Low Carbon Technology Assessment Contributing to Implementation of Viet Nam's NDC

Volume 2: Multi-criteria Assessment to Identify Prioritized Technologies and Essential Steps to Build Consensus Among Key Stakeholders

Ministry of Natural Resources and Environment of Viet Nam
in collaboration with
JICA Technical Assistance Project to Support the Planning and Implementation of NAMAs in a MRVable Manner (SPI-NAMA)

February, 2018

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ABBREVIATIONS

BUR	Biennial Update Report
CDM	Clean Development Mechanism
CNG	Compressed Natural Gas
COP	Conference of Parties
DCC	Department of Climate Change
DMHCC	Department of Meteorology, Hydrology and Climate Change
DOE	Department of Environment
DoSTE	Department of Science, Technology and Environment
DoSTIC	Department of Science, Technology and International Cooperation
FIT	Feed In Tariff
GDE	General Directorate of Energy
GHG	Greenhouse Gas
GPU	Ground Power Unit
GWP	Global Warming Potential
HFC	Hydrofluorocarbon
IEA	International Energy Agency
(I)NDC	Intended Nationally Determined Contributions
IMHEN	Institute of Meteorology Hydrology and Climate Change
ISEA	Industrial Safety techniques and Environment Agency (MOIT)
JICA	Japan International Cooperation Agency
LFG	Landfill Gas
LPG	Liquefied Petroleum Gas
LULUCF	Land Use, Land Use Change and Forestry
MARD	Ministry of Agriculture and Rural Development
MOC	Ministry of Construction
MOIT	Ministry of Industry and Trade
MONRE	Ministry of Natural Resources and Environment
MOST	Ministry of Science and Technology
MOT	Ministry of Transport
MPI	Ministry of Planning and Investment

MRT	Mass Rapid Transit
MRV	Measurement, Reporting and Verification
NAMAs	Nationally Appropriate Mitigation Actions
NC	National Communications
NOU	National Ozone Unit
PDP7	Power Development Master Plan No. VII
REDD+	Reduction of Emission from Deforestation and forest Degradation Plus
SPI-NAMA	Project to Support the Planning and Implementation of NAMA
TAC	Technology Advisory Committee
TNA	Technology Needs Assessment
UNEP	United Nations Environment Programme
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
VAFS	Vietnamese Academy of Forest Science
VNForest	Vietnam Forest Administration

Introduction

This publication presents the second volume of the technical report series issued by the Low Carbon Technology Assessment work under the technical assistance Project "Support to Planning and Implementations of NAMAs in a MRVable Manner" (SPI-NAMA), jointly implemented by Ministry of Natural Resources and Environment (MONRE) and Japan International Cooperation Agency (JICA) since February 2015. The Low Carbon Technology Assessment work, started in September 2016, has been undertaken with the clear objective to elaborate and provide a concrete means of implementation through technology angle for Viet Nam's Nationally Determined Contribution (NDC). The Assessment team comprised of a team of sectoral experts over Energy (Energy Efficiency, Power Generation), Transport, Agriculture, LULUCF, Waste and Freon gas (F-gas), under the guidance of Senior Advisory Committee by both national and international experts. In order to move forward the current proposed mitigation options of NDC into reality, the Assessment work encompasses identification of appropriate technologies corresponding to each mitigation option presented in the Viet Nam's initial NDC, multi-criteria assessment to prioritize identified technologies, and making recommendation of prototype projects to enable deployment. The Assessment values the country ownership – despite high resource requirement. All the steps were undertaken with intensive consultation and engagement of Vietnamese stakeholders, including, inter alia, climate focal point of respective line ministries, departments in charge of specific mitigation options, business sectors operates including state enterprises, associations and leading industries/companies, as well as academia and so forth, for the every sector covered.

As a result of the work, the Assessment Team has delivered *"Low Carbon Technology Catalogue, Mitigation Actions in the context of Viet Nam's Nationally Determined Contribution and Beyond" (internal document) and its synthesis document "Low Carbon Technology Assessment, Facilitating Effectiveness of Viet Nam's NDC Vol. I"* (public document) following the content of NDC technical report[1] , identifying more than 100 technologies which are all accessible in the market. These information complements Viet Nam's NDC and INDC Technical report.

This second Document captures 1) the process taken to prioritize identified technologies based on the criteria and indicators determined respectively by the 7 targeted sectors (Energy Efficiency, Power generation, Transport, Agriculture, LULUCF, Waste and F-gas), taking into account sector-specific characteristics and expected barriers for deployment in the national context., and 2) summarizes the in-depth process to reach consensus within related sectors throughout the work. Recording of such consensus building process would help strengthen the facilitative capacity required by the Government of Viet Nam to undertake effective climate responses as a whole.
The Documents are designed to directly contribute as a guiding material in the upcoming Review and Update of NDC to be complete in 2019, and to accelerate sectoral action plan formulation and its implementation following NDC.

1 Hieu NK, Thuc T., Tan PV, Huong THL, Thang NV, Trang DM, Minh NV, and Huong CTT (2015) Technical Report Viet Nam's Intended Nationally Determined Contribution
[http://www.noccop.org.vn/Data/profile/Airvariable_Projects_115693Technical%20report%20INDC.pdf]

The contents of this document are structured as follows;

Chapter 1: Describing objectives and highlights significance of the Assessment work

Chapter 2: Introducing multi-criteria assessment to prioritize technologies: this includes, inter alia, background and methodological approach for prioritization, criteria setting, its rationale, and summary of the analysis result

Chapter 3: Describing stakeholder consultations taken for consensus building

Chapter 4: Brief narrative of sectoral discussions: summarizing criteria and multi-criteria assessment results in charts and descriptions

Chapter 5: Conclusion

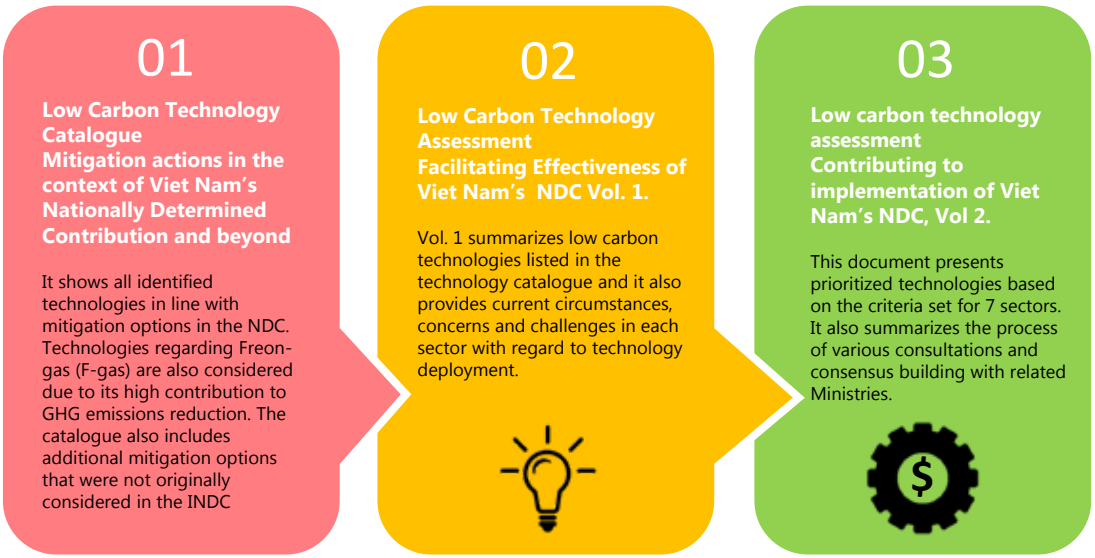


Figure 1 The Assessment work can contribute to Viet Nam's NDC implementation

Chapter 1

Significance of the Low Carbon Technology Assessment for Facilitating Implementation of Viet Nam's Nationally Determined Contribution

1 Significance of the Low Carbon Technology Assessment for Facilitating Implementation of Viet Nam's Nationally Determined Contribution

1.1 Objectives

The objectives of Low Carbon Technology Assessment are follows:

Objective 1: Enhancement of Planning, Implementation and Coordination Capacity

The Assessment work enhances capacities of the Government in multiple ways;

1) **Planning capacities** of relevant line ministries (LMs) to develop and implement robust sector-based action plans for NDC by providing more concrete technical basis and inputs.
2) **Coordination capability** among relevant departments within concerned LMs, and also between MONRE and the LMs as well as key stakeholders through reaching internal consensus among technology options presented.
3) **Facilitative capacity** of MONRE by teasing out Viet Nam's context surrounding each mitigation option under NDC while clarifying policy needs and appropriate mitigation actions to enable deployment of low carbon technologies associated with those options.

Objective 2: Direct inputs to further review and update Viet Nam's NDC

Existing proposed mitigation options under NDC are to be revisited to confirm legitimacy of assumptions, scope, and barriers against Viet Nam's country-specific context and conditions in the coming days. Further assessment and identification of potential options beyond the current scope, as presented in the Assessment work, will be the direct inputs to the updating process of NDC.

1.2 Importance of identification of Low Carbon Technologies by the Assessment Work

In INDC Technical report, analysis is conducted for 4 sectors (Energy/Transport, Agriculture, LULUCF, and Waste) and the content includes Mitigation options and Assumption, Mitigation potential, and Mitigation cost or Incremental cost. To achieve 8% Greenhouse Gas (GHG) gas emission reduction by domestic efforts and 25% reduction by international support compared with BAU, further breaking down of the classification of mitigation measures is indispensable to reach implementation. As part of that effort, low carbon technologies were identified in this Assessment work. More specifically, the Assessment work contributes to the formulation of the national plan and promotes practical implementation of the mitigation measures by going through the process of adding up the estimated reduction volume and assessing the level of target achieved, considering the balance between the reduction volume and the budget allocation, and predicting the cost and time required for introduction.

As climate change measures are essentially cross-sectoral, cooperation among ministries is vital. For example, waste to energy is a project covering the energy sector and the waste sector, and will require involvement of MONRE, Ministry of Industry and Trade (MOIT) and Ministry of Construction (MOC) and other key stakeholders such as local municipality, waste management company and certain large company producing solid and water waste from their manufacturing. For energy efficiency projects for train stations, joint effort by MOT and MOIT will be inevitable. Sharing of information through this Assessment work prior to the planning of technology introduction would help to promote effective deployment of the technologies.

Lastly, the fact that the additional options not included in the NDC were identified in the process of the SPI-NAMA assessment of low carbon technologies bears great significance. In the transport sector especially, the three main pillars for mitigation, namely modal shift, energy efficiency and fuel switch, were further classified into sub-sectors to identify applicable technologies. In the waste sector, semi-anaerobic landfill operation was proposed as an alternative to a less successful option while discussing actual technology application and emission reduction potential. Also, measures against Freon gas (F-gas) sector was added as one of the mitigation sectors upon strong request from MONRE, and appropriate technologies were proposed accordingly to reduce Freon-gas emission in Viet Nam. These additional options that have been proposed should be considered for inclusion when the NDC is revised every 5 years, and the low carbon technology assessment adds value in that context.

Chapter 2

Multi-Criteria Assessment to Prioritize Low Carbon Technologies – Methodological Approach and Findings

2 Multi-Criteria Assessment to Prioritize Low Carbon Technologies – Methodological Approach and Findings

2.1 Definitions and procedures used for the Prioritization

As emphasized in Vol I, this Assessment work defines low carbon technology as both *hardware* (e.g. energy saving infrastructure) and *software* (e.g. energy management system) that can contribute to the global climate change goal through Viet Nam's GHG emissions reduction efforts, and that encourages Viet Nam to sustainable low carbon development pathway. Not only hardware, devices, machines and facilities, which are commonly perceived technology elements, are considered, but also techniques, practices and management tools for some of the mitigation options and sectoral attributes (e.g. Agriculture, LULUCF and Waste) were included in the work.

One hundred twenty technologies identified on the basis of the 45 mitigation options in the INDC technical report were summarized in the technology sheet (Table 1), criteria and indicators were selected for each targeted sector for prioritization (including both common criteria across sectors, and sector-specific criteria).

Table 1 Contents in Technology sheet

Item	Contents
Title of Technology	✓ Identified technologies for respective NDC option. ✓ Technology elements.
Visual Aid	✓ Photos or schematics.
Summary of Technology	✓ Background and common features of the technology.
Technical Advantages	✓ Technology superiority, advantages, and assumptions.
Mitigation Potential	✓ Estimated emission reduction volume. ✓ Attributions to the identified technology such as scale are considered.
(Initial) Cost	✓ Estimated (initial) cost based on existing projects, initial cost per unit, operation cost, aggregated cost over several years. ✓ Purpose, scale, geographical features , etc. are considered.
Viet Nam's Context	✓ Information to be noted when introducing the technology to Viet Nam. (Consumer trend, recycling rates and field condition, etc.)
Existing Policy & Measures	✓ Relevant policy documents, if any.
Current State of Market and Production	✓ Market share, annual production and current development status.

2.2 Methodological Approach for the Multi-Criteria Assessment

In-depth procedure and methodological approach adopted for the prioritization is shown below. Results of step 3 to 4 are summarized in the following chapters.

Step 1 Confirmation of the Progress in climate change measures

Stakeholder interviews and consultations with relevant ministries identified gradation of maturity level over 45 mitigation options. Needs for legislation and standards to enable some options were reviewed to capture the enabling conditions and current appetite levels for policy reforms.

Step 2 Development of Low Carbon Technology List based on the INDC Technology report

With the current situation and directions of the climate change measures in Viet Nam in mind, technologies applicable in Viet Nam's context have been selected from existing technology lists.

Step 3 Determination of assessment criteria and evaluation for prioritization

Assessment criteria that can be used in common across sectors compatible with the category of information available for each technology were determined (hereinafter Common criteria), namely;

Compatibility with policy priorities, Economic efficiency, GHG emission reduction effect, Versatility, Economic/social/environmental impact, and Acceptability in Viet Nam's context. Indicators were set for each sector independently to reflect sector specific (Table 2). Criteria suitable to evaluate the technologies were selected among Common Criteria for prioritization process for that sector.
Also, sector specific criteria were added and evaluated for that sector (shown in Table 2).

Evaluation was done qualitatively as High, Middle or Low (A, B or C) for each criterion,

A: The technology is of relatively higher priority and early deployment is recommended;

B: The technology can be deployed when barriers are removed by improving enabling conditions and environment to some extent;

C. Long lead time for technology deployment in order to arrange appropriate enabling environment is anticipated.

The result was used for the final evaluation. For Economic Efficiency and GHG reduction effect in most sectors, prioritization was conducted comparatively based on the available numerical data.[2]
The content of the evaluation discussion are described separately.

Step 4 Selection of the technologies with high priority

Technologies with higher priority to be deployed were selected based on the results of the evaluation in step 3 and also Viet Nam's context reflected in the opinions from sectoral experts.

As described in Chapter 3, in-depth stakeholder consultations are conducted on on-going basis following the above process. In order to ensure objective, third party perspectives on the multi-criteria assessment for technology prioritization, inputs from advisory committee members in and out of Viet Nam[3] were also incorporated.

2 Due to different units used in the references, difficulty in estimating the project scale/anticipated production using the technology, and uncertainty in the prospect on political pricing and international market trend, assessment by absolute evaluation was not conducted for this assessment.

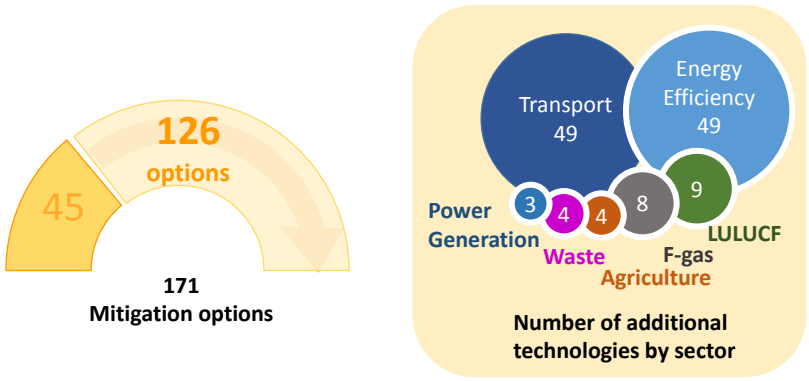
3 Member of the international TAC: Mr. Koos Neefjes Mr. Tran Thuc (IMHEN), Mr. Jean-Francois Gagné (IEA), Dr. Gumilang Retno (Dew Bandung Institute of Technology), Dr. Wongkot Wongsapai (Chiang Mai Univ.), Dr. Masato Kawanishi (JICA). Members of the domestic TAC: Dr. Hirokazu Taniguchi (Energy Conservation Center, Japan), Mr. Takahiko Onozuka (Japanese Business Alliance for Smart Energy Worldwide), Mr. Nobuyoshi Fujiwara (Japan International Research Center for Agricultural Science: JIRCAS), Prof. Atsushi Fukuda (Nihon Univ.), Dr. Tamotsu Sato (Forestry and Forest Products Research Institute: FFPRI), Dr. Kosuke Kawai (National Institute for Environmental Studies: NIES), Mr. Niro Tohi (PREC Institute. Inc.).

