective professionals to manage energy utilization in the Industrial Sector. Moreover, law enforcement is required to ensure the industrial sector compliance. Insufficient legal regulatory framework and lack of enforcement cannot induce to apply this technology.

Institutional and organizational capacity barrier

(e) Lack of capacity in the existing institution because of insufficient time and prioritized other responsibility by engaged departments

Since the EE&C department is quite new, the department has capacity limitations in most of its staff at every level apart from senior-level staff. This is another major challenge that will be faced when implementing the proposed technology because good communication in terms of technical and financial points of view would be needed between field-level staff and decision-makers to ensure the proper implementation process when they conduct an energy audit. Moreover, the existing institution has limited capacity in policy, legal and procedural matters. Therefore, the department needs adequate professionals to monitor the Industrial Sector to maintain the desired energy efficiency level and to increase the pace of work in policy, legal and procedural matters. To enhance the capacity of the existing institutions, insufficient time to build the capacity of staff is one of the key barriers. On the other hand, the existing institution has limited capacity to increase the pace of work in policy, legal and procedural matters when their engaged department has other prioritized responsibilities instead of full participation to implement the work.

Technical barriers

(f) Lack of standards and codes

Energy efficiency standards, codes, and certification concepts are new for the country. The energy-efficient motor's standard's and codes are not identified in the country, and there is no certification mechanism as well. Therefore, the country does not have a benchmark to follow for the energy-efficient motor. As a result, inferior motors are also available in the country.

(g) Poor O&M

This is the key component of the overall technology implementation process because this is integrated with the management process and operation process that can be effectively controlled with the knowledge of technical know-how while the process includes administration, the conduct of the operation, the control of equipment status, knowledge and performance of operator, the system of work control, conduct of maintenance and preventive maintenance. Based on the field visits and a bilateral meeting with UNIDO, the process listed above is incomplete.

Human skill barrier

(h) Insufficient Research and Development (R&D) and the lack of curriculum for practical training

Neither the private sector nor the government has committed adequate resources for R&D for energy-efficient motor and its related system. Most of the components are imported. As a consequence, there is limited technical human personnel for installation, repair, and maintenance of a variable speed drive system. Moreover, technical training for a motor system is almost negligible and the curriculum is not effective since there are very few practical trainings. However, very few training with short training time can be seen in the country. Consequently, there is ~~a~~ difficulty to recruit skilled labors when existing trainings are very short to ensure skilled labors.

Information and awareness barrier

(i) Inadequate knowledge and compliance on energy management system of the decision-makers in factories

Since the energy efficiency concept is new for the country especially for local enterprises, the factory owners are generally reluctant to invest in energy-efficient technology which has a high capital cost. They cannot regularly see the benefit of energy-efficient technology while most factories lack the energy management system and energy management team. These lead to occur the leakage of useful energy and waste of energy by using an oversize motor in some factories as an example. Therefore, the diffusion of the proposed technology is blocked without having adequate knowledge of the energy management system which can support factories to save energy bills and to enhance the performance of machines while some factories could not afford to invest in new technology. Moreover, inadequate knowledge of energy management system of the decision-makers in factories is one of the major barriers. Just awareness raising on the energy management system through radio, medias, journals and newspapers is insufficient. Another major important drawback is the inadequate compliance with the energy management system in factories.

2.2.3 Identified measures for Energy Efficient Motor (Using variable speed driver (VSD))

The following step-by-step process is applied to identify measures for variable speed driver technology.

i. Literatures review
ii. Field visits
iii. Bilateral meeting
iv. Guidance from TNA Guidebook
v. Stakeholder consultation meeting

During the stakeholder consultation meeting, market maps and problem trees were presented to discuss to transform from problems to solutions, and then the measures were classified and evaluated. To have comprehensive measures, stakeholders from the technical working group were requested to give more comments and feedbacks by reviewing the report.

2.2.3.1 Economic and financial measures

Measures for high capital cost barriers

(a) Barrier: High tax and import duty
(a) Measure: Reducing tax and custom duty

Local production of equipment and related accessories for proposed technology is almost negligible as mentioned in the barrier identification process. Therefore, commercial tax and custom duty levy on the equipment during the importation. If factories import energy-efficient motors or equipment for VSD function to use for their production, the government will have indirect benefits through national-level energy saving which leads to increase country's energy security. Moreover, factories may produce their products at low cost, and so this can be competitive in export markets. Therefore, the government should review the tax policy to reduce tax and custom duty on the energy-efficient motor and its related accessories. Also, the concession of tax should be considered based on the efficiency level of the motor. To do so, factories may have interest to import more efficient electric motors. Even a reduction of 5% commercial tax is a benefit for technology users since the initial cost of technology can be decreased. Reducing tax and custom duty should be considered as a plan for sustainable development, and as an invitation for investment in this proposed technology.

(b) Barrier: Insufficient financial resources and subsidies
(b) Measure: Adequate financial resources and subsidies

The government could seek financial support for energy efficiency projects on not only energy-intensive industries but also SME through international funding or supporting agencies as like as Responsible Business Fund (RBF) by Denmark which is the performance-based financial institutions for SME to improve in main thematic areas, such as, to improve energy efficiency, improve food safety, improve waste management. RBF supports up to 65% of capital cost or up to 80 million MMK of the technology based on the performance of the SME. Also, either government or private sector could seek to apply for the CDM-PoA or JCM. Moreover, the government could introduce the concept of energy efficiency and conservation in the Industrial Sector to commercial banks by

seeking cooperation between the government and commercial banking sector to offer low-interest rate loans for promoting energy efficiency projects.

(c) Barrier: Financial viability not examined

(c) Measure: Conducting feasibility studies

Since Myanmar's Industrial Sector has been developing, there is a lack of feasibility studies in energy efficiency projects even though some individual projects are active in JCM. To address this barrier, conducting financial feasibility studies of this proposed technology is recommended by relevant state institutions such as EE&C Department, DRI, or through a pilot project from the international organization as like as JCM projects or hiring consultants to do the study. Then, the study findings should be published to be able to access ~~by~~ the decision-makers from the Industrial Sector. Adequate funds should be provided to conduct these studies by seeking technical and financial assistance from international funding communities. Encouraging green financing for financial viability should be considered to happen as well.

2.2.3.2 Non-financial measures

Measure for Policy, legal and regulatory barrier

(d) Barrier: Lack of legal regulatory framework and lack of enforcement

(d) Measure: Establish energy efficiency law and develop an appropriate regulatory mechanism for enforcement

Establishing energy efficiency law to promote mitigation technologies in the Industrial Sector is a measure to address low energy efficiency in industries and reduction energy conservation at the national level. Moreover, the appropriate regulatory mechanism for enforcement to assign energy managers in industries and use energy-efficient appliances and equipment in the Industrial Sector should be designed. This leads to encouraging the continuous enhancement of energy efficiency and conservation in the Industrial Sector. Therefore, the government should encourage the Industrial Sector to the adoption of Energy Efficiency and Conservation Law, Energy Efficiency Guideline and procedures after establishing.

Measure for Institutional and organizational capacity barrier

(e) Barrier: Lack of capacity in the existing institution because of insufficient time and prioritized other responsibility by engaged departments

(e) Measure: Capacity development in an existing institution

According to UNIDO Industrial Energy Efficiency Project in Myanmar, UNIDO offers a lot of training regarding energy management systems, steam system optimization, and compressed-air system optimization not only for government staffs but also for targeted groups of people who are decision-makers of the factories, engineers, individual consultants, etc. Therefore, some staff from the EE&C Department receive capacity building program from UNIDO. As a consequence, the government could seek support from trained person to do capacity building for the department or could seek more cooperation with international organizations as like as UNIDO to do training for government staffs that they already have such initiative for energy efficiency improvement.

Measure for Technical barriers

(f) Barrier: Lack of standards and codes

(f) Measure: Develop proper standards and codes

Until now, Myanmar is following ASEAN standards for energy-efficient appliances and equipment to use in the country. However, only people who are in Energy Efficiency and Conservation and related Sector knows about this information. Department of Research and Innovation has initiated the development of energy labelling standards and codes for selected energy appliances but the implementation processes for most appliances are delaying. Therefore, it is suggested that standards and codes for energy-efficient motor should be developed with the cooperation with EE&C Department even though VSD is not entitled to set up energy efficiency standards while VSD is the extra function to enhance the efficiency level of motors. This could guide the factories' owners to follow the benchmark of the country's standards and codes for energy efficiency improvement. Besides, proper quality control can be done by checking the standards and codes of the products. This should be considered as long term continuous action, and directive should be issued to comply with these standards and codes after developing.

(g) Barrier: Poor O&M

(g) Measure: Establish a factory level O&M management system with registered after-sale services providers and maintenance services providers

As usual, a complex computer control system is integrated into almost all of the new technologies. Therefore, a good O&M system is important. To keep on the desired efficiency level for a long time, one important requirement is doing regular servicing and maintenance. Moreover, accessing proper after-sale services and spare parts availability is another essential factor for continuing the use of the energy-efficient motor.

Measure for Human skill barrier

(h) Barrier: Insufficient Research and Development (R&D) and luck of curriculum for practical training

(h) Measure 1: Develop R&D activities

The private sector, local universities, Department of Research and Innovation (DRI), and Energy Efficient and Conservation Department should initiate R&D activities in the area of energy-efficient motor and its related system. Funding for R&D activities should be provided by either the government and private sector through PPPs or donor agencies through INGOs. Moreover, the government should also consider to enhancing Industrial Based Research Activities.

Measure 2: Develop curriculum for step-by-step practical training courses

Local Universities and other tertiary institutions in the country will be encouraged to offer practical training courses on the energy-efficient motor and its related system with an emphasis on motor sizing, application, motor operation, and maintenance by developing curriculum either in university or in vocational training school. As a result, the country will have a critical pool of trained technical personnel to install, repair, and maintain not only motor but also energy-efficient motor and its related system in the country. This measure should be treated as a long term continuous action to enhance the technical capacity of future generation and to get more skilled labor.

Measure for Information and awareness barrier

(i) Barrier: Inadequate knowledge and compliance on energy management system of the decision-makers in factories

(i) Measure: Develop curriculum for energy management system course

Taking an example of the UNIDO Industrial Energy Efficiency Program, the government should develop a curriculum for an energy management system course for decision-makers, professionals, factories' owners, etc. This would result in better management of factory operation with regards to energy saving, fuel cost saving, upgrade the existing system with low-cost investment, etc. Additionally, creating this course in the university curriculum is more advantageous to secure more professionals in the Industrial Sector. Moreover, awareness raising through media and electronic media could be effective to target on factories senior management level.

2.2.4 Cost-Benefit Analysis of Energy Efficient Motor (Using variable speed driver (VSD))

Since the cash flow cannot be accessed for analysis, NPV cannot be estimated in this analysis. Therefore, only simple payback period is calculated. This cost benefit analysis (CBA) is conducted as an example for a garment factory. The CBA analysis of this proposed technology is calculated based on the following assumptions;

- 97 units of old sewing machines are needed to be replaced.
- The total investment cost for all sewing machines including engineering cost is around 57,142 USD.
- It is considered that motor operates 8 hours a day.
- O&M is not accounted here.
- Expected electricity saving of one machine is 50%.
- Social cost of carbon from US EPA (per ton) for CO_2 is 36 USD (US EPA, 2017).
- Grid emission factor is 0.32 ton CO_2/ MWh (ADB(b), 2017).

According to above assumptions, the factory consumes around 9,036 units per month. Therefore, the bill of electricity per month is around 897 USD. The meter bill calculation is provided in table 24.

Table 24: Meter bill calculation for one month

From	To	USD/units	Consumption units	Amount (USD)
0	500	0.089	500	45
501	5000	0.096	4,500	434
5001	10000	0.104	4,036	418
10001	20000	0.111		
20001	50000	0.118		
50001	100000	0.125		
100001	>100,000	0.129		
Total			9,036	897

Since one machine can save up to 50% of electrical energy, the significant energy saving can be seen in this analysis. The factory can save energy up to 102,432 kWh annually by replacing electrical sewing machine with VSD, so that the factory can reduce electricity bill around 10, 579 USD per annum. Moreover, total CO_2 emission can be reduced up to 320 ton/ year. Therefore, the benefit of CO_2 reduction cost is around 11, 523 USD. Due to the significant energy saving, the payback period of this technology intervention is around 5.31 years. However, this payback period can be reduced once the factory can access partial subsidy from subsidy program. Detail technology assessment is provided in table 25.

Table 25: Detail technology assessment of energy efficient motor (using variable speed driver (VSD))

No	Parameter	Unit	Value
1	No of motor	Qty	97
2	Capacity of motor	kW	0.5
3	Working hours/day	h	8
4	Working hours/month	h/month	176
5	Working hours/year	h/yr	2112
6	Electricity saving	kWh/annum	102,432
7	Cost of electricity saving	USD/annum	10,759.03
8	Expected investment cost	USD	57,142.86
9	Simple payback period	Years	5.31

2.3 Barrier analysis and possible enabling measures for Energy Efficient Boiler

2.3.1 General description of technology Energy Efficient Boiler

Boilers account for a significant share of industrial energy consumption and are key components in power generation and industrial plants. Industrial boiler systems are used for heating with hot water or steam in industrial process applications. Around 2,559 boilers are now used in Myanmar Industries (BID, 2019).

A closed pressure vessel is used to supply steam energy for external use by heating the fluid inside the vessel by the direct combustion of fuel which is resulting in the heat is called a boiler. The type of boiler (either fire-tube or water-tube, either the vertical tubular boiler or horizontal tubular boiler) is varied depending on the fuel used such solid fuel, liquid fuel, and gaseous fuel. In Myanmar, the predominant boiler fuel is biomass and wood fuel which is around 58% followed by oil, coal, electricity, and gas (BID, 2019).

The installation or retrofitting of an energy-efficient boiler with a traditional or an inefficient boiler can achieve the energy efficiency improvement in industrial boilers. Moreover, the design of the boiler should require low maintenance and high efficiency. Such an improved boiler would include the following:

- Boiler feedwater pre-heating using condensate return water
- Economizer – to capture heat from the exhaust gas and utilize it to preheat boiler feedwater or air for the combustion.
- Fuel switching from woodfuel to biomass pellet which has higher heating value and compact.
- Upgrading appropriate dual burners system to LPG or fuel-oil.

Improvement of boiler technology targets on energy efficiency and low-cost design while many benefits are contributing to fulfilling the national development priorities. The following benefits are contributing to the country's social development priorities by using energy efficient boilers as environmental sound technology.

- Increase job opportunities
- Improve air quality
- Reduce health and safety hazard due to heat losses

Also, economic development priorities are contributed by below advantages of the system.

- Reduce energy bill in factories
- Increase energy security in national level
- Increase country's GDP by sharing income from biomass pellets manufacturers

Below benefits are supporting to achieve to reach the target of the country's environmental development priorities.

- Reduce air pollution by substituting the use of fossil fuel with biomass pellet
- Reduce national level GHG emissions

2.3.2 Identification of barriers for technology Energy Efficient Boiler

The process of barriers analysis for energy-efficient boiler is started from the desk study of boilers used in Myanmar. Field visits to three vermicelli factories and 3 green tea leave factories support the information that obtains from the literature review to identify the barriers. The long list of barriers are therefore obtained, and it is shown in Annex V. Then, the market map was developed to visualize the supply chain of boilers and related support which are the support of the enabling environment such as policies, institutions, processes. Support from the service providers, who are also called business or extension services that support the operation of the supply chain. Energy-Efficient boilers' market map is shown in Annex II. This includes all key actors, support services, and enabling framework according to TNA Guidebook. Again, this market map and logical problem analysis are supplemented by a bilateral meeting with UNIDO. Finally, the list of barriers and market map is presented in a stakeholder consultation workshop to conform whether all barriers identified are

realistic. As a result of the stakeholder consultation workshop, barriers in Table 26 are validated as key barriers.

According to the market map, the production or manufacturing of the boiler and its accessories are almost negligible in Myanmar. Most products that use within the country are imported from China and India by boiler suppliers. However, there is some local fabrication for a small-scale boiler (can be seen from 0.5 to 1-ton steam/hr). Therefore, suppliers are identified as the key main actors of the supply chain to move forward to operate boiler business in Myanmar. Since the equipment is imported into the country, the suppliers or importers and ESCOs who are the main actors of the market face most of the identified barriers as like as actors of energy-efficient motors which mention in Section 2.2.2. Also, factory owners are important since technology is capital good. The step-by-step barriers identification process is below:

i. A desk study and literature review
ii. Field visit
iii. Market mapping tool
iv. Guidance from TNA guidebook
v. Logical Problem analysis
vi. Bilateral meeting
vii. Stakeholder consultation workshop

The major barriers in the wide diffusion of the energy-efficient boiler are categorized under economic and financial and non-financial barriers.

