PHILIPPINES

TECHNOLOGY NEEDS ASSESSMENT FOR CLIMATE CHANGE MITIGATION

Coordinated by:

CLIMATE CHANGE COMMISSION

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FOREWORD

The Philippine National Climate Change Action Plan (NCCAP) for 2011-2028 affirms the role of technology in the context of climate change, echoing the aspirational imperatives of the Technology Framework and the Technology Mechanism espoused under the Paris Agreement and the United Nations Framework Convention on Climate Change (UNFCCC), respectively.

As articulated in the NCCAP, technology can either contribute to the increasing concentration of greenhouse gases (GHG) in the atmosphere, or it can help the country pursue a low-carbon development pathway. As such, it is essential to identify climate technologies and maximize their potential as tools in addressing climate change.

In the Philippines, data shows that the projected GHG emissions will be dominated by the energy and transport sectors due to the expected population and economic growth in the country. Effective mitigation entails early and vigorous actions to curb these emissions. The Climate Change Commission (CCC), as the lead policy-making body of the Government of the Republic of the Philippines on climate change, has determined that it is an opportune time to assess and prioritize the technological needs of the country to pursue climate change mitigation.

By taking into account the country's National Communication Reports submitted to the UNFCCC, and the Strategic Framework and Action Plan on Climate Change, three major economic sectors were identified as the priority for climate change mitigation: energy, transport, and waste sectors. As a means to reduce GHG emissions from these sectors, various climate change mitigation technologies were identified and prioritized through a consultative process led by the CCC.

In view of the above, I am pleased to present the Philippine's Technology Needs Assessment for Climate Change Mitigation, which is hoped to inspire policy makers, investors, development partners, technology developers, climate change experts, and all other stakeholders who advocate for the country's sustainable development, in paving the way towards a technology-driven, resilient, and climate-smart Philippines.

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Secretary
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List of Abbreviations/Acronyms

ASIF	Activity – Structure – Intensity – Emission factor
CCAM	Climate Change Adaptation and Mitigation
CCC	Climate Change Commission
CDP	Comprehensive Development Plan
CRI	Climate Risk Index
DILG	Department of the Interior and Local Government
GEF	Global Environment Facility
GD	Guidance Document
INC	Initial National Communication
KCA	Key Category Analysis
LGU	Local Government Unit
MCA	Multi-Criteria Analysis
MVIS	Motor Vehicle Inspection System
NCCAP	National Climate Change Action Plan
NEECP	National Energy Efficiency and Conservation Program
NFSCC	National Framework Strategy on Climate Change
NGAs	National Government Agencies
NGO	Non-governmental Organization
NREP	National Renewable Energy Program
PUV	Public Utility Vehicle
RM	Reference Manual
SDG	Sustainable Development Goals
SNC	Second National Communication
SWOT	Strength-Weakness-Opportunities-Threats
TNA	Technology Needs Assessment
TWG	Technical Working Group
UDP	UNEP-DTU Partnership
UNEP	United Nations Environment Programme
UNFCCC	United Nations framework Convention on Climate Change

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EXECUTIVE SUMMARY

This Part 1 of the TNA Report presents the technology needs assessment and prioritization processes, and the results for priority sectors. Through the stakeholders' consultation processes and experts' judgments, three major economic sectors were identified as priority for the technology needs assessment for mitigation: energy, transport, and waste sectors, following what have been considered in the National Communication Reports to UNFCCC and Strategic Framework and Action Plan on Climate Change.

The lead national agency for this Project is the Climate Change Commission, which act as the over-all coordinator of the consultation and assessment activities. The National TNA Team consists of the Technical Working Group (TWG) of the Government's Climate Change Adaptation and Mitigation Cluster and the consultant-experts. Representatives from the private sector and the civil society are also included.

From a long list of technologies in the sectors, technology fact sheets were prepared for selected technologies that are deemed appropriate and applicable for the Philippines. These are then subjected to the criteria for prioritization, considering costs versus benefits. The cost of technology was grouped into capital investment and operations & maintenance. Benefits of using the technology include: (i) Greenhouse gas emissions reduction potential; (ii) Economic benefits; (iii) Social benefits; and (iv) Environmental benefits.

Priority sectors as agreed by the TNA Team and stakeholders included those that have been already considered in the country's Intended Nationally Determined Contributions or INDCs and previous assessments and studies in the Energy, Transport and Waste sectors. Prioritized technologies for the Energy sector include, (i) Testing laboratory for Electric Vehicles, (ii) Solar Thermal System, and (iii) Waste Heat Recovery System. For the Transport sector these are the Motor Vehicle Inspection System (MVIS) and Biogas for Transport. In the Waste sector the prioritized technologies are Eco-efficient Soil Cover Using Composts, and Anaerobic Digester.

Chapter 1: Introduction

The Philippines, being an archipelagic country, is highly vulnerable to the impacts of climate change and natural hazards. It is ranked fifth overall on the long-term Climate Risk Index (CRI) for the period 1994 to 2014, and first in 2013, in the Global Climate Risk Index of Germanwatch. Climate change and natural hazards will progressively impact sectors that are strategically important for the growth of the economy, e.g., agriculture, fisheries, and water resource management. Increases in temperature, coupled with changes in precipitation patterns and hydrological regimes, can only exacerbate the country's existing vulnerabilities, if not acted upon, threatening its sustainable development and the survival of future generations of Filipinos.[1]

The adverse impact of climate change on economic development is apparent from economically and socially disruptive extreme weather events, including typhoons and flash flooding, that are expected to become more frequent in the future. The concentration of population in urban and coastal areas greatly exacerbates the level of injury and death from natural disasters, causing estimated direct economic losses of at least several hundred million dollars annually[2] (USAID 2011). Total losses from Typhoon Haiyan in 2013 were estimated to be between US$12 to 15 billion, in addition to thousands of lives lost and millions made homeless. In 2012, the Climate Change Act of 2009 was amended to establish the People's Survival Fund, a long-term finance stream to assist the government to effectively address climate change in partnership with local communities and NGOs. As the Philippines economy continues to grow, the government is continuing to work to address the growth-related sustainability challenges that may slow down the pace of improvement in quality of life for its citizens.[3]

Republic Act (RA) 9729 (as amended by RA 10174) or the Climate Change Act (CCA) of 2009 created the Climate Change Commission (CCC) as the sole policy-making body of the government with the mandate to coordinate, monitor and evaluate the programs and action plans of the government relating to climate change. The CCC is composed of the President of the Republic of the Philippines who serves as the Chairperson, and three (3) Commissioners to be appointed by the President, one of whom shall serve as the Vice Chairperson of the Commission. The CCC has an advisory board (with 23 members and later increased to 26 with the amendment of the CCA through RA 1017), which includes the heads of fourteen (14) key government departments, heads of local government organizations, and representatives from the academe, the business sector; and nongovernmental organizations.

[1] Philippine Intended Nationally Determined Contribution, 2015.
[2] Philippines Country Development Cooperation Strategy 2013-2018.
[3] USAID-B-LEADERS Project Cost-Benefit Anaysis (CBA) Study, 2016.

The CCC was tasked to formulate a Framework Strategy on Climate Change and a National Climate Change Action Plan. Accordingly, CCC issued the National Framework Strategy on Climate Change 2010-2022 (NFSCC 2010-2022) in April 2010. The NFSCC emphasizes the need for climate change mitigation and adaptation that involves all levels of governance. On the other hand, the National Climate Change Action Plan 2011-2028 (NCCAP 2011-2028) issued by the CCC in November 2010 translated the framework strategy into an action plan, which prioritizes food security, water sufficiency, ecological and environmental stability, human security, climate-smart industries and services, sustainable energy, and knowledge and capacity development.

Various agencies have specific mandates to assist in the policy-making, oversight, and implementation of climate-related actions. The Department of Foreign Affairs (DFA) is mandated to review international agreements related to climate change and make the necessary recommendation for ratification and compliance by the government on matters pertinent to such agreements.

The Department of the Interior and Local Government (DILG) takes an active role in all types of climate change actions. DILG's efforts are focused on enhancing the capacity of Local Government Units (LGUs) to be at the forefront of the government's initiative to adapt, mitigate and prepare for climate change and disasters. The CCA identified LGUs as frontline agencies in the formulation, planning and implementation of climate change actions in their communities. The law requires all LGUs to formulate a Local Climate Change Action Plan (LCCAP) that should be integrated in their local development plans, and should be consistent with the NFSCC and the NCCAP.

Recent policies enable further strengthening of institutions for the governance, oversight and implementation of climate change activities. Executive Order (EO) No. 43 reorganized the Presidential Cabinet into clusters, one of which is the Climate Change Adaptation and Mitigation (CCAM) Cluster. The CCAM cluster is chaired by the Secretary of the Department of Environment and Natural Resources (DENR), with the CCC as Secretariat, and with the members coming from the Secretaries of other Departments and Chairpersons of relevant national government agencies.

The CCC acts as the national focal point or National Designated Entity (NDE) for the Green Climate Fund (GCF) and also for the Climate Technology Centre and Network (CTCN) making it well positioned to facilitate financial and technical assistance to climate-related projects from the financing and technology mechanisms of the UNFCCC.

1.1 About the TNA Project

The United Nations Environment Programme (UNEP) and UNEP-DTU Partnership (UDP) are involved in the implementation of a global Technology Needs Assessment (TNA) project funded by the Global Environment Facility (GEF). The TNA project assists developing country Parties to the United Nations Framework Convention on Climate Change (UNFCCC) determine their technology priorities for the mitigation of greenhouse gas emissions and adaptation to climate change. The overall goal of the TNA process is to come up with select technologies that will enable countries "to achieve development equity and environmental sustainability, and to follow a low emissions and low vulnerability development path" (UNDP, 2010). The TNA process is a set of country-driven activities leading to the identification, prioritization and diffusion of environmentally sound technologies.

The TNA Phase I was implemented between 2009 and 2013 in 36 countries. Phase II of the TNA started in September 2014, one month after the GEF awarded the project, where the Philippines is one of the 26 participating countries. It is expected to be completed by September 2017. The main objectives of the project are:

- To identify and prioritize technologies through country-driven participatory processes that can contribute to adaptation goals of the country, while meeting the national sustainable development goals and priorities
- To identify barriers hindering the acquisition, deployment, and diffusion of prioritized technologies.

The learning from Phase I are now included in the guidance to the TNA process for the Phase II countries (Dhar, et. al., 2014)[4]. These lessons were based on a review of two synthesis reports submitted by UNEP and UNDP to GEF in 2008 on the first TNA exercise and a TNA best practices workshop conducted by UNFCCC in 2007. The Climate Technology Centre and Network (CTCN) is the operational arm of the UNFCCC Technology Mechanism. The CTCN mission is "to stimulate technology cooperation and enhance the *development and transfer of technologies* to developing country Parties at their requests".

The UNFCC Modalities and Procedures (2013) defines the CTCN's support to developing countries, which include the following:

- Development and conduct of TNAs, road maps and actions plans to support identification of technologies and adequate planning

[4] Dhar, S., Painuly, J.Nygaard, I., and Rogat, J., 2014: Organising the National TNA Process: An Explanatory Note. Available in English, Russian, and French on: www.tech-action.org under “Publications”.

- Implementation of TNA/Technical Action Plans (TAPs) outputs in the form of technology projects, programs or strategies to enable concrete actions in-country.

A report from the United Nations Framework Convention on Climate Change (UNFCCC, 2005[5]) suggests that an adaptation technology may be defined as *"the application of technology in order to reduce the vulnerability, or enhance the resilience, of a natural or human system to the impacts of climate change".* The body notes that those technologies may be 'hard or soft', as reducing vulnerability requires not only having access to technology, but also having the mechanisms, skills and other resources that are needed to make sustainable use of the technology.

A good strategy would typically combine both hard and soft technologies. For example, an early warning system would rely on hard technologies such as measuring devices and information technology, but also on knowledge and skills to strengthen awareness and promote appropriate action when a warning is given" (UNFCCC, 2006)[6]. Several reports and policy papers distinguish between hard and soft technologies for adaptation to climate change as shown in Table 1.1. These definitions of hard and soft adaptation definitions from literature review were used in the context of Philippines identification of technology mix.

Table 1.1: A typology of definitions of technology and its variants

Source	Definitions
UNFCCC (2005)	Hard technologies could include goods and hardware while soft technologies may use "knowledge of methods and techniques that enable "hard" technologies to be applied".
OECD,2006	"Hard" adaptation measures when they imply the use of specific technologies and actions that involve capital goods, and "soft" adaptation measures that focus on information, policy and strategy development, and institutional arrangements.
IPCC,2000[7]	Technology is "a piece of equipment, technique, practical knowledge or skills for performing a particular activity" Stressed the soft-hard duality: exceeding or complementing a traditional understanding of technology as tangible hardware, the term also comprises know-how and organization
IPCC, 2007[8]	Technology is defined as "the practical application of knowledge to achieve particular tasks that employs both technical artifacts (hardware, equipment) and (social) information ('software', know-how for production and use of artifacts)"

[5] UNFCC, 2005: FCCC/SBSTA/2005/8: "Matters relating to the implementation of the framework for meaningful and effective actions to enhance the implementation of Article 4, paragraph 5, of the Convention"
[6] UNFCCC, 2006: Application of environmentally sound technologies for adaptation to climate change. Technical Paper.Doc. No. FCCC/TP/2006/2, 10 May 2006; online: http://unfccc.int/resource/docs/2006/tp/tp02.pdf
[7] IPCC,2000: Special report on Methodological and technological issues in technology transfer, Cambridge, UK: Cambridge University Press
[8] IPCC,2007: Climate change 2007: Mitigation of climate change. Contribution of Working Group III to IPCC-AR4, p.281, Cambridge, UK: Cambridge University Press

Sovacool BK, 2011[9]	Hard adaptive measures involve capital-intensive, large, complex, inflexible technology and infrastructure Soft adaptive measures prioritize natural capital, community control, simplicity and appropriateness

The definition which includes technologies intended for use in mitigation and adaptation, can be summarized as follows:

1. Hardware: Physical tools
2. Software: Processes, knowledge, and skills needed to install and manage technologies
3. Orgware: Institutional mechanisms to support the acquisition and management of technologies.

1.2 The Philippines' Technology Needs

The NFSCC ensures the commitment towards the strengthening of adaptation in the Philippines of our natural ecosystems and human communities to climate change. In the process, the Framework aspires to chart a cleaner development path for the Philippines, highlighting the mutual relationship between climate change mitigation and adaptation. On account of the Philippines' vulnerability to climate change impacts, adaptation is the anchor strategy and mitigation will be pursued as a function of adaptation. It would also ensure that Loss & Damage are minimized to ensure achievement of development goals. This reduction would stem from the energy, transport, forestry, industry and waste sectors.

The guidelines for national communications encourage non- Annex I parties, in the light of their social and economic conditions, to provide information on activities relating to: the transfer of, and access to, environmentally sound technologies and know-how; the development and enhancement of endogenous capacities, technologies and know-how; and measures relating to enhancing the enabling environment for development and transfer of technologies.[10]

The Philippines Second National Communications (SNC) to the UNFCCC outlines the policies and measures relating to the development and transfer of environmentally sound climate technologies, including the identification of barriers to their implementation. Among the national policies to promote environmentally sound technologies include:

- Republic Act 8293, also known as the Intellectual Property Code of the Philippines, provides for the establishment of an Intellectual Property Office and a detailed outline

[9] Suvacool, BK, 2011: "Climate Policy: Hard and soft paths for climate change adaptation" 1177–1183 doi:10.1080/14693062.2011.579315 # 2011; Taylor & Francis ISSN: 1469-3062 (print), 1752-7457 (online) www.climatepolicy.com

[10] Second National Communication to the UNFCCC.

of its powers and functions. It also provides for the establishment of the Documentation, Information and Technology Transfer Bureau under the Intellectual Property Office. Among the functions of this office are: to provide technical, advisory, and other services relating to the licensing and promotion of technology; carry out an efficient and effective program for technology transfer; and register technology transfer arrangements.

- Republic Act 1005, or the "Act Providing the Framework and Support System for the Ownership, Management, Use and Commercialization of Intellectual Property Generated from Research and Development Funded by Government and for Other Purposes," is also known as the Philippine Technology Transfer Act of 2009. The main objective of this act is to promote and facilitate the transfer, dissemination, and effective use, management and commercialization of intellectual property, technology and knowledge resulting from research and development funded by the government for the benefit of the national economy and taxpayers (RA 10055, Sec. 3).

- The Investment Priority Plan of 2009 provides policy and fiscal incentives to: biofuel production; renewable energy and other energy sources adopting environment friendly technologies; power-generating plants located in missionary areas and privatized plants; modernization of iron and steel production leading to at least 5% reduction in energy usage; and projects related to the Clean Development Mechanism under the Kyoto Protocol.