Table 2 Common and sector specific criteria

Sector		Indicator							Evaluation
		Energy Efficiency	Power Generation	Transport	Agriculture	LULUCF	Waste	Fgas	
Common Criteria	Policy Priority	Evidence in policy documents (decision, circular, etc.)					Evidence in policy documents and measure	Evidence in policy documents (decision, circular, etc.)	High Middle Low
	Economic Performance	Initial Cost (US$/unit)	Initial cost (US$/kWh) Operation Cost (US$/kWh)	Initial cost		Initial absorption cost/unit	Processing cost (US$/ton)	Initial cost Operation cost	
	GHG Reduction	Initial Cost (US$/unit)	Initial cost (US$/kWh) Operation Cost (US$/kWh)	Initial cost		Initial absorption cost/unit	Processing cost (US$/ton)	Initial cost Operation cost	
	Versatility	Maintenance support and operation techniques		Versatility for deployment, Maintenance support and operation techniques		Technical adaptability and capacity	Versatility for deployment, Condition of volume and quality	Maintenance support Versatility for deployment	
	Economic, Social and Environmental impact	—	Economic, Social and Environmental impact						
	VN context	—	Implementation rate	—	Easiness of utilization	Job creation	—	Market share	
Sector specific criteria		Energy efficiency rate	Implementation goal by 2030	Adaptability, Timing of implementation, Linkage of other measures	Food security, Productivity	Adaptation	-	Support availability, Adaptability, Timing of implementation, Linkage with other measures, Benefit to other sector	Narrative description

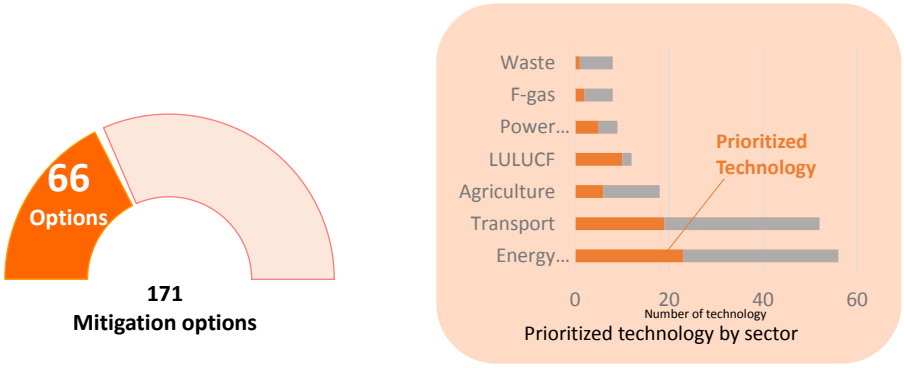
2.3 Summary of Identifying Low Carbon Technologies Corresponding to NDC Options

Based on the 45 mitigation options of Viet Nam's NDC, approximately 100 additional low carbon technologies were identified. For the transport sector, in which 3 main pillar options were re-classified into sub-categories (Passenger, Freight, Energy Efficiency (Road, Railway, Waterway and Maritime, and Aviation), and Fuel Switching), highest number of technologies were proposed. Also for the energy sector, focused mostly on demand side options, many energy efficiency improvement technologies were presented especially for industries such as paper & pulp, steel, beverage and fertilizers. For the F-gas sector, which is a new sector with no previous efforts to note, policy framework will be the basis for elaboration in the future. The technologies proposed in this sector include destruction of F-gas in cement kiln, changing to low Global Warming Potential (GWP) refrigerant and prevention of refrigerant leakage, but at the same time, necessity to build capabilities of the operators to maintain the technology is also suggested. For the waste sector, semi-anaerobic landfill operation, conversion to low carbon fuel trucks for waste collection and construction of waste transfer station are proposed. For LULUCF, options related to sequestration by land were added. For the agriculture sector, mid-season drainage, improvement of processing technology and reuse of waste of livestock husbandry production for organic fertilizer, structural adjustment capacity of the vessels are not suitable for fishing grounds and planning of routes the seafood exploitation were added upon the request from Ministry of Agriculture and Rural Development (MARD).



More than 120 mitigation options are added under the Assessment work. All sectors expanded their options and transport sector developed the highest number of mitigation options based on the main three pillars (e.g. modal shift, energy efficiency and fuel switching).

Figure 2 Additional Mitigation Options identified under the Assessment



Note: 66 options out of 171 options have relatively less barriers (left). According to each sectoral expert judgement, options in LULUCF sector are relatively approachable (right).

Figure 3 Mitigation options that have less barriers to introduce

As a result of the selection of the prioritized technologies based on criteria and expert judgement, approximately 60 technologies were determined to be relatively easy to adopt. Many technologies in the Energy/Transport sector (in refinery in the Energy Industry sector and fuel change in the Transport sector) and in LULUCF were considered more feasible with relatively few barriers to remove.

Barriers were analyzed based on the consultations and interviews with the ministries and agencies, and also for the business sectors in and out of Viet Nam, as described below. Brief summary is shown in Table 3. As a common barrier for every sector, it was pointed out that standards and policy framework are still not sufficient or not clear enough. Also, various barriers related to investment were noted, such as 'low incentive' (Energy, Waste, F-gas), 'demand risk' (Transport), and 'limited resource' (Agriculture and LULUCF). Discussions on measures to tackle these barriers in each sector are discussed in Chapter 4, but as future steps, promoting business sector involvement and to appealing to their financial incentive for investment, awareness raising on the benefits of low carbon technology and system introduction, and numerous consultations and discussions with many stakeholders including business sectors are deemed essential to remove barriers to adopt the prospective low carbon technologies.

Table 3 Summary of Barrier Analysis

Sector	Policy	Investment
Energy	• No mandatory energy efficiency standard and labeling • No environmental standard for CH_4	• Low incentive for energy efficiency measure (Industry) • Subject to payment for forest ecosystem service (Power)
Transport	• Standard not yet available for bioethanol	• Demand Risk, to secure the planned demand to fulfill project profitability (modal shift)
Agriculture	• Cross sectoral issue may occur between livestock and food security.	• High initial investment cost required
LULUCF	• Land use prioritization	• Limited financial resources
Waste	• Strategy for commercializing compost products should be in place	• Limited demand (Anaerobic treatment of organic solid waste)
F-gas	• No policy framework • Low awareness of stakeholders	• Price competitiveness of low GWP refrigerant


Current policies on greenhouse gas mitigation
JICA
Final Workshop on Low Carbon Technology Assessment
to Support Elaboration of Vietnam's NDC and for its Implementation

Chapter 3

Stakeholder Consultations in Each Sector

3 Stakeholder Consultations in Each Sector

3.1 Facilitating consultation for Vietnamese key stakeholders

Lima Call for Climate Action was adopted in the 21st
Conference of Parties (COP20) (December 2014) where contents to be included in INDC were generally determined. Contracting parties were asked to submit their INDC by COP21. However, in reality, parties were expected to prepare and submit their INDC in 9 months. Viet Nam worked steadily on the preparation and submitted the INDC in September 2015.

As international discussion on the climate change moves forward, progress on the climate change measures by Talanoa Dialogue[4] are planned to be confirmed in 2018, and revised versions of NDC are expected to be submitted in 2020, calling for a thorough examination of the contents in INDC by each party. For Viet Nam, INDC includes discussions in 4 sectors (Energy/Transport, Agriculture, LULUCF, Waste) by related ministries (MOIT, MOT, MARD, MOC and Ministry of Planning and Investment (MPI)) led by MONRE, the focal point for the climate change measures. Also in this Assessment work, interviews were conducted to related ministries and many feedbacks such as mitigation options to be considered in the NDC review and update were shared.

Climate change measures are often cross-sectoral, and cooperation among related ministries are essential to undertake actions that are effective timewise and also financially. To this end, numerous dialogues were conducted between each mitigation sectors in support of MONRE in SPI-NAMA LC-Tech. Furthermore, as it was understood that to reflect these measures in future national plans and legislations, it is vital to reach agreement not just among officials inside the leading ministry but more so between related ministries, total of 5 workshops including the final workshop in dialogue format were held to promote mutual understandings between ministries.

3.2 Process and outcome from consultation

Four joint workshops in dialogue format between related ministries conducted by Aug 2017 are summarized in Figure 4 and below.

4 Talanoa dialogue under the UNFCCC will start at 2018, [http://unfccc.int/items/10265.php]

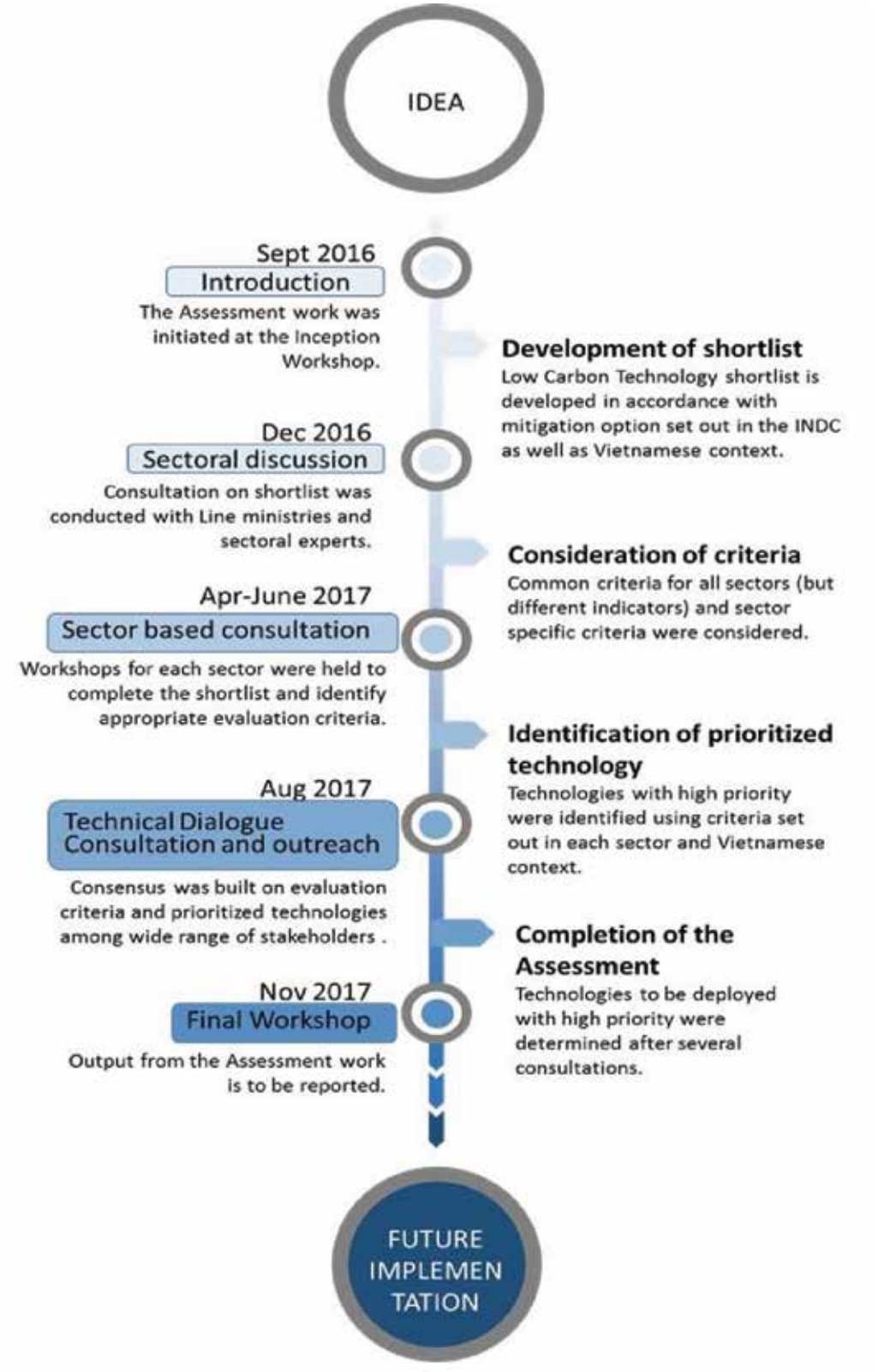


Figure 4 Timeline and process of the SPI-NAMA Low Carbon Technology Assessment

[Inception WS on 27 September 2016]

Inception WS was organized with facilitation by Mr. Nguyen Van Tue, Director-General, MONRE/ Department of Meteorology, Hydrology and Climate Change (DMHCC)[5] , with participation by LMs, development partners, various experts, for the purposes of identifying and assessing low carbon technologies applicable to each mitigation option of NDC and F-gas. The WS confirmed the steps of the Assessment work, reflecting LM's needs and Vietnamese context. Also, the work by international advisory committee (Experts from Viet Nam, ASEAN countries, International Energy Agency (IEA) and others) were shared. As summary of the discussion, it was pointed out that;

- More effective indicators for evaluation and consultation are needed in order to implement the mitigation options efficiently.
- System development and openness to business with regard to market are required.
- Collaboration between ministries and the business sector is important to enhance productive consultation and exchange of opinions, not only for policy demand but also for technology creativities.

[Sector-based discussions in December 2016]

Sector-based discussions were held in order to fully reflect needs and interest of the line ministries, more specifically to present the 1st draft of the low carbon technology shortlist; collect opinions from the line ministries on the draft for further revision; discuss evaluation criteria for low carbon technologies in respective sectors; and exchange key information relevant to driving application of those technologies. The participants for the discussions were officials of the line ministry in charge of the sector; relevant agencies under the line ministry; local specialists (researchers from research institutes); and local consultants for coordination and project finding.

Some useful suggestions received during sector-based discussions include, inter alia,

- On Technology Listing: Revision of mitigation options under NDC per se following line ministries' own review;
- Modification and break-down of mitigation options to elaborate technology deployment opportunities (e.g. Transport, breaking down into sub-sectors and different modes of transportation to make it more meaningful);
- Elaboration of technology identification beyond NDC options in order to accommodate sectoral priorities (e.g. Energy, to align with sectoral energy efficiency benchmarking development);
- Inputs to Viet Nam's context and barriers- sharing of various experience-based inputs on implementing certain technologies (e.g. proper training and guidance to minimize accident risks of handling of bio-digesters and CH_4 leakage by farmers).

5 Department of Climate Change bears the primary responsibility since 2017.

[Multi-stakeholder Dialogues in May-July 2017]

Multi-Stakeholder Dialogues were held among key stakeholders (associations, business sector, NGO/ Civil Society Organization (CSO), local governments, etc.) to finalize the technology shortlist and compile views on evaluation criteria from relevant stakeholders. Four sessions were held during May-July 2017, each session covering Energy (Energy Efficiency and Power Generation), Transport, Agriculture and LULUCF (joint session), and Waste and F-gas (joint session). Collected insights from these dialogues, particularly, of the business sector for engaging in mitigation actions, such as;

- General perception of gradual shift of consumer's preference in environmentally friendly and energy efficient products and technologies;
- Need for a clear signal and information from the government through enabling policies, in order to consolidate investment;
- Call for more opportunities for G-to-B discussions and information exchange;
- Stocktake of past lessons regarding access to financial mechanisms (e.g. CDM) from implementing entities; and
- Recognition of science-based mitigation planning with collaboration with academia, and recognition of roles of local governments in supporting actions on the ground.

[Low-carbon Technology technical dialogue in August 2017]

In light of the comments shared in the multi-stakeholder dialogues in May-July, 'Consultation Workshop on Low Carbon Technology Assessment' (for government officials) and 'Outreach Event on Low Carbon Technologies' (for business sector) were held where interim report on the evaluation results of low carbon technologies using prioritization criteria was presented. Most related ministries showed support on the result, due to the groundwork in stakeholder meetings and prior explanation by the expert team. Also, possible actions to address policy and technical barriers were discussed.

Feedback from MONRE and related ministries

- MONRE/Department of Climate Change (DCC) suggested that the low carbon technology list and the technology prioritization result from this Assessment work should be referred when the ministries prepare the action plans in the process of NDC legislation.
- Officials who attended the dialogue proposed some ideas to utilize the prioritized technology list for the efforts in their ministerial jurisdiction. (e.g. when developing standards (TCVN) in Ministry of Science and Technology (MOST))
- It was also noted that in addition to law/decree, the list should be mentioned in the Biennial Update Report (BUR) submitted to UNFCCC.

Feedback from business sector

- During fund procurement, when asked by financial organizations, there were times when one could not explain which technologies were more environmentally superior. The Low Carbon Technology List would be useful to answer to these questions.
- Some financing schemes including low carbon technologies are emerging in some parts of business sector, and the result of the evaluation in the Assessment work would be informative.

- When considering the introduction of the low carbon technologies, it is effective to take action from the perspective of 'streamlining the business'. This would be helpful to promote the investment plan internally (in a private company).

Feedback from the technical advisors

- As guidelines and political tools are missing in some sectors, it would be necessary for the ministries to promote policy measures.
- It would be advisable in the future to consider monitoring the progress of low carbon technology introduction and the impact the technology has provided (including the MRV of the mitigation impact).
- In addition to applying the results of the assessment to the future action plans, it is encouraged to apply the learnings from the process of multi-stakeholder meeting and consensus building among related ministries to the future Vietnamese efforts to combat climate change.

[Final Workshop on Low- carbon Technology Assessment to support the elaboration of Viet Nam's NDC and for its implementation in November 2017]

Final workshop was held on November 28, 2017. In this workshop, the final outcome of the SPI-NAMA LC-Tech was presented. The publications and prioritized technologies were presented and by drawing on the comments from the related ministries and advisory committee, it is expected that the workshop will help to promote the effective implementation of climate change measures in Viet Nam.

Chapter 4

Results of the Multi-Criteria Assessment by Sector

4 Results of the Multi-Criteria Assessment by Sector

This chapter describes the results of multi-criteria assessment to identify prioritized technologies for the designated 7 sectors. Structure of this chapter and discussions for each sector are as described below;

Technology Prioritization

1. Characteristics of each sector and prioritization criteria setting

   It explains characteristics of each sector and the rationale for the criteria set in line with Vietnamese context.