Table 26: Identified barriers for Energy Efficient Boiler

Category	Barrier Dimension	Main Barriers
Economic and financial barriers	Cost	(a) High capital cost due to taxes and custom duty (b) Weak access to financial resources (c) Lack of economic feasibility assessment
Non-financial barriers	Policy, legal and regulatory	(d) Lack of specific regulatory framework on boiler efficiency
	Institutional and organizational	(e) Insufficient human resource and limited capacity for boiler inspection in existing institutions
	Technical	(f) Weak O&M

		(g) Lack of efficiency standards for boilers
	Human skill	(h) Lack of Research and Development (R&D)
	Information and awareness	(i) Lack of awareness and compliance by decision-makers in factories regarding energy management system

2.3.2.1 Economic and financial barriers to Energy Efficient Boiler

Cost barriers

(a) High initial cost due to commercial tax and import duty

The market-map reveals that there is no production in the country. However, local fabrication can be seen in some places according to the information from the bilateral meeting. Due to lack of local manufacturing, the suppliers and ESCOs cannot avoid taxes and import duty when they import energy-efficient boilers into the country such as, 5% commercial tax and some amount of import duty when imported from non-FTA countries. Therefore, these are one of the main barriers to promote energy efficient boiler. These results to increase the capital cost of energy-efficient boilers.

(b) Weak access to financial resources

Currently, in Myanmar, there is no government budget to mitigate climate change in the Industrial Sector. As mentioned in the previously proposed technology, accessing loans from commercial banks is also difficult. Moreover, the rate of loan interest is high which is a minimum of 10% that also totally depends on the value of the collateral. Limited access to financial resources is blocking investment in the proposed technology in the Industrial Sector.

(c) Lack of economic feasibility assessment

Lack of economic feasibility assessment is another major barrier to technology diffusion. Since new and energy-efficient technologies are always higher in price, factories' owners are generally reluctant to invest in new technology. The reason is that they cannot easily see the financially viability of the proposed technology. Without knowing it to be financially viable, investing in new technology is taking a risk to have benefits as a return. Encouraging green financing for financial viability should be considered.

2.3.2.2 Non-financial barriers

Policy, legal and regulatory barriers

(d) Lack of specific regulatory framework on boiler efficiency

According to the Boiler Inspection Department, they generally conduct boiler safety inspection for registered boilers to check boiler safety compliance. However, there is no mandatory to use the

efficient boiler and biomass-based boiler to eliminate the use of unsustainable fuelwood and to reduce the use of fossil fuel. Also, the encouragement to have efficient practice in boiler management cannot be seen not only in Boiler Law but also in National Energy Efficiency Policy, Strategy, and Roadmap. Since steam boilers consume a lot of fuel, lack of proper regulatory framework is creating an actual impact not only on climate change but also on the operating cost. Moreover, energy efficiency law is the absence in Myanmar. Therefore, energy managers are absent in most industries since there is no regulation to assign respective professionals to manage energy utilization in the Industrial Sector. Moreover, law enforcement is required to ensure the industrial sector compliance. Insufficient legal regulatory framework and lack of enforcement cannot induce to apply this technology.

Institutional and organizational barrier

(e) Insufficient human resource and limited capacity for boiler inspection in existing institutions

Even though boiler safety inspection is in place, an energy audit of boiler efficiency is currently not in place. Also, the government has limited capacity to do an energy audit in terms of human resources and human capacity. Lack of training and capacity building for existing institutions results in insufficient human resources and limited capacity for conducting energy audits by using internal resources.

Technical barrier

(f) Weak O&M

Proper operation and maintenance are essential for boiler efficiency and this can create real impact maintaining energy efficiency at the desired level and reducing operating cost. Inadequate understating of boiler operation in the factory is also playing a major role to offset GHG emission and to increase energy security at the national level. Field visits reveal that some solid fuels for the boiler are partially wet, and some operators feed the combination of wet solid fuels and some waste such as plastic waste, wet carton box, wet wood chips. In addition, insufficient insulation along the pipe are found in some factories as well.

(g) Lack of efficiency standard for boilers

Although the boiler safety standard is in place in Myanmar, the government is not showing initiative to develop energy efficiency standards. Therefore, there is no benchmark of energy efficiency standards to follow. This results that inefficient boiler can be widely seen in the Industrial Sector.

Human skill barrier

(h) Lack of Research and Development (R&D)

There is very limited research on boiler technology within the country. The interest to invest in R&D activities is almost negligible. This result is preventing to gain the theoretical knowledge to apply in the field and to achieve practical knowledge and design of the technology while the country has limited technical capacity.

Information and awareness barrier

(i) Lack of awareness and compliance with decision-makers in factories regarding energy management system

Since the concept of an energy management system is new in Myanmar, most factories owners do not aware of this and related benefits. Even though, some owners and decision- makers know about the energy management system, they comply rarely with an energy management system. As a consequence, most factories do not have historical energy consumption data and lack of reliable data due to lack of an energy management team. Therefore, finding a solution is difficult to improve boiler efficiency.

2.3.3 Identified measures for Energy Efficient Boiler

The following step-by-step process is applied to identify measures for energy-efficient boiler technology.

i. Literature review
ii. Field visits
iii. Bilateral meeting
iv. Guidance from TNA Guidebook
v. Stakeholder consultation meeting

During the stakeholder consultation meeting, market map and problem tree are presented to discuss to change from problems to the solution, then the measures are classified and evaluated. To have comprehensive measures, stakeholders from the technical working group are requested to give more comments and feedbacks by reviewing the report.

2.3.3.1 Economic and financial measures for Energy Efficient Boiler

Measures for cost barriers

(a) Barrier: High capital cost due to taxes and custom duty
(a) Measure: Review current tax policy and import duty

The government may seek cooperation within the Ministry of Planning, Finance, and Industry to review the current tax policy and import duty for efficient boilers. This can help to reduce the initial cost of the technology and factories would be more interested in investing energy-efficient boilers. According to field visits, reducing 5% of commercial tax could also be useful for technology users since the initial cost can be decreased.

(b) Barrier: Weak access to financial resources
(b) Measure: Create an enabling framework to access concession loan

The government should review again the current loan schemes for SME and Energy Intensive Industries because the government could have indirect benefits at the national level such as reduction of national GHG emission, increase energy security if more factories invest in energy-efficient boilers. Therefore, offering concession loans for energy efficiency projects in Industrial Sector can support

reducing the high capital cost of the proposed technology. Moreover, the government could collaborate with donor agencies who have an energy efficiency initiative to consider providing adequate funds on concessionary terms to provide the private sector to diffuse this technology. It is recommended that this kind of funding should be two-step loans through the government treasury to a commercial bank.

(c) Barrier: Lack of economic feasibility study

(c) Measure: Conduct feasibility study and publish the result

The government may seek support from the international organization in Myanmar who has energy efficiency initiatives such as SMART Textile & Garment, WWF (Tha Bar Wa Project), UNIDO (IEE Project). Some energy audits are done by these organizations. Therefore, the government should collaborate with these organizations to publish study results to see the financially viability of the technology.

2.3.3.2 Non-financial measures for Energy Efficient Boiler

Measures for policy, legal and regulatory barriers

(d) Barrier: Lack of specific regulatory framework on boiler efficiency

(d) Measure: Establish energy efficiency law and review current regulation to update for energy efficiency improvement

Since there are Boiler Law and Energy Efficiency Policy, Strategy, and Roadmap, one of these policies should state about energy efficient boiler. As per discussion with EE&C Department, the manual for the boiler is being prepared, and ready to be published. It is suggested that this manual should be published at the soonest. Moreover, regulation must state stricter enforcement on fuel use per ton of steam production for each type of fuel especially for fuelwood and coal to eliminate the use of unsustainable fuelwood and coal. Establishing energy efficiency law to promote mitigation technologies in the Industrial Sector is a measure to address low energy efficiency in industries and reduction energy conservation at the national level. Moreover, the appropriate regulatory mechanism for enforcement to assign energy managers in industries and use energy-efficient appliances and equipment in the Industrial Sector should be designed. This leads to encouraging the continuous enhancement of energy efficiency and conservation in the Industrial Sector. Moreover, the government should encourage the Industrial Sector the adoption of Energy Efficiency and Conservation Law, Energy Efficiency Guideline and procedures after establishing.

Measures for institutional and organizational barrier

(e) Barrier: Insufficient human resources and limited capacity for boiler inspection in existing institutions

(e) Measure: Institutional strengthen by providing training

One of the prior necessary for introducing this proposed technology is to provide the necessary exposure to all relevant officials. This could be done through providing training and joint audit with international organizations that already have experiences in the energy audit as mention above. Moreover, the training program should be with a well-prepared curriculum including step-by-step practical training and factory visits to be familiar with the process of various factories and various

appliances. Additionally, the government should consider to produce Energy Manager and Energy Auditor by providing intensive technical training.

Measures for technical barriers

(f) Barrier: Weak O&M

(f) Measure: Proper O&M by sending operators to training and set up factory level O&M system with registered after-sales services providers

Although boiler operation training has been offered in the country, there still requires proper O&M of boiler in the Industrial Sector. Normally, every factory that uses the boiler has the main operator or engineer who has the overall responsibility to manage industry engineering. However, fuel feeding is conducted by general labor while fuel procurement and fuel management are conducted mostly finance team of some factories. In this case, inappropriate fuel feeding and fuel storage happen as mention in Section 2.3.2.2 (f). Therefore, action should be taken to train both persons from the finance team who manage the fuel storage and general labor who operate fuel feeding to ensure good O&M by sending operators training which is targeted for those people. Additionally, the availability of spare parts and after-sale services are important to maintain the efficiency level of boilers and the continued use of the boiler. As mentioned above, boiler operation training is delivered in the country. Therefore, this training program should be aiming to produce competent skilled labor.

(g) Barrier: Lack of efficiency standard for boilers

(g) Measure: Develop a minimum energy efficiency standard

Lacking minimum energy efficiency can cause widespread use of inefficient boilers in industrial, and this can indirectly affect national-level GHG emission and energy security. Therefore, the government should develop the benchmark for boilers to encourage the users to use efficient boilers, to upgrade the existing boilers and to switch the use of efficient fuel as like as pellets instead of using woodfuel. Moreover, the stricter standard, the competency standard, should be formulated for fuel used per ton of steam production to phase out using coal and unsustainable fuelwood. Therefore, developing a minimum energy efficiency standard can lead to an increase the use of efficient boilers, and the users should also adopt the energy efficiency guideline for boilers once the guideline is published.

Measure for human skill barrier

(h) Barrier: Lack of research and development (R&D)

(h) Measure: Develop R&D activities

The private sector, local universities, Department of Research and Innovation (DRI), and Energy Efficient and Conservation Department should initiate R&D activities in the area of energy-efficient boiler and steam system optimization. Funding for R&D activities should be provided by either the government or private sector through PPPs or donor agencies through INGO. Moreover, the government should encourage to do Industry Based R&D activities for ensuring the results of researches for the Industrial Sector.

Measure for information and awareness barrier

(i) Barrier: Lack of awareness and compliance by decision-makers in factories regarding energy management system -

(i) Measure: Develop curriculum for energy management system course

Taking an example of the UNIDO Industrial Energy Efficiency Program, the government should develop a curriculum for an energy management system course for decision-makers, professionals, factories' owners, etc. This would result in better management of factory operation with regards to energy saving, fuel cost saving, upgrade the existing system with low-cost investment, etc. Additionally, creating this course in the university curriculum is more advance to secure more professionals in the Industrial Sector.

2.3.4 Cost-Benefit Analysis of Energy Efficient Boiler

CBA for energy-efficient boiler is conducted, and the simple payback period of the proposed technology is calculated. Since conducting energy an audit is very wide, lengthy and out of the scope of TNA, the following consideration based on the interview and literature review are included to complete this CBA;

- High energy-efficient natural draft horizontal boiler is considered to use, and the boiler is suitable to use for all kinds of solid fuels.
- The boiler is manually fired and has simple design for ease in operation and maintenance.
- The Boiler has 3 passes solid fuel-fired with fully wet back for high energy efficiency, and complete combustion can be done.
- Technical data of the boiler and cost of the project is adopted from the project report on energy-efficient boiler (Zenith Energy Services Pvt. Ltd, 2010).
- Mix pellets are made of 50% Rice Husk and 50% Wood Dust, and the price is collected from Myanmar Biomass Power.
- Costs of fuel are collected from the local market.
- It is assumed that the efficiency of a new boiler is 60% and the boiler has a waste heat recovery system.

Table 27 provides detailed technology assessment of energy-efficient boiler which uses mixed pellets that are made of 50% Rice Husk and 50% Wood Dust. Due to the high- efficiency rate of the boiler, daily fuel consumption is reduced, and total fuelwood consumption is decreased up to 93.33 tons annually. Even though the cost of pellets is higher than firewood, the significant monetary saving could be achieved by using pellets with around 2,083 USD per annum because of the high calorific value of pellets which is 4,200 kcal/kg and at 60% boiler efficiency. Therefore, the payback period for this project is almost 29 months. A comparison of using pellets and wood in energy-efficient boiler can be seen in Annex III. Moreover, the reduction of wood consumption can reduce carbon dioxide emission of fuel combustion in the boiler as well as can reduce the rate of deforestation.

Table 27: Detail technology assessment of energy efficient boiler (using mix pellets)

No	Parameter	Unit	Old boiler (using wood)	New boiler (using mix Pellets)
1	Operating hours	hr	8	8
2	Operating days	days	240	240
3	Temperature of feed water	℃	25	25
4	Temperature of hot water required	℃	55-60	55-60
5	Steam pressure	kg/cm2	5	10
6	Calorific value of fuel	kcal/kg	3,200	4200
7	Average efficiency of equipment	%	35	60
8	Fuel consumption per day	kg/day	700	311.12
9	Wood consumption	ton/year	168	74.668
10	Saving of wood consumption	ton	N/A	93.33
11	Cost of fuel	USD/ton	22	57.14
12	Monetary saving	USD	N/A	2,083.30
13	Cost of project	USD	N/A	5,000
14	Payback period	Years	N/a	2.40

2.4 Barrier analysis and possible enabling measures for Solar Dryer

2.4.1 General description of technology Solar Dryer

A major portion of industrial energy consumption is in the form of thermal energy, and primary sources of this thermal energy are fossil fuels like coal, lignite, oil, and gas. These fuels release large quantities of pollutants. Industrial process heat is the thermal energy used directly in the preparation or treatment of materials and items manufactured by industry. In the food industries, around 29% of total energy is consumed for process heating while approximately 16% is for process cooling and refrigeration (GoN, n.d.).

Over 35% of fruits and vegetables in total production are wasted every year because of a lack of adequate post-harvesting technology and climate change. There is a great opportunity in agro-food processing factories once such amount of wastes can be avoided. Therefore, application for food preservation and food safety processing is very crucial for enhancement on the contribution from agro-food industries and agriculture sector where 60% of Myanmar workforce is there and 25% of

the country's GDP is contributed (Natural Farm Fresh Myanmar, 2020). A large portion of industrial process heat is at sufficiently low temperatures which can easily be supplied by solar energy.

Traditionally, the sun drying method is applied to dry a small amount of food in the open air in a rural area but this method is not convenient for a large amount of food since a large area of open space is needed to expose to the sun directly. Moreover, there is a difficulty in monitoring and overviewing large quantities of food to avoid contamination of the products through rain, wind, dust, insects, rodents, birds, etc. This method declines the color of dried products significantly. Moreover, 40% of spoilage occurs at drying processing (Oo, 2020). On the other hand, electric dryers are used to take out the moisture from food in SME. To maximize the energy efficiency in agro-food industries, using the solar dryer is one of the best solutions to fulfill the industries that need thermal energy.