- To encourage the development of renewable energy projects and activities, the Renewable Energy Act provides for the following fiscal incentives:

    a. Exemption of renewable energy developers from income taxes for seven years.

    b. Duty-free importation of renewable energy machinery, equipment, materials and parts for ten years.

    c. Special realty tax rates on equipment and machinery.

    d. Deduction from gross income for seven years of the net operating loss carryover (NOLCO) of the renewable energy developer during the first three years.

e. Corporate tax rate – After seven years of income tax holiday, all RE developers shall pay a corporate tax of 10% on its net taxable income as defined in the National Internal Revenue Act of 1997, as amended by Republic Act No. 9337; provided that the RE developer shall pass on the savings to the end-users in the form of lower power rates.

f. Zero percent value-added tax for the sale of fuel or power generated from renewable sources of energy, such as, but not limited to, biomass, solar, wind, hydropower, geothermal and ocean energy and other emerging energy sources using technologies such as fuel cells and hydrogen fuels. This is also extended to the purchases made by RE developers of local supply of goods, properties and services needed for the development, construction and installation of its plant facilities.

g. Entitlement of all individuals and entities engaged in the plantation of crops and trees used as biomass resources to duty-free importation, and exemption from Value-Added Tax (VAT) on all types of agricultural inputs, equipment and machinery such as, but not limited to, fertilizer, insecticide, pesticide, tractor, trailers, trucks, farm implements and machinery, harvesters, threshers, hybrid seeds, genetic materials, sprayers, packaging machinery and materials, bulk handling facilities such as conveyors and mini-loaders, weighing scales, harvesting equipment, and spare parts of all agricultural equipment.

h. Entitlement of an RE developer to a cash generation-based incentive per kilowatt hour rate generated, equivalent to 50% of the universal charge for power needed to service missionary areas where it operates the same, to be chargeable against the universal charge for missionary electrification.

i. Exemption of all proceeds from the sale of carbon emission credits from any and all taxes.

j. For the transport sector, the government, through Executive Order 488, has introduced zero percent import duty on parts and components that will be used for the assembly and manufacture of vehicles powered by alternative fuels. Under Executive Order 449, it also reduced import duties on bioethanol products to be used in the program from 10% to 1%. Executive Order 396 also reduced the rates of import duty on related equipment, parts and components being used by the compressed gas motor vehicles and natural gas vehicle industry.

As technology transfer is crucial in addressing the issue of climate change, there is a need to mainstream and institutionalize the identification of climate-friendly technologies that need to be developed and effectively transferred from mere research to commercial use.

1.3 Existing National Policies in the Philippines Related to Technological Innovation, Climate Change Mitigation and Development Priorities

1.3.1 National Inventory of Greenhouse Gases

Understanding the country's historical and projected emissions trajectory is critical to the identification and prioritization of mitigation actions. As party to the United Nations Framework Convention on Climate Change (UNFCCC), the Philippines has prepared and submitted two National Communications, which included national GHG inventories. Initially, the submissions are only seen as the country's contribution to the global scientific effort to collect data for climate projections, as calculated by complex mathematical models developed by scientists and technical experts. Today, the submissions are invaluable in the country's efforts towards the international goal to limit temperature increase above pre-industrial levels to well below 2°C and, if possible, below 1.5°C. The achievement of this goal is largely anchored on the submission of NDCs by both developed and developing member countries to the UNFCCC under the Paris Agreement on Climate Change. As such, countries must undertake domestic mitigation measures to achieve their contributions but they may also enter into voluntary cooperation schemes to increase ambition in their NDCs.

1.3.2 Institutionalization of the GHG Inventory System

In the preparation of both the Initial National Communication (INC) and the Second National Communication (SNC), the Philippine government procured the services of consultants to conduct the national inventory and to write the inventory report. The Government saw the need to institutionalize the GHG inventory reporting process in relevant government agencies due to the sensitivity of data and information in these activities as well as meet the requirements, as Country Party to the UNFCCC, for a more comprehensive mitigation analysis for climate-responsive planning and regular submission of reports. Thus CCC spearheaded the preparation and approval by the Office of the President of EO No. 174 which was officially issued on November 24, 2014.

The EO established the Philippine Greenhouse Gas Inventory Management and Reporting System (PGHGIMRS) in relevant government agencies to, among others, enable the

country to transition towards a climate-resilient pathway for sustainable development. It defines the functions and role of CCC as overall lead agency and other lead government agencies from the AWIT-FE sectors (Table 1.2) as well as the budget or financial resources therefore.

Table 1.2: Lead Coordinating Agencies in the PGHGIMRS

Sector	Agency/ Organization
Agriculture	Department of agriculture (DA), Systems-wide Climate Change Office and Philippine Statistics Authority (PSA), Sectoral Statistics Office
Energy	Department of Energy, Energy Policy and Planning Bureau
Waste and industrial processes	Department of Environment and Natural Resources – Environment Management Bureau
Land-use and forestry	Department of Environment and Natural Resources – Forest Management Bureau
Transport	Department of Transportation, Planning Service
Support institutions	PSA, Local Government Units, CSO's/NGOs, Academe

The Guidance Document (GD) which serves as the implementing rules and regulations of the EO, officially established and strengthened the institutional frameworks, arrangements and linkages for regular updates on GHG inventories. It also serves as guide or reference for future GHG inventory and NC preparation. A Reference Manual (RM) was also developed as an annex to the GD which is a detailed set of procedures for the conduct of the national GHG inventory.

1.3.3 CO^2 Emission Profile

In 1994, the Philippines prepared and submitted its first GHG inventory report as part of its commitment to the UNFCCC (DENR, 1999). The GHG inventory[11] showed that a total equivalent amount of 100.8 MtCO2-eq was released into the atmosphere.[12]

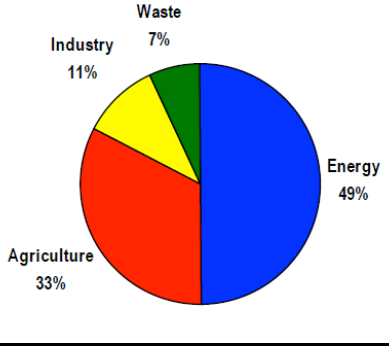
The Energy Sector accounted for about 49% (50 MtCO2-eq) of the national GHG total emissions and trailed closely by the Agriculture and Industry sectors' contribution of 33% and 11%, respectively (Figure 1.1).[13]

[11] Covers the four sectors of Energy, Industry, Agriculture, and Wastes, and the net uptake (sink) of GHGs from the Land Use Change/Forestry (LUCF) sector

[12] Excluding the contribution of the LUCF sector.

[13] Source: The Philippines' Initial National Communication on Climate Change to the UNFCCC. 19 May 2000. http://unfccc.int/national_reports/non-annex_i_natcom/items/2979.php

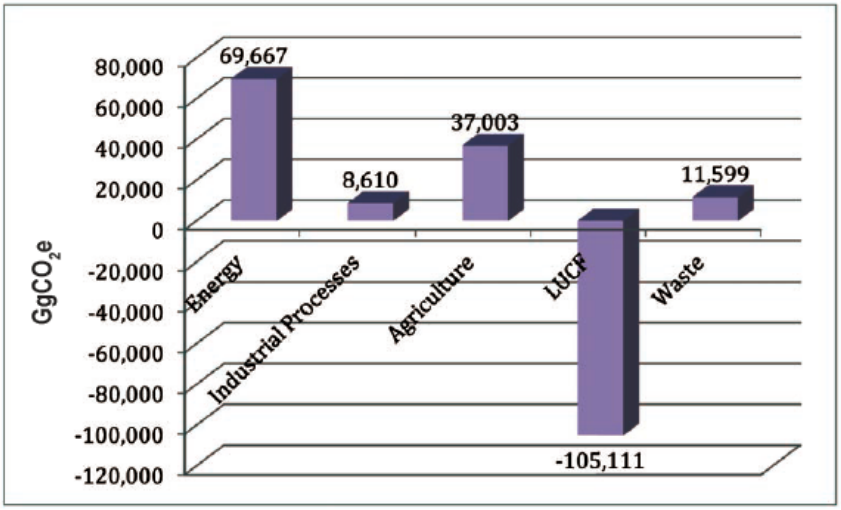
Figure 1.1: 1994 Philippine GHG Emissions



Sector	CO_2 Emissions (Gg x 10^3)
Energy	50
Agriculture	33.1
Industry	10.6
Waste	7.1
Total	100.8

The inventory underscored the country's reliance in 1995 on fossil fuel imports and the large contribution of the energy sector to GHG emissions. The 2000 Second National Communication (SNC) showed that the Philippines emitted a total of 21,767 Gg of CO2e of GHGs in the year 2000, net of sequestered carbon by LUCF (Figure 1.2). Between 2000 and 1994, total emissions excluding forestry increased by a higher rate of 26%. Emissions in all sectors also increased except industry, although the transport and energy emissions could not be disaggregated between these two sectors in the 1994 GHG emissions. In 2009 or 15 years after the first GHG inventory, statistics from DOE showed that the Energy Sector generated 68.91 $MtCO_2$-eq of emissions which is a 38% increase from the 50 $MtCO_2$-eq emissions in 1994.

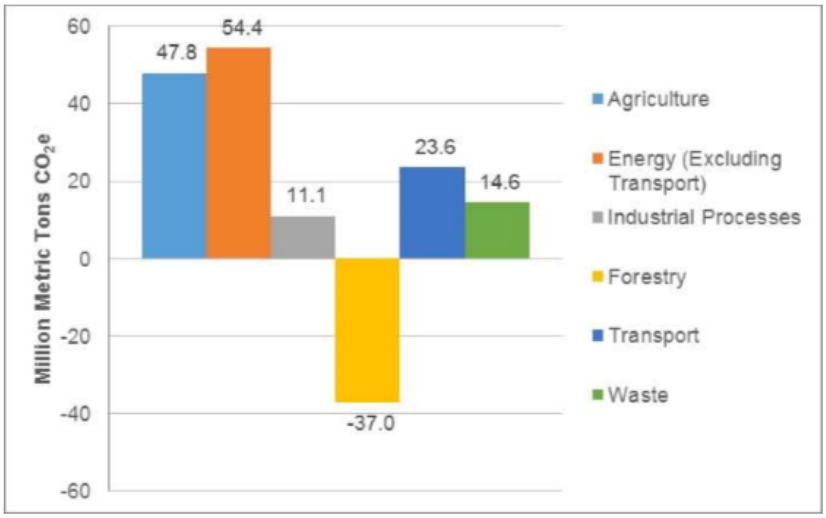
Figure 1.2: 2000 Philippine GHG Emissions[14]



[14] Second National Communication to the UNFCCC

In the CBA study[15] conducted by CCC thru the USAID-B-LEADERS Project in 2010, the estimated total emissions is at 144.9 MtCO2-eq of GHGs. If forestry is excluded, emissions are at 155 MtCO2e, an increase of 26 percent compared to the 2000 emission level reported in the SNC. GHG emissions increased in all sectors except transport. The agriculture, energy and transport sectors collectively account for more than 80 percent of the total GHG emissions in both periods. Electricity generation and energy sector together contributed to emissions of 31.49 million tons of CO_{2eq} or more than 42% of emissions with the transport in second at 35% of emissions, and industry and other sectors at 23%[16]. Total emissions increased significantly (500%) compared to the 2000 GHG inventory, although data needs to be treated with care due to changes in methods between the two inventories.

Figure 1.3: 2010 Base Year GHG Emissions and Removals for All Sectors (MtCO2e)[17]



1.3.4 Projected CO_2 Emissions

Table 1.3 shows the results for the 2010-2050 baseline which indicates that emissions will grow by over 800% by 2050. The 2010-2050 baseline projection describes projected GHG emissions under "business as usual" economic activity. It also serves as a reference against which the impacts of current and planned mitigation actions can be measured. Due to the expected population and economic growth in the Philippines, emissions are growing in all sectors, with the energy and transport sectors showing the most dramatic increase. The forestry sector will no longer be a carbon sink starting in 2030.

[15] USAID-B-LEADERS Project Cost-Benefit Anaysis (CBA) Study, 2016
[16] Source: DOE
[17] USAID-B-LEADERS Project Cost-Benefit Anaysis (CBA) Study, 2016

Table 1.3: 2010-2050 Baseline GHG Emissions and Removals for All Sectors (MtCO2e)[18]

SECTOR	Year								
	2010	2015	2020	2025	2030	2035	2040	2045	2050
Agriculture	47.8	49.6	51.3	53.8	56.3	58.3	60.3	64.2	68.1
Energy (Excluding Transport)	54.4	69.8	96.8	154.4	201.0	282.3	369.2	495.7	675.0
Forestry	-37.0	-34.8	-24.4	-10.3	3.8	16.0	28.3	40.5	52.8
Industrial Processes	11.1	13.8	16.6	20.5	24.4	30.2	36.0	44.7	53.4
Transport	23.6	38.7	47.3	58.6	72.6	89.6	110.3	136.3	169.9
Waste	14.6	17.0	19.4	21.7	23.9	26.1	28.3	30.4	32.7
Total	**114.5**	**154.0**	**207.1**	**298.6**	**391.0**	**502.6**	**623.3**	**811.9**	**1,051.9**

The mitigation component of the Philippines' INDC indicated an overall GHG emission reduction goal of 70% relative to a business-as-usual (BAU) scenario. The 70% target however is entirely conditional on financial support for the implementation of mitigation actions. If IPCC key category analysis will be applied, energy and transport sectors will be prioritized because these have significant influence on a country's total inventory of GHG in terms of the absolute level, the trend, or the uncertainty in emissions and removals. Thus, technology needs from the energy and transport sectors were prioritized in this study not only due to their ever increasing contribution in the GHG emissions level of the country but also on the TNA prioritization criteria set by stakeholders.

1.4 National Climate Change Mitigation Policies and Activities

The IPCC (2014) defines mitigation as human intervention to reduce the sources or enhance the sinks of GHGs. The Mitigation pillar in the NFSCC provides that GHG mitigation will not be the primary driver of the country's mitigation strategies and that the country's mitigation potential should be transformed strategically into mitigation options that will offer the most co-benefits to fuel sustainable development. Accordingly, the long-term objective of mitigation is to facilitate the transition towards low greenhouse gas emissions for sustainable development. To achieve such objective, six key result areas (KRA) are adopted: Energy Efficiency and Conservation, Renewable Energy, Sustainable Transport, Sustainable Infrastructure (residential and commercial buildings), National REDD+ Strategy, and Waste Management. Strategic priorities are identified for each KRA.[19]

[18] USAID-B-LEADERS Project Cost-Benefit Anaysis (CBA) Study, 2016

[19] Source: FIRST INTERIM REPORT: Development of Nationally Determined Contributions (NDC) Framework and Roadmap (2017). Prepared by Flordeliza M. Andres, PhD, NDC Consultant for the Climate Change Commission-UNDP Low Emission Capacity Building (LECB) Programme Philippine Project. Unpublished. 177pp.

The CCC with the support of the UNDP-Low Emission Capacity Building Philippine (LECB PHL) Project has developed a National Climate Change Mitigation Framework Strategy (NCCFMS or The Strategy). The main objectives of the Strategy are: (a) to provide a clear direction in the development, implementation and management of climate change actions in the country, and (b) to ensure that stakeholders clearly understand their roles and responsibilities. Apart from the Climate Change Act, national environmental policies as well as sector-specific issuances also guide the implementation of mitigation actions.

The CCC has also initiated studies of mitigation options for the Philippines with the support of "development partners" (UNDP, USAID, and ADB, in particular), which indicated alternative mitigation or low-carbon development pathways for the country.

1.4.1 The Philippines' Initial Nationally Determined Contributions (INDC)

The INDC submitted by the Philippines prioritizes adaptation measures and proposes to undertake mitigation or emission reduction measures only if external support in terms of financing resources, including technology development and transfer, and capacity building, will be available to implement them.

The mitigation options were identified through techno-economic studies that considered not only the emission reduction impact but also the "co-benefits" or consequent direct benefits such as avoided illnesses and premature deaths through improved air quality, job and income generation as well as foreign direct investments in renewable and waste management technologies, reduced pollution and higher income opportunities through more efficient vehicles and improved traffic conditions. The impact of the selected mitigation options in the key sectors (waste, industry, transport, energy and forestry) is a 70 percent GHG emission reduction from business as usual (BAU) scenario for 2000-2030.

The President signed the Instrument of Accession for the Paris Agreement on 28 February 2017 with the Senate of the Philippines unanimously adopting a resolution concurring to the accession on 14 March 2017. The Instrument of Accession was accepted/approved by the UNFCCC on 23 March 2017 and officially entered into force on 22 April 2017.

With the Philippines' accession to the Paris Agreement, CCC is taking the lead in developing an NDC framework and roadmap. The NDC is to present a paradigm shift toward low-carbon development and will be aligned with national policies and strategies so as to also promote the country's economic development and industrialization goals. The development of

the Philippine NDC roadmap is guided by the following principles as espoused by the government:

a) It should emphasize adaptation as the anchor strategy and mitigation will be pursued as a function of adaptation, in consideration of the Philippines' vulnerability to climate change impacts. The main driver will not be emission reduction but the "co-benefits" or impact on sustainable development of mitigation actions. Implementation of the mitigation actions is contingent on financial support, including technology transfer and capacity building that will be received;

b) It should allow the country to industrialize and not be pressured to limit its carbon emissions ***(climate justice)*****;**

c) It shall advocate for developed countries to pay for climate change related damages in vulnerable countries such as the Philippines ***(compensation, loss & damage)*****;** and

d) It should be aligned with the national long-term vision and strategies under the Philippine Development Plan towards inclusive growth and a globally-competitive economy.

Summary of the mitigation options under the INDC for selected sectors are as follows:

Energy

1. Energy efficiency and conservation (commercial/residential appliances, street lighting)
2. Low carbon clean, renewable energy esp. for power generation.

Transport

1. Improving vehicle efficiency including road maintenance
2. Adoption of fuel economy and emission standards
3. Promotion of mass transit (rail system and buses)
4. Traffic management including vehicle demand reduction and promotion of non-motorized transport/walking.

Waste

1. Solid waste management (composting, waste to energy generation)
2. Wastewater treatment (industrial and domestic).

1.4.2 The Paris Agreement on Climate Change

In the December 2015 UNFCCC 21st Conference of Parties (COP21)in Paris, countries adopted a historic international Paris Agreement on Climate Change to **strengthen the global response to climate change in the context of sustainable development.** Article 2 of the Paris Agreement outlines three major goals: First is to limit increase in global average temperature rise to 2ºC, and even further 1.5ºC. Second is to build capacities to adapt to the impacts of climate change. And third is to make finance flows consistent with goals mentioned.

The Nationally Determined Contribution (NDC) is a country's pledge or contribution to achieve the said global emission target and climate-resilient development. As such, it articulates plans/projects or programs to reduce GHG emissions as well as to increase climate resiliency.