2. Results of the multi-criteria assessment in each sector

   Results of the low carbon technology multi-criteria assessment are summarized. Qualitative assessment was conducted with a view to difficulties in deployment and evaluation output using the criteria set in 1.

3. Major barriers and solutions

   Identified barriers for deployment of low carbon technologies and possible solutions are described.

Stakeholder Consultations for Consensus Building

1. Overview of the procedures/meeting schedule

   Overview of the steps taken and series of consultation conducted in this Assessment work are drawn.

2. Key suggestions and opinions provided by stakeholders

   Suggestions and comments provided in the consultations described in 1 are summarized.

3. Lessons leant and possible solutions for challenges

   Lessons leant from the consensus building and identified challenges and its solutions are provided.

4.1 Energy (Energy efficiency)

4.1.1 Technology prioritization

1. Characteristics of the Energy Efficiency sector and Prioritization Criteria Setting

The energy efficiency technologies deployed are selected in line with requirements of energy users, most notably industries and companies for their manufacturing process, production cycle, line structure and product type, while taking into account business factors such as initial investment cost, payout time and the amount of energy saved by introducing the technology. Also, regulations such as energy efficiency laws encourage the introduction of energy saving technologies. Consequently, for the Energy Efficiency sector, Compatibility with policy priorities, Economic efficiency, GHG reduction effect and Versatility were chosen as the common criteria (Table 4 and 5).

For **Economic efficiency**, initial investment cost is used as the basic criteria for evaluation, with operation cost also considered according to availability of relevant data. For **Versatility**, technologies were assessed on the basis of whether it only requires simple replacement of an old equipment or it takes major upgrade of the production line. This is because application of technology takes few years from the planning if it requires changes to the entire production line, and normally the technology introduction need to wait until the next round of facility upgrade. In the meantime, since technologies contributing to energy efficiency improvement are applied for the purpose of energy saving to begin with, meaningful prioritization was deemed difficult for economic, social and environmental impact. For **Acceptability in Viet Nam**, data on estimated adoption rate for 2030 by Audinet et al. (2016)[6] was used. This is because, firstly, the technologies explored for this assessment are mostly commercialized; secondly, data on acceptability for individual technology are insufficient; and thirdly, it was determined that the assessment based on the present adoption rate to be applied up to 2030 was not appropriate. For sector specific criteria, **energy efficiency impact** such as energy savings by energy consumption and the amount of energy reduction were assessed.

Lastly, due to the diversity of application target in the Energy efficiency sector (consumer and various industries), the prioritization was conducted separately for each industry sub-sector, and not for the overall sector.

6 Audinet P. et al., (2016) Exploring a Low-Carbon Development Path for Vietnam, World Bank

Table 4 Criteria/Indicators used for the Energy Sector (Energy Efficiency)

Criteria	Indicators		Evaluation
Compatibility with policy priorities	Availability of policy document	High	Law/Decree/Action Plan
		Medium	Strategical document only
		Low	No policy document
Economic efficiency	Initial cost	High	Top 1/3
		Medium	Middle 1/3
		Low	Bottom 1/3
GHGs emission reduction effect	Absolute amount	High	Top 1/3
		Medium	Middle 1/3
		Low	Bottom 1/3
Versatility	Operation and Maintenance System	High	Existing system can be utilized
		Medium	Requires only minor change
		Low	Requires major upgrade such as changing production line

Table 5 Sector Specific Criteria/Indicators for the Energy Sector (Energy Efficiency)

Criteria	Indicators	Evaluation
Energy efficiency impact	Energy savings by energy consumption	Qualitative evaluation
	Energy reduction amount	Qualitative evaluation

2. Result of the Multi-criteria Assessment for the Energy Efficiency sector

Most of the technologies for energy efficiency improvement turned out to be rated either as A (i.e. The technology is of relatively higher priority and early deployment is recommended)(see Table 6) or B (i.e. The technology can be deployed when barriers are removed by arranging the deployment environment to some extent.). In particular, all technologies in Refinery industry are rated A. This is due to the fact that refinery industry is considered an equipment-oriented industry where installation of proper equipment ensures certain level of success. Also, since the first refinery in Viet Nam has just been constructed and more construction is expected to follow in the future, it is considered appropriate to install energy efficient equipment from the beginning. The only technologies that have been rated C (Long time may be required for technology deployment in order to arrange appropriate environment) were 'Dry Kilns with Multistage Pre-Heaters and Pre-Calcination' in Cement-making technology and 'Increased use of recycled pulp' in Pulp and Paper industry. 'Dry Kilns with Multistage Pre-Heaters and Pre-Calcination' process was rated C because the time required for installation was estimated to be long as the technology is usually adopted for newly constructed plant or in a major process upgrade.

As for 'Increased use of recycled pulp', it was rated C due to its extremely high initial investment cost and the need for treating the sludge from the manufacturing process. It may be worth noting that both of these technologies are already implemented in the developed countries.

Sector specific evaluation had some difficulty due to smaller number of technologies to evaluate, or insufficient data to be evaluated by multiple criteria. For example in Pulp and Paper industry, evaluation was conducted based on the energy saving potential rather than GHG reduction amount since the data was incomplete for comparison.

For energy efficiency sector, regardless of the evaluation results, technologies should be implemented to match the industry and company needs, considering the introduction are expected to be promoted by removing the barriers, which are mentioned in the following paragraphs.

Table 6 List of Technologies rated as 'A' for the Energy Sector (Energy Efficiency)

Subsector	Options
Residential and Commercial	High efficiency air conditioner for household
	LED, CFL
	Solar water heaters
Cement	Cement-making technology (Kiln Shell Heat Loss Reduction)
	Cement-making technology (VFD Installation)
Steel	Steel (Heat recuperation from hot blast stoves)
	Steel (Sintering plant heat recovery)
	Steel (BOF gas sensible heat recovery)
	Steel (Hot charging in rolling mill)
	Steel (Variable speed drives in steel making)
Refinery	Refinery (Online furnace cleaning)
	Refinery (Optimization of power consumption in utility boiler drives and auxiliaries)
	Refinery Steam savings by trap management)
	Refinery (Condensate recovery)
	Refinery (Flare gas recovery and utilization for process heating requirements)
	Refinery (Installation of low excess air burner)
	Refinery (Oil recovery from crude tank bottom sludge by chemical treatment)
Fertilizer	Fertilizer (Calcium Silicate Insulation of High Pressure Steam Pipe Line)
	Fertilizer (High Conversion Rate Synthesis Reactor)
	Fertilizer (Installation of Variable Speed Drives for Cooling Tower Fans in Fertilizer)
	Fertilizer (Steam Trap Management)
Pulp and paper	Pulp and paper (Waste heat recovery from paper drying)
	Pulp and paper (Black liquor gasification)

Table 7 Assessment Results for the Energy Sector (Energy Efficiency)

	Sub-sector	NDC#	Options	Rate[7]	Evaluation
1	Residential and Commercial	E1&10	High efficiency air conditioner for household	A	▪ For AC, standards for energy efficiency and labeling system are already established, and the main issue for introduction is its high initial cost. ▪ Adoption rate (2012) is still low at 11.6% for the country and 31.4% for the urban areas, but the recent rapid increase calls for early deployment and priority is high.
2		E2	High efficiency residential refrigerators	B	▪ For refrigerators, standards for energy efficiency and labeling system are already established and adoption rate (2012) is high at 49.7% for the country and 75.7% for the urban areas. As it is used 24 hours a day, its energy saving potential is considered high. ▪ Meanwhile, in Viet Nam, low cost refrigerators with 2 doors (150-200 liter capacity), also limited in energy efficiency technologies it can carry, are the most popular type of product, and in spite of the fact that larger products are getting popular, it is expected it will require some time until energy efficient refrigerators prevail in Viet Nam.
3		E3	LED, CFL	A	▪ For lighting, standards for energy efficiency and labeling system have been established for a while, and use of CFLs has been promoted through support programs by international organizations. ▪ Due to its low investment cost and high energy saving impact, the priority is high and early deployment is recommended.
4		E4	Solar water heaters	A	▪ The use of Solar Water heater is suitable to the weather in Viet Nam. As the demand for hot water is rising due to the increase in people's income, the GoV is encouraging the use of Solar Water heaters to replace electric water heater machine. ▪ It is also expected to lower the electricity load during the peak time (18:00-20:00). ▪ Meanwhile, the efficiency of solar water heaters are largely affected by weather and this can become a technical bottleneck, however the priority for introduction is high and early deployment is recommended.

7 **A**: The technology is of relatively higher priority and early deployment is recommended. **B**: The technology can be deployed when barriers are removed by arranging the deployment environment to some extent. **C**: Long time may be required for technology deployment in order to arrange appropriate environment.

	Sub-sector	NDC#	Options	Rate[7]	Evaluation
5	Cement	E5	Cement-making technology (Waste Heat Recovery from Cement)	B	▪ Its energy saving impact is high ▪ However the initial investment cost is also high and requires major equipment upgrade. ▪ As the installation would have to wait the facility renewal timing, it is considered deployable when barriers are removed by arranging the environment to some extent.
6		E5	Cement-making technology (Dry Kilns with Multistage Pre-Heaters and Pre-Calcination)	C	▪ The use of process heat from the Kiln and clinker coolers to pre-heat the raw meal to be fed into the Kiln are expected to improve energy efficiency; ▪ However, the installation would have to be applied for a new plant or would have to wait the major facility upgrade. Hence, possibility for quick installation is limited and introduction is expected to take time.
7		E5	Cement-making technology (Vertical Roller Mill)	B	▪ The energy saving effect during operation is high, leading to cost reduction from less use of electricity. At the same time, initial cost is high and its system is relatively complex, resulting in difficulties in maintenance. ▪ If the electricity price is low, payout time can become longer than anticipated. ▪ The installation would be considered when the facility is upgraded, hence it is considered deployable when barriers are removed by arranging the environment to some extent.
8		E5	Cement-making technology (Kiln Shell Heat Loss Reduction)	A	▪ Observing at installation in China, the payout time is less than a year and the initial cost is relatively low. ▪ Also, production cost would be lowered due to reduction in startup time and less downtime, the priority for introduction is high and early deployment is recommended.
9		E5	Cement-making technology (VFD Installation)	A	▪ The energy used for motors can be optimized by variation in motor frequency. The technology is in commercial use and its application is fairly easy, but its impact to save energy varies depending on the environment and the equipment used. ▪ In cement industry, the energy saving effect would depend on the flow pattern and the load, and its installation will be determined based on the electricity price, but generally the technology is of high priority and early deployment is recommended.

	Sub-sector	NDC#	Options	Rate[7]	Evaluation
10		E5	Cement-making technology (Combustion Optimization)	B	▪ Initial investment cost is relatively low, and in the case in China, the payout time was 2-3 years. ▪ There are several types of combustion optimization technologies, and for Gyro-Therm technology that can be used for rotary kilns, on top of the energy saving effect, rise in productivity and lowered NOx emission can be expected.
11	Brick	E6	Brick-making technology improvements (Vertical Shaft brick kilns)	B	▪ In addition to its energy saving effect, vertical shaft brick kilns contributes to reduce emission of SPMs and pollution sources, resulting in promoted commercial use in China and India. ▪ Based on the experience in India, technology transfer and trainings on the complexity of VSBK technology can be an issue for the introduction in Viet Nam.
12	Steel	-	Coke Dry Quenching	B	▪ In CDQ, on top of its energy saving effect, cokes is cooled down in closed system leading to no emission of white smoke such as dust, and consequently to improvement of the working environment. ▪ Meanwhile, its initial investment cost is high and payout time, with some variance depending on the electricity price, is more than 3 years. As it requires major upgrade, it is considered deployable when barriers are removed by arranging the environment to some extent.
13		-	WHR-based power generation	B	▪ The level of initial cost is moderate and its reduction effect is the highest in the industry. The technology is established and deployed in many countries to reduce dependency to grid electricity. It is considered deployable when barriers are removed by arranging the environment to some extent, such as increase in electricity price.
14		-	Heat recuperation from hot blast stoves	A	▪ Its initial cost is the lowest and it is widely in use internationally. Audinet et al. (2016) estimates its adoption rate in Viet Nam for 2030 to be 80%, and its rapid introduction is expected by and large. Its GHG reduction effect is somewhat limited, however introduction priority is high and early deployment is recommended.

	Sub-sector	NDC#	Options	Rate[7]	Evaluation
15		-	Sintering plant heat recovery	A	▪ Initial investment cost is relatively low, however the payout time is estimated to take about 3-5 years. Internationally, the technology is deployed in developed countries and also in developing countries such as China and India. Audinet et al. (2016) estimates the adoption rate for Viet Nam in 2030 to be 80%. The priority is high and early deployment is recommended.
16		-	BOF gas sensible heat recovery	A	▪ Initial cost is moderate compared to other technologies, and significant energy saving effect is expected in the BOF process when introduced. The technology is commonly used in China and India, and its introduction is of high priority and early deployment is recommended.
17		-	Natural gas injection in BF	B	▪ Initial cost is low and the amount of cokes to be fed into the furnace can be reduced. The technology can be expected to bring moderate energy saving effect, however as the introduction may be affected by gas procurement and price.
18		-	Pulverized coal injection (PCI) in blast furnace	B	▪ Initial cost is low and the amount of cokes to be fed into the furnace can be reduced. The technology can be expected to bring moderate energy saving effect, however as initial cost may become high depending on the furnace size and its allocation, it is considered deployable when barriers are removed.
19		-	Continuous casting	B	▪ Continuous casting improves productivity significantly and since it requires no furnace re-heating, its energy saving effect is also expected to be significant. Meanwhile, the technology is more suitable for application to large-sized plants, and due to its high initial cost, it is considered deployable when barriers are removed by arranging the environment to some extent.
20		-	Hot charging in rolling mill	A	▪ Initial cost and energy saving effect is considered to be moderate, but the feasibility for installation is dependent on the layout of other process facilities in the plant. Due to the rising tendency of the use of electricity furnace, the future potential for GHG reduction is considered high. Hence, the priority is high for this technology and early deployment is recommended.

	Sub-sector	NDC#	Options	Rate[7]	Evaluation
21		-	Installation of the top pressure recovery turbine	B	▪ Initial cost and GHG reduction effect is moderate, and requires installation of recovery system for the blast furnace gas and the power generating system, leading to high O&M cost. Meanwhile, by introducing this technology, dependency to the grid electricity is reduced.
22		-	Variable speed drives in steel making	A	▪ Initial cost is low and its energy saving effect is also small, however it will contribute to reduce consumption of grid electricity. The technology is adopted in major countries, and its introduction is of high priority. Early deployment is recommended.
23	Refinery	-	Online furnace cleaning	A	▪ Initial cost is relatively high and its energy saving effect is low, however the adoption rate for 2030 is estimated to be 90% by Audinet et al. (2016) because it is already technologically established. The priority is high for this technology and early deployment is recommended.
24		-	Optimization of power consumption in utility boiler drives and auxiliaries	A	▪ Initial cost is relatively high and its energy saving effect is low, however the adoption rate for 2030 is estimated to be 90% by Audinet et al. (2016) because it is already technologically established. The priority is high for this technology and early deployment is recommended.
25		-	Steam savings by trap management	A	▪ Initial cost is low and energy saving effect is high. The technology is already deployed in China and India, and the priority is high and early deployment is recommended.
26		-	Condensate recovery	A	▪ Initial cost is moderate, and energy saving effect is small, however, the installation is easy and it is widely used both in developed and developing countries. The priority is high and early deployment is recommended.
27		-	Flare gas recovery and utilization for process heating requirements	A	▪ Initial cost is high, but the energy saving effect is significant. Expertise knowledge is required for installation but the technology itself is established and is used both in developed and developing countries. The priority is high and early deployment is recommended.
28		-	Installation of low excess air burner	A	▪ Initial cost is moderate and energy saving effect is relatively small, however the technology can reduce the amount of fuel used for boilers, and is widely used in developing and developed countries. The priority is high and early deployment is recommended.

	Sub-sector	NDC#	Options	Rate[7]	Evaluation
29		-	Oil recovery from crude tank bottom sludge by chemical treatment	A	▪ The technology to recover oil from the oil storage tank has the secondary benefit of reduction of hazardous waste. Initial cost and energy saving effect is both moderate, however the priority is high and early deployment is recommended.
30	Fertilizer	-	Calcium Silicate Insulation of High Pressure Steam Pipe Line	A	▪ Initial cost is low and energy saving effect is high. It is a safe alternative to asbestos, hence the priority is high and early deployment is recommended.
31		-	Heat Recovery from MP Decomposer Vapors in Urea Plant by Installation of Pre-Concentrator	B	▪ Initial cost is moderate, but the energy saving effect is high. By introducing this technology, improvement of productivity and reduction in vapors used for process is expected.
32		-	Isothermal CO Conversion Reactor	B	▪ Initial cost is high and energy saving effect is moderate. GHG reduction in the manufacturing process can be expected, hence it is considered deployable when barriers are removed by arranging the environment to some extent.
33		-	High Conversion Rate Synthesis Reactor	A	▪ Initial cost is low and energy saving effect is also low, however the technology can reduce the amount of grid electricity consumption and therefore introduced in developing and developed countries, the priority is high and early deployment is recommended.
34		-	Installation of Variable Speed Drives for Cooling Tower Fans in Fertilizer	A	▪ Initial cost is low and energy saving effect is also low, however the technology can reduce the amount of grid electricity consumption and therefore introduced in developing and developed countries, the priority is high and early deployment is recommended.
35		-	Steam Trap Management	A	▪ Initial cost is low and energy saving effect is also low, however the technology can reduce the amount of grid electricity consumption and therefore introduced in developing and developed countries, the priority is high and early deployment is recommended.