The solar dryer is a relatively simple concept. The basic principles are including three functions which are transforming light to heat, heat-trapping, and heat transfer to the food (JIN, n.d.). The moisture from the product is therefore taken out to make it dry, and these results in the prevention of food decaying and food spoilage. There are various solar dryer designs. Solar driers are principally categorized into three groups (1) natural convection driers, (2) forced convection driers and (3) tunnel driers. The choice of the driers is depended on the user specification such as the production capacity of the products, the available space to set-up the dryer, etc. Also, various categories of solar dryer systems are available based on the intended use of each type of system. Some simple to-create and simple to work dryers are available which is reasonable to use at small scale factories. This is a low-cost technology that is promptly introduced in the rural area to avoid food spoilage, to enhance the quality of the product, and in general processing cleanliness. These units are intended to get dried out little amounts of units, vegetables, or herbs for reason for broadening the accessibility of those items at the family level. Medium-scale systems are intended to meet the requirement of either individuals or groups, either cooperatives businesses or associations to supply better product quality to spread more markets. Large scale systems, commercial size systems, require a high amount of capital cost since this system is intended to dry a huge quantity of products for the operation of large commercial farming and village cooperatives as well.

The following benefits are contributing to the country's social development priorities by using solar dryers as environmental sound technology.

- Increase food security
- Enhance labor and farmers health conditions
- Enhance nutritional conditions
- Access better quality and hygiene products
- Increase job opportunities
- Improve air quality

Also, economic development priorities are contributed by below advantages of the system.

- Reduce the energy bill in factories

- Increase energy security at the national level
- Increase the market value of the product through processing into a variety of different products from dry food
- Save transportation cost by reducing the volume of products
- Reduce poverty
- Generate more incomes to the farmers

Below benefits are supporting to achieve to reach the target of the country's environmental development priorities.

- No air pollution by substituting the use of fossil fuel with solar dryers
- Reduce national-level GHG emissions

2.4.2 Identification of barriers for Solar Dryer

First of all, the literature review is conducted to develop a market map of solar dryers and to obtain the long list of barriers which is in Annex V. Then, the information from field visits is combined to modify the market map. Additionally, the bilateral meeting with Natural Farm Fresh Myanmar is conducted by the consultant to identify more barriers and to determine the supply chain of the market. Finally, logical problem analysis is conducted by using a market map which is included information from previous steps and guidance from the TNA guidebook. Once the problem tree and market map are finished to modify, these are presented during the online stakeholder consultation meeting to validate as key barriers with the Industry Sector technical working group who receives a draft report after the meeting to review the report.

The market map reveals that the supply chain of this technology is very short. There are only suppliers or importers and users or customers. However, there is no manufacturing of solar dryer equipment and accessories within the country. There is only one supplier who can supply the system professional but local fabrication can be seen within Myanmar. Moreover, only solar tunnel type driers can be supplied. Recently, most of the solar dryer related accessories are imported from Thailand. Therefore, the supplier has many challenges to overcome barriers such as financial, policy, and technical. Moreover, financial barriers are important for users.

The step-by-step process of barrier identification is based on a combination of information from relevant stakeholders such as factories, suppliers, consultant's knowledge, and stakeholder consultation meeting. The overall process is following to identify barriers hindering the diffusion of solar dryers.

i. A desk study and literature review
ii. Market mapping tool
iii. Field visit
iv. Bilateral meeting
v. Logical Problem analysis
vi. Guidance from TNA guidebook
vii. Stakeholder consultation workshop

The major barriers in the wide diffusion of solar dryer technology are categorized under economic and financial and non-financial barriers.

Table 28: Identified barriers for Solar Dryer

Category	Barrier Dimension	Main Barriers
Economic and Financial barriers	Cost	(a) Lack of tax exemption (b) Insufficient subsidy program and Improper financial resources (c) Lack of economic feasibility assessment
Non-financial barriers	Policy, legal and regulatory	(d) Absence of legal and policy framework and lack of enforcement
	Technical	(e) Lack of standard on materials
	Human skill	(f) Insufficient skilled manpower and absence of technology transfer (g) Lack of technical capacity by farmers
	Information and awareness	(h) Insufficient awareness and information (i) Insufficient awareness on the energy management system from decision-makers in factories

2.4.2.1 Economic and financial barriers for Solar Dryer

Cost barriers

(a) Lack of tax exemption

Even though solar PV system components (excluding breakers and batteries) are listed in commercial tax exemption goods, there is no tax exemption for components of solar dryer technology currently (VDB Loi, 2019). According to a bilateral meeting, the solar dryer supplier is levied 5% commercial tax, 5% customs duty, and 2% withholding tax on components of solar dryer. Since all components are imported, the supplier sometimes faces a high exchange rate for paying taxes. As a result, the cost of the technology is raised due to the lack of tax exemption.

(b) Insufficient subsidy program and Improper financial resources

The government of Myanmar does not provide any subsidies for climate change mitigation technology for the Industrial Sector. As mentioned in previously proposed technologies, local commercial banks lend high-interest loans which is a 13% interest plus a 1% service fee and a 1% commission fee for people who want to have the loan for the proposed technology. Therefore, a solar dryer is difficult to be accessible with insufficient subsidy programs and improper financial resources especially for low income enterprises, SMEs, and farmers due to high capital costs.

(c) Lack of economic feasibility assessment

Lack of economic feasibility assessment is another major barrier to technology diffusion. Since new climate mitigation technologies are higher in price, people are generally reluctant to invest in new technology. The reason is that they cannot easily see the financially viable of the proposed technology. Without knowing financially viable, investing in new technology is taking a risk to have benefits as a return.

2.4.2.2 Non-financial barriers for Solar Dryer

Policy, legal and regulatory barrier

(d) Absence of legal and policy framework and lack of enforcement

Myanmar does not have Renewable Energy Policy and Energy Efficiency Law, and there is no mandatory to use renewable energy in the industry sector. Most of the related initiative activities are voluntary. The absence of legal and policy frameworks and lack of regulatory enforcement is difficult to attract people to apply this technology in industries. Also, lack of capacity of the existing organizations in terms of work relating to policy, regulatory and procedure matters leads to happen this barrier.

Technical barrier

(e) Lack of standard on materials

Due to the lack of a standard for solar driers, low-quality system components can be seen in local fabrication solar driers in the country. Such low-quality system components are normally imported from China and these are generally unreliable and degrade in efficiency shortly after installation since there is not UV layer on the polycarbonate sheet for the solar dryer dome. The main reason for the availability of low-quality components is much cheaper than a good one. This can reduce the initial cost. Therefore, the proper standard is required to control the materials of solar driers. Moreover, the country does not have a technical service to measure and test the performance of solar driers and its related materials.

Human skill barriers

(f) Insufficient skilled manpower and absence of technology transfer

Insufficient skilled personnel to install, operate, and maintain the technology professionally even though some local fabrication can be seen around the countries by using inappropriate materials. Currently, there is only one professional supplier who can install and operate solar tunnel dryers well since he is trained by Silpakorn University from Thailand. Even though solar tunnel dryer technology already arrives in Myanmar, other types of driers are not accessible in the country due to the absence of technology transfer in the country and limited network with international universities.

(g) Lack of technical capacity by farmers

Normally, farmers are unfamiliar with O&M of this proposed technology compared to the engineer from industries even though they are also not familiar. Without knowledge of O&M, the technology cannot be sustainable in the agriculture sector where most farmers are there.

Information and awareness barriers

(h) Insufficient awareness and information

Although food processing industries are the most needed this proposed technology in the country, the information of solar dryer (not included local fabrication of solar dryer dome or tunnel dryer) such as benefits, advantages, costs, sources of financing and potential of the market is insufficient for people to be aware. Moreover, the awareness-raising through social media and electronic media are absence to raise awareness in factories.

(i) Insufficient awareness on the energy management system from decision-makers in factories

The energy management system is not popular in Myanmar since this knowledge just transfers to the country. Therefore, most people do not aware of its benefit. Due to insufficient awareness about the energy management system, most factories lack proper energy data management to find a solution to reduce energy consumption from inefficient machines or equipment in factories. This leads to a waste of useful end-use energy.

2.4.3 Identified measures for Solar Dryer

The following step-by-step process is applied to identify measures for solar driers technology.

i. Literature review
ii. Field visits
iii. Bilateral meeting
iv. Guidance from TNA Guidebook
v. Stakeholder consultation meeting

During the stakeholder consultation meeting, market map and problem tree are presented to discuss to change from problems to the solution, then the measures are classified and evaluated. To have comprehensive measures, stakeholders from the technical working group are requested to give more comments and feedbacks by reviewing the report.

2.4.3.1 Economic and financial measures for Solar Dryer

Measures for cost barriers

(a) Barrier: Lack of tax exemption
(a) Measure: Create an enabling framework for either tax exemption or reducing tax

As mention in the identification of the barrier section, the components of the solar dryer are levied different taxes and duties, and these lead to increasing the cost of the technology. Therefore, the government is suggested to create an enabling framework either to reduce taxes or to exempt taxes of the technology components. As a consequence, the capital cost would decrease, and more people would be accessible to this technology.

(b) Barrier: Insufficient subsidy program and Improper financial resources
(b) Measure: Engage subsidy programs and cooperate with commercial banks

The government could engage international environmental programs and other aids as like as RBF that already have initiative for energy efficiency projects to develop subsidy program for energy efficiency projects or government may seek a loan from funding agencies as like as the World Bank or ADB to provide partial subsidy to factories for their energy efficiency improvement project. Moreover, the government may guarantee to access a concession loan from the commercial bank.

(c) Barrier: Lack of economic feasibility study
(c) Measure: Conduct feasibility study and publish the result

This is suggested that the relevant ministry should conduct an economic and financial feasibility study of this proposed technology. Then, this study results should be available to the public and decision-makers by disseminating the study result. Competent national personnel should conduct this study for ensuring the results. To conduct the study, the government should reserve the budget or engage INGOs who already have the initiative on promoting a solar dryer.

2.4.3.2 Non-financial measures for Solar Dryer

Measure for policy, legal and regulatory barrier

(d) Barrier: Absence of legal and policy framework and lack of enforcement
(d) Measure: Formulate appropriate policy, legal and regulatory mechanisms

Formulating appropriate policy, legal and regulatory mechanisms could encourage and promote the technology. Therefore, the country is suggested to develop the Renewable Energy Policy and to Energy Efficiency Law for the Industrial Sector. These would enable the country to overcome the reluctance of the industries to adopt the proposed technology. However, these should be reinforced by the strong enforcement of the policy, strategy, and law to comply with policy and law.

Measure for technical barrier

(e) Barrier: Lack of standard on materials
(e) Measure: Set up a quality control system

Since the products and components standards are lacking, inferior quality products are widely seen in the country due to lower price than good products even though the quality of the product is unreliable. Therefore, setting up the standard for solar driers can control the quality of the product from importation and production. This can also effect local production when local manufacturing ~~is~~ has appeared. Moreover, the government should convince technology suppliers to set up the service which is testing and measuring the performance and efficiency of solar driers to monitor the efficiency of technology. Consequently, technology with better quality components will reduce the requirement of maintenance and raise system reliability. This information will echo among customers, and the diffusion of this proposed technology could be increased more.

Measures for human skill barriers

(f) Barrier: Insufficient skilled manpower and absence of technology transfer
(f) Measure: Technical education, adequate training and technology transfer

Human skills development is essential for ensuring every technology operation and management. Therefore, technical training with practical knowledge should be facilitated, and cooperation between line ministry and relevant ministry should be in place to develop technical education. The technical training should be with enough training times to get competent skilled labor. Moreover, the government may seek the support of either international organizations or suppliers from Myanmar to cooperate for conducting training. Apart from the solar tunnel dryer, the technology for designing other types of the dryer should be transferred to those who are interested in applying other types of the dryer. Technology transfer programs could be done by the support of DRI or by engaging with international universities who have such initiatives like AIT.

(g) Barrier: Lack of technical capacity by farmers
(g) Measure: Capacity development for farmers

This technology is directly linked to farmers in the Agriculture Sector to apply crop drying as post-harvesting technology. The farmers should equally access to join the training, and they should be trained in the technology used especially for operation and maintenance.

Measures for information and awareness barriers

(h) Barrier: Insufficient awareness and information
(h) Measure: Information and awareness campaigns

This technology potential should be provided with relevant information such as benefits, costs, sources of financing or subsidy programs, market potential. Such information could be shared by conducting adequate information and awareness campaigns through print, electronic media, and social media. Also, the motivation of media could be sought to develop an interest in sharing information about technology.

(i) Barrier: Insufficient awareness on the energy management system from decision-makers in factories
(i) Measure: Conduct energy management system course

The government could introduce an energy management system and its related benefits in workshops, meetings, websites, and social media. Moreover, training in the energy management system should be facilitated for the senior-level staff of factories and companies, engineers. Additionally, this knowledge should be the exchange between line ministries who are linked with agriculture industries, food processing industries, garment industries, etc. This would lead to enhancing better management of industries in terms of energy efficiency and factory operation.

2.4.4 Cost-Benefit Analysis of Solar Dryer

In this analysis, NPV of cost and benefit are estimated for Solar Dryer. According to the supplier interview, tunnel drying is mostly used to dry Chocolate Bell Chili which is one of the most common chili in Myanmar as a spice. The size of the dryer is different depending on the user. But this analysis

uses the assumption of the size which is 8 m x 6.2 m, and the capacity is 200 – 300 kg. Normally, the traditional chili drying method (Sun Drying) takes 7 to 10 days to dry chili with 75 – 80 % of moisture content to get 5 – 8 % of moisture content. When using a tunnel dryer, the length of the drying time is significantly decreased which is around 3 – 4 days based on the interview. Moreover, 50% of losses that are caused by spoilage and wastage can be reduced. Also, technology users can get superior quality of products compared to sun drying. Therefore, users can get more income when superior products can get double the price than normal products.

The following assumption are also included in CBA which are the cost of the dryer, labor cost, energy cost, marketing cost and packaging cost. The Profit of chili powder is the difference between the cost of chili powder that dries with a solar dryer and the cost of normal chili powder that uses the traditional sun drying method. The Cost difference is 0.5 USD per 80 g which is one box in the market. The currency exchange rate is assumed as 1,400 USD per MMK. In ~~the~~ Year 1, only half production is expected which is 1,563 boxes (1 box is 80 g) ~~in~~ each month, and production ~~is~~ has proceeded in only four months.

The total cost of the technology intervention is estimated at around 36, 843 USD but the user may not generate profit at Year 1 while the production is two times less than the actual production time due to taking time to familiarize with the usage of the solar dryer. After Year 1, the investment of solar dryer yields a net benefit of 47,086 USD. This intervention generates 225,455 USD of NPV for 10 years with 1.41 benefit-cost ratio, and the IRR is 227%. Therefore, investment in the solar dryers can generate more benefits for users.

Table 29: Total implementation cost of the Solar Dryer program at first year (USD)

Description	NPV at Year 1 (USD)
Total cost	36,843
Profit of chili powder	18,750
Net benefit	(18,093)
NPV	(16,448)
Total NPV for 10 years	225,455
BCR	1.41
IRR	227%

2.5 Linkages of the barriers identified

Since the country's industrial sector has been opened very recently, the sector is not ready to mitigate GHG emission by using appropriate enabling framework and mitigation technologies. Therefore, most barriers identified in this report are similar to each other. These similar barriers to all three technologies are grouped as common barriers, and these are mentioned below.

1. **High capital cost due to commercial tax and import duty**

Since equipment of all three technologies is imported to the country, these equipments are levied commercial tax and import duty at the point of importation. Moreover, the tax holiday is absent for industries that invest energy efficiency technologies to operate their manufacturing and production. Therefore, capital investment which is a common barrier is high for all three technologies. Consequently, most industries are hesitating to invest in new technologies.

2. **Insufficient financial resources and subsidies**

This is another common barrier for all technologies. In Myanmar, the loan interest rate which is a minimum of 13% for industries is high from the commercial bank, and collateral is required to attach to the loan proposal. On the other, the subsidy program for investing energy-efficient technologies is not in place to promote as mitigation technologies to enhance energy efficiency. Due to insufficient financial resources and subsidies, technology development in Industrial Sector is highlighting requiring attention as one of the key main barriers.

3. **Lack of economic feasibility assessment**

All three technologies are not examined for economic viability for industries. To carry out this kind of assessment needs either funding or investment. Therefore, some people from the private sector especially local factories do not be aware of the economic, social, and environmental benefits of these technologies because there is no reference information about technologies in terms of financial and energy efficiency level.

4. **Insufficient regulatory framework and enforcement**

Since the concept of energy efficiency and increase utilization of renewable energy in the Industrial Sector is new for the country especially for local industries, the regulatory framework is not comprehensive for this sector. This is considered another common barrier to all three technologies while one strong regulation is enough for energy efficiency improvement in industries even though the nature of all technologies is different. Therefore, insufficient regulatory framework and enforcement is a common barrier to promote energy efficiency and increase the utilization of renewable energy in the sector.