Prior to the Paris Agreement, countries including the Philippines submitted their Intended Nationally Determined Contribution or INDC. The INDC state that the country will reduce 70% of its GHG emissions by 2030 from the business-as-usual scenario of 2000-2030. The reduction target is **conditional** to the provision of the means of implementation that the country will receive (finance, capacity building and technology transfer). The reduction target is consistent with national policies and frameworks. The reduction target is consistent with national policies and frameworks.

On account of Philippines' vulnerability to climate change impacts, adaptation is the anchor strategy and mitigation will be pursued as a function of adaptation. It would also ensure that Loss & Damage are minimized to ensure achievement of development goals. This reduction would stem from the energy, transport, forestry, industry and waste sectors.

1.5 Energy Sector Mitigation Strategy Frameworks

The Department of Energy (DOE) oversees the preparation and implementation of the Philippine Energy Plan (PEP), the country's blueprint and investment plan for the integrated development, utilization and management of all forms of energy sources. The DOE integrates all programs and projects of its attached agencies, including government owned and controlled corporations, and those of the private sector, which are heavily involved and make up the bulk of investments in the Philippine energy industry. The current version of the PEP (2012-2030) is aligned with the Philippine Development Plan (PDP) for 2011-2016. Tables 1.4 shows the key environmental laws and mitigation policies and their objectives in the energy sector:

Apart from the PEP, the DOE also oversees the preparation and implementation of plans and programs for energy sub-sectors, including the NREP, the National Energy Efficiency and Conservation Program, and the Alternative Transport Fuels Program. DOE outlined the strategic directions for 2016-2030 with the following elements:

a) Ensure energy security;
b) Expand energy access;
c) Promote a low carbon future;
d) Encourage investment in infrastructure and facilities;
e) Pursue development and implementation of local energy plans;
f) Implement and monitor sectoral roadmaps and action plans;
g) Advocate the passage of the Department's legislative agenda;
h) Strengthen consumer welfare and protection; and
i) Foster stronger international relations and partnerships.

The DOE updated the National Renewable Energy Program and the roadmaps for Energy Efficiency and Alternative Transport Fuels. These can provide the basis for elaborating the mitigation options for the energy as well as the transport and industry sectors in the NDC.

Table 1.4: Policy Frameworks for Mitigation in the Energy Sector

Overarching/Crosscutting	
Laws/Issuances	R.A. 9729 as amended by R.A. 10174 (Climate Change Act)
	R.A. 8749 (Clean Air Act of 1999)
	R.A. 9003 (Ecological Solid Waste Management Act of 2000)
Strategy/Planning and Frameworks	National Framework Strategy on Climate Change (NFSCC) 2010-2022 Mitigation – Key Result Areas "Energy Efficiency and Energy Conservation" and "Renewable Energy"
	National Climate Change Action Plan (NCCAP)
	Philippine Development Plan (PDP) 2011 – 2016
Energy Sector Specific	
Laws/Issuances	R.A. 7156 (Mini-Hydroelectric Power Incentive Act of 1991)
	R.A. 7638 (Department of Energy act, 1992)
	R.A. 9136 (Electric Power Industry Reform Act of 2001)
	R.A. 9367 (Biofuels Act of 2006)
	R.A. 9513 (Renewable Energy Act of 2008)
Strategy/Planning and Frameworks	Philippine Energy Plan (PEP) 2012 – 2030
	National Renewable Energy Program (NREP)
	National Biofuels Program
	National Efficiency and Conservation Program
	Alternative Transport Fuels and Technologies Program

1.6 Transport Sector Mitigation Strategy Frameworks

The Department of Transportation (DOTr) is the primary policy, planning, programming, coordinating, and implementing entity of the government for the promotion, development and regulation of the country's network of transportation systems. ESITU, a special unit within the DOTr, assists in identifying and overseeing the implementation of sustainable transport projects of the DOTr and its attached agencies. In 2011, DOTr formulated the **National Implementation Plan (NIP) 2016-2020 on Environment Improvement in the Transport Sector,** which is the national strategy for environmentally sustainable transport (EST) covering all modes of transportation – Air, Rail, Water, and Road. The NIP also contains programs to realize low-carbon and low-pollution transport systems. It is also aligned to DOTr mission in achieving a safe, secure, efficient, viable, competitive, dependable, integrated, environmentally sustainable and people-oriented Philippine transportation system. Table 1.5 lists the key instruments that constitute the policy, strategy and planning framework for mitigation in the transport sector.

Table 1.5: Policy Frameworks for Mitigation in the Transport Sector

Overarching/Crosscutting	
Climate Change/ Environmental Laws	Climate Change Act 2009 (R.A. 9729/R.A. 10174)
	Clean Air Act of 1999
	Toxic Substances and Hazardous and Nuclear Waste Control Act of 1990 (R.A 6969)
Strategy and Planning Frameworks	National Framework Strategy on Climate Change (NFSCC) 2010-2022 Mitigation – Key Result Areas
	National Climate Change Action Plan (NCCAP)
	Philippine Development Plan (PDP) 2011 – 2016
Transport Sector Specific	
Laws/Issuances	Land Transport and Traffic code (RA 4136)
	Imposing A Motor Vehicle User's Charge 2000 (R.A. 8794)
	Biofuels Act of 2006
	Reducing the Rates of Import Duty on CNG Motor Vehicles (E.O. No. 396)
	Committee on Fuel Conservation and Efficiency in Road Transport (EO No. 472)
Strategy/Planning and Frameworks	DOE National Energy Efficiency and Conservation Program (NEECP)
	DOE Alternative Transport Fuels Program

1.7 Waste Sector Strategy Frameworks

The *National Solid Waste Management Framework*, prepared in 2004 provides a comprehensive but practical guide for LGUs and other sectors concerned involved in the implementation of RA 9003. The *National Solid Waste Management (NSWM) Strategy (2012-2016)* was subsequently developed to serve as a roadmap for the implementing bodies and provide directions with well-defined steps in achieving goals towards the fulfillment of RA9003 and the National Solid Waste Management Framework.

The NWSMS aimed to achieve an *improved waste management* wherein a 50% diversion of solid wastes from waste disposal facilities through reuse, recycling and composting activities and other resource recovery activities have been achieved by 2016. Eight components were identified and envisioned to address the strategic issues and gaps that hinder the smooth implementation of RA 9003. These are: (a) Bridging policy gaps and harmonizing policies, (b) Capacity development, Social marketing and advocacy, (c) Sustainable financing, (d) Creating economic opportunities, (e) Knowledge management on technologies and innovation, (f) Organizational development and enhancing inter-agency cooperation, (g) Compliance monitoring, enforcement and recognition, (h) Good governance, Caring for vulnerable groups, and Reducing disaster and climate change risks.

The NSWMC subsequently developed and adopted the *NSWM Framework for the Informal Waste Sector* to address issues regarding the absence of livelihood of some waste pickers and itinerant buyers after the closure of open dumps and controlled disposal facilities. Table 1.6 are the key environmental laws and mitigation policies and their objectives in the waste sector[20]:

Table 1.6: Policy Frameworks for Mitigation in the Waste Sector

Overarching/Crosscutting	
Laws/Issuances	*Climate Change Act 2009 (R.A. 9729/R.A. 10174)*
	Local Government Code (LGC) of 1991 (R.A 7160)
Strategy and Planning Frameworks	*National Framework Strategy on Climate Change (NFSCC) 2010-2022* *Mitigation – Key Result Areas*
	National Climate Change Action Plan (NCCAP)
	Philippine Development Plan (PDP) 2011 – 2016

[20] FIRST INTERIM REPORT: Development of Nationally Determined Contributions (NDC) Framework and Roadmap (2017). Prepared by Flordeliza M. Andres, PhD, NDC Consultant, for the Climate Change Commission-UNDP Low Emission Capacity Building (LECB) Programme Philippine Project. Unpublished. 177pp.

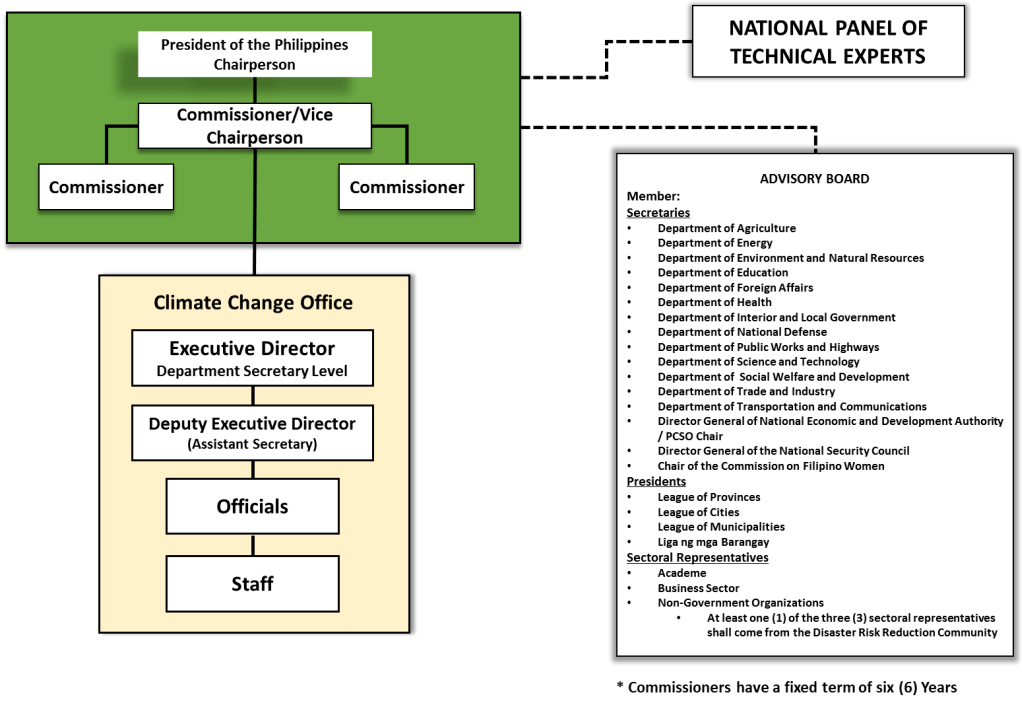
	Solid Wastes	***Wastewater***
Laws/Issuances	*Ecological solid Waste Management Act of 2000 (R.A 9003)*	*Clean Water Act of 2004 (R.A 9275)*
	Toxic Substances and Hazardous and Nuclear Waste Control Act of 1990 (R.A 6969)	*Code on Sanitation of the Philippines (P.D. 856)*
	Renewable Energy Act of 2008 (R.A. 9513), Sec. 30	
Strategy and Planning Frameworks	*National Framework Plan for the Informal Waste Sector in Solid Waste Management 2009*	*Philippine Sustainable Sanitation Roadmap, 2010*
	National Solid Waste Management Strategy 2012-2016	*2016 National Sustainable Sanitation Plan*
	LGU Municipal Solid Waste Management Plans	

Chapter 2: Institutional arrangement for the TNA and stakeholders' involvement

2.1 Overview

Republic Act 9729 (Climate Change Act of 2009 and was amended by Republic Act 10174) created the Climate Change Commission. Its main function is to recommend legislation, policies, strategies, programs on and appropriations for climate change adaptation and mitigation and other related activities. The President of the Philippines is the Chairperson of the Commission, as shown in the organizational Chart in Figure 2.1.

Figure 2.1: Organizational Chart of the Philippine Commission on Climate Change



The Climate Change Commission is the national designated entity for the Climate Technology Center and Network (CTCN). It spearheaded the launch of the TNA project on June 24 to 26, 2015 in the presence of representatives from the TNA Regional Center at the Asian Institute of Technology[21] (AIT) in Bangkok, Thailand; sector representatives from the

[21] The UNEP Risoe Center (URC) in Denmark has engaged the Centre of Excellence for Sustainable Development in the context of Climate Change (SDCC), AIT, for implementing Technology Needs Assessment (TNA) in developing Asian countries. Two

Government and national experts. Dr. Rajendra P Shrestha and Dr. Sudhir Sharmagave an overview of the TNA process, institutional structure and steps to be taken from the TNA to the preparation of Technical Action Plan (TAP).

2.2 Institutional Arrangement

The TNA process in the Philippines adopts the institutional structure (Figure 2.2) as recommended[22]. The national institutional setup for the project constitutes:

- The steering committee,
- The national TNA coordinator - responsible for political acceptance of the final technology action plan (tap)
- The national TNA committee and the sector working groups - participates and conduct a wider stakeholder consultation
- The national consultants (adaptation and mitigation) - in charge of doing the analytical basis and reporting

The steering committee is the CCAM Cluster and is composed of the Heads (Secretary or Chair) of fifteen government agencies (See Table 2 below) headed by the Department of the Environment and Natural Resources with the Climate Change Office of the Climate Change Commission providing secretariat support. Participation is however, not limited to the identified core members. For this reason, the Chair of the Committee may require the presence of other departments and/or agencies as may be necessary.

Table 2.1: CCAM Cluster, Member Agencies

Chair: Secretary, Department of Environment and Natural Resources	
Members:	
1. Chair, Housing and Urban Development Commission	9. Secretary, Department of National Defence
2. Secretary, Department of Science and Technology	10. Secretary, National Economic and Development Authority
3. Secretary, Department of Interior and Local Government	11. Chair, Metro Manila Development Authority
4. Secretary, Department of Public Works and Highways	12. Executive Secretary, Office of the President
5. Secretary, Department of Social Welfare and Development	13. Secretary, Presidential Management Staff
6. Secretary, Department of Agriculture	14. Secretary, PCDPSO

Regional Centers serve as the focal points for adaptation and mitigation respectively. These centers in cooperation with URC play a substantial role in providing technical support and capacity building to the national TNA teams and consultants.

[22] SUBASH DHAR, JYOTIPAINULY, IVAN NYGAARD, JORGE ROGAT. 2014. *ORGANISING THE NATIONAL TNA PROCESS: AN EXPLANATORY NOTE*. Available in English, Russian, and French on: WWW.TECH-ACTION.ORG under "Publications".

7. Secretary, Department of Agrarian Reforms	15. Presidential Legislative Liaison Office
8. Secretary, Department of Energy	**Secretariat:** Climate Change Commission

Working groups are staffs from the Cluster who are typically the technical people of the departments or agencies.

2.3 Stakeholder Engagement Process

The TNA process is typically country driven and stakeholder consultations are strongly recommended. The Philippine TNA project is coordinated by the Climate Change Commission. The TNA report reflects the discussion and consultation process, which involves small group meetings as well as face to face meetings. A list of the stakeholders involved in the technology prioritization process is provided in the appendices. It includes representatives of the national agencies member of the CCAM cluster and other government agencies, academic institutions and non-governmental organizations. While the TNA team members are the joint contributors to the TNA report, the choice of sector and technology priorities is validated by a range of stakeholders. The TNA report is in line with the national sustainable development objectives of the country.

The TNA process relied mainly on expert inputs from government, academia and non-government organizations. Thus, the TNA prioritization of technologies had to build upon earlier stakeholder consultations and government policies as well in order to provide a contribution coherent with national development objectives.

The TNA Study followed the recommended prioritization process:

1. Identifying development priorities;
2. Identification of sectors with high vulnerability to climate change; and
3. Prioritization of sectors in terms of development priorities, and vulnerability to climate change.

The following consultative activities with stakeholders were undertaken (see Annex IV for the highlights/summaries of these activities):

1. TNA Consultation, 06 February 2018 Training Room, Energy Center, Rizal Drive, Taguig City, Metro manila
2. TNA Consultation, 19 March 2018, 4/F PNOC Building V, Bonifacio Global City, Taguig City, Metro Manila
3. TNA Consultation, 24 April 2018, B Hotel, Scout Rallos Street, Quezon City, Metro Manila.

Prior to consultation, stakeholders were requested to submit their priority list of technology needs. It was decided during these consultations that for this TNA study, the mitigation actions/options, as discussed above, which were identified and prioritized in the INDC that was submitted by the Government to the UNFCCC, will be used as initial basis or references in the identification, selection and prioritization of technology needs.

Chapter 3: Sector Prioritization

3.0 An Overview of Sectors, Projected Climate Change and the GHG Emission Status and Trends of the Different Sectors

The Philippines is party to the UNFCCC, and as such is required to periodically submit a report – referred to as National Communications – of the inventory of its greenhouse gas emissions. As stated earlier, the country was able to draft two (2) reports: the Initial National Communications (INC) based on year 1994 data and published in 2000 and the Second National Communications (SNC) using year 2000 data. Table below provides a comparative summary of emissions from the INC and the SNC.

Table 3.1: GHG Emissions Comparison, INC and SNC (in Gg CO2e)

Sectors	1994: INC (Gg CO2e)	2000: SNC (Gg CO2e)	% change ⇧/(⇩)
Energy	50, 038.00	69,667.24	39%
Waste	7,094.00	11,599.07	64%
Agriculture	33,130.00	37,002.69	12%
LUCF	(126.00)	(105,111.37)	83322%
Industrial Processes	10,603.00	8,609.78	(19%)
Totals	100,739.00	21,767.41	(78%)
Totals (net of LUCF)	**100,865.00**	**126,878.78**	**26%**

The table shows that there is a notable decrease of emissions by 78% between years 1994 and 2000 due to a considerable increase in the net uptake of the forestry (LUCF) sector. Without the contribution/effect of the LUCF sector in the country's total emissions, there is a 26% increase in non-LUCF sectors within a six-year period.

3.1 Overview of the Energy Sector

3.1.1 Indigenous Energy Resources

The Philippines is endowed with relatively modest reserves of crude oil at about 25 million barrels (MB); 54 million barrels of condensate; 3 trillion cubic feet (tcf) of natural gas; and about 420 million metric tonnes (MMt) of coal. It has, however, vast RE resources (Table *3.2*).