	Sub-sector	NDC#	Options	Rate[7]	Evaluation
36	Pulp and paper	-	Heat recovery in thermo-mechanical pulping	B	▪ Initial cost is low and energy saving effect is moderate. The technology is widely used in developed and developing countries. Factories where the technology is not introduced are normally an old facility.
37		-	Waste heat recovery from paper drying	A	▪ Initial cost is low and energy saving effect is high. The technology is widely used in internationally. The priority is high and early deployment is recommended.
38		-	Increased use of recycled pulp	C	▪ Reduction impact is significant, however initial cost is extremely high, and there is also an issue of treating sludge resulting from the manufacturing process. Long time may be required for technology deployment in order to arrange appropriate environment.
39		-	RTS pulping	B	▪ Initial cost is moderate and energy saving effect is also moderate. The technology is expected to be introduced over time as the existing facility expires.
40		-	Black liquor gasification	A	▪ Initial cost is moderate and reduction impact is small, however the technology can contribute to minimize emission of pollutants such as SOx, NOx, CO, and organic matter. Major companies have already deployed the technology and its potential in the developing countries is considered large, hence the priority for introduction is high and early deployment is recommended.
41		-	Extended nip press	B	▪ Initial cost is moderate and reduction impact is small, however the technology can contribute to reduce the energy consumption required for the drying process and expected to improve the capacity of the dryer by lessening the load. Certain operation cost is expected, hence the technology is considered deployable when barriers are removed by arranging the environment to some extent.

3. Major barriers and Solutions

Major barriers for the promotion of energy efficiency improvement effort are as follows;

1) **limited funding and financial environment** where investment is difficult if the payout time is long,
2) **limited information/know-how** on the technology,
3) **Institutional barrier** such as lack of cooperation from the employee in private companies due to lack of understanding,

4) concern to affect the product quality and complaints from the employees, etc. Also, it is pointed out that the incentive for saving energy is low in Viet Nam because the electricity price and energy cost is relatively low.

The Vietnamese government has already enacted the Energy Efficiency Law and introduced the energy efficiency standards and labeling system. It has also formulated policies for industrial sector, setting energy consumption benchmarks for specific industry sub-sectors and ESCOs. In future, discussions on measures to strengthen the management and monitoring system to improve the viability of the existing framework, and to promote incentives of the consumers and private companies for energy efficiency improvement, such as subsidiary funding for installation of energy efficient facilities, are considered useful. Moreover, to remove the barriers due to insufficient information, provision of information on energy efficient product and technologies, and facilitation of capacity building and training for business owners and employees are called for to avoid the risk of institutional barriers and adverse effect to business operation.

4.1.2 Stakeholder Consultations for Consensus Building

The Assessment conducted a series of stakeholder consultation meetings to build a consensus with the relevant stakeholders on the list of climate change mitigation technologies and its priority in the process of technology assessment. This section summarizes them with the discussions and opinions made in the meetings.

1. Overview of the meeting schedule

Table 8 Major meetings/WSs related to discussions on the priority assessment

Date	Meetings/WSs
September 28-30, 2016	Discussion with MOIT/Science, Technology and Energy Efficiency (STEE) and Interview to private companies.
December 2	Sectoral meeting and Discussion with MOIT/GDE[8]
January 11, 2017	1st Advisory Committee (Japanese experts)
June 8, 2017	Sector-based Stakeholder's WS on Low Carbon Technology Assessment for energy sector
August 28, 2017	Consultation WS on Low Carbon Technology Assessment
November 28, 2017	The Final WS on Low Carbon Technology Assessment
December 8, 2017	2nd Advisory Committee (Japanese experts)

The first meeting with the General Directorate of Energy (GDE) under MOIT for discussion for prioritizing the short-listed technologies was conducted during the second field survey mission in Nov –Dec 2016. Some comments were provided by the GDE in the sector based workshop on energy and power generation that was held immediately after the first meeting. More comments on the prioritization criteria were also obtained from the committee members at the first domestic advisory committee meeting held in January 2017.

8 General Directorate of Energy: GDE

Sector based Stakeholder workshops were held during the third field survey trip conducted in June 2017, and discussion on prioritization criteria were conducted involving many stakeholders.

The results of the evaluation based on the prioritization criteria reflecting these discussions were presented at the forth field survey mission in August 2017, and more in-depth discussions were carried out.

2. Key suggestions and opinions from the stakeholders

There were no issues raised for the criteria itself, but it was pointed out that there is no need to have different criteria for each sub-sector (industry, residential, etc.) because easiness of operation and economic efficiency are weighed as important factor for every sub-sector.

Also, for some superior technologies that are not yet introduced due to improper installation or insufficient installation skills, efforts to overcome these issues are included for consideration when operation cost is estimated for this technology.

It was suggested to include cross-sectoral equipment such as pumps, motors and compressors, and also some conventional technologies as assessment target, and was duly noted for future discussion.

3. Learnings from the stakeholder consultation meetings and workshops

In this assessment, a year has been spent to discuss and summarize the prioritization criteria and the evaluation result with the policy makers, researchers, business sectors, etc. It was confirmed that to secure sufficient time to conduct in-depth discussions and enhance communications with multiple stakeholders that are essential to maintain wide perspective on the issue. At the same time, it may sometimes be difficult to reach consensus due to diverse priorities depending on the participants' positions. This may be resolved to some extent by securing a team member who has high capability in communication and network coordination. The main format of the discussions was in workshop style for this project, but committee style discussion and handing out questionnaire to private companies and related stakeholders may also be an option.

4.2 Energy (Power generation)

4.2.1 Technology Prioritization

1. Characteristics of the Power Generation sector and Prioritization Criteria Setting

One significant factor in the power generation sector is that the power generation development target for 2030 is set for each power source in the National Power Development Plan VII (PDP7) of which revision was approved in March 2016. The plan is aimed to address the increase in power demand due to economic growth and promotes supply capacity improvement for renewable energy such as natural gas, biomass, wind, solar and small to medium scale hydropower, to support the supply by coal-fired power plant. Another factor to consider is the large difference in generation capacity for large scale thermal power plant and renewable energy. To make a fair comparison, the cost was evaluated using cost per generation capacity (USD/kW) and cost per power generated (USD/kWh) for this Assessment. This method is accepted as common practice in the power generation sector, although degree of cost accuracy may be considered an issue.

For the Power Generation sector, Compatibility with policy priorities, Economic efficiency, GHG reduction effect, Versatility, Economical/Social/Environmental Impact and Acceptability in Viet Nam's Context were chosen as the common criteria.

As sector specific criterion, **Target share of the power source** was chosen, prioritizing options with higher share target for 2030 as High Priority. The target is based on the introduction target specified in PDP7 (Table 9).

Table 9 Criteria/Indicators used for the Energy Sector (Power Generation)

Criteria	Indicators	Evaluation[9]	
Compatibility with policy priorities	Availability of policy document	High	Law/Decree/Action Plan
		Medium	Strategical document only
		Low	No policy document
Economic Efficiency	Initial cost (US$/kW)	High	Top 1/3 (Below 1,700 USD/kW)
		Medium	Middle 1/3 (1,700-2,000 USD/kW)
		Low	Bottom 1/3 (More than 2,000 USD/kW)
	Power generation cost (US$/kWh)	High	Top 1/3 (Below 0.1 USD/kWh)
		Medium	Middle 1/3 (0.1-0.15 USD/kWh)
		Low	Bottom 1/3 (More than 0.15 USD/kWh)
GHGs emission reduction effect	Emission Intensity (g-CO_2/kWh)	High	Below 660g-CO_2/kWh
		Medium	660-810g-CO_2/kWh
		Low	More than 810g-CO_2/kWh
Versatility	Operation and Maintenance System	High	Requires only irregular inspection (No need for fully committed operator)
		Medium	Requires regular inspection (No need for fully committed operator)
		Low	Requires fully committed staff for operation and maintenance

9 Numerical criteria are shown as reference. The numbers show the representative value of the Top/Middle/Bottom group and are liable to change due to policy/market trend/technology improvement.

Criteria	Indicators		Evaluation[9]
Economical, Social and Environmental Impact	Economical aspect	High	Positive effect to the economy
		Medium	Limited positive effect to the economy
		Low	Adverse effect to the economy (if no actions are taken)
	Social aspect	High	Positive effect to the society
		Medium	Limited positive effect to the society
		Low	Adverse effect to the society (if no actions are taken)
	Environmental aspect	High	Not subject to environmental regulation (NO consideration required)
		Medium	Not subject to environmental regulation (Consideration required)
		Low	Subject to environmental regulation
Acceptability/ Current practice in Viet Nam's Context	Current Adoption Rate (kW)	High	Market share more than 10%
		Medium	Market share 2-10%
		Low	Not adopted or Market share less than 2%

Table 10 Sector Specific Criteria/Indicators for the Energy Sector (Power Generation)

Criteria	Indicators		Evaluation
Level of Target Share (Power generated in 2030)[10]	Target Percentage of electricity produced to the Total Electricity Generated (%)	High	Market share more than 10%
		Medium	Market share 2-10%
		Low	Not adopted or Market share less than 2%

2. Result of the Multi-criteria Assessment for the Power Generation Sector

The result of the multi-criteria assessment of power generation technologies (7 technologies for power generation, 2 technologies for power transmission) based on the above criteria is summarized in the chart below. To summarize, solar power, USC, natural gas (CCGT) were categorized as A, biomass and biogas power generation were categorized as B, and wind power and small/medium scale hydropower were categorized as C. For transmission technologies, high efficiency power transmission line and high efficiency transformer were both categorized as A.

10 Based on PDP 7 Revised (2016).

Table 11 Evaluation Results for the Energy Sector (Power Generation)

	NDC#	Options	Rate[11]	Evaluation
1	E11	Biomass power generation	B	In Viet Nam, biomass power generation has been adopted at the sugar refining factories. Since agriculture is very active in Viet Nam, bi-products such as rice husks are considered as good source to be utilized. However, some measures need to be taken to ensure stable supply as these bi-products are only available during certain times of the year.
2	E12	Small hydro power generation	C	Currently in Viet Nam, the principal source of power is from large scale hydropower, and although there are certain possibilities for small scale hydropower, it may take some time to take measures to prevent flood damage by irrigation system attached with hydropower.
3	E13&14	Wind power generation	C	Wind conditions are studied in Viet Nam, however total cost is higher than other power generation methods (hydro and coal), hence it may require some time to arrange for introduction. Although the price per unit power is still higher than hydro or coal power it is lower than diesel and many estimates of gas power already, whereas the prices are coming down year by year gradually.
4	E15	Biogas power generation	B	Since agriculture is very active in Viet Nam, waste from livestock is considered as good source to be utilized. However, as certain amount of waste is necessary for biogas power generation, and farming business is often in small scale, introduction is only possible if measures are taken to ensure stable supply of sufficient waste.
5	E16	Coal power generation (USC)	A	To address the increase in power demand due to economic growth in Viet Nam, introduction of large scale power generating facility is expected. There is a plan for construction of coal-fired power plant, which can be operated with low cost, however, introduction of supercritical coal-fired power plant (USC) which has higher power generation efficiency and emits limited amount of CO_2 is considered a better option and early deployment is recommended. Yet it should bear in mind investment cost is stable, whereas solar PV and also wind power costs are on a clear downward trend.
6	E17	Solar PV generation	A	There are only few examples in Viet Nam, but as installation cost for solar PV is expected to drop in the international market, higher number of installation is anticipated. Priority is high and early deployment is recommended.

11 **A**: The technology is of relatively higher priority and early deployment is recommended. **B**: The technology can be deployed when barriers are removed by arranging the deployment environment to some extent. **C**: Long time may be required for technology deployment in order to arrange appropriate environment.

	NDC#	Options	Rate[11]	Evaluation
7	-	Natural gas power generation	A	To address the increase in power demand due to economic growth in Viet Nam, introduction of large scale power generating facility is expected. There is a plan for construction of coal-fired power plant, which can be operated with low cost, however, introduction of natural gas power generation which has higher power generation efficiency and emits limited amount of CO_2 is considered a better option and early deployment is recommended. In addition, early deployment is much easier than coal power plant construction and associated waste (landfill) facilities.
8	-	High efficiency power generation transmission line	A	To address the increase in power demand due to economic growth in Viet Nam, introduction of large scale power generating facility is expected. The expansion of the transmission network to deliver electricity to the demand area is also included in the plan. High efficiency transmission line is of higher priority and early deployment is recommended.
9	-	High efficiency transformer	A	To address the increase in power demand due to economic growth in Viet Nam, introduction of large scale power generating facility is expected. The improvement of the transformers to manage the electricity under appropriate voltage is also included in the plan. Application of high efficiency transformer is of higher priority and early deployment is recommended.

3. Major barriers and solutions

Major barriers for the promotion of low carbon technologies in the Power Generation sector are as follows;

1) **Unclear requirements/permit system** in the current regulation,

2) **Environmental protection** (subject to Payment to Forest Ecosystem Services).

There are certain policy and technical barriers that need to be addressed for the swift introduction and steady implementation of PDP7. In light of this, solid and practical plan is needed to be developed with collecting relevant information in power sector. There is still some room for clarification on current regulations such as grid connection less than 1 MW and for sufficient permit procedure in order to bring more attention from business sector.

Difficulties in securing the fund for installation is a common barrier for all technologies, consequently a funding scheme such as international aid is in need. At the same time, the Vietnamese government is in the process of enhancing policies for introduction, and Feed-in-Tariff (FIT) program for renewable energy has been implemented. For example, FIT for solar PV generation was enforced in June 2017. Need for some improvements are pointed out for this FIT program, which are expected to be realized in light of further development.

Environment protection is one of the issues bearing in mind when considering power sector. The payment for forest ecosystem service (PFES) set out in 2010 to institutionalize a national policy aiming to protect vital ecosystem service. To protect natural forest and healthy environment are one hand, stable supply of quality biomass to the plant is the other hand. Utilization of agricultural residues could avoid timber from forest yet precise information on biomass material and alternative fuel resources need to be considered in case of its shortage. In order to stimulate the action for biomass power generation, additional environmental standards, such as CH_4 emission to atmosphere for existing QCVN for pig farm, are needed to be considered.

4.2.2 Stakeholder Consultations for Consensus Building

1. Overview of the meeting schedule

Table 12 Major meetings/WSs related to discussions on the priority assessment

Date	Meetings/WSs
September 28-30, 2016	Discussion with MOIT/Science, Technology and Energy Efficiency (STEE) and Interview to private companies.
December 2	Sectoral meeting and Discussion with MOIT/GDE
January 11, 2017	Advisory Committee (Japanese experts)
June 8, 2017	Sector-based Stakeholder's WS on Low Carbon Technology Assessment for energy sector
August 28, 2017	Consultation WS on Low Carbon Technology Assessment
November 28, 2017	The Final WS on Low Carbon Technology Assessment
December 8, 2017	2nd Advisory Committee (Japanese experts)

The first meeting with the General Directorate of Energy (GDE) under MOIT for discussion for prioritizing the short-listed technologies was conducted during the second field survey mission in Nov –Dec 2016. Some comments were provided by the GDE in the sector based workshop on energy and power generation that was held immediately after the first meeting. More comments on the prioritization criteria were also obtained from the committee members at the first domestic advisory committee meeting held in January 2017.

Sector based Stakeholder workshops were held during the third field survey trip conducted in June 2017, and discussion on prioritization criteria were conducted involving many stakeholders.
The results of the evaluation based on the prioritization criteria reflecting these discussions were presented at the forth field survey mission in August 2017, and more in-depth discussions were carried out.

2. Key suggestions and opinions from the stakeholders

Major comments/advices on prioritization criteria raised at above meetings/workshops were as follows. There were no issues raised for the criteria itself, but it was pointed out that the criteria to be applied may differ depending on the technology, and also that weight of the importance of the criteria may be different for each technology. For cost evaluations, it was suggested to include operation and environmental cost to be added to the current criteria on initial cost. Additionally, it was noted that the data in the publicly disclosed cost analysis are based on different evaluation timing, target year and level of policy impact and may affect the prioritization result depending on which data to choose for the evaluation.

3. Learnings from the stakeholder consultation meetings and workshops

In this assessment, a year has been spent to discuss and summarize the prioritization criteria and the evaluation result with the policy makers, researchers, business sectors, etc. It was confirmed that to secure sufficient time to conduct in-depth discussions and enhance communications with multiple stakeholders that are essential to maintain wide perspective on the issue. At the same time, it may sometimes be difficult to reach consensus due to diverse priorities depending on the participants' positions. This may be resolved to some extent by securing a team member who has high capability in communication and network coordination. The main format of the discussions was in workshop style for this project, but committee style may also be an option.

4.3 Transport

4.3.1 Technology Prioritization

1. Characteristics of the Transport sector and Prioritization Criteria Setting

A distinctive point of the Viet Nam's NDC in the transport sector is that measures on modal shift (passenger and freight), which require large infrastructure projects, are set as major activities. The MOT's suggestion on climate change mitigation measures in the transport sector is to set three pillars of measures, i.e. modal shift (passenger and freight), energy efficiency (in 5 subsectors: road, railway, inland waterway, maritime and aviation) and fuel switch, thus it should not be limited to the three mitigation options indicated in the INDC Technical Report (E7: Substitution of Ethanol to Gasoline, E8: Passenger Transport Modal Shift from Private to Public, and E9: Freight Transport Switch from Road).