5. **Insufficient institutional capacities**

Insufficient institutional capacities in existing state institutions responsible for technology implementation is a common barrier for VSD and energy-efficient boiler technologies since technical knowledge is needed to inspect for energy efficiency monitoring purposes after a certain period of technology installation. Therefore, state institutions need adequate professionals to monitor the industrial sector to maintain a minimum energy efficiency level of country regulation.

6. **Lack of standard and labelling**

Lack of standard and labelling for all three technologies is a barrier to encourage to apply these technologies in industries for improvement of energy efficiency and conservation and to build confidence and trust in industries on the respective technologies. The reason is that inferior quality

products are available in the market, and users may lose the confidence in technology by using these products since the country does not have the proper standard for each technology.

7. **Poor O&M**

This barrier is more applicable to VSD and EEB because users need a certain amount of time to familiarize themselves with these technologies. For example, VSD is equipped with sophisticated electronic and computer devices while there is no such kind of system in the fundamental motor. Also, an energy-efficient boiler needs proper attention to maintain an achievable energy-efficient level for operation. Moreover, the unavailability of proper O&M facilities, service providers, and spare parts can cause poor O&M which leads to blocking to disseminate and popularize these technologies in the Industrial Sector.

8. **Insufficient Research and Development (R&D)/ technology transfer and Unfocused Training**

This can be mentioned as another common barrier for all technologies. However, insufficient research and development is more relevance to VSD and energy-efficient boiler while insufficient technology transfer is for solar dryer. Shortage and limited skilled personnel for technologies operation and maintenance and related equipment to keep achievable energy efficiency level is another barrier because of the absence of unfocused training for users.

9. **Insufficient awareness of energy management system from decision-makers in factories**

Since the concept of an energy management system is new in Myanmar, most factories owners and decision-makers do not aware of this and related benefits. As a consequence, most factories do not have historical energy consumption data and lack of reliable data because of lack of an energy management team. Moreover, decision-makers of industries are difficult to engage in to invest in energy-efficient technologies even if there is an energy management team or energy manager in their industries. Therefore, drawing up to increase the energy efficiency level in industries is difficult to implement.

2.6 Enabling framework for overcoming the barriers in the Industrial Sector

The common barriers are already identified in the previous section. These common barriers are broad categories into (1) High capital cost due to commercial tax, and import duty (2) Insufficient financial resources and subsidies, (3) Lack of economic feasibility assessment, (4) Insufficient regulatory framework and enforcement, (5) Insufficient institutional capacities, (6) Lack of standard, (7) Poor O&M, (8) Insufficient research and development/ technology transfer and Unfocused Training (9) Insufficient awareness on energy management system from decision-makers in factories. The below table is proposing an enabling framework for common barriers.

Table 30: Common barriers and proposed enabling framework for Industrial Sector

No	Common barriers	Enabling framework	Technology
1.	High capital cost due to commercial tax and import duty	1. Create enabling tax policy to decrease high capital cost for energy efficiency improvement in Industrial Sector	VSD, EEB, Solar Dryer
2.	Insufficient financial resources and subsidies	2. Create enabling environment to access concession loan and develop subsidy programs	VSD, EEB, Solar Dryer
3.	Lack of economic feasibility assessment	3. Conduct economic viability assessment and publish the results	VSD, EEB, Solar Dryer
4.	Insufficient regulatory framework and enforcement	4. Establish energy efficiency law and review current regulation for enforcement for energy efficiency improvement	VSD, EEB, Solar Dryer
5.	Insufficient institutional capacities	5. Institutional strengthen by providing training	VSD, EEB
6.	Lack of standard and labelling	6. Establish proper standard and labelling	VSD, EEB, Solar Dryer
7.	Poor O&M	7. Establish factory level O&M management system with registered after sale services providers and maintenance services providers	VSD, EEB
8.	Insufficient Research and Development (R&D)/ technology transfer and Unfocused Training	8. Conduct R&D activities and engage for technology transfer 9. Develop a curriculum for practical training courses	VSD, EEB, Solar Dryer
9.	Insufficient awareness on energy management system from decision makers in factories	10. Awareness raising program for factories' decision-making level staffs	VSD, EEB, Solar Dryer

Detailed Enabling frameworks for common barriers are proposed below.

1. Create enabling tax policy to decrease high capital cost for energy efficiency improvement in Industrial Sector

There is an opportunity in the Industrial Sector to encourage factory owners to invest in energy-efficient technologies if enabling tax policy is created in the country. The government should develop tax privileges (for example – tax holiday or tax reduction) to encourage factory owner to invest energy-efficient equipment and machines, performance-based tax incentive program (for example – a certain amount of energy-saving value is returned to the industry owner through income tax reduction until the limited period of the program), cost-based incentive program (example – a certain amount of actual capital investment is allowed for a tax deduction by phasing the deduction over a certain period of the program). Creating an enabling tax policy would be helpful to decrease high capital cost, and this can be one of the most effective measures since industries have been induced economically. Moreover, the government's revenue loss can be return as indirect saving by saving national-level energy consumption and by penetrating the export market with the support of industries' ability to manufacture products at low cost.

2. Create enabling environment to access concession loan and develop subsidy programs

The government could seek financial support for energy efficiency projects on not only energy-intensive industries but also SME through international funding or supporting agencies who have such kind of initiative to support developing countries as like as Responsible Business Fund by the Denmark Government which is the performance-based financial institutions for SME to improve in main thematic areas such as improve energy efficiency, improve food safety, improve waste management. RBF Fund supports up to 65% of capital cost or up to 80 million MMK of the technology based on the performance of the SME. Also, either government or private sector could seek to apply for the CDM-PoA or JCM. Moreover, the government could introduce the concept of energy efficiency and conservation in the Industrial Sector to commercial banks by seeking cooperation between the government and commercial banking sector to offer low-interest rate loans for promoting energy efficiency projects. Additionally, the government should create revolving funds or soft loans that are provided to promote energy efficiency investment in the Industrial Sector by providing capital investment with a low-interest rate for a certain period according to government procedure as like as Thailand Energy Efficiency Revolving Fund (Irawan & Heikens, 2012).

3. Conduct economic viability assessment and publish the results

Economic viability assessments are never done before for energy efficiency projects even though some individual projects are active in JCM and there is some technical feasibility study for solar driers. Such assessments could inform decision-makers how technologies are economically viable for industries in terms of energy and production efficiency to encourage to invest in energy efficiency equipment and technologies. Therefore, it is recommended that either the government, by assigning relevant institutions or pilot project which is implemented by the international organization, should be done such assessments for all three technologies and relevant technologies for industrial energy efficiency. Then, the results and study findings should be published to access potential private industrial sector investors. As the nature of feasibility assessment which needs to consider many

issues, a team of experts consisting of economists, engineers in the specialization of energy efficiency, and conservation in the Industrial Sector should be formed to conduct assessments.

4. Establish energy efficiency law and review current regulation for enforcement for energy efficiency improvement

According to the stakeholder consultation meeting, industrial stakeholders confirm that the country is in urgent need of Energy Efficiency Law while the country's Industrial Sector is growing quickly. To achieve the country mitigation target and energy efficiency target in the industry sector, Energy Efficiency Law is a critical policy document to guide and order the private industry sector to achieve energy efficiency improvement in respective industries. Additionally, the energy manager/ engineer assignment and formation of the energy management team in the industry are suggested to state in the policy. Moreover, this legal and regulatory framework should be followed by law enforcement to promote continuous improvement of energy efficiency and conservation.

5. Institutional strengthening by providing training

To address insufficient institutional capacities barrier, institutional strengthening by providing training could address this barrier with necessary skills and capacities. Mid-level employees' empowerment could improve institutional capacities by providing skills development in-service training, joining training from the international organization as like as UNIDO, etc. Moreover, cooperation between institutions and industries regarding the implementation of technologies could enable to enhance institutional capacities. Additionally, a joint audit with an international organization like UNIDO and institutions is also a solution to overcome the barrier of insufficient institutional capacities.

Moreover, the government should initiate to engage with the international university as like as AIT to send government officials to join their training program or their professional master's degree program. In this case, the government of Myanmar could adopt the current experience of engagement for a professional master's degree program in project management in construction at AIT to strengthen institutional capacities by sending officials to join a professional master degree program in the field of energy efficiency in Industrial Sector at international university.

6. Establish proper standards and labelling

Currently, the Department of Research and Innovation and Energy Efficiency and Conservation Department has some initiative for the development of energy efficiency standards and labelling for some selected appliances and items. It is suggested that the energy efficiency standard and labelling program should be extended to cover energy-efficient technologies for industries as well.

7. Establish a factory level O&M system with registered after-sale services providers and maintenance services providers

Good operation and maintenance system is an important need for industries for making sure the continued desire efficiency of new or advanced technologies and equipment. Most advanced technologies are set up with sophisticated computer control systems (for example – variable speed driver), and some are required proper maintenance (for example – proper insulation alongside steam

pipe and ashes are needed to be removed properly in the boiler which used biomass pellets). Therefore, regular maintenance and servicing, as a major factor, are generally required to keep the desire efficiency level throughout the lifetime of the technology. On the other hand, the availability of spare parts and after-sale services are other major factors for ensuring technology sustainability to be continued to require efficiency level of application.

8. Conduct R&D activities and engage for technology transfer

Generally, R&D activities could provide information on technologies in terms of cost, technology know-how, pros and cons of technologies, etc according to the objectives of activities. Conducting research and development in the field of energy efficiency technologies and mitigation technologies in the Industrial Sector could be enabled to overcome the reluctance of industries for investing in such kind of technologies. Therefore, the private sector, local universities, Department of Research and Innovation (DRI), and Energy Efficient and Conservation Department should initiate R&D activities in the area of energy-efficient technologies and climate mitigation technologies in Industrial Sector. To carry out R&D activities, funding should be provided either by the government's budget or by seeking support from donor agencies. These can be done through cooperation between research institutions and stakeholders from industries.

To address the insufficient technology transfer barrier, the government may seek the support of either international organizations or suppliers from Myanmar to cooperate for conducting training. Apart from the solar tunnel dryer, the technology for designing other types of the dryer should be transferred to those who are interested in applying other types of the dryer in their production process. Technology transfer programs could be done by the support of DRI or by engaging with international universities who have such initiatives.

9. Develop a curriculum for practical training courses

Due to the unfocused training and insufficient training, lack of/ limited skilled personnel for technologies implementation, operation, and maintenance in the Industrial Sector is a critical issue to address for energy efficiency improvement. This barrier could be enabled by providing practical training courses for users. Therefore, it is suggested that the government should develop practical training courses for industries. Additionally, focusing technical education at the university level could enable it to secure for young professionals for industries. Moreover, sustaining skill development effort should be facilitated by adequate capital investment in training facilities in the long run.

10. Awareness-raising program for factories' decision-making level staffs

To increase awareness of factories' decision-making level staff on energy efficiency, the government should initiate to engage with decision-makers and factory owners by introducing an energy management system and its related benefits in workshops, meetings, websites, and social media. Additionally, energy management system training or knowledge sharing session should be facilitated for them. These would result in better engagement for decision-makers for investing energy-efficient technologies.

Enabling framework for each technology: As mentioned above, there are ten common barriers for three different technologies and ten measures for them. However, the proposed enabling frameworks for technologies specific are presented in tables 31, 32 and 33 since some barriers are a bit different between each other, especially in barriers of technical, human skills, and institutional and organizational capacity.

Table 31: Enabling framework for Energy Efficient Motor (Using Variable Speed Driver (VSD))

Barriers Category	Barrier Dimension	Main Barriers	Enabling framework
Economic and Financial Barriers	Cost	(a) High taxes and import duty (b) Insufficient financial resources and subsidies (c) Financial variability not examined	(a) Regulation on the exemption of tax and import duty of machinery, appliances, and goods for energy efficient and climate technologies (b) Provision of financial and banking services for energy efficiency projects, and providing financial incentives to industries under appropriate financial mechanism (c) Study on the potential of CDM-PoA/ internationally supported NAMA concept in Energy Efficiency and Conservation Projects for electrical appliances (d) Create economic feasibility

			assessment activities in different industry sub-categories which are using VSD system
Non- Financial Barriers	Policy, legal and regulatory	(d) Lack of legal regulatory framework and lack of enforcement	(e) Establish energy efficiency law and develop appropriate regulatory mechanism for enforcement
	Institutional and organizational capacity	(e) Lack of capacity in the existing institution because of insufficient time and prioritized other responsibility by engaged departments	(f) Capacity development in existing institution
	Technical	(f) Lack of standards and codes (g) Poor O&M	(g) Develop proper standards and codes (h) Establish factory level O&M management system with registered after sale services providers and maintenance services providers
	Human skill	(h) Insufficient Research and Development (R&D) and lack of curriculum for practical training	(i) Develop R&D activities (j) Develop curriculum for step-by-step practical training courses
	Information and awareness	(i) Inadequate knowledge and compliance on energy management system of the decision-makers in factories	(k) Technology transfer of energy management system

Table 32: Enabling framework for Energy Efficient Boiler

Category	Barrier Dimension	Main Barriers	Proposed measures
Economic and financial barriers	Cost	(a) High capital cost due to taxes and custom duty (b) Weak access to financial resources (c) Lack of financial feasibility assessment	(a) Regulation on the exemption of taxes and import duty of boilers and its related accessories for energy efficient and climate technologies (b) Provision of financial mechanisms and incentives (c) Study on the potential of CDM-PoA/ internationally supported NAMA concept in Energy Efficiency and Conservation Projects for energy efficient boiler and fuel switching technologies in boilers (d) Create economic feasibility assessment activities in different industry sub-categories which are using boilers
Non-financial barriers	Policy, legal and regulatory	(d) Lack of specific regulatory framework on boiler efficiency	(e) Establish energy efficiency law including specific section for boiler and review current regulation to update for energy efficiency improvement

	Institutional and organizational	(e) Insufficient human resource and limited capacity for boiler inspection in existing institutions	(f) Institutional strengthen by providing training
	Technical	(f) Weak O&M (g) Lack of efficiency standard for boilers	(g) Establish critical mass of locally trained personnel and establish training programs for technical and operators (h) Develop minimum energy efficiency standard
	Human skill	(h) Lack of Research and Development (R&D)	(i) Develop Industrial based R&D activities
	Information and awareness	(i) Lack of awareness and compliance by decision-makers in factories regarding energy management system	(j) Technology transfer of energy management system

Table 33: Enabling framework for Solar Dryer

Category	Barrier Dimension	Main Barriers	Proposed measures
Economic and Financial barriers	Cost	(a) Lack of tax exemption (b) Insufficient subsidy program and Improper financial resources (c) Lack of economic feasibility assessment	(a) Develop either tax exemption or reducing tax mechanism to encourage the use of renewable technology in industrial sector (b) Establish subsidy programs and provision of financial and baking services (c) Create economic feasibility assessment activities

Non-financial barriers	Policy, legal and regulatory	(d) Absence of legal and policy framework and lack of enforcement	(d) Formulate enabling policy, legal and regulatory framework for solar driers
	Technical	(e) Lack of standard on materials	(e) Set up a quality control system
	Human skill	(f) Insufficient skilled manpower and absence of technology transfer (g) Lack of technical capacity by farmers	(f) Establish technical education, adequate training and technology transfer programs (g) Capacity development program for farmers
	Information and awareness	(h) Insufficient awareness and information (i) Insufficient awareness on energy management system from decision makers in factories	(h) Create information and awareness campaigns (i) Technology transfer of energy management system

Chapter 3 Conclusion

Barrier Analysis and Enabling Framework Report, the Technology Needs Assessment (TNA) Report II, is the follow-up report for the results of technologies identification and prioritization in climate change mitigation sectors which was presented in TNA Report I.

The report analyzed the barriers throughout the technologies supply chain through literature review and root cause analysis and developed measures for enabling framework for technologies transfer and diffusion of prioritized technologies in the Energy and Industrial Sectors. The purpose of applying root cause analysis is to present the relationship between the problem trees, solution trees and the market maps for each technology. The outcome of these analyses was discussed with key stakeholders and presented in the online stakeholder consultation meeting with the technical working group to validate the results for the report.