Table 3.2: Indigenous energy resources potential

	Unit	Value
Crude Oil (including condensates)	MB	79
Natural Gas	Tcf	3
Coal (Sub-bituminous Class C)	MMt	420
Renewable Energy (geothermal, hydro, wind, biomass, ocean, etc.)*	MW (potential)	109,000

Source: DOE, *NREL, WWF

The Philippines is among the largest producers of geothermal power in the world next to the United States and Indonesia. It has been estimated that the country has a geothermal power potential of at least 5,000 MW. Untapped hydropower resource potential in the country is about 13,000 MW, 85% of which are considered large and small hydros (~11,000 MW), 14% are mini-hydros (1,800 MW) and less than 1% are considered micro-hydros (27 MW). Estimates from the Department of Agriculture (DA) and the Department of Environment and Natural Resources (DENR) reveal that the country's agriculture sector produces at least 270 million barrels of fuel oil equivalent (MMBFOE) of biomass annually.

Based on a wind resource analysis and mapping study[23], there are around 10,000 sites in the country with good to excellent resource levels equivalent to an annual average wind power of 300 W/m^2 or greater and can support at least 76,600 MW of installed capacity that could generate about 195,200 GWh/year. Using US-NREL's Climatological Solar Radiation (CSR) Model, it has been estimated that the country has an annual potential average of 5.1 kWh/m^2/day. Ocean energy potential capacity is estimated at about 17,000 MW[24]. Based on these various studies, the country's RE resource potential can generate up to 109,000 MW of electricity.

RE has long been a major contributor to the country's primary energy supply mix. In 2010, the country's total primary energy supply reached 40.7 million tons of oil equivalent (MTOE). Of this amount, 23.4 MTOE was sourced locally, setting the energy self-sufficiency level at 57.5%. RE resources contributed the highest share (68.1%) of the indigenous energy supply mix. Among the renewables, geothermal provided the biggest share of 53.2% of the RE supply mix. This is followed by biomass at 33.3% and hydro at 12.1%.

The National Renewable Energy Program (NREP) under the RE Law embodies DOE's objectives, goals, policies and strategies as well as programs and projects not only to further develop the renewable energy sector but as its primary program to combat climate change. NREP aims to increase use of green fuels such as geothermal, hydro, wind, biomass and solar, within the perspective of the sector's supply and demand prospects and current stage of

[23] US Department of Energy – National Renewable Energy Laboratory (NREL)
[24] HTTP://WWW.DOE.GOV.PH

development given its critical role in the country's energy future. Thus, mitigation actions from the energy sector in the INDC are mainly on RE programs and projects.

3.1.2 Power Generation

As of 2016, the country's total installed capacity is at 20,055 MW an increase of 3,893 MW from 16,162 MW in 2011 as shown in the figure below.

Table 3.3: Philippine Installed and Dependable Capacity by Plant Type[25]

Philippines														
Philippine Installed Capacity	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Coal	3,958	3,967	3,967	4,177	4,213	4,213	4,277	4,867	4,917	5,568	5,568	5,708	5,963	7,419
Oil Based	3,604	3,669	3,663	3,602	3,616	3,353	3,193	3,193	2,994	3,074	3,353	3,476	3,610	3,616
Natural Gas	2,763	2,763	2,763	2,763	2,834	2,831	2,831	2,861	2,861	2,862	2,862	2,862	2,862	3,431
Renewable Energy (RE)	4,799	5, 147	5,226	5,261	5,277	5,284	5,309	5,438	5,391	5,521	5,541	5,998	6,330	6,958
Geothermal	1,932	1,932	1,978	1,978	1,958	1,958	1,953	1,966	1,783	1,848	1,868	1,918	1,917	1,916
Hydro	2,867	3,217	3,222	3,257	3,293	3,291	3,291	3,400	3,491	3,521	3,521	3,543	3,600	3,618
Biomass Solar, Wind	0	0	26	26	26	34	64	73	117	153	153	437	812	1,424
Total	**15,124**	**15,548**	**15,679**	**15,803**	**15,941**	**15,681**	**15,610**	**16,359**	**16,162**	**17,025**	**17,325**	**17,944**	**18,765**	**21,423**
Philippine Dependable Capacity	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Coal	3,691	3,696	3,432	3,638	3,467	3,412	3,813	4,245	4,651	5,206	5,206	5,378	5,613	6,979
Oil Based	3,175	3,216	3,043	2,879	2,670	2,702	2,528	2,488	2,579	2,561	2,846	2,705	2,734	2,821
Natural Gas	2,703	2,703	2,703	2,703	2,703	2,562	2,700	2,756	2,770	2,760	2,760	2,760	2,759	3,291
Renewable Energy (RE)	3,828	4,251	4,419	4,407	4,650	4,370	4,285	4,413	4,478	4,539	4,559	4,789	5,325	6,005
Geothermal	1,568	1,560	1,685	1,682	1,667	1,387	1,322	1,350	1,434	1,462	1,482	1,607	1,601	1,689
Hydro	2,260	2,690	2,725	2,715	2,973	2,950	2,919	3,021	2,963	2,983	2,983	2,982	3,073	3,181
Biomass Solar, Wind	0	1	10	10	10	34	44	41	80	94	94	201	651	1,135
Total	**13,397**	**13,865**	**13,598**	**13,627**	**13,490**	**13,047**	**13,326**	**13,902**	**14,477**	**15,066**	**15,371**	**15,633**	**16,432**	**19,097**

The huge increase is associated to the increased installation of large coal-fired power plants as baseload capacities for stable and reliable power supply. On the other hand, the installed capacity of Renewable Energy (RE), both the conventional type such as geothermal, hydroelectric and biomass, and the variable RE such as solar and wind grew significantly during the period. From 5,391 MW in 2011, RE installed capacity increased in 2016 at about 6,958 MW (Table 3.3). This is due to the continuous promotion and encouragement of the DOE to RE developers through fiscal and non- fiscal incentives, such as the Feed-In Tariff (FIT) and Must/ Priority Dispatch System under the RE Law.

[25] Source: DOE, Power Development Plan 2016-2040.

3.1.3 Climate Change Impacts

In 1994, the Philippines prepared and submitted its first GHG inventory report as part of its commitment to the UNFCCC (DENR, 1999). The GHG inventory[26] showed that a total equivalent amount of 100.8 $MtCO_2$-eq was released into the atmosphere[27].

The Energy Sector accounted for about 49% (50 $MtCO_2$-eq) of the national GHG total emissions and trailed closely by the Agriculture and Industry sectors' contribution of 33% and 11%, respectively (see Figure 1.1).[28]

In 2009 or 15 years after the first GHG inventory, statistics from DOE showed that the Energy Sector generated 68.91 $MtCO_2$-eq of emissions (Table 3.4). This is a 38% increase from the 50 $MtCO_2$-eq emissions in 1994. Electricity generation accounts for 39.9% of the total emissions, followed by the transport sector at 35.6%, industry (17.0%) and the remaining 7.5% from the commercial, agricultural and residential sectors combined.

Table 3.4: 1994 and 2009 CO_2 Emissions from the Energy Sector

Sector	CO_2 Emissions (in $MtCO_2$-eq)			
	1994	%	2009	%
Industry	9.50	19.0	11.71	17.0
Transport	15.89	31.8	24.50	35.6
Power Generation	15.51	31.0	27.48	39.9
Others (1)	9.12	18.2	4.84	7.5
Total GHG Emissions	**50.03**	**100.0**	**68.91**	**100.0**

Data Source: DOE for 2009 and DENR for 1994.
(1) Commercial, agricultural and residential sectors plus fugitive emissions.

It can be noted that emissions grew at an annual average of 0.6% for the period 1994 – 2009. The GHG emissions are largely CO_2 and, as it was in 1994, come mainly from fuel combustion in the electricity generation, transportation, and industrial sectors (Figure 3.1).

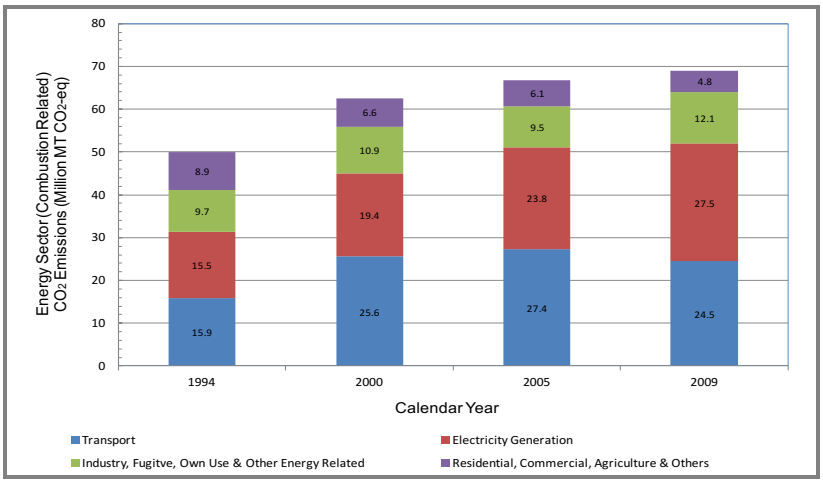
3.1.3.1 CO_2 Emissions from Electricity Generation

CO_2 emission from oil has reduced from 49 to 39 million MT CO_2-eq between 2000 and 2009 due to reduction in the use of oil and a corresponding increase in the share of coal and

[26] Covers the four sectors of Energy, Industry, Agriculture, and Wastes, and the net uptake (sink) of GHGs from the Land Use Change/Forestry (LUCF) sector
[27] Excluding the contribution of the LUCF sector.
[28] Source: The Philippines' Initial National Communication on Climate Change to the UNFCCC. 19 May 2000. http://unfccc.int/national_reports/non-annex_i_natcom/items/2979.php

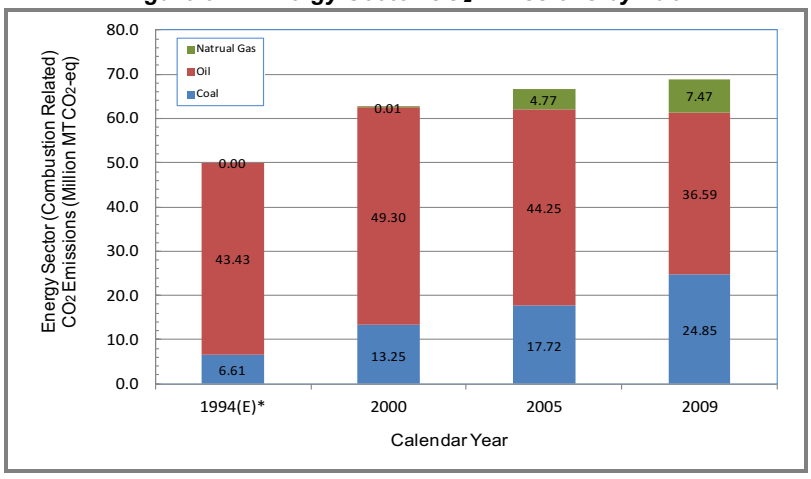
gas in the electricity generation sector. In 2009, combustion of oil accounted for 36.59 $MtCO_2$-eq/y, coal for 24.85 $MtCO_2$-eq/y, while use of natural gas contributed 7.47 $MtCO_2$-eq/y (Figure 3.3). These figures represent 53.1%, 36.1% and 10.8%, respectively, of the country's total annual CO_2 emissions. Figure 3.2 represents the combustion related CO_2-eq emissions contributed by each fuel type (i.e. coal, natural gas, and oil) between 1994 and 2009.

Figure 3.1: Total CO_2 Emissions from Fuel Combustion



Source: DOE and DENR

Figure 3.2: Energy Sector CO_2 Emissions by Fuel



Source: DOE and DENR

3.1.3.2 Projected Emissions

Based on the projected additional generation capacity under the DOE Power Development Plan for 2012-2030, the corresponding additional CO_2 emissions from committed and indicative fossil-based power plants in Luzon, Visayas and Mindanao would be 30.93 Mt/y by the year 2020 (Table 3.5). The additional CO_2 emissions of about 75.3% (or 23.29 Mt/y) will come from new plants in Luzon. These figures are estimated based on typical emissions of 950 kg CO_2/MWh for coal-fired subcritical plants, 340 kg CO_2/MWh for natural gas combined cycle (NGCC) plants and 600 kg CO_2/MWh for oil-fired plants, and assuming an 80% capacity factor for all plants.

Table 3.5: Estimated CO_2 Emissions from New Power Plants by 2020*

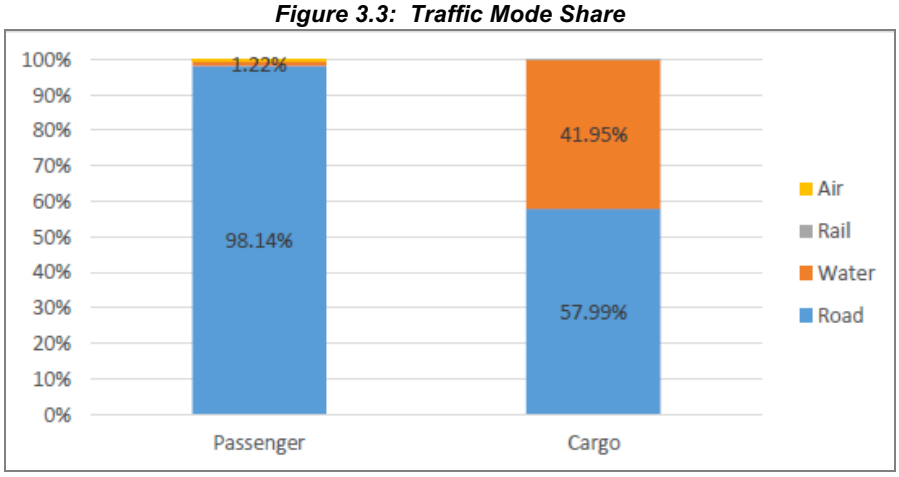
Grid	Coal-Fired Plants		Natural Gas-Fired Plants		Diesel/Oil-Fired Plants	
	Additional Capacity (MW)	Additional CO2 Emissions (Mt/y)	Additional Capacity (MW)	Additional CO2 Emissions (Mt/y)	Additional Capacity (MW)	Additional CO2 Emissions (Mt/y)
Luzon	2,885	19.21	850	2.04	21	0.88
Visayas	446	2.97	0	0	0	0
Mindanao	700	4.67	0	0	27.5	1.16
Total	**4,031**	**26.85**	**850**	**2.04**	**48.5**	**2.04**

Source: ADB - * Emissions are the projected additional amounts starting in year 2010.

3.2 Overview of the Transport Sector

The ever growing demand for transportation, both passenger and freight, has had significant implications to the Philippine economy, society and environment, including those related to climate change. Transportation goals are mainly centered on the provision of reliable, efficient, timely and safe transportation services that allow people and goods to move around. The reduction of GHG emissions in the transport sector equates to better energy efficiencies of the system components and thus savings in terms of fuel costs, operating and maintenance costs, as well as reductions in other externalities such as local air pollutants.

Figure 3.3: Traffic Mode Share



Source: AUSAID, 2008

Thus mitigating GHG emissions from the transportation sector is a major government initiative towards alleviating impacts on the changing climate. Mitigating GHG emissions from the sector would be essential, not just in terms of contributing to the global efforts to reduce climate change, but also in terms of achieving national goals such as reducing imported energy dependence, improving system efficiencies and reducing costs, as well as providing access and timely transport services to the public.

Available information (AUSAID, 2008) reveals that road transport is the main mode for passenger traffic (in terms of passengers) and road transport and water transport are the main modes for moving cargo (Figure 3.3).

3.2.1 Climate Change Impacts

The direct impacts of climate change in relation to transportation would be mostly felt through the transportation infrastructure. Higher temperatures can cause road pavements to soften and expand and can create disturbances in the integrity of the road infrastructure in general and can therefore increase the total costs of maintenance. Exposure to flooding can also shorten the expected life of roadways. Similar impacts can happen to railway infrastructure-higher temperatures can affect railway tracks, heavy rains can lead to disruptions and delays in operation, as well in maintenance activities. Heavy precipitation will also impact air transport vehicles as well as air travel in general. Similar negative impacts can be observed for water transportation, as disruptions in precipitation can affect shipping channels. Coastal infrastructure will also be directly impacted by storm surges and changes in sea levels. World Bank (2009) estimates that typhoons Ondoy and Pepeng caused transport-related damages and impacts

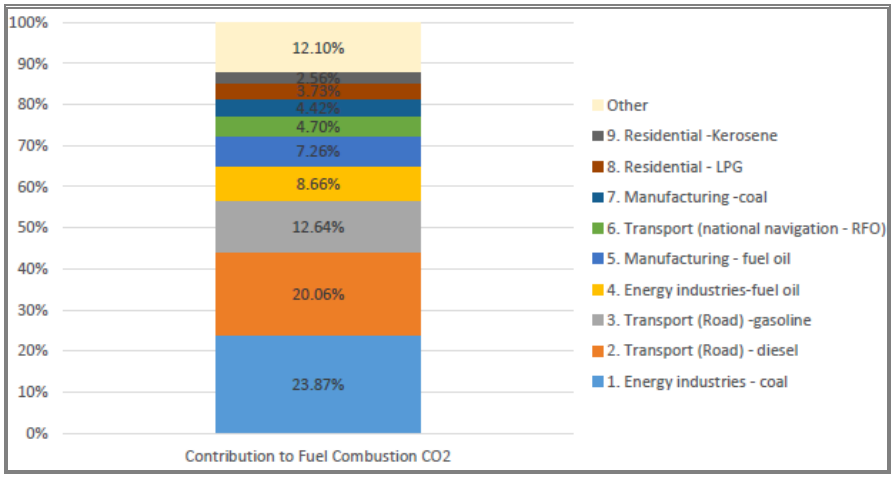
equivalent to PhP 7.5 billion, i.e., PhP 2.6 billion damages to national roads, PhP 3.9 billion damages to local roads and PhP 1 billion damages in transport losses.[29]

Unusual weather events, such as recent strong storms that have plagued the country, can also lead towards flooding of roadways and other transportation infrastructure, which directly disrupt transportation behavior as well as cause delays in repairs and maintenance activities. Moreover, in times of emergencies, fully functioning transportation systems are of utmost importance in order to ensure timely delivery of supplies and aid.