For the Transport sector, Compatibility with policy priorities, Economic efficiency, GHG reduction effect, Versatility and Economical/Social/Environmental Impact were chosen as the common criteria. As sector specific criteria, Compatibility to the local needs, Implementation timing and Coordination with other options were chosen.

Table 13 Criteria/Indicator used for the Transport Sector

Criteria	Indicators		Evaluation
Compatibility with policy priorities	Availability of policy document	High	Law/Decree/Action Plan
		Medium	Strategical document only
		Low	No policy document
Economic efficiency	Initial cost	High	Bottom 1/3 (Low cost)
		Medium	Middle 1/3
		Low	Top 1/3
GHGs emission reduction effect	Absolute amount	High	Top 1/3 (Large reduction volume)
		Medium	Middle 1/3
		Low	Bottom 1/3
Versatility	Technical ease for deployment	High	Autonomous production/introduction in Viet Nam is relatively easy at this time
		Medium	Production and introduction in Viet Nam is possible
		Low	Autonomous production/introduction is difficult at this time
	Operation and Maintenance System	High	Existing system can be utilized
		Medium	Requires only minor change
		Low	Requires major upgrade such as changing production line

Criteria	Indicators		Evaluation
Economical, Social and Environmental Impact	Economical aspect	High	Positive effect to the economy
		Medium	Limited positive effect to the economy
		Low	Adverse effect to the economy (if no actions are taken)
	Social aspect	High	Positive effect to the society
		Medium	Limited positive effect to the society
		Low	Adverse effect to the society (if no actions are taken)
	Environmental aspect	High	Not subject to environmental regulation (NO consideration required)
		Medium	Not subject to environmental regulation (Consideration required)
		Low	Subject to environmental regulation

Table 14 Sector Specific Criteria/Indicators for the Transport Sector

Criteria	Indicators	Evaluation
Compatibility to the local needs	Compatibility by area	What are the major target of area to deploy the option
Implementation timing	Lead time until the introduction (Short, Medium, Long)	Indicate lead time for launch/introduction (Short-2 years, Medium-3-5 years, Long-more than 6 years)
Coordination with other options	Level of synergy effect with other options, Most prioritized synergy effect when conducted jointly	Is coordination with other options essential? Is it a prioritized option to be implemented? Would it offer any synergy effect if conducted jointly with other options?

2. Result of the Multi-criteria assessment for the Transport Sector

The result of the multi-criteria assessment of transport technologies based on the above criteria is summarized in the chart below. To summarize, 1) urban railway (Metro, LRT, etc.) and bus route development for passenger transport, and introduction of new freight car and renovation of rail tracks for freight transport were categorized as A as options for Mode Shift. 2) 14 options were categorized as A for Energy Efficiency, namely, low emission vehicle, eco-driving, ITS, parking management, infrastructure, LED lights, high efficiency transformer, engine and locomotive renovation for railway, energy efficient cargo handling machine, renewable energy at ports and airports, electric vehicle and LED lights at airports. 3) Use of Compressed Natural Gas (CNG) and Liquefied Petroleum Gas (LPG) were categorized as A for Fuel Switching option.

Table 15 Evaluation Results for the Transport Sector

	Sub-sector	Mitigation option[12]	Rate[13]	Evaluation
1	Mode shift	Passenger – Urban railway (Metro, LRT, monorail)	A	▪ In large cities such as Hanoi and Ho Chi Minh City, road congestion has been extremely serious, therefore establishment of public transport networks including Mass Rapid Transit (MRTs) and buses are an urgent task, and some of MRT construction are proceeding. The technology is of relatively higher priority and early deployment is recommended.
2		Passenger – Inter-city railway (Renovation of rail tracks)	B	▪ Currently, the main means of transportation between cities is limited to long distance buses and air, therefore, it is necessary to improve transportation capacity of existing inter-city railway.
3		Passenger – Inter-city railway (High speed railway)	B	▪ Introduction of high-speed railways, which are high-speed and mass transportation between cities, are expected to contribute to further development of the economies of large cities and local cities in Viet Nam, but many processes are required before the development.
4		Passenger – Bus (BRT)	B	▪ Several projects have been implemented, e.g. one BRT route already operated in Hanoi. On the other hand, issues are also concerned such as congestion of roads outside the BRT exclusive route.
5		Passenger – Bus (Bus route development/ improvement)	A	▪ Road congestion has been getting worse in urban areas, and it is urgent task to enhance public transportation such as buses. It is relatively easy to develop new routes and restructure existing routes. The technology is of relatively higher priority and early deployment is recommended.

12 Three pillars are indicated in the INDC technical report namely Mode shift, Energy efficiency and fuel switching. Transport sector is expanded mitigation option based on the pillars.

13 **A**: The technology is of relatively higher priority and early deployment is recommended. **B**: The technology can be deployed when barriers are removed by arranging the deployment environment to some extent. **C**: Long time may be required for technology deployment in order to arrange appropriate environment.

	Sub-sector	Mitigation option[12]	Rate[13]	Evaluation
6		Passenger – Inland waterway (River bus/ boat)	B	▪ In urban areas, not only road transportation but also utilization of water transportation are being promoted, but it is necessary to accumulate know-how on route selection and effective operation etc.
7		Passenger – Promotion of public transportation (IC card, automatic ticket gate)	B	▪ The measure is necessary to increase users when public transport networks including such as MRT and bus are established, and some pilot projects are already implemented.
8		Passenger – Promotion of public transportation (Bus location system)	B	▪ The measure is important to increase the number of bus users, on the other hand, in order to make the location system more effective, measures to ensure punctuality of bus operation, such as eliminating road congestion, are necessary.
9		Passenger – Promotion of public transportation (Park & Ride (e.g. Mechanical parking tower))	B	▪ In order to promote the use of MRT, it is recommended to build parking facilities together with the development of MRT.
10		Passenger – Multi-modal promotion (Connection between different mode of transportation (Combination of multiple measures))	C	▪ Public transportation such as MRT and bus needs to be developed as a network, and this measure is necessary to continuously implement as a tool to improve user-friendliness of the public transportation.
11		Freight – Shift from road to railway (Development of access railways to ports)	C	▪ One of the important measures for smoothly implementing freight mode shift, on the other hand, it is important to evaluate the priority in comparison with other means of transportation, taking into account cost and other factors. Long term may be required for technology deployment in order to arrange appropriate environment.
12		Freight – Shift from road to railway (Introduction of new freight car, large size container)	A	▪ One of the important measures to promote freight mode shift. The technology is of relatively higher priority and early deployment is recommended.
13		Freight – Shift from road to railway (Renovation of rail tracks)	A	▪ One of the important measures to promote freight mode shift. The technology is of relatively higher priority and early deployment is recommended.

	Sub-sector	Mitigation option[12]	Rate[13]	Evaluation
14		Freight – Shift from road to railway (Development/ improvement of railway freight terminal/ ICD and set up necessary equipment, e.g. high-top lifter at rail freight terminals)	B	▪ One of the important measures to promote freight mode shift, and it is important to study and assess in details including the place and scale to be developed.
15		Shift from road to waterway (Development/ improvement of port and related equipment)	B	▪ One of the important measures to promote freight mode shift, and detailed study and assessment are required including selection of appropriate place and scale to be developed.
16		Freight – Shift from road to waterway (Development of harbor road)	B	▪ One of the important measures to promote freight mode shift, and detailed study and assessment are required including selection of the port and road to be developed.
17		Freight – Shift from road to waterway (Development/ improvement of canals)	C	▪ Detailed study including selection of canals expected to have high impact are required.
18		Freight – Multi-modal promotion (Combination of multiple measures)	C	▪ It is important to increase freight transport options such as road, railway and waterway, and is necessary to continuously implement measures to improve their conveniences. Long term may be required for technology deployment in order to arrange appropriate environment.
19	Energy efficiency	Road – Improve fuel efficiency of vehicle (Low emission vehicle (High fuel economy vehicles, not including Hybrid/ Electric/ CNG/ LPG))	A	▪ Not only newly installation, but introduction at the time of vehicle replacement is expected. The technology is of relatively higher priority and early deployment is recommended.
20		Road – Improve fuel efficiency of vehicle (Fuel car labeling)	B	▪ Already implemented.

	Sub-sector	Mitigation option[12]	Rate[13]	Evaluation
21		Road – Improve fuel efficiency of vehicle (Eco-driving for drivers (safety and environmental friendly driving and maintenance/ technology to improve fuel efficiency such eco-tire))	A	▪ It is relatively low cost and has cost-effectiveness. Already implemented by logistics companies and supported by donors. The technology is of relatively higher priority and early deployment is recommended.
22		Road – Improve fuel efficiency of vehicle (Eco-driving for freight vehicle (safety and environmental friendly driving and maintenance/ technology to improve fuel efficiency such eco-tire))	A	▪ It is relatively low cost and has cost-effectiveness. Already implemented by logistics companies and supported by donors. The technology is of relatively higher priority and early deployment is recommended.
23		Road – Improve traffic flow (ITS (Traffic control center, Intelligent traffic signals (including LED), ETC), IOT)	A	▪ Reducing traffic congestion is an urgent issue in large cities, and measures to mitigate traffic congestion taking into account the characteristics of cities are necessary. The technology is of relatively higher priority and early deployment is recommended.
24		Road – Improve traffic flow (Traffic management (Truck ban, road pricing))	C	▪ Detailed study is required taking into account the traffic characteristics of the city. Long term may be required for technology deployment in order to arrange appropriate environment.
25		Road – Improve traffic flow (Parking management)	A	▪ Already implemented and especially in urban area the technology is of relatively higher priority and early deployment is recommended.
26		Road – Improve traffic flow (Infrastructure (Road (bypass, ring-road), pavement utilizing recycled material, fly-over, bridges, tunnels))	A	▪ Already implemented, and especially in cities where road congestion is serious, the technology is of relatively higher priority and early deployment is recommended.
27		Road – Others (LED lights for highways)	A	▪ Already implemented or piloted, and the technology is of relatively higher priority and early deployment is recommended.

	Sub-sector	Mitigation option[12]	Rate[13]	Evaluation
28		Road – Others (High efficiency transformer for electricity supply for tunnel (at construction and operation))	A	▪ Already implemented or piloted, and the technology is of relatively higher priority and early deployment is recommended.
29		Road – Others (Promotion of bicycle use (e.g. bicycle Lane))	B	▪ The technology can be deployed when barriers, such as development/securing of bicycle lanes, are removed by arranging the deployment environment to some extent.
30		Road – Others (Freight Exchange Centre)	C	▪ It is important not only to share technical know-how, but also to ensure active participation by the user during operation. Long term may be required for technology deployment in order to arrange appropriate environment.
31		Railway – Urban and inter-city railway (Energy efficient railway vehicle (Light weight vehicle, VVVF, regenerative braking system, electric-diesel hybrid railway vehicles))	C	▪ Development of MRTs are prerequisite. Long term may be required for technology deployment in order to arrange appropriate environment.
32		Railway – Urban and inter-city railway (Energy efficient appliances and renewable energy for stations/depots (e.g. LED, PV system))	B	▪ Already implemented at the national railway station, and it can be implemented in the future at MRT stations. The technology can be deployed when barriers are removed by arranging the deployment environment to some extent.
33		Railway – Inter-city railway (Engine and locomotive renovation)	A	▪ Already planned and implemented by the national railway authority.
34		Railway – Inter-city railway (Improve fuel economy)	C	▪ Although there are pilot cases, the effect is not certain. Long term may be required for technology deployment in order to arrange appropriate environment.
35		Railway – Inter-city railway (Electrification)	C	▪ Many steps are required including selection of the route, detailed study, planning, designing, construction and so on. Long term may be required for technology deployment in order to arrange appropriate environment.

	Sub-sector	Mitigation option[12]	Rate[13]	Evaluation
36		Inland waterway and Maritime – Port (Energy efficient cargo handling machinery)	A	▪ An effective measure for low carbonization of ports with less barriers. The technology is of relatively higher priority and early deployment is recommended.
37		Inland waterway and Maritime – Port (On-shore power supply system)	B	▪ An effective measure for low carbonization of ports, however preparations by users (vessels) are needed.
38		Inland waterway and Maritime – Port (Energy efficiency chiller container)	B	▪ Efforts to improve awareness of the technology and to evaluate cost effectiveness in introduction are needed.
39		Inland waterway and Maritime – Port (Renewable energy, e.g. PV system)	A	▪ An effective measure for low carbonization of ports with less barriers. The technology is of relatively higher priority and early deployment is recommended.
40		Inland waterway and Maritime – Vessels (Technical renovation, transformation waterway vehicles, utilize vessels)	B	▪ Efforts to improve awareness of the technology and to evaluate cost effectiveness in introduction are needed.
41		Inland waterway and Maritime – Vessels (Improve energy efficiency in ship building yard)	B	▪ The technology can be deployed when barriers are removed by arranging the deployment environment to some extent, through studying on good practices in other countries.
42		Aviation – Airport (APU (Auxiliary Power Unit) -> GPU (Ground Power Unit))	B	▪ An effective measure for low carbonization of airports, however preparations by users (airlines) are needed.
43		Aviation – Airport (Renewable energy, e.g. PV system)	A	▪ An effective measure for low carbonization of airports with fewer barriers. The technology is of relatively higher priority and early deployment is recommended.
44		Aviation – Airport (Electric vehicles)	A	▪ An effective measure for low carbonization of airports with fewer barriers. The technology is of relatively higher priority and early deployment is recommended.
45		Aviation – Airport (LED lights)	A	▪ An effective measure for low carbonization of airports with fewer barriers. The technology is of relatively higher priority and early deployment is recommended.
46		Aviation – Air craft (Modernize aircraft)	B	▪ Not only newly installation, but introduction at the time of aircraft replacement is expected.

	Sub-sector	Mitigation option[12]	Rate[13]	Evaluation
47	Fuel switching	Biofuel – Ethanol	B	▪ Already implemented.
48		Biofuel – Biodiesel	B	▪ Stable supply, such as securing feedstock and quality assurance are needed.
49		Gaseous fuel – CNG, LPG (CNG for buses, trucks, taxis and waterways)	A	▪ CNG buses have already been introduced. Technical barriers for introduction to taxis are also relatively low (pilot studies are necessary for ships). The technology is of relatively higher priority and early deployment is recommended.
50		Electricity – Electricity (Electric buses/taxis/ bikes)	C	▪ Although electric scooters and electric carts have already been introduced, electric buses are being demonstrated but electric cars and trucks are not yet entering the market. In the longer term the technology deployment will require an appropriate environment including electricity charging infrastructure.
51		Electricity – Hybrid (Hybrid buses/taxis/ bikes)	B	▪ Compare to electric or CNG vehicles, technically, easier to be introduced to bus and taxi fleet, but the cost is the major barrier.

3. Major barriers and solutions

Major barriers for the promotion of low carbon technologies in the Transport sector are as follows;

1) **Lack of information** on low carbon technologies/measures

In general, planning/ implementing entity seems to be in lack of the latest information on low carbon technologies/ measures including good practices. Examples of low carbon technologies/ measures need to be presented in comprehensive and systematical ways, i.e. through low carbon technology/ measure platform.

2) **High cost**

High cost of the low carbon technologies, especially high initial-cost, is often a major barrier. Life cycle cost including operational cost as well as initial-cost should be compared and considered. Also, efforts should be made to access climate finances.

3) **Need of various related infrastructure**

For example, for electric or CNG vehicles, related infrastructure such as charging/fueling facilities should be developed widely to accommodate needs of users of these vehicles. There should be a well-designed strategy to introduce these technologies/measures in efficient and effective manner.

4) **Assessing possibility of domestic production**

Localization is one of the important factors in order to widely spread/deploy the low carbon technologies/measures in Viet Nam. Consequently, before introducing the technologies, it is important to assess whether the technology/measures can be designed, manufactured, provided, or developed by local enterprises.

5) **Coordination among various stakeholders**

Transport projects often involve various stakeholders including local government, private companies and users. Therefore, it is important to coordinate and reach consensus among stakeholders to introduce the technologies/ measures.

6) **Lack of incentives** to choose low carbon technologies/measures

Deployment of low carbon technologies often require high costs thus it is less attractive to introduce it. In case where high cost is apparently the major barrier, incentives such as subsidies, tax benefits, low-interest loan, or carbon credit schemes should be studied for effective deployment of the technology.

7) **Need of awareness raising and behavioral change**

For example on public transportation, in addition to developing the infrastructures, it is also important to raise awareness of citizens to promote the use of buses instead of using cars and motorcycles. Public transportation operators or administrators should continuously present importance and benefits of using low carbon transportation modes to citizens.

4.3.2 Stakeholder Consultations for Consensus Building

1. Overview of the meeting schedule

Major meetings/workshops related to discussions on the priority assessment are shown in the Table 16.

Table 16 Major meetings/WSs related to discussions on the priority assessment

Date	Meetings/WSs
September 28-30, 2016	Discussion with MOIT/Science, Technology and Energy Efficiency (STEE) and Interview to private companies.
December 2	Sectoral meeting and Discussion with MOIT/GDE
January 11, 2017	Advisory Committee (Japanese experts)
June 8, 2017	Sector-based Stakeholder's WS on Low Carbon Technology Assessment for energy sector
August 28, 2017	Consultation WS on Low Carbon Technology Assessment
November 28, 2017	The Final WS on Low Carbon Technology Assessment
December 8, 2017	2nd Advisory Committee (Japanese experts)

2. Key suggestions and opinions from the stakeholders

Major comments/advices, especially on additional evaluation criteria, raised at above meetings/ workshops were as follows.