The major barriers to the wide diffusion of prioritized technologies are categorized under economic and financial barriers and non-financial barriers, and the identification of measures is followed to overcome these barriers. Moreover, the proposed enabling framework to address the barriers is presented in two stages which are enabling framework for common barriers and the technology-specific barriers. The common barriers identified in the energy sector i.e. solar mini-grid, LED and LPG are high capital cost due to import tax, lack of/ insufficient financial support and subsidy, lack of / Insufficient policy, legal and regulatory framework, insufficient coordination between key stakeholders or line ministries, insufficient capacity in a key institution and limited market information.

The proposed enabling framework for Energy Sector to overcome these common barriers primarily include facilitate tax reduction or tax removing scheme on the importation of technologies in respect of Energy Efficiency Projects, engage with international funding agencies for solar mini-grid, create subsidy program for Energy Efficiency in the residential sector, develop appropriate policy and regulatory framework to promote mitigation technologies, set up appropriate coordination channel within key stakeholders, provide technical training to staffs and create awareness campaign through various media as well as the enabling framework for technology-specific barriers are presented in Section 1.6.

The common barriers in Industrial Sector for VSD, Energy Efficient Boiler and Solar Dryer are high capital cost due to commercial tax and import duty, insufficient financial resources and subsidies, lack of economic feasibility assessment, insufficient regulatory framework and enforcement, insufficient institutional capacities, lack of standard and labelling, poor O&M, insufficient Research and Development (R&D)/ technology transfer and unfocused training and insufficient awareness on energy management system from decision-makers in factories. The proposed enabling framework for Industrial Sector mainly includes create enabling tax policy to decrease high capital cost, create enabling environment to access concession loan and develop subsidy program for energy efficiency projects, facilitate to conduct technologies economic feasibility assessment. Moreover, energy efficiency law is needed to establish the enforcement of energy efficiency improvement, and establishing proper standards and labelling for proposed technologies is necessary. Training programs are necessary to strengthen the institutional capacity, and the development of curriculum for practical training is required to ensure a pool of skilled personnel. Additionally, conducting R&D

activities and engagement for technology transfer is the requirement for technologies diffusion, and awareness-raising programs for factories' decision-making level staffs is needed to encourage the factory to apply energy management systems in factories. In section 2.6, technology-specific enabling frameworks are presented as well for the Industrial Sector.

These proposed enabling framework for Energy and Industrial Sectors are required to be integrated with other relevant sectoral policies and strategies in somehow. Consequently, these measures could facilitate the elimination of barriers and diffusion and adoption of prioritized technologies to reduce greenhouse gas emission. Therefore, Myanmar could be in place on a low green economic growth path.

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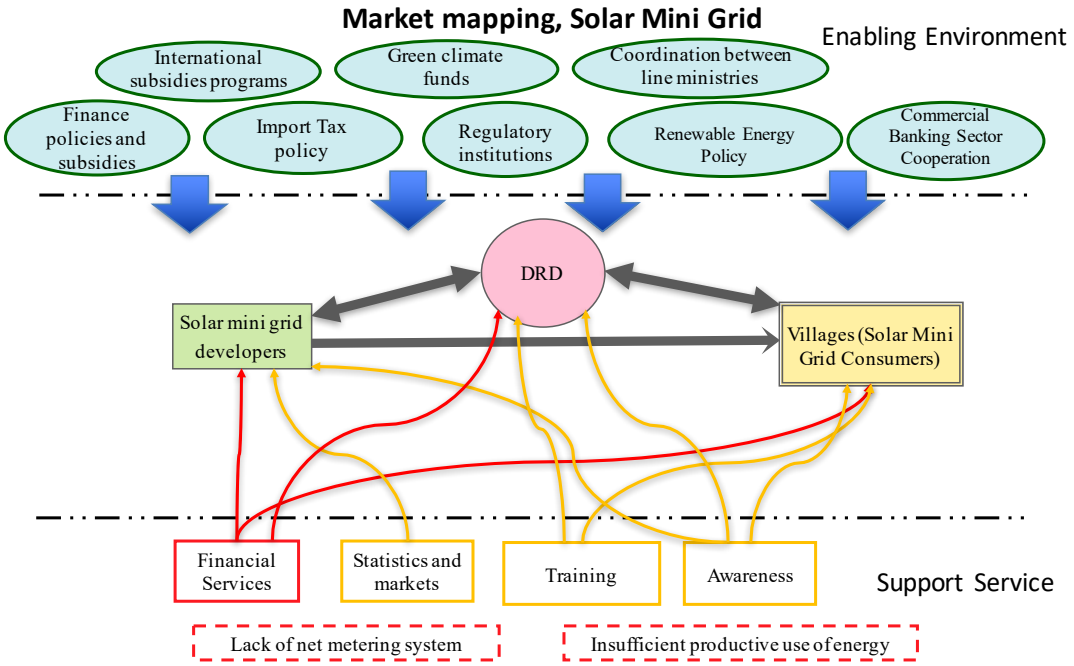
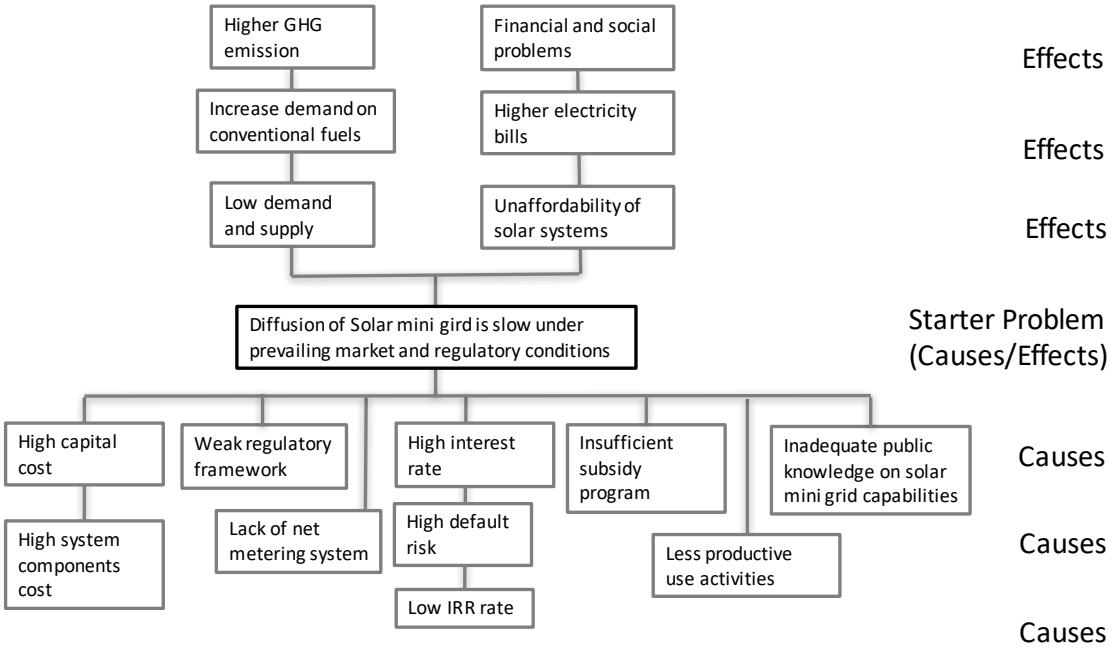
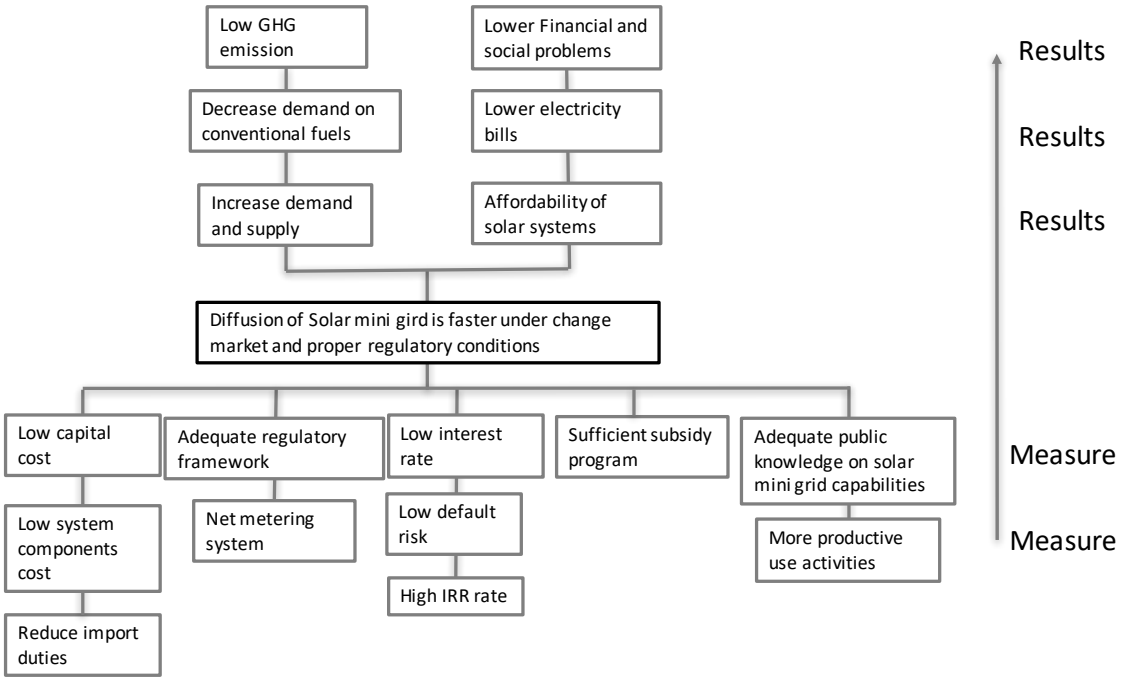
Annex I: Market maps and problem trees for Energy Sector

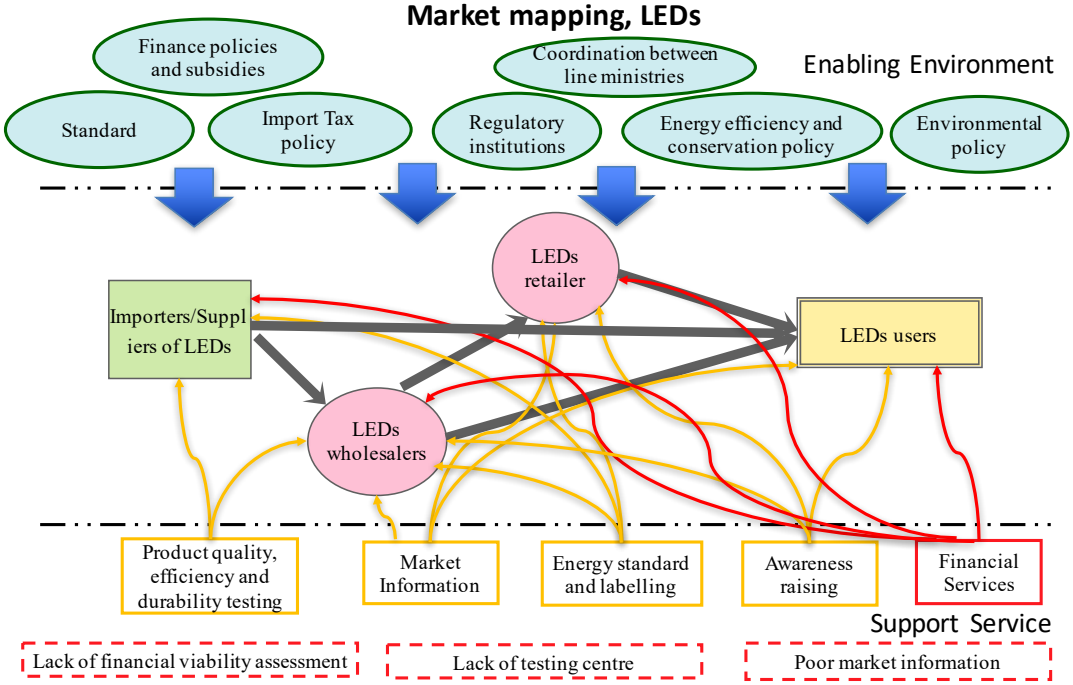




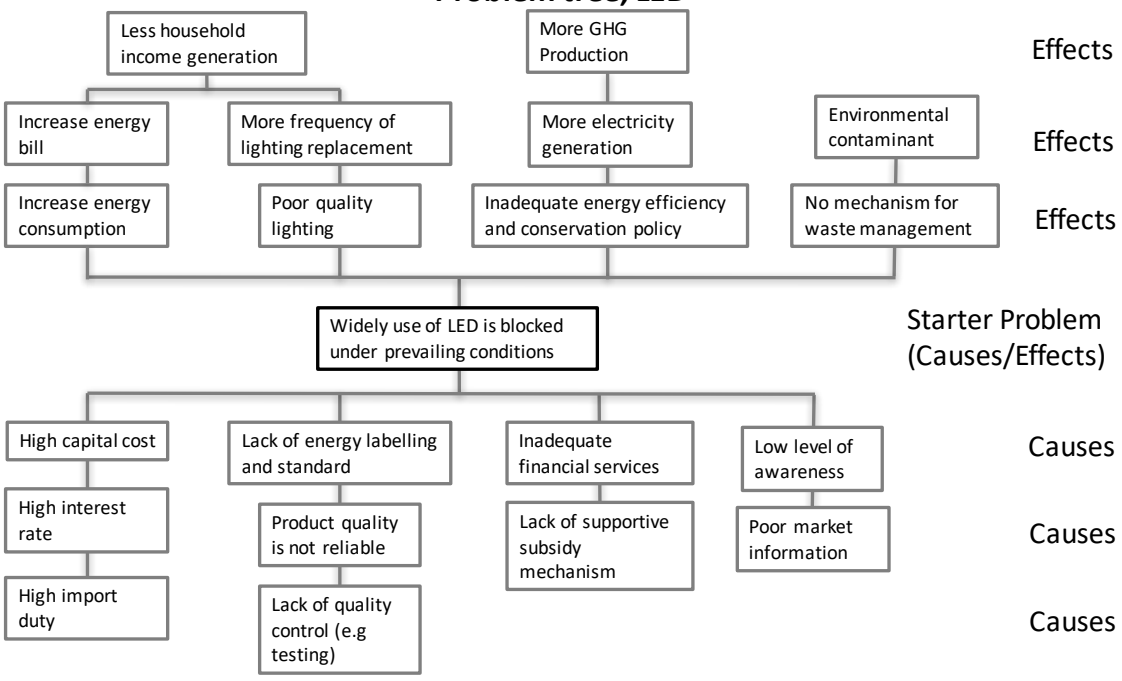
Translated Problems to Solutions, Solar Mini Grid