A closer look at the energy sector GHG emissions reveal that the transportation sector is the biggest contributor among the energy sub-sectors which include the following: power generation/energy industries; industries; residential; agriculture/forestry/fishing; commercial; fugitive. The contribution of the transportation sector to the total GHG emissions from the energy sector has gone up from 32% in 1994 to 37% in 2000. The sector has contributed 15.8 million tCO2e in 1994 and 25.9 million tCO2e in 2000. This translates to an annual growth rate of 8.5% between the years 1994 to 2000. This is much higher than the growth rate of the total energy-related GHG emissions at 5.7% per annum.

Road transportation is a key segment of the energy sub-sector fuel contribution when it comes to GHG emissions. Further analysis of the 2000 GHG inventory values reveal that road transportation contribute about 32% (gasoline at 12.64% and diesel at 20.06%) or a third of the total energy-related CO2 emissions in the Philippines as shown in the graph below (Figure 3.4):

Figure 3.4: Energy Sub-sector Fuel % Contribution to Total GHG Emissions

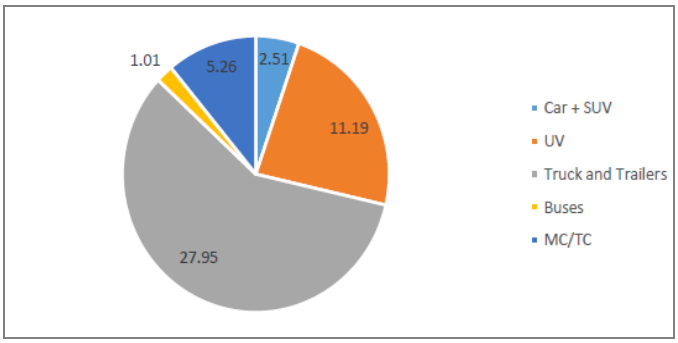


Source: Data from the Second National Communications to the UNFCCC

[29] Source: "Revised First Interim Report (Parts I and II): Sub-Contract for the Development of Nationally Appropriate Mitigation Actions (NAMAs) by Berkman International. Inc. for the Climate Change Commission-UNDP Low Emission Capacity Building Philippine Project.

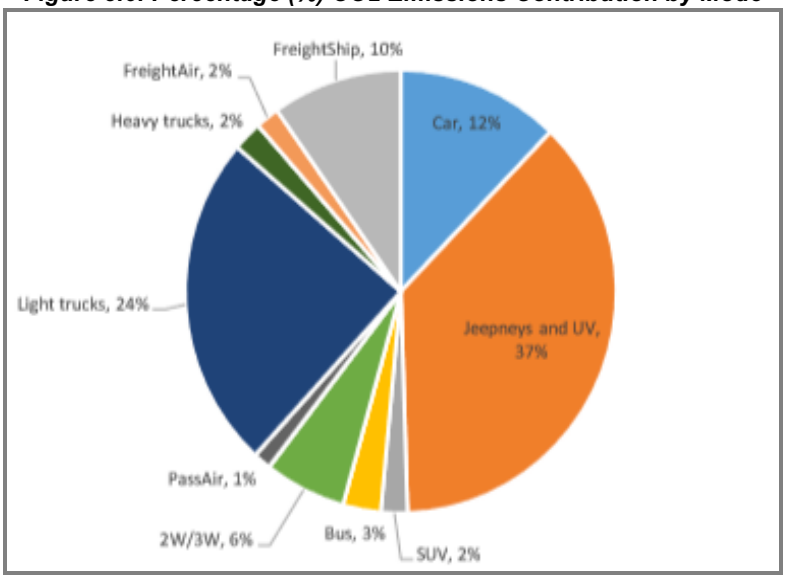
A study conducted by Clean Air Asia (2012) estimated the CO2 contribution of the different vehicle types from the road transport sector using the ASIF framework (activity – structure – intensity – emission factor). The study takes into consideration the number of vehicles on the road, the estimates in terms of vehicle activity per vehicle type, the composition of the vehicle types in terms of fuel used, fuel efficiencies of different vehicle-fuel segments and the amount of CO2 per amount of fuel. Figure 3.5 shows the estimated contribution of the different road vehicle types to CO2 emissions in 2010, based on this study.

Figure 3.5: Estimated % Contribution to GHG Emissions from the Road Transport Sub-Sector



Another study by Regidor and Javier (2014) which was undertaken under the Institution for Transport Policy Studies and Clean Air Asia on Long-Term Action Plans for the ASEAN Region, provides an estimated break down of emissions per mode (CO2 emissions for the transport sector) using 2005 as base year, as shown in Figure 3.6 below.

Figure 3.6: Percentage (%) CO2 Emissions Contribution by Mode



3.2.2 Projected Emissions

As part of SNC reporting, a key category analysis (KCA) of emission sources was undertaken to prioritize sectors/sub-sectors which contributed greatly to the country's emissions. The results are presented in the table below:

Table 3.6: Key Category Analysis Results, SNC*

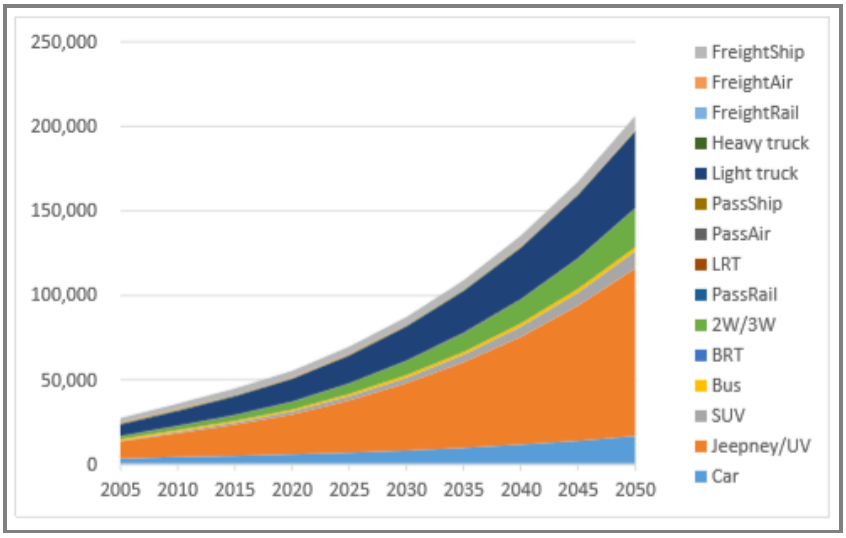
Sectors	Sub-sector emission sources	% contribution to total
Transport	CO2 emissions from mobile combustion-road vehicles	**19.3**
Agriculture	CH4 emission from rice production	**15.6**
Industry	CO2 emission from manufacturing industries and construction	**8.5**
Agriculture	N2O direct and indirect emissions from agricultural soils	**8.5**
Agriculture	CH4 emission from enteric fermentation on domestic livestock	**6.3**

** **Excluding LUCF***

The KCA results reinforce the transport sector, particularly mobile combustion's significant contribution to climate change. Thus, the need to single-out potential sources so that mitigation actions can effectively address CO2 emissions associated with it.

The study by Regidor and Javier (2014) shows that GHG emissions from the transport sector may possibly grow at an annual rate of 4.6% from 2005-2050 (Figure 3.7), increasing up to 206 ktCO2e in 2050, 7.6 times the 2005 value (27.2 ktCO2e).

Figure 3.7: CO_2 Projections for the Transport Sector

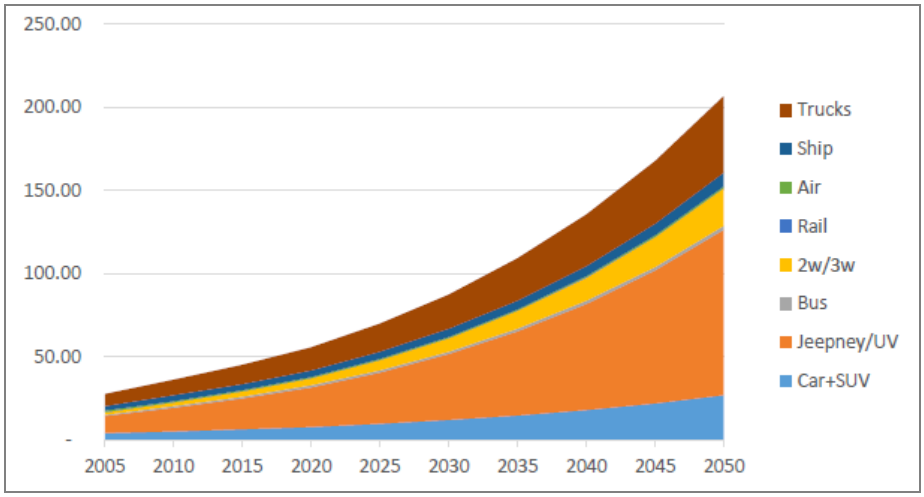


The study also implemented a similar calculation methodology utilizing the ASIF parameters and projected the CO2 emissions from the transport sector up to 2050 (Figure 3.8). The study reveals that under a business-as-usual scenario, the emissions from the transport sector (land, air, water) will grow annually by 4.6% from 2005- 2050. The 2005 CO2 emissions (27 million tons CO2) will double by 2020, triple by 2030 and will be multiplied 7.5 times by 2050 (206 million tons) with 96% of the 2050 emissions coming from road vehicles. This translates to a per capita CO2 emission for transport at 1.3 tons by 2050 (0.31 tons in 2005).

3.3 Overview of the Waste Sector

The Philippines' Initial National Communication on Climate Change (INC), that was based on the year 1994 data and published in 2000, and the Second National Communication that used the year 2000 data have included the waste sector as one of the five (5) sectors for greenhouse gas (GHG) inventory, along with energy, agriculture, land use change and forestry (LUCF), and Industrial Processes and Product Use.

Figure 3.8: Projected GHG Emissions from the Transport Sector (million tons CO2e)



In the comparative summary of sectoral emissions from these two reports, as shown in Table 3.7, and excluding the estimated emissions of the LUCF sector, the waste sector emissions in 1994 comprises 7% of the total net. This has increased to 9% during the second inventory in the year 2000, a 64% net GHG emissions increase in six years.

Table 3.7: GHG Emissions Comparison by Sector, INC and SNC (in Gg CO2e)

Sectors	1994: INC		2000: SNC		% change
	(Gg CO2e)	*%*	*(Gg CO2e)*	*%*	*+/-*
Energy	50,038.00	49.61	69,667.24	54.91	39%
Waste	7,094.00	7.03	11,599.07	9.14	64%
Agriculture	33,130.00	32.85	37,002.69	29.16	12%
LUCF	-126		-105,111.37		83322%
Industrial Processes	10,603.00	10.51	8,609.78	6.79	-19%
Totals	100,739.00		21,767.41		-78%
Totals (net of LUCF)	100,864.00	100.00	126,878.78	100.00	26%

Waste sector emissions are classified under four (4) subsectors: solid waste and the three sub-groups of wastewater, namely: domestic/commercial wastewater, industrial wastewater, and human sewage. The SNC specified that solid waste disposal on land contributes to methane (CH4) while wastewater contributes methane and nitrous oxide (N_20).

3.3.1 Climate Change Impacts

Not only does the management of wastes contribute to GHG emissions. The quantity of wastes generated and the greenhouse gas emitted are associated with human consumption. The manufacture, distribution and use of goods and food as well as the management of the resulting wastes all require energy. And most of this energy comes from fossil fuels, which are the largest global source of heat-trapping greenhouse gas emissions (US-EPA, 2014).

Climate change likewise impact on waste management in some degree to waste management infrastructure such as landfills and wastewater treatment facilities. Solid waste disposal sites have a significantly long-lived pollution potential due to methane production and potential leachate escape. Increased temperatures could cause more problems with pests at these disposal sites. Also, incidence of extreme weather events could make current infrastructure vulnerable to flooding and rising sea levels. These impacts need to be understood so that measures can be put in place to ensure resilience to such events while future facilities have to consider these potential impacts.

3.3.2 Projected Emissions

For waste, the mass balance approach which was used in the INC and the First Order Decay (FOD) Model of the most recent IPCC guidelines which was used in the SNC are the two approaches used in calculating GHG emissions. The comparative emissions for the waste sub-sectors using mass balance approach are shown in the table below:

Table 3.8: Comparative Waste Subsectors GHG Emissions, INC and SNC (in Gg CO2e)

Sectors	1994: INC		2000: SNC		% change
	(Gg CO2e)	*%*	*(Gg CO2e)*	*%*	*+/-*
Energy	50,038.00	49.61	69,667.24	54.91	39%
Waste	7,094.00	7.03	11,599.07	9.14	64%
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LUCF	-126		-105,111.37		83322%
Industrial Processes	10,603.00	10.51	8,609.78	6.79	-19%
Totals	100,739.00		21,767.41		-78%
Totals (net of LUCF)	100,864.00	100.00	126,878.78	100.00	26%

The waste sector GHG emissions increased by 64% which may be attributed to the increase in population, thus the increase in demand for food and goods may have resulted to more wastes from manufacture and eventually consumption of these food and goods. Solid wastes increased by 28% while those from wastewaters increased by around 117%. It will be noted that in the 1994 inventory, solid wastes comprise approximately 60% of the total wastes GHG emissions with wastewater comprising the remaining 40%. In the year 2000 inventory, however, this trend was reversed, with GHG emissions from solid wastes comprising about 47% and 53% from wastewater handling. The significant increase of emissions came from municipal wastewaters brought about by urbanization of communities and the increasing efforts of abating GHG emissions from the solid waste sector.

3.4 Process and Criteria of Prioritization

The list of mitigation actions/options which were identified by stakeholders from the selected sectors and considered in the INDC submitted by the Government to the UNFCCC under the Paris Agreement were subjected to the Multi-Criteria Analysis (MCA). MCA is a structured approach used to determine overall preferences among alternative options. It is also used as a decision-making tool where techniques can be used to identify a single most preferred option, to rank options, to short-list a limited number of options for subsequent detailed appraisal, or simply to distinguish acceptable from unacceptable possibilities.

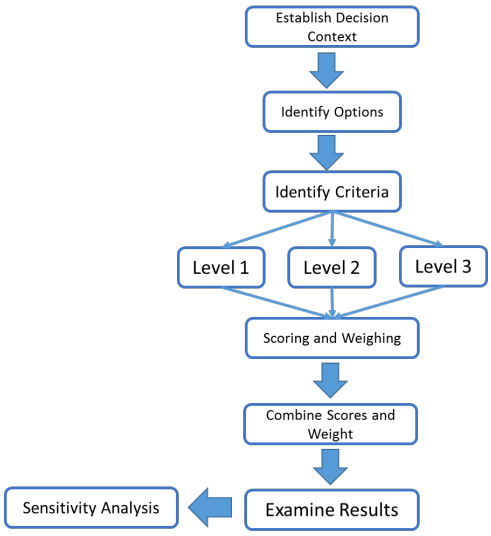
3.4.1 Mitigation Options in the INDC

The CCC through its UNDP-Low Emission Capacity Building Philippine (LECB PHL) Project and with support from its development/institutional partners, spearheaded the conduct of a series of MCA workshops, focus group discussions and consultation meetings on the mitigation options with stakeholders from the AWIT-FE[30] sectors. The activities resulted in the ranking of mitigation options which were considered in the development of the INDCs.

The following is the methodology core of the MCA [31] used in the selection and prioritization of mitigation options in the prioritized sectors, i.e., energy, transport and waste (Figure 3.9):

1. Establish the criteria to evaluate each option on how it meets the objectives of the decision making;
2. Based on indicators for criteria, develop a performance matrix;
3. Based on performance matrix, score the technology;
4. Assigning weights to the criteria;
5. Calculate overall weighted scores for each option;
6. Examine the result and decide on the ranking of options; and
7. Subject the results to sensitivity analysis, if needed.

Figure 3.9: MCA Methodology Flowchart[32]

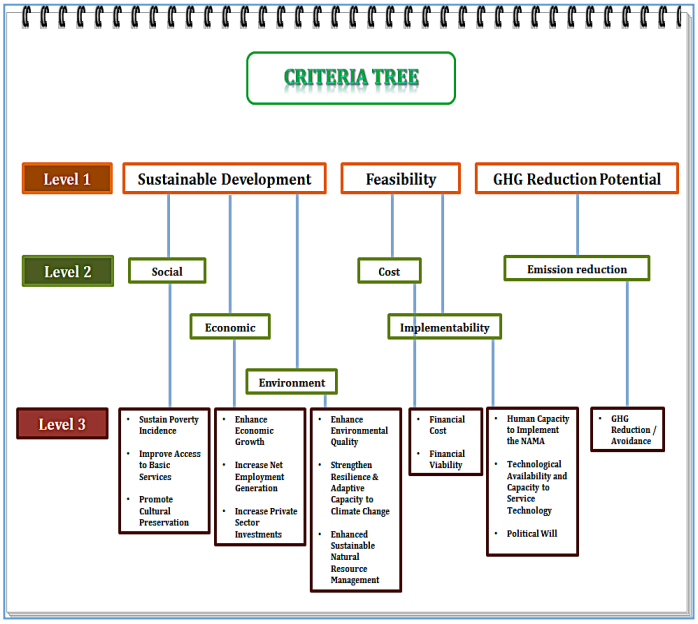


The INDC mitigation options were grouped and categorized as follows (Figure 3.10)[33]:

[30] Agriculture, Waste, Industry, Transport, Forestry and Energy
[31] Power point presentation on the Basic concepts of MCA, by Denis Desgain (UNEP Risoe Centre), Training workshop on Multi-Criteria Analysis (MCA) for prioritization of NAMA in the Philippines, Manila, Philippines, 9-10 December 2013.
[32] Source: CCC-UNDP LECB PHL Project

1. Climate Change Impacts
   a. GHG Reduction Potential (specific GHG reduction/ avoidance)
2. Mitigation Characteristics
   a. Cost (financial cost/ viability)
   b. Implementability (human capacity to implement the actions, technological capacity and availability to service the technology, and political will)
3. Sustainable Development Impacts
   a. Economic
   b. Social
   c. Environmental.