- Applicability of the technology: relatively easy to apply to Vietnamese market and has potential of localization.
- Easiness of application can be divided into "feasibility of technology", "feasibility/readiness of policy/regulation" and "feasibility of application".

- Sustainability of the technology in terms of operation and maintenance.
- Economic and social impacts as well as environmental impact.
- Inter-sectoral benefits other than benefits to the transport sector.
- Impacts of by-products and wastes generated by the new technology.
- Economic efficiency is most important.
- Cost-effectiveness: emission reduction per investment cost.
- GHG emission reduction through introduction of the new technology should be provided.
- Lifecycle costs.
- Synergy effects by combination of measures
- Timing of implementation of measures, phased implementation.
- Measures should be different by scales of cities.

3. Learnings from the stakeholder consultation meetings and workshops

Lessons learnt through the processes to identify the evaluation criteria are summarized as follows.

Through consultations with various stakeholders such as other donors, academics, private enterprises as well as relevant ministries and agencies, various advices were obtained and appropriate evaluation criteria/indicators were set. However, since very few private companies participated, it is necessary to invite further wide-ranging companies through such as some sectoral associations, and also to provide incentives for the participation.

In the transport sector, there was room for discussion as to whether it would be appropriate to evaluate horizontally the wide variety of technologies/measure (including modal shift, energy efficiency improvement, fuel conversion etc.). Regarding this point, an evaluation by scoring is not performed, and qualitative evaluation and issues to be solved are described for each technology/measure.

In the infrastructure projects of the transport sector (MRT, road development/improvement, logistics base improvement, etc.), economic and social benefits are regarded as more important aspect, and GHG emission reductions are generally regarded as one of the side effects and quantification are not often performed. Quantification of GHG emission reduction of each measure should be appropriately performed together with socio-economic benefits so that the measures can be assessed by economic, social and environmental aspects.

4.4 Agriculture

4.4.1 Technology Prioritization

1. Characteristics of the agricultural sector and Prioritization Criteria Setting

Fifteen mitigation options were identified in the agriculture sector. 11 of them were prioritized and eventually adopted in the Plan for Implementation of the Paris Agreement that the MARD submitted to MONRE in August 2016. They are in line with the Action Plan on Climate Change Response of Agriculture and Rural Development Sector in the Period 2011-2015 and Vision to 2050 (March 2011), and Decision on Approving Programme of GHG Emissions Reduction in the Agriculture and Rural Development Sector up to 2020 (December 2011). It is underlined that some of these 11 mitigation options show higher marginal abatement costs, which would require a careful implementation plan for the NDC.

MARD put emphasis that profitability and food security for farmers are the first priority rather than GHG reduction. Profitability ensures economic sustainability of mitigation actions especially for farmers, while a slightest burden or lower yield will prevent them from adopting measures even if marginal abatement costs for measures at national level are acceptable.
Rural development is one of the mandates of MARD. "Co-benefits" should be prioritized over GHG emission reduction, such as income increase, products with better quality and safety, stable production and productivity, less environmental pollution, lower labor burden and so on.

Reflecting these backgrounds, Compatibility with policy priorities, Economic efficiency, GHG reduction effect, Versatility, Economical/Social/Environmental Impact and Acceptability in Viet Nam's context were chosen as the common criteria. As sector specific criteria, level of contribution to food security improvement and agricultural productivity were chosen.

Table 17 Criteria/Indicators used for the Agriculture Sector

Criteria	Indicators	Evaluation	
Compatibility with policy priorities	Availability of policy document	High	Law/Decree/Action Plan
		Medium	Strategical document only
		Low	No policy document
Economic efficiency	Cost (Mitigation cost)	High	Bottom 1/3 (less expensive)
		Medium	Middle 1/3
		Low	Top 1/3
GHGs emission reduction effect	Mitigation potential (Value of referential GHG reduction volume in the shortlist)	High	Top 1/3
		Medium	Middle 1/3
		Low	Bottom 1/3

Criteria	Indicators	Evaluation	
Versatility	Level of technical ease at introduction	High	All resources/materials can be procured in Viet Nam
		Medium	Part of the resources/materials can be procured in Viet Nam
		Low	Difficult to procure resources/materials in Viet Nam
	Operation and Maintenance System	High	Existing system can be utilized
		Medium	Requires only minor change
		Low	Requires major upgrade such as changing production line
		High	All maintenance cost can be borne.
		Medium	Part of maintenance cost can be borne.
		Low	Maintenance cost cannot be borne.
Other Environmental, Economic Impact	Economic aspect	High	Income of the beneficiary increases.
		Medium	No change to the income of the beneficiary.
		Low	Income of the beneficiary decreases.
	Social aspect	High	Strengthens social cohesion (connection).
		Medium	Slightly strengthen social cohesion (connection).
		Low	No change to the social cohesion (connection).
	Environmental aspect	High	Contributes to eliminate environmental pollution (soil, rivers, sea, air)
		Medium	Slightly contributes to eliminate environmental pollution (soil, rivers, sea, air)
		Low	Does not contribute to eliminate environmental pollution (soil, rivers, sea, air)
Acceptability in Viet Nam	Acceptability of the technology use	High	Requires only short time for the training to master the technology.
		Medium	Requires moderate time for the training to master the technology.
		Low	Requires long time for the training to master the technology.

Table 18 Sector Specific Criteria/Indicators for the Agriculture Sector

Criteria	Indicators	Evaluation
Level of contribution to the food security improvement	Farming cost, Change of Income usage	Increase/decrease of farming cost, Usage of Income (breakdown such as food cost, education cost, etc.) (Livelihood of the beneficiary improves if economical access to food is enabled or made easier through decreased farming cost or increased income).
Level of contribution to the agricultural productivity	Change of income usage	Increase/decrease of income (Livelihood of the beneficiary improves if the increase in yield results in increase in income).

2. Result of the Multi-criteria Assessment for the agricultural sector

The result of the multi-criteria assessment of agriculture technologies based on the above criteria is summarized in the chart below. To summarize, biogas digester, on-farm composting of agricultural residue/upland crop residue, and biochar manufacturing equipment were categorized as A.

Agricultural waste/residues and wastewater treatment measures can add more values to agricultural production, improve rural environment, prevent soil and water pollution, and increase sanitation.

Table 19 Evaluation Results for the Agriculture Sector

	NDC#	Options	Rate[14]	Evaluation
1	A1	Increased Use of biogas (Biogas digester (small scale use for pigs, cattle, chickens and buffalos)	A	▪ Resources/materials can be procured domestically and maintenance system is in place. Introduction is highly possible.
2	A2	Reuse of agricultural residue as organic fertilizer (On-farm composting from agricultural residues)	A	▪ Maintenance and procurement of resources are considered easy. Contributes to reduction in farming cost to protect environment (reducing chemical fertilizer, increase organic fertilizer).
3	A3, A9	Alternate wetting and drying and Improved rice cultivation system (Small and Large scale) (Alternate Wetting and Drying)	B	▪ Introduction is possible if barriers are removed, such as setting up a water management association or management company. The capacities of existing groups and companies may need to be built-up.

14 **A**: The technology is of relatively higher priority and early deployment is recommended. **B**: The technology can be deployed when barriers are removed by arranging the deployment environment to some extent. **C**: Long time may be required for technology deployment in order to arrange appropriate environment.

	NDC#	Options	Rate[14]	Evaluation
4	A3, A9	Alternate wetting and drying and Improved rice cultivation system (Small and Large scale) (Solar pump for drainage system, coffee irrigation)	B	▪ Introduction is possible if barriers are removed, such as setting up a water management association or management company.
5	A4	Introduction of biochar (Small scale) (Biochar Manufacturing Equipment)	A	▪ Priority for technology introduction is high since use of biochar can reduce farming cost. Early deployment is recommended.
6	A10	Introduction of biochar (Large scale) (Biochar Manufacturing Equipment)	A	▪ Priority for technology introduction is high since use of biochar can reduce farming cost. Early deployment is recommended.
7	A5	Integrated Crop Management (ICM) in rice cultivation (High Efficiency Pump)	B	▪ Introduction is possible if barriers are removed, such as setting up a water management association or management company.
8	A6	Integrated Crop Management (ICM) in upland annual crop cultivation (Biochar Manufacturing Equipment)	A	▪ Priority for technology introduction is high since use of biochar can reduce farming cost. Early deployment is recommended.
9	A7	Substitution of urea with SA fertilizer (Sulfate Amon $(NH_4)_2SO_4$) (Energy Efficient Gas-based production unit)	B	▪ Introduction may be possible if barriers are removed, such as setting up an operation management system for maintenance.
10	A8	Reuse of upland agricultural residue (On-farm composting for upland crop residues)	A	▪ Maintenance and procurement of resources are considered easy and the technology would contribute to the reduction of farming cost. Priority for introduction is high and early deployment is recommended.
11	A11	Improvement of livestock diets (Lipid supplements for ruminants, feed-use amino acid (Lysine) for pigs and chickens	B	▪ Introduction is possible if barriers are removed, such as setting up a cooperative purchase system for associations and group of farmers to reduce material procurement cost.
12	A12	Improvement of quality and services available for aquaculture, such as inputs and foodstuff (Effluent treatment for livestock wastewater, food processing wastewater including aquaculture)	B	▪ Introduction is possible if barriers are removed, such as setting up an operation management system for maintenance.

	NDC#	Options	Rate[14]	Evaluation
13	A13	Improvement of technologies in aquaculture and waste treatment in aquaculture (Biomethanation and Power generation)	B	▪ Introduction is possible if barriers are removed, such as setting up an operation management system for maintenance. The capacities of existing groups and companies may need to be built-up.
14	A14	Improved irrigation for coffee (Drip irrigation)	B	▪ Introduction is possible if barriers are removed, such as enabling farmers to plan appropriate irrigation cycle including maintenance.
15	A15	Improved technologies in food processing and waste treatment in agriculture, forestry and aquaculture (High efficiency cooling for chilling and freezing facilities in cold chain process)	B	▪ Introduction is possible if barriers are removed, such as setting up an operation management system for maintenance.
16	-	Improvement of processing technology and reuse of waste of livestock husbandry production for organic fertilizer (Biomethanation and Power generation)	B	▪ Introduction is possible if barriers are removed, such as setting up an operation management system for maintenance. It needs to promote use of effectiveness of organic fertilizers
17	-	Mid-season drainage (Solar pump for drainage system, coffee irrigation)	B	▪ Introduction is possible if barriers are removed, such as setting up a water management association or management company.
18	-	Improvement of Fishing vessel structure and planning/methods (LED lighting for squid fishing vessel)	B	▪ Introduction is possible if barriers are removed, such as setting up an operation management system for maintenance.

3. Major barriers and solutions

Major barriers for the promotion of low carbon technologies in the Agriculture sector are as follows;
1) **High cost** for initial investment or for maintenance,
2) **Insufficient skilled and trained labor** required to construct or maintain the technologies.

Because one of the unique characteristics in Agricultural sector is that the farmers, who are the most vulnerable against climate change and generally from low income population, are the major stakeholder in demand of the technology deployment. While low initial cost is inevitable for farmers when introducing

new technologies/techniques, risk of investment recovery for suppliers is a considerable issue. Sufficient capacity development for technology/techniques and a comprehensive technology transfer plan including maintenance management, beyond a purchase of single equipment for beneficiaries is required.

Answers to farmers' needs to effectively increase their income should be identified by bottom up approach, rather than introducing low carbon technology by top-down instruction. In a same line, farmers need to recognize that using low carbon technologies would potentially bring better living standard. Considering the financial burden to farmers, agricultural association consisted of groups of farmers or a unit of a village could help the farmers to acquire the financial support.

4.4.2 Stakeholder Consultations for Consensus Building

1. Overview of the meeting schedule

Major meetings/workshops related to discussions on the priority assessment are shown in the Table 20. Major meetings/WSs related to discussions on the priority assessment

Table 20 Major meetings/WSs related to discussions on the priority assessment

Date	Meetings/WSs
October 4, 2016	Discussion with line ministry
December 12 and 13, 2016	Discussion with relevant organizations
December 15, 2016	Sectoral meeting
January 11, 2017	Advisory Committee (Japanese experts)
June 2, 2017	Discussion with Relevant stakeholders
June 6, 2017	Sector-based Stakeholder's WS on Low Carbon Technology Assessment
August 28, 2017	Consultation WS on Low Carbon Technology Assessment
November 28, 2017	The Final WS on Low Carbon Technology Assessment
December 8, 2017	2nd Advisory Committee (Japanese experts)

2. Key suggestions and opinions from the stakeholders

Major comments/advices, especially on additional evaluation criteria, raised at above meetings/ workshops were as follows.

1. Comments on the Low Carbon Technology Shortlist
   - The definition for "low carbon technology" needs to be clarified.
   - It is important to pick up low carbon technologies that have competitiveness in the value chain, especially in the market.
   - When using biogas at small households, it is better to also consider power generation in addition to the use as cooking gas (need to consider integrated system). Solar pump is a good idea.

2. Comments on criteria used to prioritize low carbon technologies
   - Economic impact is the most important factor.
   - Considering the continuous use of the low carbon technologies, it is important to understand the position and status of the technology in Viet Nam's context.

3. Comments on the efforts for technology promotion, barrier removal and realization of innovation
   - Cooperation with research institutions and private companies is key for introducing low carbon technologies.

3. Learnings from the stakeholder consultation meetings and workshops

Lessons learnt through the processes to identify the evaluation criteria are summarized as follows.

Agriculture consists approximately 80% of labor population in Viet Nam, and the sector also contributes to a very large portion of the overall GHG emission. Meanwhile, emission per farming household is very low. In future, GHG gas emission from agriculture will need to be managed by a system consisted of various programs.

Persons in charge of the agriculture sector, including the members in the Vietnamese ministries, are especially looking for efforts that benefit the farmers, who are the end-users. It is important to raise awareness of the farmers on GHG emission reduction efforts and to build capacity of the related technologies.

In spite of the large labor population, there is not much action observed among the agricultural associations. Issues still remain in strengthening the ties between farmers and between farming villages through local associations.

In relation to the strengthening of capacity building and unit based programs for farming villages mentioned above, it is considered that promoting co-benefit efforts that improves production yields by using low carbon technologies would be effective in the future.

4.5 LULUCF

4.5.1 Technology Prioritization

1. Characteristics of the LULUCF sector and Prioritization Criteria Setting

The characteristics of low carbon technologies in the LULUCF sector is that, since it mostly deals with carbon sequestration by carbon sinks, it is difficult to discuss from point of view of low carbon and/or cutting-edge technologies. Instead, evaluation of technologies of this sector relies on the point of view on forestry management techniques. It is very important to effectively manage techniques based on conventional management techniques that have been widely applied in Viet Nam.

To establish criteria for prioritization of the options, the LULUCF sector expert had a discussion with Department of Science, Technology and Environment (DoSTE) of MARD, Department of Science, Technology and International Cooperation (DoSTIC) of Viet Nam Forest Administration (VNFOREST), and Vietnamese Academy of Forest Science (VAFS). There are three evaluation criteria normally used in the Viet Nam's LULUCF sector such as economy, environment and social aspects. The elements from these three criteria are all included in the five items chosen as common criteria for the LULUCF sector (Economic efficiency, GHG emission reduction effect, Versatility and Economical/Social/Environmental impacts)). As sector specific criterion, Adaptation effects were evaluated for each technology, however only as a qualitative analysis on additional benefits to be noted.

The LULUCF sector's criteria and indicators for this assessment are shown in the table below.

Table 21 Criteria/Indicators used for the LULUCF Sector

Criteria	Indicators	Evaluation	
Compatibility with policy priorities	Availability of policy document	High	Law/Decree/Action Plan
		Medium	Strategical document only
		Low	No policy document
Economic efficiency	Initial absorption cost per unit Reduction cost?	High	Top 1/3
		Medium	Middle 1/3
		Low	Bottom 1/3
GHGs emission reduction effect	Absolute amount Absorption potential per unit	High	Top 1/3
		Medium	Middle 1/3
		Low	Bottom 1/3
Versatility	Technical adaptability	High	Existing system can be utilized
		Medium	Requires only minor change
		Low	Requires major upgrade such as changing production line

Criteria	Indicators		Evaluation
Other Environmental, Economic Impact	Environmental aspect	High Medium Low	No augmentation of ecological service to augmentation of the service
	Economic aspect	High Medium Low	No impacts on economy to impacts on economy
	Social aspect	High Medium Low	No job creation to job creation

Table 22 Sector Specific Criteria/Indicators for the LULUCF Sector

Criteria	Indicators	Evaluation
Adaptation effects	Adaptation effect	Qualitative evaluation

2. Result of the Multi-criteria assessment for the LULUCF sector

According to study and discussion with relevant stakeholders, identified options were categorized into 7 sub-categories under the LULUCF sector, namely; Conservation, Afforestation and Reforestation, Rehabilitation of mangrove, Long rotation, Scattered tree planting, REDD+ and CO_2 isolation by large scale plantation. Under these sub-categories, all (I)NDC options for the LULUCF sector (from F1 to F9) were classified. For example, under Conservation sub-category, F1 as well as F6 (protection of natural forest for 1 million ha and 2.2 million ha) were classified. On the other hand, 3 additional sub-sectors were identified by the Study team and relevant stakeholders, namely scattered tree planting, REDD+ and CO_2 isolation.