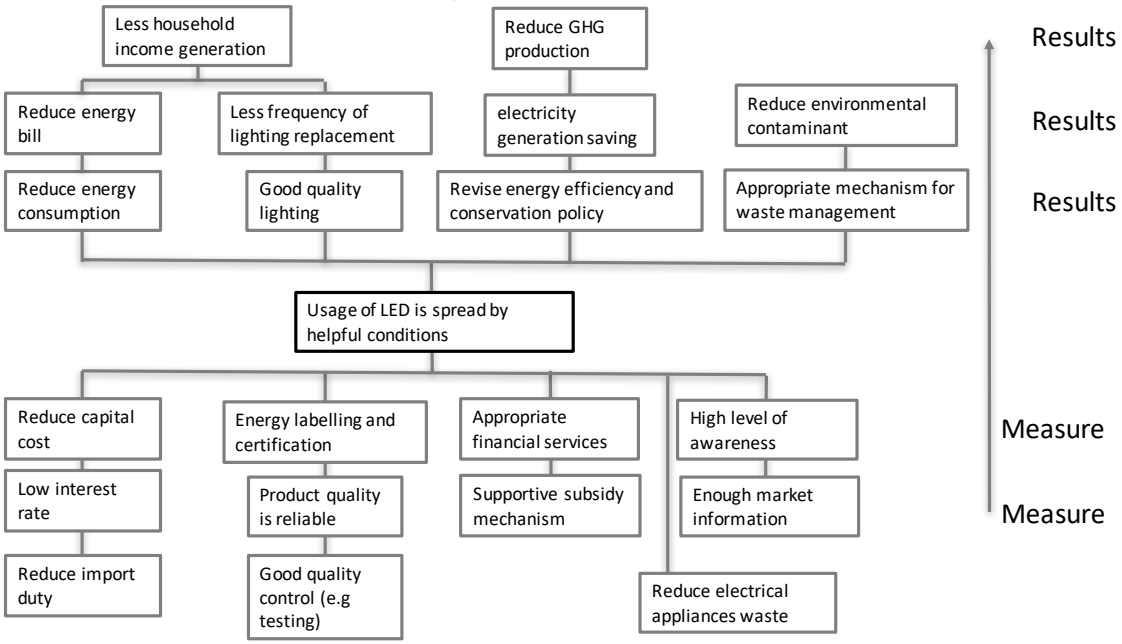
Market mapping, LEDs



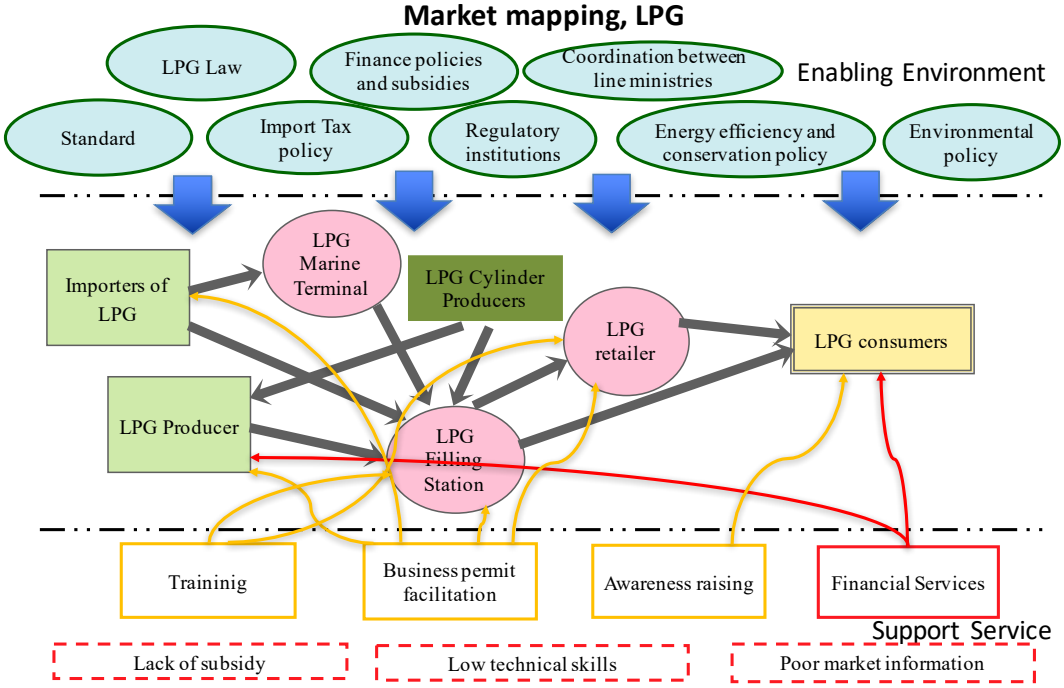
Problem tree, LED



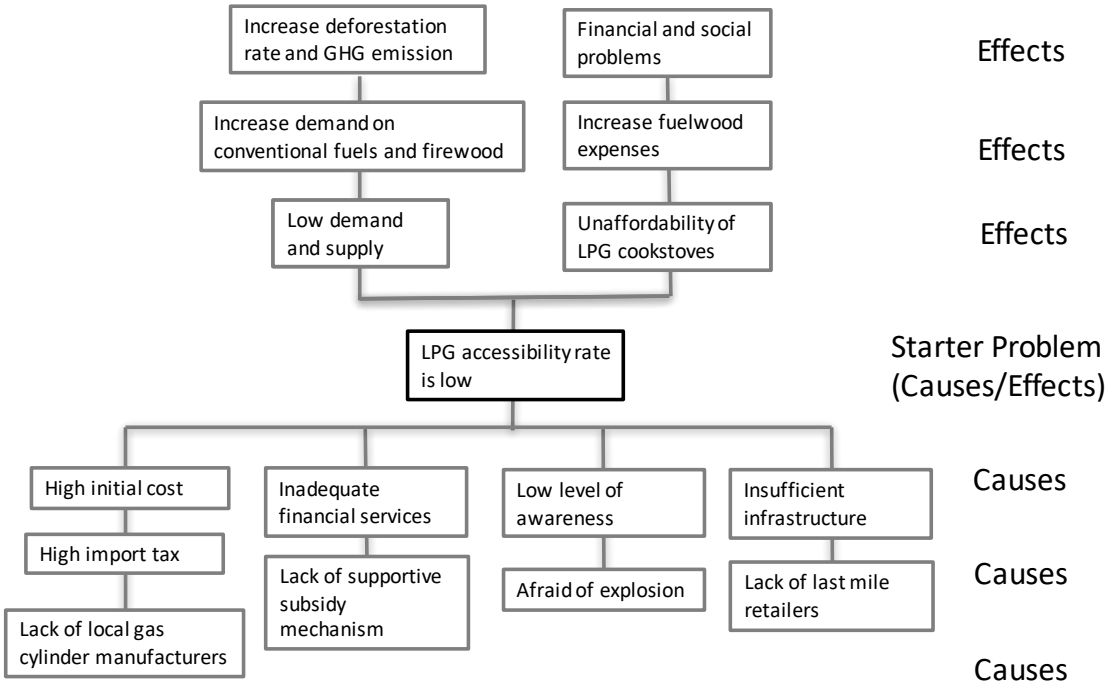
Translated problems to solutions, LED



Market mapping, LPG



Problem tree, LPG



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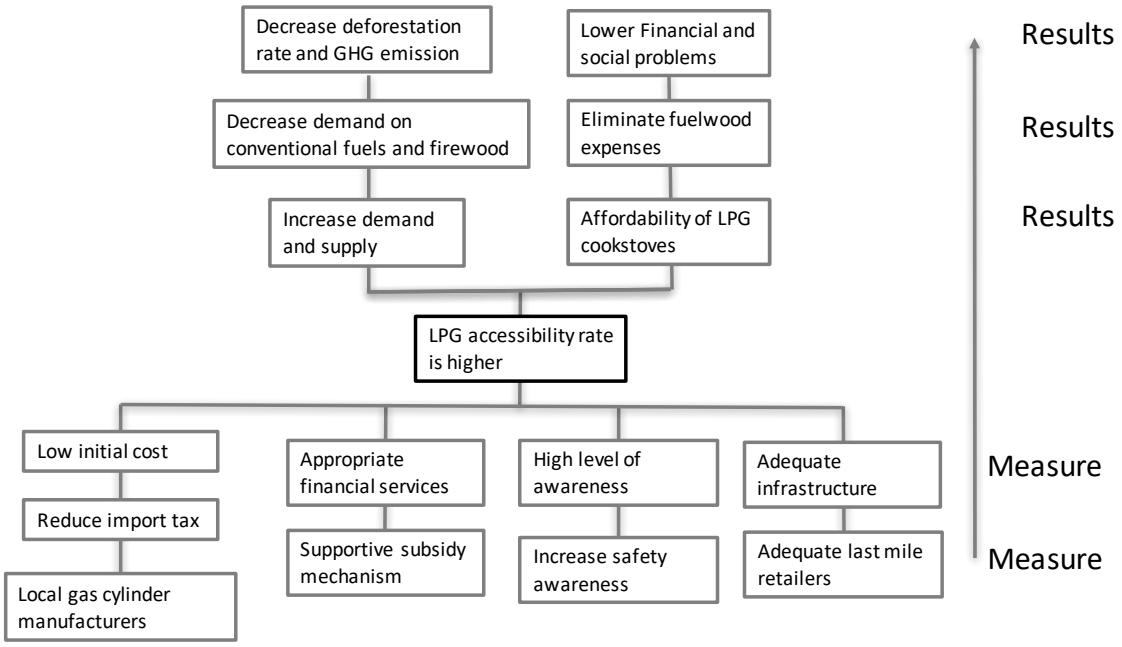
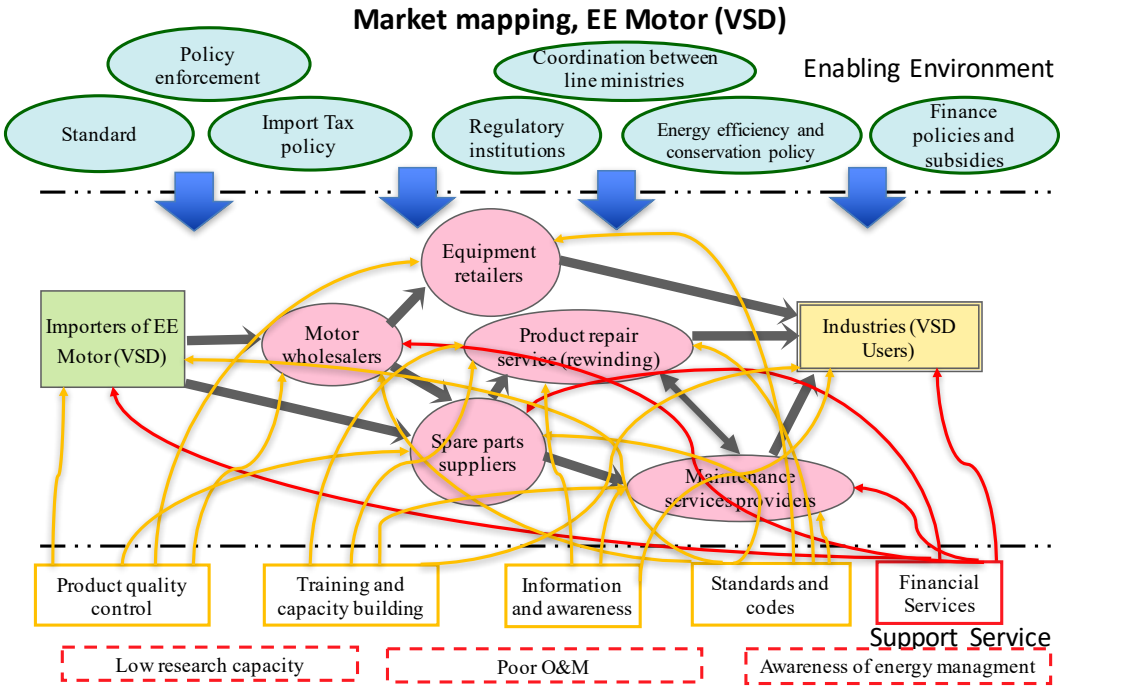
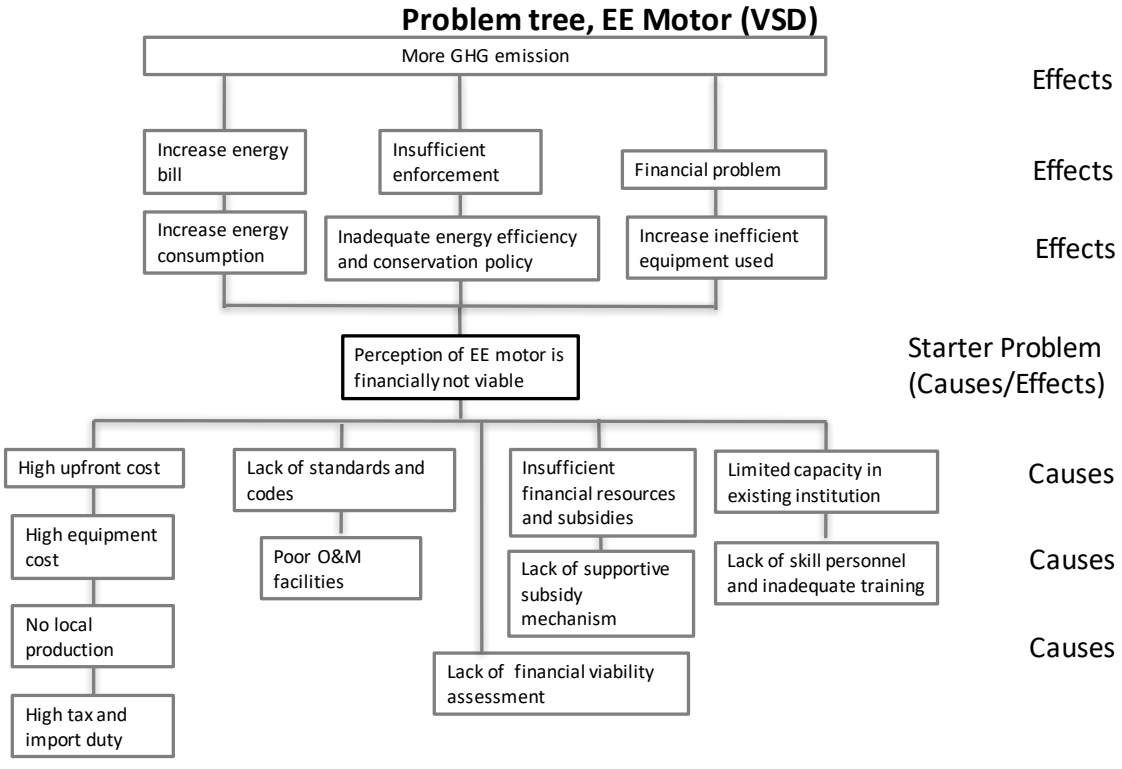
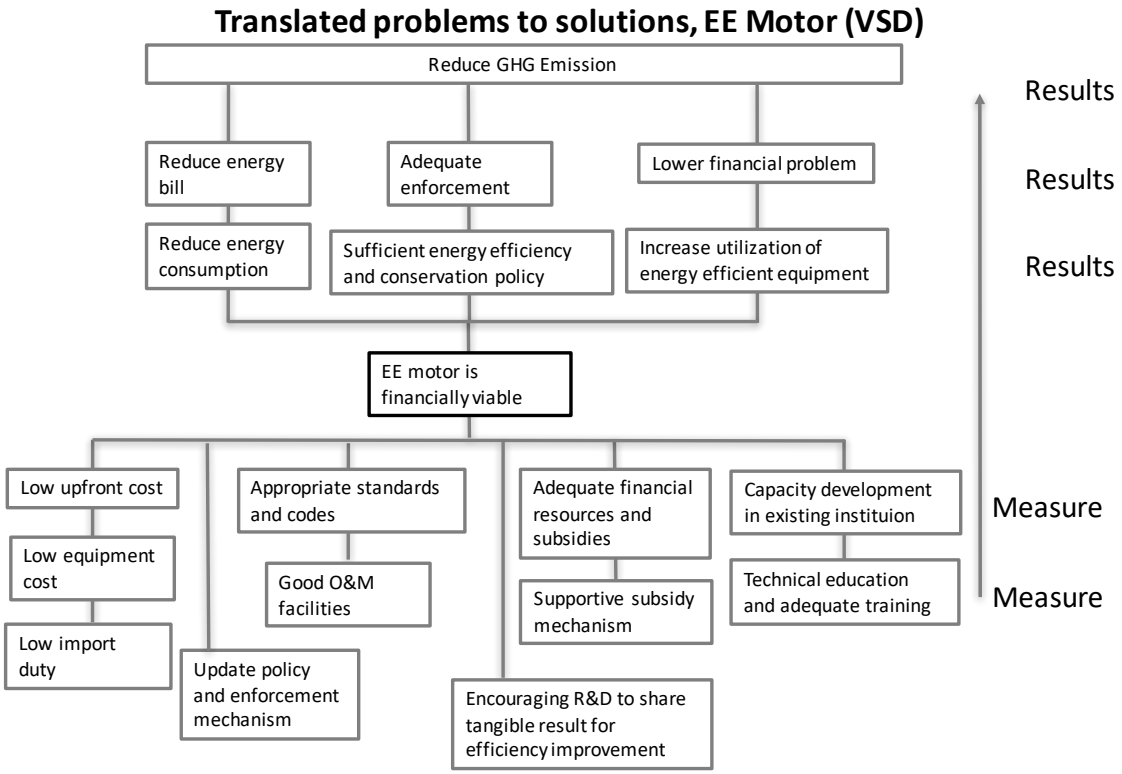
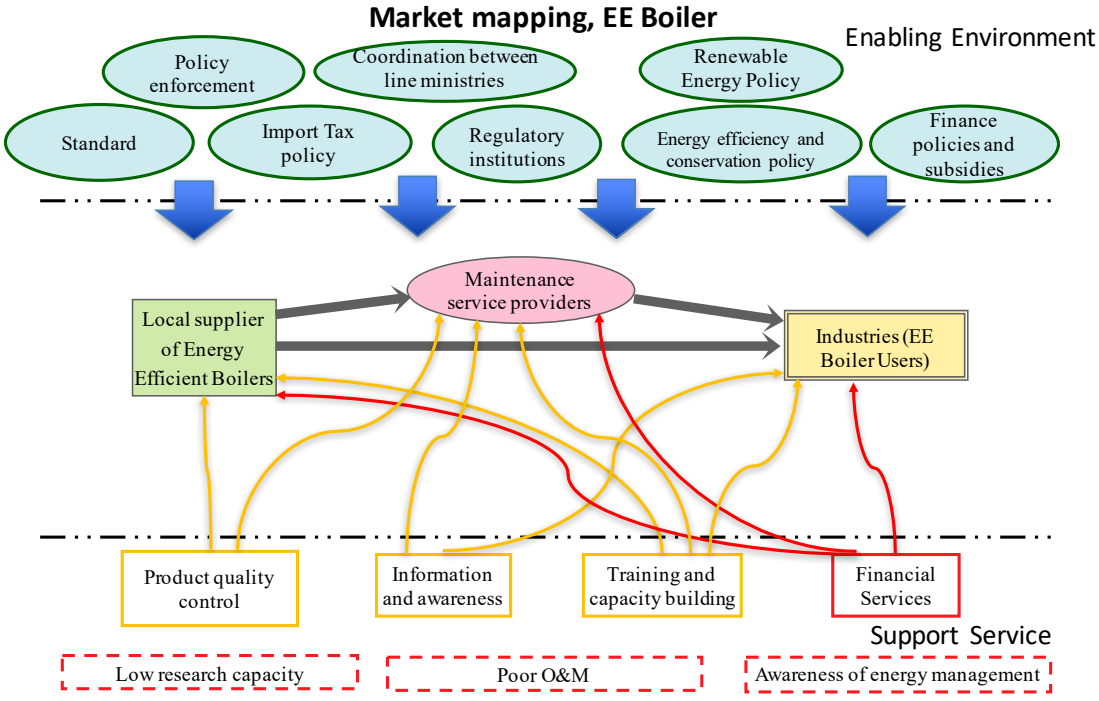