Figure 3.10: MCA Criteria Tree for Mitigation



The first-level criteria as well as the weights have been set or fixed by CCC, as follows: sustainable development (60%), feasibility (20%) and GHG reduction potential (20%). On the other hand, the weights for the second- and third-level criteria were decided on by the sectoral lead national government agencies (NGAs) of AWIT-FE.

The results of the MCA for the prioritized sectors of Energy, Transport and Waste are shown in Figures 3.11 to 3.13.[34]

Figure 3.11: Result of MCA for Energy

[33] Source: CCC-UNDP LECB PHL Project

[34] Climate Change Commission-UNDP Low Emission Capacity Building Philippine (LECB PHL) Project - Case Study: Prioritization of Climate Change Mitigation Options in the Sectors of Transport, Energy, Waste, and Forestry in the Philippines. Unpublished.

Criteria Level 1	Criteria Level 2	%	Mitigation Activities / Programs																	
			Energy efficient street lighting - HPS & LED		NREP Biomass		NREP Small Hydro		NREP Large Hydro		NREP Wind		NREP Solar		NREP Ocean		NREP Geothermal		*Substituting Natural Gas for Coal (last)*	
			%	Result	%	Result	%	Result	%	Result	%	Result	%	Result	%	Result	%	Result	%	Result
GHG Reduction Potential	Specific GHG reduction/avoidance (tCO2e)	**0.2**	53	10.6	33	6.6	43	8.6	90	18	57	11.4	5	1	10	2	76	15.2	71	14.2
Feasibility	Implementability	**0.12**	90	10.8	70	8.4	100	12	50	6	60	7.2	60	7.2	10	1.2	90	10.8	10	1.2
	Cost	**0.08**	76	6.08	48	3.84	33	2.64	14	1.12	71	5.68	62	4.96	67	5.36	95	7.6	19	1.52
Sustainable Development	Economic	**0.36**	20	7.2	80	28.8	90	32.4	95	34.2	60	21.6	40	14.4	30	10.8	95	34.2	40	14.4
	Social	**0.138**	80	11.04	70	9.66	80	11.04	70	9.66	55	7.59	80	11.04	50	6.9	85	11.73	40	5.52
	Environment	**0.102**	90	9.18	90	9.18	80	8.16	50	5.1	80	8.16	90	9.18	40	4.08	50	5.1	70	7.14
RESULTS				**54.9**		**66.5**		**74.8**		**74.1**		**61.6**		**47.8**		**30.3**		**84.6**		**44.0**

Source: CCC-UNDP LECB PHL Project

The prioritized INDC mitigation options for energy were ranked as follows (Figure 3.12): No. 1-NREP Geothermal (84.6%), No. 2-NREP Small Hydro (74.8%), and No. 3-NREP Large Hydro (74.1%).

On the other hand, the prioritized INDC mitigation options for transport were ranked as follows (Figure 3.12): No. 1-Congestion Charging (54.5%), No. 2-Jeepney Modernization (51.8%), and No. 3-MVIS (51%). The Jeepney Modernization mitigation option is now called PUV Modernization Program.

Figure 3.12: Result of MCA for Transport

Criteria Level 1	Criteria Level 2	%	Mitigation Programs/Actions													
			Congestion Charging		MVIS		Enhanced Bus Services		Driver Training		Jeepney Modernization		Air Traffic Control Improvement		Airport Taxiway Improvements NAIA	
GHG Reduction Potential	Specific GHG reduction/ avoidance (tCO2)	0.2	75	15	56	11.2	25	5	50	10	94	10.8	38	7.0	31	6.2
Feasibility	Implementability	0.12	45	5.4	60	7.2	80	9.6	40	4.8			100	12		8.4
	Cost	0.08	62	4.96	69	5.52	77	6.16	46	3.68	54	4.32	0	0	0	0
Sustainable Development	Economic	0.18	80	14.4	0	0	41.71	7.508	0	0	6.4	1.152	0	0	0	0
	Social	0.21	60	12.6	90	18.9	95	19.95	90	18.9	75	15.75	80	16.8	80	16.8
	Environment	0.21	10	2.1	39	8.19	3	0.63	0	0	33	6.93	0	0	0	0
Results				**54.5**		**51**		**48.8**		**42.2**		**51.8**		**36.4**		**31.4**

Source: CCC-UNDP LECB PHL Project

Figure 3.13: Result of MCA for Waste

Criteria Level 1	Criteria Level 2	%	NAMA OPTIONS											
			WTE Conversion of Residual Waste		Composting		Eco-Efficient Soil Cover		Methane Recovery at D.S (Flaring)		Methane Recovery at D.S (Elect.)		Methane Recovery at A.D.	
GHG Reduction Potential	Specific GHG reduction/ avoidance (tCO2 /tWaste)	0.14	3	0.42	5	0.7	1	0.14	3	0.42	4	0.56	5	0.7
	Scalability of GHG reduction/ avoidance (tCO2e)	0.06	2	0.12	5	0.3	5	0.3	2	0.12	1	0.06	5	0.3
Feasibility	Implementability	0.12	2	0.24	5	0.6	3	0.36	3	0.36	3	0.36	2	0.24
	Cost	0.08	1	0.08	5	0.4	2	0.16	5	0.4	1	0.08	2	0.16
Sustainable Development	Economic	0.24	5	1.2	1	0.24	0	0	0	0	2	0.48	3	0.72
	Social	0.12	5	0.6	3	0.36	5	0.6	3	0.36	3	0.36	3	0.36
	Environment	0.24	5	1.2	5	1.2	5	1.2	5	1.2	5	1.2	5	1.2
Results				**3.86**		**3.8**		**2.76**		**2.86**		**3.1**		**3.68**

Source: CCC-UNDP LECB PHL Project

Finally, the prioritized INDC mitigation options for waste were ranked as follows (Figure 3.13): No. 1-WTE-Conversion of Residual Waste (3.86%), No. 2-Composting (3.8%), and No. 3-Methane Recovery (3.68%).

The results of these MCAs were then used as reference in the prioritization of technology needs of the selected sectors for the TNA study, i.e., energy, transport and waste.

3.4.2 TNA on Mitigation

The TNA Study followed the recommended prioritization process:

1. Identifying development priorities;
2. Identification of sectors with high vulnerability to climate change; and
3. Prioritization of sectors in terms of development priorities, and vulnerability to climate change.

For the TNA for the Mitigation Sector, the following consultative activities with stakeholders were undertaken:

1. TNA Consultation, 6 February 2018, Training Room, Department of Energy, Taguig City, Metro Manila
2. TNA Consultation, 19 March 2018, 4/F PNOC Building V, Bonifacio Global City, Taguig City, Metro Manila
3. TNA Consultation, 24 April 2018, B Hotel, Scout Rallos Street, Quezon City, Metro Manila.

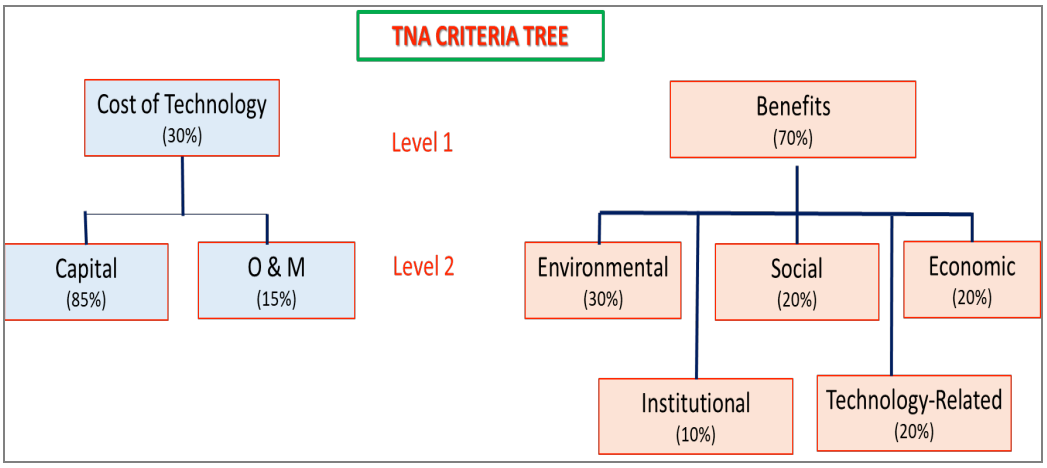
Stakeholders from the Mitigation Sector of the TNA study were requested to submit their priority list of technology needs (see Annex II). It was decided during these consultations that for this TNA study, the mitigation actions/options, as discussed above, that were identified and prioritized in the INDC submitted by the Government to the UNFCCC, will be used as initial basis or references in the identification, selection and prioritization of technology needs.

Most of the technologies in the INDC are already matured and internationally available and would only require diffusion of the same, for the Government to implement and achieve its development plans, programs and projects. In the energy sector, for example, energy resource development projects are implemented or undertaken on the ground by the private sector through the Service Contract System. Under the system, all technical and financial resources needed for the development of energy resources are provided for by private companies. Likewise, construction of corresponding power plant facilities for these energy resources are undertaken by private/independent power producers.

Thus, it was decided upon that relatively new and emerging technologies including those that need further promotional activities, and which are needed in the achievement of the Government's development plans and programs, especially its NDCs, be prioritized. The MCA Criteria Tree for the TNA study is shown in Figure 3.14 below.

The first-level criteria as well as the weights have been set or fixed by CCC, per the TNA Process, as follows: Cost of Technology (30%) and Benefits (70%). On the other hand, the weights for the second-level criteria were decided on by stakeholders of the energy, transport and waste sectors.

Figure 3.14: TNA Criteria Tree



Chapter 4: Technology Prioritization for the Energy Sector

4.0 An Overview of Possible Mitigation Technology Options and Mitigation Benefits

A comparative Strength-Weakness-Opportunities-Threats (SWOT) analysis[35] showed that the most attractive investment area among RE power technologies would be in the wind sector in view of its faster deployment, expansion potential (due to its modular nature), a wider selection of project locations, and wind power's increasing price competitiveness. However, due to its intermittent and seasonal nature, wind power cannot be used as baseload plant.

Small hydropower offers the least cost base-load electricity, especially in isolated grids in mountainous areas. It uses the most proven technology, and offers ancillary benefits of providing water supply and irrigation. The size of a hydropower project however should address any adverse social or environmental impact.

While geothermal power is the most reliable among RE technologies and is ideal as base load power, its site-specificity limits its wider applicability.

Biomass is an ideal and efficient source of energy for transport and household use, however, it requires tremendous infrastructure support and logistics as a fuel source for power generation. Biomass power projects are ideally not developed as stand-alone power projects, but instead would need strong partnerships with agricultural companies, farmer organizations, and logistic consolidators. Although biomass power may not be the most efficient of all RE power technologies, it is often attractive to host governments in view of its rural livelihood opportunities.

Solar power is the least competitive among the five RE power technologies studied, because of its high cost per kWh. Solar home systems in particular require extensive distribution networks because of its retail oriented nature. Solar power will be a viable investment only in areas where Government can provide significant subsidy, e.g. Barangay Electrification Program.

The production cost associated with RE power plants is broken down into capital, operations & maintenance (both fixed and variable) and fuel costs (if any).

1. Capital costs for RE-based resources are generally higher compared to fossil-based generating plants because the latter can be built in larger capacities, thus gaining some measure of economies of scale.

[35] Source: ***Perez, Vincent S. Jr., (2006)***, Paper Thesis on "Renewable Power in Emerging Countries: A Business Case for Investing in Renewable Power in Emerging Countries", World Fellows Program, Yale University, USA.

2. Overall O&M costs for RE-based power plants are higher than for coal- and oil-fired generating plants. Again, this is due to economies of scale and low capacity factors for some RE sources.
3. RE-technologies like wind farms and hydro do not incur fuel cost. On the other hand, steam (fuel) cost for geothermal power plants varies, depending on the nature, and characteristics of the resource. This may be also true for biomass-powered facilities whose fuel cost may vary depending on factors such as tipping fees, waste transportation/acquisition costs, etc.
4. The overall generation cost of RE-based power plants are almost always cost competitive as compared to oil-fired and to coal-fired generating stations.
5. The production cost of RE-plants are below the generation charges imposed by utilities and do not adversely impact the cost of power to end-users or to their customers.

4.1 Current Status of Technologies in the Energy Sector

The Philippine Energy Plan (PEP) 2016-2030 contains the policies, plans and programs that will significantly contribute to the country's transition towards a low carbon economy – an economy that generates minimal output of GHG emissions into the biosphere. In the update to the PEP, the DOE is in the process of formulating a responsive and dynamic energy mix, as well as establishing the local reserve requirements to further support the growing industrialization of the Philippines.[36] The energy mix will be technology neutral and will identify power requirement based on plant categorization. Based on the new energy mix policy for power generation, the power plant technologies considered per type of operation are as follows:

1. 70 percent baseload capacity from coal, geothermal, big hydropower, natural gas, nuclear and biomass (during availability of feedstocks);
2. 20 percent mid-merit capacities from natural gas;
3. 10 percent of peaking capacities from oil-based plants and variable renewable energy such as solar photovoltaic (during daytime) and wind.

The above policy can be best applied to island electrification in power development planning. It will also provide energy planners and policy makers the platform for exploring the possibility of going nuclear. Likewise, for the energy sector, the policy is expected to address pressing issues such as the high cost of electricity, sporadic power interruptions, limited and unreliable transmission system, delayed and unpredictable permitting process in the application for power projects, limited power electricity market and electrification gaps in off-grid areas.

[36] Source: HTTPS://WWW.DOE.GOV.PH/PEP. Date accessed: 10 May 2018.

4.1.1 The National Renewable Energy Program (NREP)

NREP outlines the policy framework enshrined in Republic Act 9513, Renewable Energy Act of 2008. It sets out indicative interim targets for the delivery of renewable energy within the timeframe of 2011 to 2030. The NREP lays down the foundation for developing the country's renewable energy resources, stimulating investments in the RE sector, developing technologies, and providing the impetus for national and local renewable energy planning that will help identify the most feasible and least-cost renewable energy development options.

The NREP seeks to increase the RE-based capacity of the country to an estimated 15,304 MW by the year 2030, almost triple its 2010 level (Table 4.1). On a per technology basis, the NREP intends to: (i) increase geothermal capacity by 75.0 percent; (ii) increase hydropower capacity by 160 percent; (iii) deliver additional 277 MW biomass power capacities; (iv) attain wind power grid parity with the commissioning of 2,345 MW additional capacities; (v) mainstream an additional 284 MW solar power capacities and work towards achieving the aspirational target of 1,528 MW; and (vi) develop the 1st ocean energy facility for the country.

Table 4.1: National Renewable Energy Program[37]

Sector	Installed Capacity (MW) as of 2010	Target Capacity Addition by				Total Capacity Addition (MW) 2011-2030	Total Installed Capacity by 2030
		2015	2020	2025	2030		
Geothermal	1,966.0	220.0	1,100.0	95.0	80.0	1,495.0	3,461.0
Hydro	3,400.0	341.3	3,161.0	1,891.8	0.0	5,394.1	8,724.1
Biomass	39.0	276.7	0.0	0.0	0.0	276.7	315.7
Wind	33.0	1,048	855.0	442.0	0.0	2,345.0	2,378
Solar	1.0	269.0	5.0	5.0	5.0	284.0	285.0
Ocean	0.0	0.0	35.5	35.0	0.0	70.5	70.5
Total	**5,438.0**	**2,155.0**	**5,156.5**	**2,468.8**	**85.0**	**9,865.3**	**15,304.3**

4.1.2 Energy Efficiency

The National Energy Efficiency and Conservation Program (NEECP) long term vision is to make energy efficiency "a way of life" for Filipinos. It is then further stated as "an energy efficient nation that contributes in achieving the country's economic development and helps ensure energy security, optimal energy pricing and sustainable energy systems." The objective

[37] Source: DOE

is also stated that the final energy demand of the country needs to be reduced by 10% cumulatively by the end of the 2011- 2030 period.

4.1.3 Feed-in Tariff

Section 7 of the Renewable Energy Act of 2008 mandates, among others, the setting of the FITs to apply to wind, solar, run-of-river hydro, biomass, and ocean RE resources. Under the FIT system, the eligible RE developers will be paid the FITs applicable to them for the energy they feed into the grid. The categorization of technologies under the FIT system is shown in Table 4.2.

Table 4.2: Technology Categorization, Feed-in Tariff System[38]

Technology	Fuel Capacity	Size of Representative Project
Biomass		
Cogeneration of Heat and Power	Bagasse and other feedstocks	12.4 MW
Straight Power Generation	Agricultural residues, woodchips & other biomass	8.3 MW
Waste to Energy	Livestock waste	1.0 MW
Waste to Energy	Municipal waste	8.3 MW
Run-of-River Hydro		
Micro Hydro	<= 100 kW	
Mini Hydro	100kW – 10 MW	8 MW
Small Hydro	> 10 MW	15 MW
Ocean		10 MW
Solar		
Residential	<= 100 kW	50 kW
Ground Mounted	> 100 kW	20 MW
Building-Installed	> 100 kW	10 MW
Wind		
Residential	<= 100 kW	
Commercial	> 100 kW	30 MW

[38] Feed-in Tariff Review (2010). Prepared by Benito, F. and Pacudan, R., for Asian Development Bank. Unpublished, 74pp.