The result of the multi-criteria assessment of agriculture technologies based on the above criteria is summarized in the chart below. To summarize, conservation, rehabilitation of mangrove, afforestation and reforestation, long rotation for timber forest and REDD+ were categorized as A.

Table 23 Evaluation Results for the LULUCF Sector

	Sub-sector	NDC#	Options	Rate[15]	Evaluation
1-2	Protection of Natural Forest (1 million ha and 2.2 million ha)	F1&6	Conservation	A	▪ The option is compatible with policy priorities and economic efficiency improvement and GHG reduction effects can be recognized. The versatility is high, and environmental, economic and social impacts are also high. The technology is of relatively higher priority and early deployment is recommended.

15 **A**: The technology is of relatively higher priority and early deployment is recommended. **B**: The technology can be deployed when barriers are removed by arranging the deployment environment to some extent. **C**: Long time may be required for technology deployment in order to arrange appropriate environment.

	Sub-sector	NDC#	Options	Rate[15]	Evaluation
3-5	Protection of Coastal Forest (100,000, 10,000, and 30,000 ha)	F2&3&7	Rehabilitation of Mangrove	A	▪ The option is compatible with policy priorities and economic efficiency improvement and GHG reduction effects can be recognized. The versatility is high, and environmental, economic and social impacts are also high. The technology is of relatively higher priority and early deployment is recommended.
6-8	Natural forest/ Production Forest Regeneration (200,000 ha)	F4 & 8 &9	Afforestation and Reforestation	A	▪ The option is compatible with policy priorities and economic efficiency improvement and GHG reduction effects can be recognized. The versatility is high, and environmental, economic and social impacts are also high. The technology is of relatively higher priority and early deployment is recommended.
9	Plantation of Large Timber Production Forest (150,000 ha)	F5	Long Rotation	A	▪ The option is compatible with policy priorities and economic efficiency improvement and GHG reduction effects can be recognized. The versatility is high, and environmental, economic and social impacts are also high. The technology is of relatively higher priority and early deployment is recommended.
10	-	-	Scattered tree planting	B	▪ This option is not compatible with political priorities. Economical and GHG reduction effects can be recognized. The versatility is high, but environmental, economic and social impacts may be medium level.

	Sub-sector	NDC#	Options	Rate[15]	Evaluation
11	-	-	Reducing emissions from forest degradation and deforestation (REDD+)	A	▪ The option is compatible with policy priorities. Although there are rooms to improve on economic aspects, GHG reduction effects can be confirmed. The versatility is high, and positive environmental, economic and social impacts are also recognized. REDD+ should promptly be implemented as a financial scheme rather than a solo technical option. The technology is of relatively higher priority and early deployment is recommended.
12	-	-	CO_2 isolation by large scale plantation	C	▪ At present, there is no political need for this option. It is difficult to concretely assess economical and GHG reduction effects. While the versatility is low, environmental, economic and social impacts can be recognized. Long time may be required for technology deployment in order to arrange appropriate environment.

3. Major barriers and solutions

Major barriers for the promotion of low carbon technologies/carbon sequestration technologies in the LULUCF sector are as follows;

1) **limited extension/degradation of forest area due to competitive land-use with arable land and urbanization,**
2) **limited funding and state budget** where investment is difficult due to its priorities,
3) **low modernization** of information acquisition/archive system.

Although there has been increased effort to decrease deforestation and improve water resources management, progress has been slow due to weak enforcement and limited institutional capacity with overlapping, and sometimes conflicting, responsibilities. Through further inter-ministerial dialogues and consensus, an institutional arrangement to achieve rapid deployment of technical and financial resources for optimal land planning should be put in place to alleviate the issue.

LULUCF can also enhance adaptation, especially in terms of forest protection, regeneration, improvement, thus finance for mitigation, adaptation and cross-cutting actions can be applied. Protection of coastal areas, for example, links mitigation to adaptation, which may create additional room to find appropriate financial resources. In this context, an updated forest fire warning system, which is adaptation rather than mitigation, can also be considered as an effective mitigation technology in LULUCF, possibly adopted as part of an integrated system with monitoring, warning, communication and evacuation features for all climatic issues, i.e. flooding.

Given the current international transparency framework under the Paris Agreement, development of domestic data collection and reporting system can be facilitated. In addition, business sector and other stakeholders related to LULUCF may collect relevant information in a voluntary basis.. As research on Mekong delta is in progress these days, collaboration with academic institutes can also be considered as a good option to acquire and archive information.

4.5.2 Stakeholder Consultations for Consensus Building

1. Overview of the meeting schedule

Major meetings/workshops related to discussions on the priority assessment are shown in the Table 24.

Before organizing the consultation workshop with relevant stakeholders, the LULUCF sector expert carried out 2 times of field and domestic studies. During the study, the expert prepared a low carbon technology short list together with MARD (DoSTE, VNFOREST, VASF) and other relevant people. After this, some comments were collected from major stakeholders and final comments were gathered at the consultation workshop. A brief process up to the consultation workshop is given as below:

Table 24 Major meetings/WSs related to discussions on the priority assessment

Date	Meetings/WSs
22-26 September, 2016	Discussion with MARD (DoSTE, VAAS, JICA expert)
29th November, 2016	Discussion with MARD (DoSTE, VNFOREST, VAFS)
1st December, 2016	Sectoral Discussion
22nd December, 2016	Interview to the Forestry and Forest Products Research Institute, Japan (Domestic Advisory committee member)
11th January, 2017	The first advisory committee in Japan
14th April, 2017	Sector based stakeholder WS
28th August 2017	Consultation on low carbon technology
November 28, 2017	The Final WS on Low Carbon Technology Assessment
December 8, 2017	2nd Advisory Committee (Japanese experts)

2. Key suggestions and opinions from the stakeholders

Participants' reaction about criteria for prioritization of low carbon technologies can be summarized as below;

- Simplicity of techniques should be considered.
- A criterion which deals with both mitigation and adaptation should be prioritized.

3. Learnings from the stakeholder consultation meetings and workshops

During the workshop, some ideas of solution were exchanged such as;

- There are some projects that apply PPP scheme in the Agriculture sector by Korean enterprises with Korean ODA. Therefore, it might be possible to apply PPP scheme in the Forestry sector which is under severe financial shortfall.
- Foreign enterprises tend to seek a large-scale forest lands, but they are scattered. Therefore, it is necessary to adapt land policy to resolve scattered forest lands.

4.6 Waste

4.6.1 Technology Prioritization

1. Characteristics of the Waste sector and Prioritization Criteria Setting

The sources of GHGs emissions in the sector mainly are consisted of:

- Energy related CO_2 emission by the waste collection/haulage vehicles and trucks,
- CH_4 emission from organic components of the waste arising in the process of their decomposition in an anaerobic condition in the final disposal landfill, and
- CO_2 emission from intermediate waste treatment such as waste incineration.

Incineration of organic waste before its decomposition may reduce the net GHGs emission by converting the methane into carbon dioxide as well as energy recovery of its thermal treatment. Incineration of plastic waste (fossil fuel based plastic) can be regarded as net GHGs emission even with the heat/energy recovery, however, it is advantageous when its high incineration heat can be utilized effectively.

The climate change mitigation technologies in the sector mainly address methane emission from decomposition of organic components in the municipal solid waste (agricultural wastes is not discussed in this chapter, but in the agriculture sector) though it also discusses possible emission reduction of CO_2 arising from waste collection and haulage vehicles and trucks.

All of the technologies identified were evaluated of its feasible application potentials for the following common criteria: Compatibility with policy priorities, Economic efficiency, GHGs emission reduction effect, Versatility and Social and environmental impacts (positive and negative). No sector specific criterion was chosen for this sector.

Details of the assessment parameters are shown in Table 25.

Table 25 Criteria/Indicators used for the Waste Sector

Criteria	Indicators	Evaluation	
Compatibility with policy priorities	Presence of supporting policies and policy tools/ measures	High	Presence of supporting policies and policy tools/ measures
		Medium	Presence of supporting policies
		Low	No relevant policy
Economic efficiency	Cost of waste handling/ treatment per ton of waste	The estimated unit cost in US$/ton of waste	
GHGs emission reduction effect	GHGs emission reduction per ton of waste	The estimated unit GHGs emission reduction in ton CO_2eq/ ton of waste	

Criteria	Indicators	Evaluation	
Versatility	Simplicity/easiness of the technology application	High	Already applied or conventional technology in the country
		Medium	Training or technical transfer is required for a certain period.
		Low	Regular monitoring and supervision by the technical expert is required.
	Limitation in technology application in terms of waste amount and/or composition	High	No limitation
		Medium	Limitation in terms of waste amount or composition
		Low	Limitation in terms of waste amount as well as composition
Social and environment impacts	Social impacts	Identify and describe positive and negative impacts on society (qualitatively)	
	Environmental impacts	Identify and describe positive and negative environmental impacts (qualitatively)	
Overall Assessment	Identify and describe the extent and conditions of technology application with its priority evaluation.		

2. Result of the Multi-criteria Assessment for the Waste sector

The multi-criteria assessment results of each climate change technology in the Waste sector are as summarized in the table below. To summarize, semi-aerobic landfill operation was the only option that was categorized as A for the Waste sector.

Table 26 Evaluation Results for the Waste Sector

	INDC #	Options	Rate[16]	Evaluation (inc. the extent and conditions of technology application)
1	W1	Production of organic fertilizers from organic waste (composting)	B	▪ Conventional technologies in Viet Nam. ▪ Strict control of waste composition is required to produce good quality compost to compete with chemical fertilizers. ▪ A certain area of land is required to handle large amount of waste (40,000m2/daily handling of 100 tonnes).

16 **A**: The technology is of relatively higher priority and early deployment is recommended. **B**: The technology can be deployed when barriers are removed by arranging the deployment environment to some extent. **C**: Long time may be required for technology deployment in order to arrange appropriate environment.

	INDC #	Options	Rate[16]	Evaluation (inc. the extent and conditions of technology application)
2	W2	Landfill gas (LFG) capture/recovery and energy utilization	B	▪ To effectively introduce the target technology, establishing the appropriate condition such as the amount and quality of waste (i.e. sufficient amount of organic waste) and the condition at the final disposal facility (anaerobic treatment) is vital. The technology is not applicable to facilities not meeting these conditions. The technology is only applicable if above conditions are met, and also if sufficient amount of methane gas are estimated to be recoverable, hence the opportunity for it to be applicable is extremely limited.
3	W3	Recycling of solid waste	C	▪ Although recycling is the win-win technologies to serve for GHGs emission as well as for reduction of waste itself, the recyclable and salable materials in the waste have already been collected and recycled under the current market mechanism. ▪ The remaining materials in the waste are mostly not technologically or financially feasible to recycle due to the types of materials or contamination by or mixture of strange materials. ▪ Potential of GHGs emission by recycling is very limited.
4	W4	Anaerobic treatment of organic waste with methane recovery for power and heat generation	B	▪ There is an example of this technology application in Ho Chi Minh. ▪ Suitable for the areas where there are a certain amount (50 to 100 tonnes daily) of food waste is stably generated, such as the wet market (fish meat, and vegetable market), hotels, and restaurants. ▪ If the above amount of food waste can be regularly obtained, this technology is worth applying for food waste management.

	INDC #	Options	Rate[16]	Evaluation (inc. the extent and conditions of technology application)
5		Semi-aerobic landfill operation	A	▪ Semi-aerobic landfill is a low cost and simpler technology of sanitary landfill as well as contributing to GHGs emission reduction. As a standard for construction and operation of sanitary landfill, semi-aerobic landfill is technologically and economically suitable in Viet Nam if proper technological transfer is carried out.
6		WTE	B	▪ There is no full scale application of WTE technology though there are some existing waste incineration facilities in operation with no energy recovery. ▪ Treatment cost is the highest while waste reduction ratio is also the highest. ▪ A certain amount of waste is required to reach an economy of scale in applying this technology. ▪ A certain level of heat value is required in waste to keep its self-sustaining combustion with minimized input of supplementary fuel. (The higher the heat value of waste, the higher the potential of energy recovery from waste.)
7		Conversion to low-carbon fuel trucks for waste collection/haulage vehicles	B	▪ No application in Viet Nam ▪ Low-carbon trucks can contribute not only to climate change mitigation, but also to improvement of air quality (vehicle-related air pollution). ▪ Supply infrastructure and network needs to be built for the low-carbon fuels. ▪ The cost of truck and fuel may increase.
8		Construction of waste transfer station	B	▪ There are several waste transfer station built and currently in operation in Viet Nam. ▪ It can also mitigate the traffic congestion and improve the transportation efficiency in waste collection and haulage. ▪ The impact of transfer station upon transportation efficiency depends upon the distance between waste generation sources and final destinations (landfill) and traffic conditions (traffic volume, road conditions, etc.)

3. Major barriers and solutions

Major barriers for the promotion of low carbon technologies in the Waste sector are as follows;

1) **Technical issues** related to each technology (i.e. product quality, proper control of landfill, infrastructure installation, or separation process)
2) **High investment cost** to meet the requirements for proper waste management,
3) **Insufficient market size** due to low acceptance level in the society.

The barriers against introduction and application of climate change mitigation technologies in the waste sector mainly consist of technological, financial/economic, and social/environmental aspects.

The technological barriers come from unique characteristics of each technology. Each technology mentioned above is designed to serve specific purposes such as waste volume reduction, energy/ materials recovery of waste, and many other pollution preventions. None of the technologies above is specifically designed and developed for climate change, but for solving various issues related to waste management. They are all originally waste management/treatment technologies and measures. The technological barriers in this sector can be rephrased as the specific conditions for application of each technology. If the conditions are met, each technology will serve for the purpose at its maximum. On the other hand, it can even worsen the waste management situation if the technology is applied in the conditions not meeting the requirements. Especially in this sector, many of the technologies and measures have the requirement related to waste amount and quality (composition) such as the case of composting, LFG capture, WTE and so force. The users of the technology needs to pay due attentions to the characteristics and required conditions of application of each technology.

The financial/economic barriers come from the cost arising from applying the technologies. Some technologies need a large amount of initial investment as well as operation cost even though they have bigger positive impacts upon waste management such as waste volume reduction, minimizing the use of landfill. WTE is a typical example of such technology. Each technology needs to be carefully assessed in terms of its overall benefit and cost hopefully in its monetary value especially for the technology requiring big investment. It is also important to consider the impacts of the technology not in the short term, but also long term. In this regard, waste volume reduction rate is an important parameter to consider in applying the technologies in this sector. The waste volume reduction rate is far more important in the longer term than in the short term. As to the technology that needs a larger investment, the government may need to provide some financing and/or incentives as the seed money to promote introduction and application of such technology.

The social and environmental barriers consist of the social (public) acceptance level of the technologies and their environmental soundness and sustainability. Some of the technologies (i.e. composting, recycling, waste transfer station) have already been applied while there are new technologies (WTE, low-carbon trucks) to introduce in Viet Nam. Market acceptance level is another important aspect to consider as a parameter to identify the social acceptance level of technologies. For example, in the case of composting, the technology itself has already been popular and widely applied; however, the market for composting product is still not yet well developed. Because of this, the produced compost is currently facing severe competition with chemical fertilizers in terms of its quality as well as price. In the case of recycling, the so-called material recycling is popular in Viet Nam and many recyclable salable items are collected and recovered formally as well as informally. Most of the remaining materials have low market value or difficulty in recycling and recovery with the conventional technology. It means that the market is mature enough for such recycling. Further elaboration of recycling needs more investment

while it may not be financially feasible in the current market situation. In such a case, government intervention into the market is required if it requires further recycling of waste. Some of the technologies such as incineration may be opposed by the general public as a NIMBY (Not-in-my-backyard) facility. Those things need to be considered as to identify the acceptance level of the society. In such a case, government intervention is required to raise public awareness to build its consensus.

Environmental barriers are the potential negative impacts arising from applying the above technologies, which need to be properly addressed in due course in accordance with the relevant laws and regulations especially in introducing the new technologies.

4.6.2 Stakeholder Consultations for Consensus Building

The Study conducted a series of stakeholder consultation meetings to build a consensus with the relevant stakeholders on the list of climate change mitigation technologies and its priority in the process of technology assessment. This section summarizes them with the discussions and opinions made in the meetings.

1. Overview of the meeting schedule

Table 27 Major meetings/WSs related to discussions on the priority assessment

Date	Meetings/WSs
October 12, 2016	Discussion with MOC
December 13, 2016	Second Discussion with MOC Consensus building on shared draft of the Technology Shortlist
January 11, 2017	First National Advisory Committee (Japanese experts)
May 18, 2017	Sector-based Stakeholder's WS on Low Carbon Technology Assessment (Jointly with the F-gas sector)
August 28, 2017	Consultation WS on Low Carbon Technology Assessment
November 28, 2017	The Final WS on Low Carbon Technology Assessment
December 8, 2017	2nd Advisory Committee (Japanese experts)

The 1st kick-off meeting was held in the office of the Ministry of Construction on 12 October 2016. The JICA Expert explains the overall work plan of the SPI-NAMA Project, followed by the detailed scope of the study in waste management sector with the initial draft shortlist of climate change mitigation technology options in this sector.

The 2nd meeting with MOC was held on 13 December 2016 to explain the 1st draft shortlist of climate change mitigation technology options in waste management sector. MOC agreed on the shortlist with some comments and request for further technological information on each listed technology. The meeting also basically agreed on the methodology and parameters for assessing viability of each technology.