Annex II: Market maps and problem trees for Industrial Sector

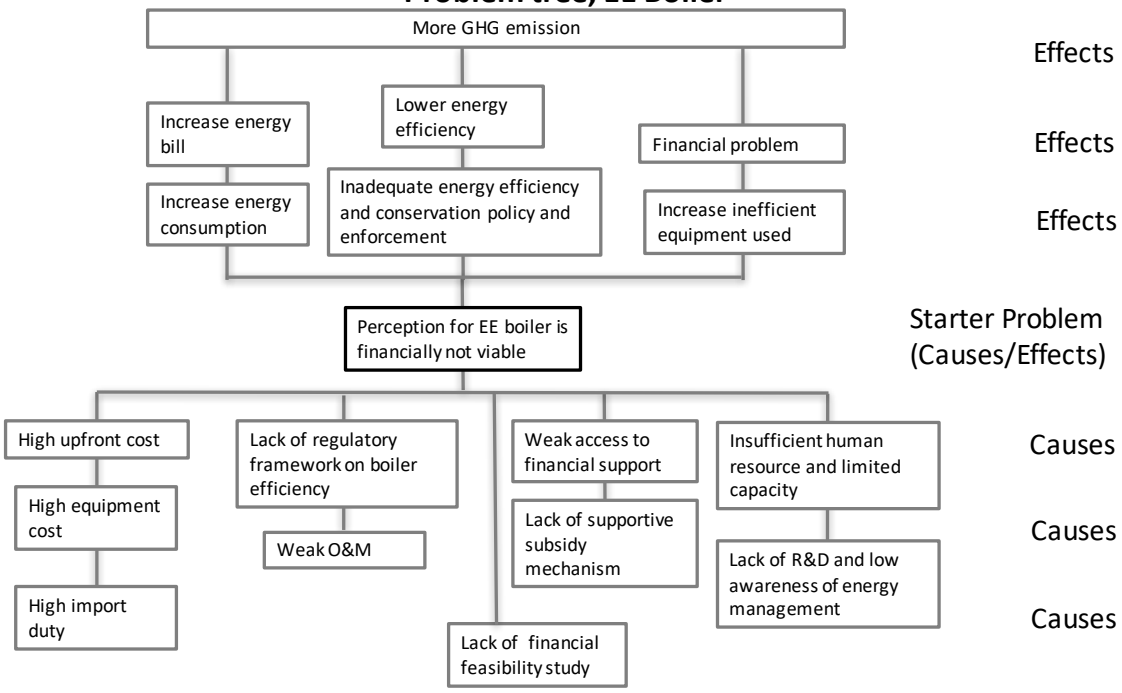




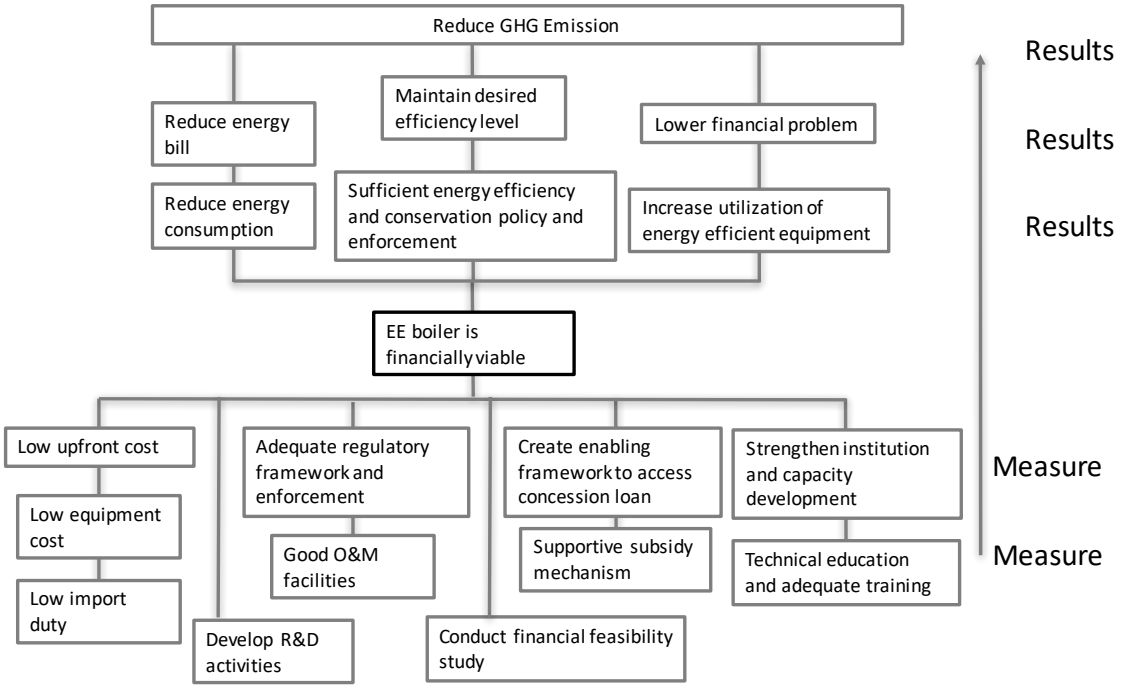

Translated problems to solutions, EE Motor (VSD)
Reduce GHG Emission
Reduce energy bill
Adequate enforcement
Lower financial problem
Reduce energy consumption
Sufficient energy efficiency and conservation policy
Increase utilization of energy efficient equipment
EE motor is financially viable
Low upfront cost
Low equipment cost
Low import duty
Appropriate standards and codes
Good O&M facilities
Update policy and enforcement mechanism
Adequate financial resources and subsidies
Supportive subsidy mechanism
Encouraging R&D to share tangible result for efficiency improvement
Capacity development in existing instituion
Technical education and adequate training
Results
Results
Results
Measure
Measure


Market mapping, EE Boiler
Enabling Environment
Policy enforcement
Coordination between line ministries
Renewable Energy Policy
Standard
Import Tax policy
Regulatory institutions
Energy efficiency and conservation policy
Finance policies and subsidies
Maintenance service providers
Local supplier of Energy Efficient Boilers
Industries (EE Boiler Users)
Product quality control
Information and awareness
Training and capacity building
Financial Services
Support Service
Low research capacity
Poor O&M
Awareness of energy management

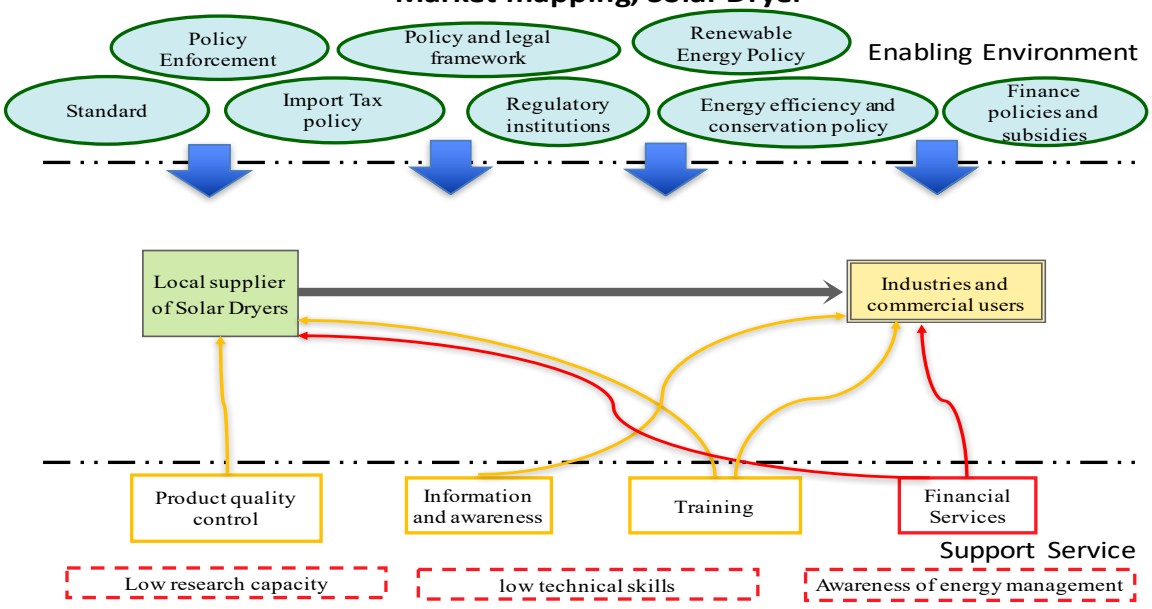
Problem tree, EE Boiler



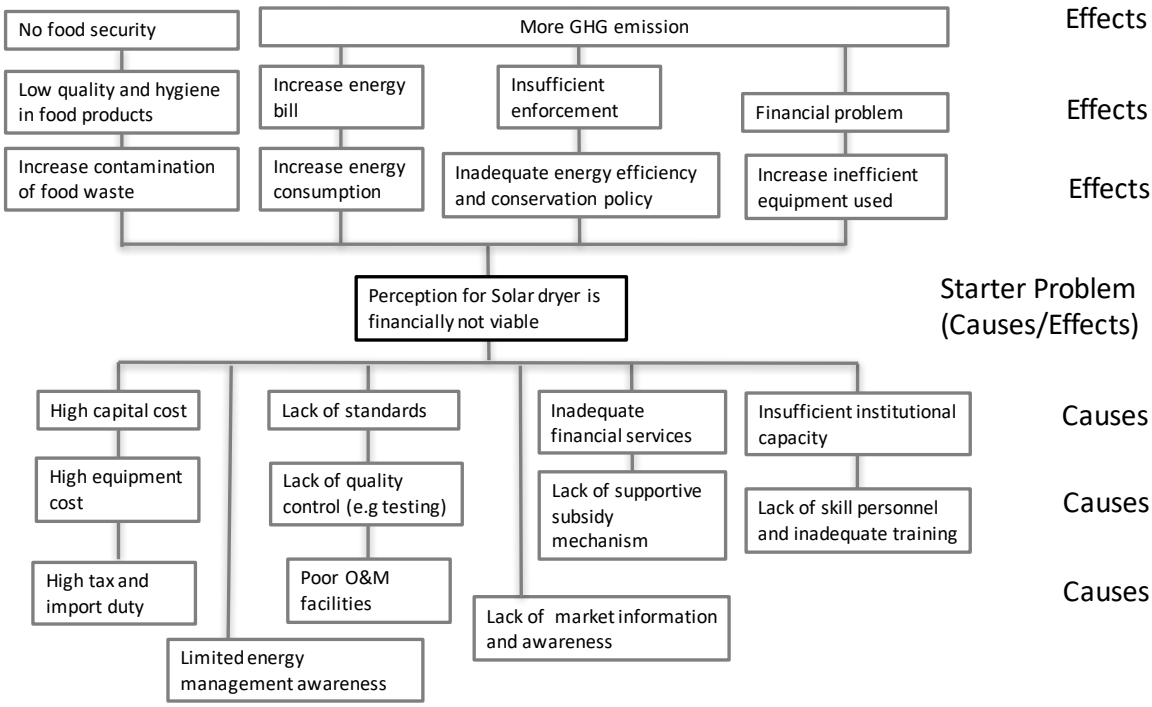
Translated problems to solutions, EE Boiler



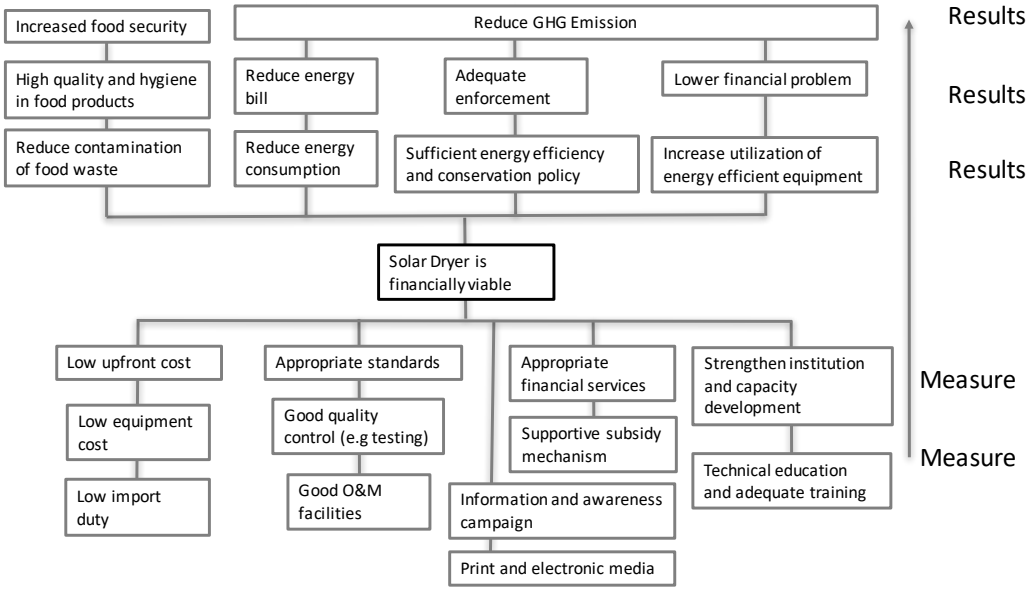
Market mapping, Solar Dryer



Problem tree, Solar Dryer



Translated problems to solutions, Solar Dryer



Annex III: Cost-benefit Analysis Calculation

Economic viability calculation for LED program

The unit of all costs is USD.