4.2 Selection of Mitigation Options

The mitigation options in the INDC were selected based on the following considerations/process set by the CCC:

1. Identification of mitigation options which are reflected in national policies, regulations and development plans for the Philippines and/or options that are being considered for future implementation or adoption;
2. Mitigation options that are included in prior mitigation studies and reports for the Philippines (e.g. efforts by the UNDP, ADB and USAID) to prioritize and/or analyze mitigation options for various sectors; and
3. The mitigation options have the potential to reduce and/or avoid GHG emissions in the Philippines.

As discussed in Chapter 3 on Sector Prioritization, and following the decision by stakeholders to limit and prioritize mitigation options to relatively new and emerging technologies, the list was narrowed down to the technology options shown in Table 4.3. The list includes new technology options recommended by stakeholders in consultation meetings during the course of this study.

Table 4.3: Selected Technology Needs - Energy

Subsector	Technology Needs
Renewable Energy	Promotion and Development of solar-greenhouse
	Wind turbine, Off-Shore
	Biofuels (Bioethanol and Biodiesel) – research on feedstock
	Ocean Power
Renewable Energy, thermal energy	Solar Thermal System
Renewable Energy (Energy Storage)	Lithium-Iron Phosphate (LiFePO4) – a revolutionary energy storage with three times power density of conventional battery that could be used to store excess energy from RE generating facilities such as solar PV
	Power to Gas Storage – utilizing excess energy from RE facility such as Solar energy Facility to produce Natural gas (CH4) through the combination of Carbon Dioxide (CO2) and Hydrogen (H2)
Supply side and demand side: power industries/ other manufacturing industries/ commercial establishments/ households/ transport	SMART Grid (Electricity Transmission and Distribution Efficiency Improvement)
Supply side and demand side: power industries/ other manufacturing industries/ commercial establishments/ households/ transport	Energy-Efficient Chillers – e.g. Magnetic Bearing Chiller with environment safe refrigerant
	Energy-Efficient Electric Motors

	Variable Speed Drive/Variable Frequency Drive
	Waste Heat Recovery System
	Energy Management System (EMS)
	Building Management System (BMS)
	Next generation vehicle testing laboratory for hybrid, plug-in hybrid and electric vehicles will be used for validating the vehicle parts performance such as motor, battery and engine

4.3 Criteria and Process of Technology Prioritization

The selected technologies in Table 4.3 were subjected to MCA by stakeholders. Each of the mitigation technologies has been scored on a scale of 1 to 100 according to the prioritization criteria described in Chapter 3. The final ranking represents a consensual position among stakeholders through a consultation meeting facilitated by the TNA management team. Table 4.4 shows the MCA matrix for the energy sector technologies.

Table 4.4: MCA Matrix for Energy Technologies

Sector	Subsector	Technology Needs	Cost of Technology 30%		Total Score	Benefits - 70%					Total Score	OVERALL (Total Cost x .30)+ (Total Benift x .70)	Ranking
			Capital	O&M		Institutional/ political	Environmental	Social	Economic	Technology-related			
			85%	15%	%	10%	30%	20%	20%	20%	%	%	
ENERGY	Renewable Energy	Promotion and development of solar-greenhouse	80	15	95	5	25	20	20	10	80	84.5	
		Wind turbine, Off-Shore	50	5	55	10	20	20	20	15	85	76	
		Biofuels (Bioethanol and	70	15	85	8	15	10	20	15	68	73.1	
		Ocean Power	30	5	35	10	30	20	20	10	90	73.5	
	Renewable Energy, thermal energy	Solar thermal System	70	10	80	10	30	20	20	20	100	94	2nd
	Renewable Energy (Energy Storage)	Lithium-Iron Phosphate (LiFePO4)- a revolutionary energy storage with three times power density of conventional battery that could be used to store excess energy from RE generating facilities such as solar PV	40	15	55	10	10	20	20	15	75	69	
		Power to Gas Storage - utilizing excess energy from RE facility such as Solar Energy Facility to produce Natural gas (CH_4) through the combination of Carbon Dioxide (CO_2) and Hydrogen (H_2)	35	10	45	10	20	10	10	10	60	55.5	
	Supply side and demand side: power industries/other manufacturing industries/commercial establishments/ households/ transport	SMART Grid (Electricity Transmission and Distribution Efficiency Improvement)	50	5	55	10	30	20	20	20	100	86.5	
	Supply side and demand side: power industries/other manufacturing industries/commercial establishments/ households/ transport	Energy- Efficient Chillers – e.g. Magnetic Bearing Chiller with environment safe refrigerant	50	10	60	10	30	20	20	15	95	84.5	
		Energy-Efficient Electric Motors	60	5	65	10	30	20	20	20	100	89.5	
		Variable Speed Drive/Variable Frequency Drive	50	10	60	10	25	20	20	15	90	81	
		Waste Heat Recovery System	70	10	80	10	30	20	20	15	95	90.5	3rd
		Energy Management System (EMS)	30	10	40	10	30	20	20	20	100	82	
		Building Management System (BMS)	40	10	40	10	30	20	20	20	100	82	
		Next generation vehicle testing laboratory for hybrid, plug-in hybrid and electric vehicles- will be used for validating the vehicle parts performance such as motor, battery and engine	80	15	95	10	30	20	20	20	100	98.5	1st

4.3 Result of Technology Prioritization

The top three ranking technologies are, (1) Testing Laboratory for Electric Vehicles now called Next Generation Vehicle Testing Laboratory, (2) Solar Thermal System which was further clarified as Floating Solar PV System, and (3) Waste Heat Recovery (WHR) System. These are followed by, (4) Energy-Efficient Electric Motors, and (5) SMART Grid (Electricity Transmission and Distribution Efficiency Improvement).

The final ranking represents a consensus among the members of the TNA mitigation team and stakeholders and has been obtained through a series of discussions and consultation.

Chapter 5: Technology Prioritization for the Transport Sector

5.0 An Overview of Possible Mitigation Technology Options and Mitigation Benefits

Mitigating GHG emissions in the transportation sector is often framed using the "Avoid-shift-improve" framework:

1. Avoiding the need to travel.
2. Shifting travel demand to lower carbon transport modes.
3. Improving the operational efficiencies of the transport modes and the fuels that are used in transportation.

The employment of such strategies is beneficial in terms of achieving other "nationally appropriate" goals and can equate to the following economic, social and environmental benefits:

1. Reduction in energy demand, particularly imported fossil fuels.
2. Reduction in wasted costs due to inefficiencies (both in terms of passenger and freight transport) and thus making funds available for other essential services.
3. Improved health and safety due to the reduction in health costs from air pollution and accidents.
4. Increased productivity of the citizens due to reduced travel times and improved access to jobs and services.
5. More livable cities due to safer and higher quality transportation services, less congestion, cleaner air.

As discussed in Chapter 3, mitigation options for the transport sector that were included in the INDC were considered by stakeholders in the identification and selection of technology needs of the transport sector. However, stakeholders also included a new option in the said list, i.e., Biogas for Transport.

A summary of the technology options is shown in Table 5.1 below:

Table 5.1: Technology Options for the Transport Sector

Technology Needs Options[39]	Description[40]
Motor Vehicle Inspection System (MVIS)	This program tests and regulates emission of in-use vehicles to ensure compliance with the emission standards to which they are certified. An enhanced inspection and maintenance program could improve in-use vehicle efficiency and emissions performance by establishing new testing facilities nationwide and improving system wide reliability.
Jeepney (PUV) Modernization	Because jeepneys are re-built rather than newly manufactured, they are not subject to emissions of fuel economy standards. This measure involves fiscal incentives that promote the sale of battery electric jeepneys equipped with lithium-ion batteries. Since electric jeepneys may not be suitable for all routes, they are assumed only to apply to up to 25% of the New UV registrations by 2030.
Congestion Charging	Improves implementation of a program in Metro Manila modeled after London's Congestion Charging Scheme. Such scheme would levy a charge on four-wheeled traffic during specified hours, thereby reducing the volume of vehicle travel, improving travel speeds, and reducing fuel use, and associated vehicle emissions.
Driver Training	Driving behavior has a substantial effect on the in-use fuel economy. Training vehicle drivers to use fuel-saving best practices such as maintaining a steady speed and avoiding unnecessary acceleration and braking can reduce fuel use. Eco driving programs have been recognized for their benefits to health, safety, and the environment.
Biofuels	Biodiesel and ethanol pathways are evaluated based on the 2012 – 2030 Philippine Energy Plan. These pathways are compared for a baseline in which biofuel blends remain at historical levels (8.3% ethanol, and 2% biodiesel for gasoline and diesel brands, respectively)
Enhanced Bus Services Including BRT	This involves the transformation and expansion of road-based public transport in Metro Manila and other major urban areas nationwide, including the C-5 and Manila bus rapid transit (BRT) systems, express buses with dedicated lanes and facilities for non-motorized transport, and intelligent transportation systems that support bus monitoring, priority signaling, and remote traffic enforcement.
Rail (Mass Transit)	Considers the impacts of six rail projects on DOTC's project pipeline, MRT 3 Capacity Expansion, Mass Transit System Loop, LRT 1 South Extension, MRT 7, LRT 2 East and West Extensions, and expansion of the North-South Railway (Limcaoco, 2014)
Biogas for Transport[41]	Anaerobic digestion is a collection of processes by which microorganisms break down biodegradable material in the absence of oxygen. It is used to treat biodegradable waste and sewage sludge. As part of an integrated waste management system,

[39] Based on INDC.
[40] Source: Climate Change Commission
[41] Agreed upon by stakeholders to be included in the TNA Study.

	anaerobic digestion reduces the emission of landfill gas into the atmosphere. The process produces a biogas, consisting of methane which can be used directly as fuel, in combined heat and power gas engines, alternative-fuel vehicles or upgraded to natural gas-quality biomethane.

CO – BENEFITS	
Indicators	**Description**
Congestion	The three (3) mitigation actions – Congestion Charging, Buses and BRT, and Rail – result in reductions on overall vehicle activity, expressed in units of vehicle travelled (VKT). By reducing vehicle activity in densely populated areas, these actions have the co-benefit of reducing traffic congestion and time (time savings) spent in traffic by all road users.
Health	Cumulative number of outdoor air pollutants-related deaths avoided. Outdoor air pollution-related female deaths avoided.

As shown in the table, the co-benefits of the technology options include reduction of traffic congestion and time savings spent in traffic and avoided outdoor air pollutants-related deaths. On the other hand, estimated GHG emission reduction potential from MVIS and Jeepney Modernization are 11.4 and 22.36 million tons of CO2 equivalent, respectively.

5.1 Current Status of Technologies in the Transport Sector[42]

Climate change considerations are often not the primary drivers in choosing investments in the transportation sector and thus, the reduction in GHG emissions can perhaps be treated as a co-benefit in moving towards more environmentally sustainable and energy efficient transportation systems.

5.1.1 Road Transport

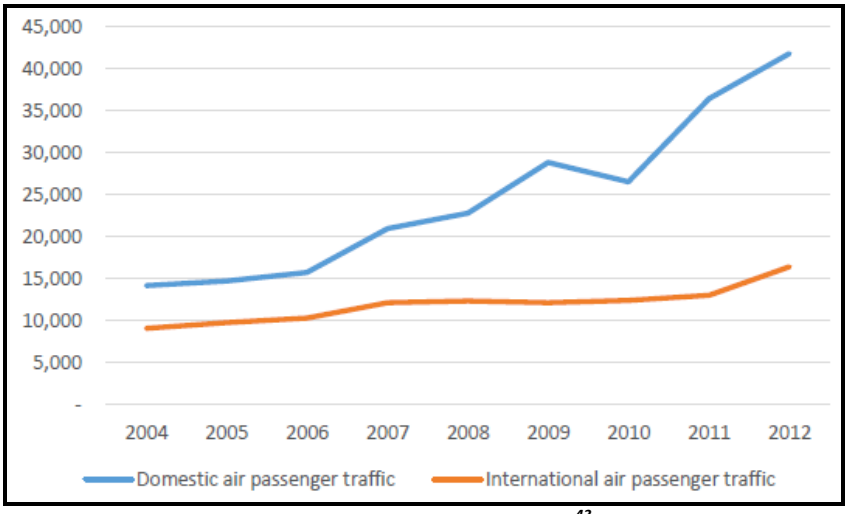
The number of registered road transport vehicles is growing at a robust rate annually at an average of 6% per annum from 2000 to 2013. Of the vehicles registered in 2005, 55% are motorcycles and tricycles which have been increasing at an annual rate of 10% per annum (2000-2013). Cars and sports utility vehicles are growing at 4% per annum while trucks and trailers are at 3% per annum.

[42] Source: "Revised First Interim Report (Parts I and II): Sub-Contract for the Development of Nationally Appropriate Mitigation Actions (NAMAs) by Berkman International. Inc. for the Climate Change Commission-UNDP Low Emission Capacity Building Philippine Project.

5.1.2 Air Transport

The country has 85 airports, 10 of which are international ones. Passenger air traffic (Figure 5.1) has been growing robustly in recent years (domestic air passenger traffic 14.5% per annum, international air passenger traffic 7.7% per annum), while air cargo traffic has been growing at a moderate pace (domestic air cargo traffic 2.8% per annum, international air cargo traffic 1.16%)

Figure 5.1: Air Passenger Traffic (thousand persons per year)



Source: Data from CAAP, MIAA compiled by AJTP[43]

5.1.3 Water Transport

There are around 2,451 ports in the country. 423 of these are private ports for exclusive use of the owners. There are 421 fishing ports, majority of which are under the administration of the Philippine Fisheries Development Authority (Regidor and Javier, 2014). Domestic sea passenger transport has not been growing robustly in the recent past (0.04% per annum) while domestic sea cargo transport has been growing at 5.7% per annum (2004-2011); international sea cargo transport has been diminishing at -0.71% per annum.

5.1.4 Railways

Transportation by rail in the country is mainly concentrated in Metro Manila as the four operational railway lines in the country are situated in the capital region. The Philippine National Railways (PNR) line serves the Southern regions of Luzon.

[43] Civil Aviation Authority of the Philippines (CAAP), Manila International Airport Authority

Table 5.2: Railway Stations and Passengers per Year

	Stations	Passenger/Year (million) 2011
MRT	13	159
LRT1	20	157
LRT2	11	64
Source: DOTC and LRTA		

Rail ridership has been increasing at a rate of 7% per annum from 2004-2012, again mainly due to the increased rail transport demand in Metro Manila (Table 5.2).

The main goals and thrusts of the national policies relating to transportation are more or less consistent with the goal of reducing GHG emissions from the transport sector. For example, the goal of providing quality public transportation to the masses is a goal that will also impact the emissions from the transportation sector – by shifting the demand for travel into more environmentally friendly and energy efficient modes. The use of modern communications technologies to substitute the need to travel for business meetings and other similar activities is also a GHG mitigating strategy. The push for standards and technologies for making road vehicles safer, energy efficient and less polluting, are also strategies to mitigate GHG emissions from the sector.

5.2 Criteria and Process of Technology Prioritization

In the consultation meeting conducted by the TNA Management Team, stakeholders decided to limit the options from Table 5.1 to the following technologies: PUV (Jeepney) Modernization, Motor Vehicle Inspection System (MVIS) and Biogas for Vehicles. These technology options were then subjected to MCA by stakeholders according to the prioritization process and criteria described in Chapter 3. The final ranking represents a consensual position among stakeholders through a consultation meeting facilitated by the TNA management team. Table 5-3 shows the MCA matrix for the transport sector technologies.

5.3 Results of Technology Prioritization

As shown in Table 5.3, the prioritization exercise resulted in the following ranking of the technologies: (1) MVIS, (2) Biogas for Vehicles and the last priority is PUV or Jeepney Modernization.

Table 5.3. MCA Matrix for Transport Technologies

Sector	Subsector	Technology Needs	Cost of Technology 30%		Total Score	Benefits – 70%					Total Score	OVERALL (Total Cost x .30)+(Total Benefit x.70)	Ranking
			Capital	0&M		Institutional/ Political	Environ-mental	Social	Econo-mic	Technology-related			
			85%	15%	100%	10%	30%	20%	20%	20%	100%	100%	
Transport	Land Transport	PUV Modernization	60	10	70	10	25	10	10	20	75	73.5	
		MVIS	85	10	95	10	30	20	20	20	100	98.5	1st
		Biogas	80	10	90	10	25	20	20	20	95	93.5	2nd

Chapter 6: Technology Prioritization for Waste Sector

6.0 An Overview of Possible Mitigation Technology Options and Mitigation Benefits

The CCC through its UNDP-Low Emission Capacity Building Philippine (LECB PHL) Project conducted a study on the development of Nationally Appropriate Mitigation Actions (NAMAs)[44]. The study generated a raw list of at least ten mitigation actions for the waste sector which was further sorted and bundled. The exercise resulted in three (3) potential NAMAs, namely:

1. Waste to energy technology deployment;
2. Improved segregation of solid waste; and
3. Improved waste water management.

Two complementary actions were also identified:

1. Provision of assistance to LGUs in the implementation of their Solid Waste Management (SWM) Plans; and
2. Institution of voluntary and regulated programs to reduce industrial and commercial waste generation.

The raw list was used by the CCC, national government agencies (NGAs) and other development partners/institutions such as ADB and USAID, in the identification, selection and prioritization of mitigation options/actions that were considered in the INDCs submitted by the Government to UNFCCC under the Paris Agreement on Climate Change.

Mitigation technologies in the waste sector divide roughly into those that can potentially produce income and those that remain a pure cost. Priority should be given to technologies that can produce income at relatively low investment costs and which have large potential for GHG abatement. Income generating technologies are those that create products at competitive prices and have supportive robust markets, such as power.