Based on the above discussions with MOC, the Project held a stakeholder consultation workshop together with the F-Gas sector on 18 May 2017, inviting other public as well as private stakeholders to hear from the opinions and suggestions on the shortlisted technology options.

2. Key suggestions and opinions from the stakeholders

The key suggestions and opinions made from the stakeholders are as follows:

(MOC)

- As to the compost technology, its market competitiveness (price competition with other fertilizers), requirement for strict separation (to keep good quality of compost), land requirement (larger land required for handling a large amount of waste especially in urban areas) are the issues and obstacles to be considered and addressed.
- As to the LFG collection and energy utilization technology, accurate estimation of recoverable LFG is the key to its sustainable application.
- Semi-aerobic landfill technology can be applied to newly built landfills and extended areas of the existing ones.
- Methane collection and energy utilization through anaerobic fermentation of organic waste is applied in Ho Chi Minh. It can be applied to other areas if the required pre-conditions for application are met.
- More detailed technology-wise issues, obstacles, co-benefits, and development effects are specified in the low-carbon technology short list.

(MOIT)

- We need more detailed information especially about WTE technologies such as the providers of the technologies, technological specification, CAPEX and OPEX required.
- We need to review the current FIT scheme based on the above information.

(Private Stakeholders)

- To introduce and apply WTE technology, we need further support from the government in addition to fit, including the support mechanism in relation to infrastructure development under PPP.
- As to WTE technology, we need detail technological information on flue gas treatment of incinerators.
- We also would like to know the reasons for failure of LFG capture and energy utilization technologies as CDM projects.

3. Learnings from the stakeholder consultation meetings and workshops

The stakeholder consultation was a good opportunity to hear their suggestions and opinions from the stakeholders who are directly involved in waste management with various technologies. The stakeholders can provide precious information about the unique local issues in applying the new as well as conventional technologies. It was also a good opportunity to discuss and exchange between public and business sector on their views.

4.7 F-gas

4.7.1 Technology Prioritization

1. Characteristics of the F-gas sector and Prioritization Criteria Setting

Measures on F-gases are not identified in the NDC and other climate change related strategy and policy documents of Viet Nam. However, F-gases are greenhouse gases and have high global warming potentials (GWP), calling for F-gas related mitigation actions.

To implement efficient and effective actions in the F-gas sector, technologies and measures which can be adopted in the life cycle of F-gases including production (import), proper use and disposal stages were researched and examined.

Through the interviews with the National Ozone Unit (NOU), MONRE and Industrial Safety Techniques and Environment Agency (ISEA), MOIT as line ministry of F-gas issues expressed their interests on F-gas destruction at cement kiln using existing facilities, changing to low GWP refrigerant and leakage inspection/maintenance as prioritized technologies and actions. The ISEA also pointed out that inflammable refrigerant may not be suitable for Viet Nam.

After listing the F-gas related technologies and actions, criteria for prioritization were determined as; Compatibility with policy priorities, Economic efficiency, GHGs emission reduction effect and Versatility. Also, the following factors were chosen as sector specific criteria; Arrangement of support scheme, Regional compatibility, Implementation schedule, Linkage with other options, and Benefits for other sectors.

Based on the above criteria, the study team conducted evaluation for prioritized climate change mitigation technologies and actions. The F-gas sector's criteria and indicators for this assessment are shown in the table below.

Table 28 Criteria/Indicators used for the F-gas Sector

Criteria	Indicators		Evaluation
Compatibility with policy priorities	Availability of policy document	High	Law/Decree/Action Plan
		Medium	Strategical document only
		Low	No policy document
Economic efficiency	Initial cost	High	Top 1/3
		Medium	Middle 1/3
		Low	Bottom 1/3
GHGs emission reduction effect	Absolute quantity of reduction	High	Top 1/3
		Medium	Middle 1/3
		Low	Bottom 1/3
Versatility	Operation and Maintenance System	High	Existing system can be utilized
		Medium	Requires only minor change
		Low	Requires major upgrade such as changing production line

Table 29 Sector Specific Criteria/Indicators used for the F-gas Sector

Criteria	Indicators		Evaluation
Arrangement of support scheme	Incentives to stakeholders	High Medium Low	Describe contents of existing and planned incentives to stakeholders, if it is available.
Regional compatibility	Regional compatibility by each region	High Medium Low	Describe action area/region.
Implementation Schedule	Duration of implementation, operation and introduction period	High Medium Low	Short-term (less than 2 years) Middle-term (3 to 5 years) Long-term (over 6 years)
Linkage with other options	With or without of linkages and synergies	High Medium Low	Whether collaboration with other countermeasures is necessary and whether synergy effects can be obtained or not.
	Priority in implementing collaboration with other countermeasures	High Medium Low	Whether it is a measure to be preferentially implemented or not.
Benefits for other sectors	Benefits for other sectors	High Medium Low	Whether cross-sectoral benefits can be obtained or not.

2. Result of the Multi-criteria Assessment for the F-gas sector

The study team carried out evaluation of prioritized technologies and actions which were agreed at the Sector-based stakeholder's workshop on May 18, 2017 in Hanoi. The study team evaluated technologies and options under three sub-sectors, including, Destruction of F-gas at cement kiln, Change Low GWP refrigerant (Residential Refrigerator, Commercial Refrigerator, Air Conditioner and Automobile Air Conditioner) and Maintenance.

The result of the multi-criteria assessment is summarized in the table below. To summarize, destruction of F-gas at cement kiln, and leakage inspection (maintenance) of refrigerator and air conditioner in commercial sector were categorized as A.

Table 30 Evaluation Results for the F-gas Sector

No.	Sub-sector	Options[17]	Rate[18]	Evaluation
1	F-gas destruction	Destruction of F-gas at Cement Kiln	A	▪ LaFarge Holcim Vietnam's cement kiln already has a pilot project for combustion destruction. Utilizing existing facility can reduce initial cost compared with newly construction of facilities. ▪ F-gas recovery and transport mechanism is necessary to implement F-gas destruction, however, GHG reduction amount is relatively high through F-gas destruction actions and priority is also high. F-gas destruction should be implemented at an early stage.
2	Change Low GWP Refrigerant	Residential Refrigerator	B	▪ While sales of household electronical appliances are growing in Viet Nam, it is considered that introduction of household refrigeration equipment using low GWP refrigerant is one of effective countermeasures against climate change issues targeting consumers and general public. ▪ Introduction of low GWP refrigerant can be implemented if overcoming barriers include raising awareness of consumers for non-CFC and/or low GWP, in addition to existing efforts such as energy-saving labels.
3		Commercial Refrigerator	B	▪ Due to the amount of F-gas in the commercial refrigerators and cold storages is larger than other equipment, the effect of reducing GHG emissions can be expected high even with standalone efforts. ▪ CO_2 free, natural refrigerant equipment are still expensive and they are not disseminated in the Vietnamese market. But if overcoming the barriers to introduce these natural refrigerant equipment with using financial support such as subsidy, many new natural refrigerant equipment will be introduced widely.

17 F-gas is not included in mitigation option in the INDC technical report, thus no NDC#

18 **A**: The technology is of relatively higher priority and early deployment is recommended. **B**: The technology can be deployed when barriers are removed by arranging the deployment environment to some extent. **C**: Long time may be required for technology deployment in order to arrange appropriate environment.

No.	Sub-sector	Options[17]	Rate[18]	Evaluation
4		Air Conditioner	B	▪ While sales of household electronical appliances are growing in Viet Nam, it is considered that introduction of air-conditioners using low GWP refrigerant is one of effective countermeasures against climate change issues targeting consumers and general public. ▪ Introduction of low GWP refrigerant can be implemented if overcoming barriers include raising awareness of consumers for non-CFC and/or low GWP, in addition to existing efforts such as energy-saving labels.
5		Automobile Air Conditioner	B	▪ While sales of automobiles are growing in Viet Nam, it is considered that introduction of cooler gas using low GWP refrigerant of car air conditioners is one of effective countermeasures against climate change issues targeting consumers and general public. ▪ However, importing large number of low GWP cooler gas is a major barrier.
6	Maintenance	Leakage inspection (Maintenance) of Refrigerator, Cold Storage and Air Conditioner of Commercial sector	A	▪ It seems that the effect of refrigerant (F-gas) leakage from commercial refrigeration and air conditioning equipment is not small (= there are no survey data of F-gas leakage), and from the viewpoint of proper management of these commercial equipment, train equipment inspectors, maintenance service staffs and engineers are effective and important actions for mitigate leakage. Maintenance actions should be implemented at an early stage.

3. Major barriers and Solutions

Major barriers for the deployment of F-gas related technologies are as follows;

1) **lack of policy framework** guiding collection, re-use, recycle of Hydrofluorocarbons (HFCs),
2) **lack of incentives/price competitiveness** of low GWP refrigerant,
3) **insufficient number of skilled technicians** to safely handle refrigerant and conduct maintenance/ repairing.

The barriers against introduction and application of climate change mitigation technologies and actions in the F-gas sector mainly consist of policy/market and technical aspects. The one of the biggest issues is lack of policy framework guiding collection, re-use, recycle of HFCs from existing appliances, and penalty for releasing gas into the atmosphere. Some companies are taking an action in advance and start collecting F-gas as voluntary efforts and some others are destroying F-gas with manufacture facilities.

Administration need to takes a lead and decide sufficient regulation on F-gas and indicate direction's toward near future, which allows many of business sectors take into account and integrate it into their strategic plan. In addition, development of incentive (e.g. any solution for price competitiveness of Low GWP refrigerant), training for F-gas handling (e.g. flammable item) and capacity development for properly maintenance and repairing (e.g. tightening of bolts, changing air joints, brazing patching of pipes, renewal, on-site confirmation of leakage) are required. Some of private companies are conducting training course for their employees with regard to future demand to the F-gas sector. Government authorities should support, consult and learn from them and pave the way forward for further mitigation action.

4.7.2 Stakeholder Consultations for Consensus Building

1. Overview of the meeting schedule

The study team tried to communicate and build consensus among stakeholders from government and business communities. Major meetings and workshops related to discussions on the priority assessment of F-gas technologies and actions are as follows.

Table 31 Major meetings/WSs related to discussions on the priority assessment

Date	Meetings/WSs
November 25, 2016	Discussion with MONRE/NOU
November 28-29, 2016	Discussion with Panasonic Vietnam, Daikin Vietnam and Energy Conservation Center (ECC-HCMC)
November 30, 2016	Sectoral discussion (MONRE/NOU, MOIT/ISEA, VNEEC and JICA study team)
December 1, 2016	Discussion with MONRE/DCC
January 11, 2017:	1st advisory committee in Tokyo
May 15, 2017	Discussion with Vietnam Society for Refrigeration and Air Conditioning Engineers (VISRAE) and Vietnam Electronic Industries Association (VEIA)
May 16, 2017	Discussion with Vietnam Automobile Manufacturers' Association (VAMA)
May 18, 2017	Sector-based stakeholder's WS
August 28, 2017	Consultation on low carbon technology
November 28, 2017	The Final WS on Low Carbon Technology Assessment
December 8, 2017	2nd Advisory Committee (Japanese experts)

2. Key suggestions and opinions from the stakeholders

The key suggestions and opinions delivered from the stakeholders are as follow.

- Strengthening of legal framework on F-gas management in Viet Nam (including F-gas inventory)
- Enhancement of incentives for business sector to use alternative options to F-gas
- Alternative technologies to F-gas in cooling industries (alternative gases, F-gas recovery and destruction)
- Training to technicians and service staffs for maintenance of refrigerators and air-conditioners, and awareness raining to the public.
- Pros and cons of refrigerants for household/commercial air-conditioners and refrigerators/cold storages.

3. Learnings from the stakeholder consultation meetings and workshops

Through the stakeholder consultation meetings and workshops, it turned out that interests for F-gas related technologies and actions were high among stakeholders. Meanwhile, the knowledge level and correspondence of each stakeholder, especially business sector was uneven.

Since there is no clear policy position of F-gas issue in the climate change field of Viet Nam, it is required to define the Viet Nam's policy with discussion among line ministries. Our study team received similar requests and comments from business sector and they need incentives for take actions on climate change mitigation in the F-gas sector.

5 Conclusion

Through the joint effort by MONRE and JICA to assess low carbon technologies based on the NDC, low carbon technologies to be applied for the 45 mitigation options were presented and, additionally, more options and technologies as further mitigation measure were identified. As mentioned in Chapter 2 and 3, numerous sessions were held for the purpose of extracting low carbon technologies and selecting prioritized technologies by gathering comments and feedback from stakeholders, and subsequently building consensus. Through this process, the following outcomes were achieved.

Elaborating breakdown of mitigation actions for sectoral NDC action plans with low carbon technologies

The time given for INDC preparation was very short and measures for achieving the reduction target and the implementation plan requires regular and continuous evaluation. This Assessment work laid out an important foundation for the execution of mitigation policies by identifying major low carbon technologies that are applicable to mitigation options in the NDC, and presenting vital information for implementation such as mitigation potential and initial cost. As the NDC will be reviewed and updated in 2019, further examination and enforcement of mitigation measures tailored to the policies and environment in Viet Nam will be essential as part of global stocktake. At the same time, implementation of appropriate mitigation policies will be enabled through monitoring and reviewing of the progress on low carbon technology introduction.

Barrier and its solutions

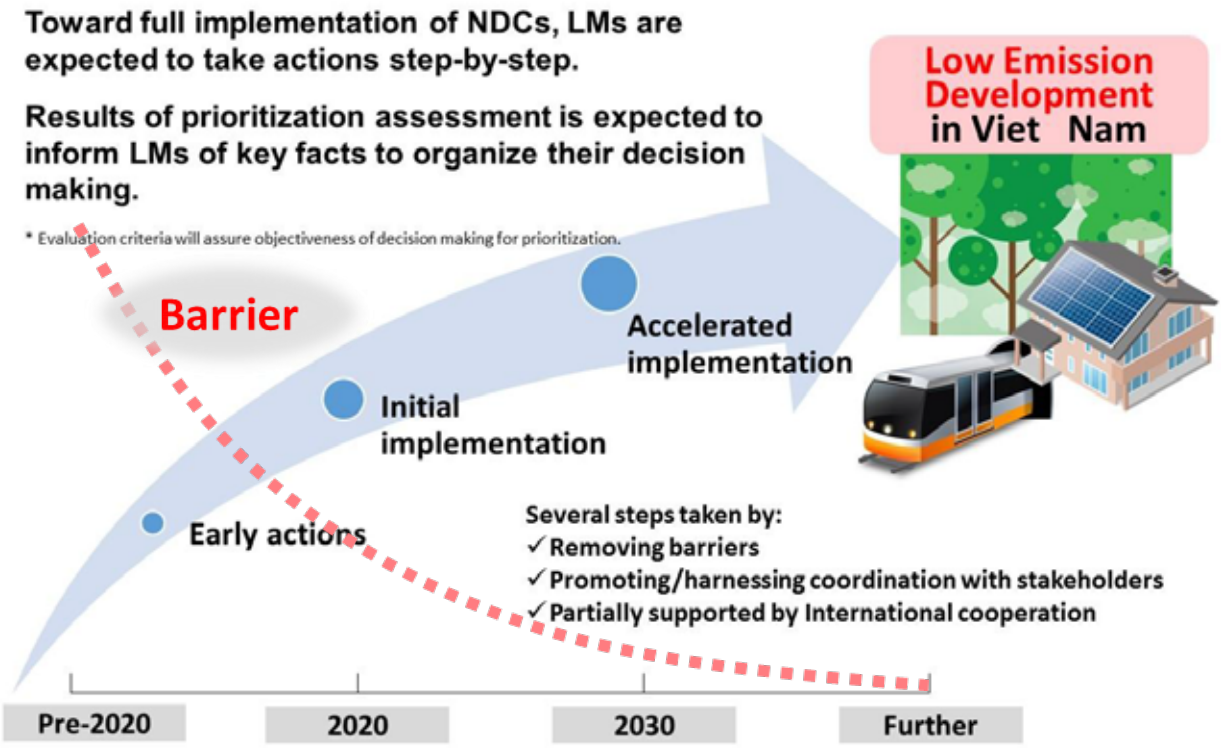
In the Assessment process, in addition to the analysis on the needs on low carbon measures, current and future barriers were investigated. The identified barriers included issues related not only to financial or management situations, but also to cases where restructuring of management systems or capacity building of operators is required. To remove these barriers, regular discussions to consider long-term measures in full coordination by the central government, local governments and private companies, and promotion of climate finance and capacity building to enable low carbon technology to be introduced and applied throughout the country will be essential.

Continued involvement of and dialogue with key stakeholders, in particular the business sector for low carbon technology deployment

The most significant outcome of the low carbon technology assessment was the process in bottom-up approach taken to select the technologies appropriate for each mitigation measures. Discussions previously taken up by the ministry in charge were brought back to all related ministries. Important mitigation options that were missed in the past were re-visited and appropriate technologies were selected to be agreed at the meetings attended by the stakeholders with as much related ministries as possible.

Integration of continuous low carbon assessment into development and update of a long term climate change strategy

This Low Carbon Technology Assessment can contribute directly to the NDC revision process to be conducted by 2020, and to further revisions every 5 years thereafter. Meanwhile, planning of policies in light of the mid-term mitigation policy for 2030 and the long-term scenario for 2050 will also be required in future. Planning for 2050 will be a challenge as it naturally involves uncertain factors; however, it is effective in considering mid to long term economic development in Viet Nam. Accordingly, further assessment and implementation consistent not only to the climate change framework but also to the national economic development plan will be necessary.



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Power generation development target for 2030 is set for each power source in the National Power Development Plan VII

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