No	Items	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
1	Developing Minimum energy performance standard and labelling	12,500	12,500	12,500	12,500						
2	Staff cost for 4 years program	60,000	60,000	60,000	60,000						
3	Market Monitoring, verification and enforcement for 4 years	250,000	250,000	250,000	250,000						
4	Awareness raising and demonstration project for 4 years	250,000	250,000	250,000	250,000						
5	Hiring experts for assessment and analysis	16,667	16,667	16,667							
6	Testing Center	50,000									
7	Training for Testing Center	5,000	5,000	5,000	5,000						
8	LED subsidy for one time during program years (50%)	7,972,222									
9	HH buying new LED for replacement					15,944,444					15,944,444
	Total Cost	8,616,389	594,167	594,167	577,500	15,944,444					15,944,444
10	Total HH electricity saving bill	2,485,024	2,485,024	2,485,024	2,485,024	2,485,024	2,485,024	2,485,024	2,485,024	2,485,024	2,485,024

11	Total avoided replacement cost of lighting fixtures due to LED		5,038,690	5,038,690	5,038,690		5,038,690	5,038,690	5,038,690	5,038,690	
12	Avoided Capital investment for electricity generation		6,808,284	6,808,284	6,808,284	6,808,284	6,808,284	6,808,284	6,808,284	6,808,284	6,808,284
13	Total emission reduction cost (CO2)		2,333,051	2,333,051	2,333,051	2,333,051	2,333,051	2,333,051	2,333,051	2,333,051	2,333,051
	Total benefit	2,485,024	16,665,049	16,665,049	16,665,049	11,626,358	16,665,049	16,665,049	16,665,049	16,665,049	11,626,358
	Net benefit	(6,131,365)	16,070,882	16,070,882	16,087,549	(4,318,086)	16,665,049	16,665,049	16,665,049	16,665,049	(4,318,086)
	Discount rate	10%									
	NPV	(5,573,968)	13,281,721	12,074,291	10,988,012	(2,681,192)	9,406,985	8,551,805	7,774,368	7,067,607	(1,664,809)
	Total NPV	59,224,821									
	Discount benefit	(5,573,968)	13,281,721	12,074,291	10,988,012	(2,681,192)	9,406,985	8,551,805	7,774,368	7,067,607	(1,664,809)
	Discount cost	7,833,081	491,047	446,406	394,440	14,494,949					14,494,949
	Total discount benefit	59,224,821									
	Total discount cost	38,154,873									
	BCR	1.55									
	IRR	224%									

Economic viability calculation for LPG program (The unit of all costs is USD.)

No	Items	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
1	Total starter pack	22,000,000	0	0	0						
2	Marketing and promotion	22,857	22,857	22,857	22,857						
3	Inspection Training for officials	7,143	7,143	7,143	0						
4	Cost of retailer shop	142,857	0	0	0						
5	Subsidy rate of gas for 4 kg	1.43	1.43	1.43	1.43						
6	Total refill cost for 1,000,000 HH for 3 years	15,714,286	17,142,857	17,142,857	17,142,857						
7	User manual for 1,000,000 HH	5,714,286	0	0	0						
8	Training for 10 retailer shops	3,571	0	0	0						
9	Staffing cost for program	72,000	72,000	72,000	72,000						

	Total program cost	43,677,000	17,244,859	17,244,859	17,237,716						
10	Total avoided cost of people who suffer UPRD per year (40% HH)	9,142,857	18,285,714	18,285,714	18,285,714	18,285,714	18,285,714	18,285,714	18,285,714	18,285,714	18,285,714
11	Benefit of cooking time saving (4 hr doing income generation by 40% of HH)	8,228,571	8,228,571	8,228,571	8,228,571	8,228,571	8,228,571	8,228,571	8,228,571	8,228,571	8,228,571
12	Income generation by avoiding fuelwood collection per total HH per year (20% of HH)	8,228,571	8,228,571	8,228,571	8,228,571	8,228,571	8,228,571	8,228,571	8,228,571	8,228,571	8,228,571
13	Total fuelwood cost saving for 1,000,000 HH	1,428,571	1,428,571	1,428,571	1,428,571	1,428,571	1,428,571	1,428,571	1,428,571	1,428,571	1,428,571
14	Total emission reduction cost	0	2,777,688	2,777,688	2,777,688	2,777,688	2,777,688	2,777,688	2,777,688	2,777,688	2,777,688
	Total benefit	27,028,571	38,949,116	38,949,116	38,949,116	38,949,116	38,949,116	38,949,116	38,949,116	38,949,116	38,949,116

	Net Benefit	(16,648,429)	21,704,257.8	21,704,258	21,711,401	38,949,116	38,949,116	38,949,116	38,949,116	38,949,116	38,949,116
	Discount rate	10%									
	NPV	(15,134,935)	17,937,403	17,937,403	16,312,097	26,602,771	24,184,337	21,985,761	19,987,055	18,170,050	16,518,228
	Sum NPV	164,500,169.265									
	Discount Benefit	(15,134,935)	19,731,143	17,937,403	16,312,097	26,602,771	24,184,337	21,985,761	19,987,055	18,170,050	16,518,228
	Discount Cost	39,706,364	15,677,144	14,251,949	12,950,951						
	Sum discount benefit	166,293,910									
	Sum discount cost	82,586,408									
	BCR	2.014									
	IRR	121%									

Economic viability calculation for VSD

No	Parameter	Unit	Value
1	No of motor	Qty	97.0
2	Capacity of motor	kW	0.5
3	Working hours/day	h	8.0
4	Working hours/month	h/month	176.0
6	Electricity saving	kWh/annum	102,432.00
7	Cost of electricity saving	USD/kWh/annum	10,759.03
8	Expected investment cost	USD	57,142.86
9	Simple payback period	Years	5.31

National CO_2 emission reduction due to electricity saving = 102,432 kWh / 0.32 ton CO_2/MWh = 320.1 ton CO_2

Total emission reduction cost = 320.1 ton CO_2 x 36 USD/ton = 11,523.6 USD

Economic viability calculation for Energy Efficient Boiler

No	Parameter	Unit	Old	New (Wood)	New (Mix Pellets)
1	Operating hours	hr	8	8	8
2	Operating days	days	240	240	240
3	Temperature of feed water	℃	25	25	25
4	Temperature of hot water required	℃	55-60	55-60	55-60
5	Steam preasure	kg/cm2	5	10	10
6	Calorific value of wood	kcal/kg	3,200	3,200	4200
7	Average efficiency of equipment	%	35	60	60
8	Fuel consumption per day	kg/day	700	408	311.12
9	Wood consumption	ton/year	168	98	74.668
10	Saving of wood consumption	ton	N/A	70	93.33
11	Cost of wood	USD / ton	22	22.32	57.14
12	Monetary saving	USD	N/A	1,562.50	2,083.30
13	Cost of project	USD	N/A	5,000	5,000
14	Payback period	Years	N/a	3.2	2.40

Economic viability calculation for Solar Dryer

The unit of all costs is USD.

No	Items	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
1	Cost of Dryer	8,929									
2	Operating cost	8,571	8,571	8,571	8,571	8,571	8,571	8,571	8,571	8,571	8,571
3	Electricity cost	8,571	8,571	8,571	8,571	8,571	8,571	8,571	8,571	8,571	8,571
4	Packaging cost	10,714	10,714	10,714	10,714	10,714	10,714	10,714	10,714	10,714	10,714
5	Marketing cost	57	57	57	57	57	57	57	57	57	57
	Total cost	36,843	27,914	27,914	27,914	27,914	27,914	27,914	27,914	27,914	27,914
3	Profit of chili powder	18,750	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000
	Net benefit	(18,093)	47,086	47,086	47,086	47,086	47,086	47,086	47,086	47,086	47,086
	NPV	(16,448)	38,914	35,376	32,160	29,237	24,162	21,966	21,966	19,969	18,154
	Total NPV	225,455									
	Discount benefit	(16,448)	42,805	42,805	42,805	42,805	42,805	42,805	42,805	42,805	42,805
	Discount cost	33,494	25,377	25,377	25,377	25,377	25,377	25,377	25,377	25,377	25,377
	Total discount benefit	368,799									
	Total discount cost	261,883									
	BCR	1.408256881									
	IRR	227%									

Annex IV: List of stakeholders involved and their contacts in consultation meeting, bilateral meetings, field visits and mini grid developer round table

List of stakeholders in the Energy Sector stakeholder consultation meeting

No	Name	Designation/ Phone Number	Department	Email Address
1.	U Myint Htun Kyaw	Deputy Director	Energy Efficiency and Conservation Department (EE&CD), Directorate of Industrial Collaboration	myinthtunkyaw81@gmail.com
2.	U Myo Myo	Deputy Director	Department of Rural Development	myomyonpd@gmail.com
3.	Daw Su Su Soe	Deputy Director	Oil and Gas Planning Department	suusuusoe@gmail.com
4.	U Soe Ko Ko Aung	Assistant Director	Department of Electric Power and Planning	dazagga@gmail.com
5.	Daw Swe Lin Myint	Assistant Director	Myanmar Petrochemical Enterprise	shwelinmyint@gmail.com
6.	Daw Khin Cho Oo	Assistant Director	Myanmar Petrochemical Enterprise	khinchooo.mpe@gmail.com
7.	Daw Win Min Phyo	Director	Department of Trade	dotregional@gmail.com
8.	Dr. Nan Sandar Lwin	Director	Renewable Energy Department, Department of Research and Innovation	sandar.lwin75@gmail.com
9.	Dr. Hla Myo Aung	Director, Head of Department	Renewable Energy Department, Department of Research and Innovation	hlamyo.25@gmail.com

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12.	U Pyae Phyo Aung	Energy Officer	World Wide Fund for Nature(WWF)	pyaephyo.aung@wwf.org.mm
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18.	Daw Shwe Yamin Oo	Staff Officer	Climate Change Division, Environmental Conservation Department	Shweyamin00890ecd@gmail.com
19.	U Kyaw Swan Thu	Deputy Staff Officer	Climate Change Division, Environmental Conservation Department	kyawswamthu.9915@gmail.com

List of stakeholders in the Industrial Sector stakeholder consultation meeting

No	Name	Designation	Department	Email Address
1.	Daw Wai Wai Kyaw	Deputy Director	Myanmar Customs	waimoekyaw94@ gmail.com
2.	U Myint Htun Kyaw	Deputy Director	Energy Efficiency and Conservation Department (EE&CD), Directorate of Industrial Collaboration	myinthtunkyaw81@ gmail.com
3.	Daw Swe Thi Htut	Assistant Director	Directorate of Industrial Supervision and Inspection (DISI)	shtut2008@gmail.com
4.	U Kyaw Zin Oo	Director	Boiler Inspection Department (BID), Directorate of Industrial Supervision and Inspection (DISI)	kyawzinboiler01@gmail. com
5.	Daw Nyine Aye	Director	Small-scale Industrial Department	nyeinayessid@gmail.com
6.	Daw Win Min Phyo	Director	Department of Trade	dotregional@gmail.com
7.	Dr. Nan Sandar Lwin	Director	Renewable Energy Department, Department of Research and Innovation	sandar.lwin75@gmail.com
8.	Daw Aye Aye Htet	Staff Officer	Union of Myanmar Federation of Chambers of Commerce and Industry	ayeayehtet67@gmail.com

9.	Dr. San Oo	Deputy Director General	Environmental Conservation Department	sthandaroo@gmail.com
10.	U Kyaw San Naing	Director	TNA Coordinator, Environmental Conservation Department	kyawsannaing.env@ gmail.com
11.	Daw Thin Thuzar Win	Deputy Director	Climate Change Division, Environmental Conservation Department	thinthuzar1981@ gmail.com
12.	Daw Zin Mar Phyu	Staff Officer	Climate Change Division, Environmental Conservation Department	zinmarphyu123@gmail.com
13.	U Thein Htaik Aung	Staff Officer	Human Resource Division, Environmental Conservation Department	theinhtaikaung.ecd@gmail.com
14.	U Kyaw Swan Thu	Deputy Staff Officer	Climate Change Division, Environmental Conservation Department	kyawswamthu.9915@gmail.com

List of participants and sites for bilateral meetings, interviews, and field visits

No	Name	Position	Organization/Company	Contact	Types
1.	U Toe Toe	Director	Myanma Petrochemical Enterprise	directorinspection2019 @gamil.com	Bilateral meeting
	Daw Yin Yin Aung	Deputy Director		yyaung87@gmail.com	
	U Min Min Oo	Deputy Director		Mmo12577@gmail.com	

2.	U Than Oo	National Project Manager for Improvement of Industrial Energy Efficiency (IEE) in Myanmar Project	UNIDO	T.OO@unido.org	Bilateral meeting
3.	U Kyaw Thiha	Managing Director	Nara Green Tea	naragreentea.kth@gmail.com	Bilateral meeting
4.	U Nay Oo	Managing Director	Natural Farm Fresh Myanmar	nfarmfreshmd@gmail.com	Bilateral meeting
5.	Amarnath Reddy	Team Leader	Responsive Business Fund by Denmark Government	reddy@rbfmyanmar.com	Bilateral meeting
6.	Daw Nan Tharaphu Tin	Managing Director	Thaung Tan Ni Green Tea Factory	taraphu.ttn@gmail.com	Field visit
7.	Lin Pyae Htun	Director	Maw Shan Green Tea Factory	linpyaehtun@mawshan.com	Field visit
8.	U Than Kyaw	Manager	Duwun Rice Vermicelli Factory		Field visit
9.	U Soe Tun	Owner	Moepyan Rice Vermicelli Factory	09797906046	Field visit
10.	U Min Zaw Oo	Factory Manager	Hong Kong Rice Vermicelli Factory	09777715483	Field visit
11.	U Zay Min Htike	Deputy Manager	AYA Bank	09254052916	Phone meeting
12.	NEP solar mini-grid project		Thanpyar Chaung Village, Yesagyo Township, Magway Region		Field visit
13.	NEP solar mini-grid project		Tet Thit Kyun Village, Padaung Township, Bago Region		Field visit

14.	NEP solar mini-grid project		Koke Kaing Village, Daik-U Township, Bago Region		Field visit
15.	Nan Htaik Kyaw Electric	Retailer	Interview for LED	09250528078	Interview
16.	Mega Power Electrical Supplies	Retailer	Interview for LED	yusopthinsoe@gmail.com	Interview
17.	U Nay Aung	Founder	Monaliza Construction Co., Ltd	09444988960	Interview
18.	Daw Lwin Thein Thein Htay	User	User interview for LPG and LED	095148130	Interview
19.	Daw Khin Nyunt Lwin	User	User interview for LED	09799598853	Interview
20.	Dr. Hla Soe	Managing Director	Myanmar Biomass Power	md@khattar-oo.com	Interview

Annex V: Long list of barriers

Energy Sector

No	Solar Mini-grid	LED	LPG
1	High capital cost	High initial cost	High capital cost
2	High interest cost	No tax exemption during importation	Taxes and import duty
3	Need collateral for loan	High import duty	Weakness of LPG law
4	Short loan term from commercial banks	Lack of legal, regulatory and enforcement framework for lighting	Weakness of cooperation between focal agency and stakeholders
5	Not enough funding and subsidy	Lack of performance standard	Lack of last mile retailer in rural areas
6	No mini grid regulation	Lack of labelling	No cylinder manufacturing facilities
7	No net metering or grid interconnection system	Lack of quality control	Difficulty for inspection
8	No renewable energy policy	No testing laboratory	No standard of LPG transportation
9	Limited productive use of energy in off-grid areas	Limited market information	Afraid of explosion
10	Limited capacity of township level staff	Low awareness	Low level of public awareness on LPG stove
11	Limited knowledge of public on mini-grid capacity	Unaffordable due to household income	Less information about LPG stove
12	High tariff rate	Lifestyle choices	Easily access to firewood than LPG in most of the villages
13	High battery cost	English term “LED” might be difficult to pronounce for most of the Myanmar people and might have difficulties to order/ ask/ buy	Unaware of the positive effect of LPG stove compare to firewood and charcoal stove

14	Energy storage problem	Lack of energy efficiency campaign	
15	Lack of skills at the end users/ locals level		

Industry Sector

No	Energy Efficient Motor (using variable speed driver (VSD))	Energy Efficient Boiler	Solar Dryer
1	High capital cost	High capital cost	High capital cost
2	High taxes and import duty	High taxes and import duty	No tax and custom duty exemption
3	No significant result of technology in terms of energy saving and cost saving	Lack of economic feasibility study	No result of financially viable on this technology
4	Limited subsidy program	Weak access to financial resources	Improper financial resources
5	Limited financial resources for energy efficiency	No regulatory framework for boiler efficiency	Insufficient subsidy program
6	No legal and regulatory framework to use energy efficient technology	Weak O&M	Absence of legal and policy framework and lack of enforcement
7	No enforcement to eliminate using of inefficient technology	No efficiency standards of boilers	Lack of standard
8	Lack of standards and codes	Lack of R&D	Limited skilled manpower
9	Poor O&M	Limited capacity for boiler inspection	No technology transfer
10	Insufficient R&D	Limed human resources	Lack of technical capacity by farmers
11	Lack of vocational training	No enough awareness on boiler efficiency	Insufficient awareness and information

12	Inadequate knowledge of energy management system	Lack of compliance on boiler efficiency	Difficulty of understanding on energy management system
13	Weak compliance on energy efficiency and conservation	Low awareness on energy management system	Easily access to inferior quality products cheaply
14	Lack of capacity in existing institutions	Difficult to engage factories decision-makers for technical audit	Low interest on this technology from existing institutions
15	High cost for energy and environmental audit in factory		