As discussed in Chapter 3, mitigation options for the waste sector that were included in the INDC were considered by stakeholders in the identification and selection of technology needs of the waste sector. On top of the mitigation options from the INDC, stakeholders also included new options in the said list, i.e., Eco-Efficient Soil Cover Using Compost, and Anaerobic Digester (AD). Table 6.1 below is the summary of the technology options for the waste sector:

[44] Revised First Interim Report: Sub-Contract for the Development of Nationally Appropriate Mitigation Actions, prepared by Berkman International, Inc. for the Climate Change Commission-UNDP Low Emission Capacity Building Philippine (LECB PHL) Project, December 2014. 193pp.

Table 6.1: Technology Options for the Waste Sector

Technology Needs Options[45]	Description
Municipal Solid Waste Digestion	Includes diversion and collection of biodegradable waste for digestion and power generation.
Methane Recovery from Sanitary Landfills	Includes deployment of methane recovery for electricity generation.
Methane Flaring	Includes deployment of methane recovery for flaring at Large OD and CDFs
Composting	Includes increasing the percentage of biodegradable waste that is composed. Increased composting results and additional biodegradable waste diversion from landfills, reducing CH_4 emission and overall disposal requirements.
Eco-Efficient Soil Cover Using Compost[46]	Deployment of eco-efficient soil cover using composts. Composting maximizes the use of biodegradable materials and supports the goal of "zero-waste" Philippines as bio-waste comprises about half (52.31%) of MSW.
Anaerobic Digester[47]	Anaerobic digestion is a collection of processes by which microorganisms break down biodegradable material in the absence of oxygen. It is used to treat biodegradable waste and sewage sludge. As part of an integrated waste management system, anaerobic digestion reduces the emission of landfill gas into the atmosphere. The process produces a biogas, consisting of methane which can be used directly as fuel, in combined heat and power gas engines, alternative-fuel vehicles or upgraded to natural gas-quality biomethane.
CO – BENEFITS	
Indicators	**Description**
Income Generation	Composting includes increased in segregation of biodegradable waste for the production compost product, which has market value. GHG mitigation strategies that result in additional compost materials provide an income co-benefit from the eventual sale of these materials into the marketplace.

[45] Based on INDC
[46] Recommended by stakeholders of the TNA Study.
[47] Recommended by stakeholders of the TNA Study.

6.1 Current Status of Technologies in the Waste Sector[48]

Solid waste management is governed by the Solid Waste Management Act of 2000; wastewater management by the Clean Water Act of 2004. Both laws are administered by the Environmental Management Bureau (EMB) of the Department of Environment and Natural Resources (DENR) together with the environment offices of the local governments. Legislation was passed as a response to an urgent need to halt dumping of garbage and the uncontrolled release of effluent into public waterways. Before the law, there were no sanitary landfills in the country that were compliant with global standards of design and operation. Wastewater treatment plants were found mostly in large industrial operations that were protective of their corporate reputations. Most was dumped directly into open waterways. Human waste was deposited in septic tanks and collected by designated evacuators, even if, lacking accredited treatment plants, the final disposition of the waste remained a mystery. There is much evidence that it was merely dumped in open waterways. Storm water was often made to run directly into waterways.

Other than disposal in open or controlled dumpsites, open burning and incineration were the default ways for the disposal and treatment of solid waste. The Solid Waste Management Act required that sanitary landfills replace those within 3 years of its enactment. Until now, the few licensed sanitary landfills take only an insignificant amount of solid waste generation.

Initially, all forms of incineration for final waste disposal were strictly forbidden by the Clean Air Act thereby driving the practice underground. The Philippine Supreme Court later struck down that provision in the law. Nevertheless, few large incineration based projects were developed for fear of permitting difficulties and backlash from civil society. The latest landfills employ efficient gas collection systems and have used the collected gas to generate power albeit in modest amounts.

Following the enactment of the waste and wastewater laws and the privatization by concession of the Metropolitan (Manila) Waterworks and Sewerage System (MWSS), the private operators undertook the build out of a large fleet of sewerage treatment plants, currently numbering over a hundred. Recent attempts to employ biodigester technology to accelerate the breakdown of the collected waste and to produce biogas for power generation have met with limited success. In fact, the abundance of treated sewage sludge as a result of more effective collection has become a major disposal issue for the Manila water companies. At present, the treated waste is trucked and disposed of in landfills

The management of solid wastes in the country are constrained by the limited areas for solid waste disposal sites, along with health considerations. Thus the national target of increasing solid waste diversion from solid disposal facilities is mainly through reuse, recycling,

[48] Source: “Revised First Interim Report (Parts I and II): Sub-Contract for the Development of Nationally Appropriate Mitigation Actions (NAMAs) by Berkman International. Inc. for the Climate Change Commission-UNDP Low Emission Capacity Building Philippine Project.

composting and other resource recovery activities. Immediate benefits for the waste generators of this strategy include less expense from reuse and additional income from compost and recyclable materials.

The stringent requirements for wastes for co-processing limit the optimum use of this strategy by many local government units (LGUs). LGUs are looking into waste-to-energy schemes that meet both national government policies and their urgent need of ways to manage and dispose generated wastes in a socially acceptable manner.

Management of industrial wastewaters is a continuing process of improvement, not only to meet existing effluent standards but also to identify specific elements of the wastewater management system, along with the whole production process, where companies can save on or recover resources.

Municipal wastewaters are currently at varying stages of action. Unlike industrial wastewater that is regulated by the DENR, along with wastewaters from relatively large commercial establishments, municipal wastewaters are within the jurisdiction of the local government units (LGUs). Open defecation is still existing throughout the country, both in rural and urban areas, and one of the millennium sanitation goals is to eradicate open defecation. The Department of Health (DOH) is working with the concerned LGUs in addressing this concern, a toilet for every Filipino household. The type of management varies from it privies to septic tanks.

Only a number of highly urbanized cities have existing sewerage, thus septage management is being considered. This includes ensuring that septic tanks are appropriately designed and constructed and septage treatment facility in-place with appropriate septage desludging system. Decentralized wastewater treatment systems are likewise becoming popular with LGUs for specific operations like public markets, hospitals, and slaughterhouses.

The various wastewater management systems in the LGUs, however, are more into addressing pollution of water resources rather than abating any GHG emissions coming from the wastewater or from the system managing these wastes.

Similarly, improvement of wastewater management systems can also derive renewable energy from the organic fractions, protect water resources, and provide savings for industries and local government units.

6.2 Criteria and Process of Technology Prioritization

In the consultation meeting conducted by the TNA Management Team, stakeholders decided to limit the options from Table 6-1 to two (2) technologies: Eco-efficient Soil Cover Using Composts and Anaerobic Digester. As with other sectors, these technology options were then subjected to MCA by stakeholders according to the prioritization process and criteria

described in Chapter 5. The final ranking represents a consensual position among stakeholders through a consultation meeting facilitated by the TNA management team. Table 6-2 shows the MCA matrix for the waste sector technologies.

6.3 Result of Technology Prioritization

As shown in Table 6.2, the result of the prioritization exercise on the ranking of the technologies is as follows: (1) Eco-efficient Soil Cover Using Composts, and (2) Anaerobic Digester.

Sector	Subsector	Technology Needs	Cost of Technology 30%		Total Score	Benefits – 70%					Total Score	OVERALL (Total Cost x .30)+(Total Benefit x.70)	Ranking
			Capital	0&M		Institutional/ Political	Environ-mental	Social	Econ-omic	Tech-nology related			
			85%	15%	100%	10%	30%	20%	20%	20%	100%	100%	
WASTE	Solid Waste	Eco-efficient Soil Cover using compost	80	10	90	8	25	20	20	20	93	92.1	1st
		Anaerobic digester	60	10	70	7	25	15	20	20	87	81.9	2nd

Chapter 7: Conclusions

Table 7.1 summarizes the prioritized technology needs of the Mitigation Sector of energy, transport and waste.

Table 7.1: Summary Table of Technology Needs of the Mitigation Sector

Mitigation Sector	Technology	Ranking
Energy	Next Generation Vehicle Testing Laboratory/(Testing laboratory for Electric Vehicles)	1st
	Solar Thermal System	2nd
	Waste Heat Recovery System	3rd
Waste	Eco-efficient Soil Cover Using Composts	1st
	Anaerobic Digester	2nd
Transport	Motor Vehicle Inspection System (MVIS)	1st
	Biogas for Transport	2nd

Following the TNA process, each of these technologies will now undergo analyses of market conditions and to identify barriers for enhanced deployment including appropriate technical, financial and policy instruments to facilitate implementation and deployment of the technologies.

Next Generation Vehicle Testing Laboratory. Globally, countries are exerting efforts to reduce GHG emissions in the transport sector by decreasing the use of fossil fuels. One technology option being pursued is the use of EV technology. However, like any other technologies, they have to be tested in state-of-the-art laboratories to ensure the accuracy in the assessment of their performance, possible risks and hazards. Based on internationally recognized test protocols, relevant tests should be conducted on the vehicles and their new components such as the motor, battery and controller. Also, the testing facility whould be equipped with the right tools, equipment, standards and materials to obtain accurate results.

Solar Thermal System. There are two types of solar thermal systems: passive and active. A passive system requires no equipment, while an active system requires some way to absorb and collect solar radiation and then store it. The technology will use a **parabolic trough** design to collect the sun's radiation. These collectors are known as linear concentrator systems, and the largest are able to generate 80 megawatts of electricity.

They concentrators are shaped like a half-pipe and have linear, parabolic-shaped reflectors covered with mirrors that are able to pivot to follow the sun as it moves during the day. Because of its shape, this type of plant can reach operating temperatures of about 750 degrees F (400 degrees C), concentrating the sun's rays at 30 to 100 times their normal intensity onto

heat-transfer-fluid or water/steam filled pipes. The hot fluid is used to produce steam, and the steam then spins a turbine that powers a generator to make electricity.

Waste Heat Recovery (WHR) System. Waste heat refers to energy that is generated in industrial processes without being put to practical use. Sources of waste heat include hot combustion gases discharged to the atmosphere, heated products exiting industrial processes, and heat transfer from hot equipment surfaces. Efforts to improve industrial energy efficiency focus on reducing the energy consumed by the equipment used in manufacturing (e.g., boilers, furnaces, dryers, reactors, separators, motors, and pumps) or changing the processes or techniques to manufacture products.

WHR therefore is a valuable alternative approach to improving overall energy efficiency as it captures and reuses the lost or "waste heat" that is intrinsic to all industrial manufacturing. Captured and reused waste heat is an emission free substitute for costly purchased fuels or electricity.

Eco-efficient Soil Cover. The technology applies microbially mediated methane oxidation in smaller dumpsite covers by using methanotrophic microorganisms to counter the rise in methane emissions. The closed dumpsites in which microorganisms, will decompose methane into carbon dioxide in composts.

Anaerobic Digester. Organic waste management through aerobic composting is already an accepted practice in the Philippines. However, aerobic composting is a relatively slow process and requires space/land. For urban LGUs with high waste generation rates and limited space for organic waste processing, anaerobic digestion seems to provide a sustainable solution. The technology includes diversion and collection of biodegradable waste for anaerobic digestion using anaerobic digester wherein methane is capture and use for power generation.

An effective collection, and more importantly, effective and efficient segregation of waste is necessary. That is because only a fraction of the biodegradable waste stream can be used. While there are laws, regulations and ordinances for solid waste management that includes segregation, the ultimate motivation for segregating waste and keeping waste segregated rests on the prospective economic value that can be created from the segregated waste.

Biogas for Transport. On-site anaerobic bio-energy plants convert processing residues from manufacturing operations, such as distilleries and dairies, into valuable renewable energy for factory use. To date utilizing the biogas on factory sites has mainly involved Combined Heat and Power (CHP) engines. The transport sector has been identified as a potential growth market for small scale, on-site production of biomethane as a low carbon alternative to diesel in commercial vehicles. Most OEMs still use fossil-based fuels and the Government is keen to decarbonise transport and encouraging the adoption of renewable transport fuels.

Motor Vehicle Inspection System (MVIS). All vehicles are mandated to be dutifully checked and pass through the necessary inspection in order to be deemed roadworthy and for the government to sustain "improved air quality and reduced traffic accidents, as well as benefits to users from greater vehicle reliability and reduced running costs." The project will be pursued with a private sector partner that will be tasked to 'develop, operate, and maintain a network of Motor Vehicle Inspection Centers (MVICs) all around the Philippines that will keep up with global standards."

The MVIS is already in place but outdated. However, the lack of proper implementation has allowed owners of non-compliant vehicles to register their vehicles. The lack of controls in administering the system has given individual inspectors too much discretion in qualifying vehicles. This situation has, in turn, led to a rise in corrupt practices and a loss of trust in the system.

While new testing, verification and reporting technologies that are less prone to being gamed can contribute to a properly functioning MVIS, holding individuals accountable for their actions will likely yield better results over the long term.

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ANNEX I: TECHNOLOGY FACT SHEETS

A. Energy

1. Technology: Next Generation Vehicle Testing Laboratory	
Introduction	Globally, countries are exerting efforts to reduce GHG emissions in the transport sector by decreasing the use of fossil fuels. One technology option being pursued is the use of EV technology, thus several companies are developing, promoting and demonstrating the use of new and advanced energy technology such as hybrid, plug-in hybrid and electric vehicle. However, like any other technologies, they have to be tested in state-of-the-art laboratories to ensure the accuracy in the assessment of their performance, possible risks and hazards. Based on internationally recognized test protocols, relevant tests should be conducted on the vehicles and their new components such as the motor, battery and controller. Also, the testing facility should be equipped with the right tools, equipment, standards and materials to obtain accurate results.
Technology characteristics	The laboratory may require state-of-the art dynamometer that can be used for dynamic simulation tests to assess the performance of next generation vehicles at various speed and torque levels. EV batteries should be tested on their charging and discharging cycles at different state of charges to determine their performance and life cycles. Simulation test on the EVs maximum speed, maximum acceleration, and maximum range in flat and uphill terrains should be conducted to determine their performance characteristics.
Cost to implement mitigation options	(To be determined)
Potential development impacts, benefits	
Economic	Obtaining performance test results from well-equipped and state-of-the art test facility will provide basis in developing policies that will promote more energy efficient transport technologies. Policies may include formulation of incentives for investors, standards and regulations to ensure public safety and to build users' confidence that will result to accelerate mainstreaming of efficient EV technologies.
Social	The test facility will support local inventors, innovators, scientists and engineers in their research, development, demonstration and deployment of new and emerging transportation technologies.
Environmental	Establishing the actual performance of new and advanced energy technologies such as hybrid, plug-in hybrid and EVs will

	accelerate their commercial application, hence, provides the transport sector more environment-friendly modes of transport, contributing to emission reduction attributed to conventional petroleum fueled vehicles.
Status of technology in the Philippines	No existing test facility.
Barriers	High investment cost and limited funding sources for putting up and maintaining test facilities. Inadequate incentives to research and development of new and advanced technologies that are needed to encourage investments in putting up test facilities. Outdated standards and regulations that inhibit the development and implementation of low carbon transport technologies.
Acceptability to local stakeholders	Putting up the test facility is a significant platform for engineers, researchers, scientists, inventors, and innovators to determine the techno-economic viability of their endeavors. It may also encourage early EV adopters once these technologies are tried and tested in a well-equipped facility.
Endorsement by experts	Consultations will be done with the DOST, academe and EV industry on the appropriate equipment for the test facility.
Timeframe	To be determined.
Institutional capacity	Technology transfer should form part of the procurement arrangement.
Adequacy for current climate	There are no negative consequences of the mitigation optionin the current climate.
Size of beneficiaries group	Policymakers, engineers, researchers, scientists, inventors, innovators, and commuters.
References	To be provided.

2. Technology: Solar Thermal System[49]	
Introduction	There are two types of solar thermal systems: passive and active. A passive system requires no equipment, while an active system requires some way to absorb and collect solar radiation and then store it. The most common type of solar thermal power plants, including those plants in California's Mojave Desert, use a **parabolic trough** design to collect the sun's radiation. These collectors are

[49] Information is provided by the Consultant based on published information but will be confirmed with/updated by the Department of Transportation.

	known as linear concentrator systems, and the largest are able to generate 80 megawatts of electricity. **Solar power tower systems** are another type of solar thermal system. Power towers rely on thousands of **heliostats**, which are large, flat sun-tracking mirrors, to focus and concentrate the sun's radiation onto a single tower-mounted receiver. Like parabolic troughs, heat-transfer fluid or water/steam is heated in the receiver (power towers, though, are able to concentrate the sun's energy as much as 1,500 times), eventually converted to steam and used to produce electricity with a turbine and generator. A third system is the **solar dish/engine**. Compared to the parabolic trough and power towers, dish systems are small producers (about 3 to 25 kilowatts). There are two main components: the solar concentrator (the dish) and the power conversion unit (the engine/generator). The dish is pointed at and tracks the sun and collects solar energy; it's able to concentrate that energy by about 2,000 times. A thermal receiver, a series of tubes filled with a cooling fluid (such as hydrogen or helium), sits between the dish and the engine. It absorbs the concentrated solar energy from the dish, converts it to heat and sends that heat to the engine where it becomes electricity.
Technology characteristics	The project would employ the parabolic trough design or linear concentrator system, to collect the sun's radiation. They concentrators are shaped like a half-pipe and have linear, parabolic-shaped reflectors covered with mirrors that are able to pivot to follow the sun as it moves during the day. Because of its shape, this type of plant can reach operating temperatures of about 750 degrees F (400 degrees C), concentrating the sun's rays at 30 to 100 times their normal intensity onto heat-transfer-fluid or water/steam filled pipes. The hot fluid is used to produce steam, and the steam then spins a turbine that powers a generator to make electricity.
Cost to implement mitigation options	An 80 MW plant would cost from $150 to $200 Million or by the rule of thumb, $2.5 Million per megawatt capacity.
Potential development impacts, benefits	
Economic	Increased private sector investment, enhanced energy security, diversified energy/power supply.
Social	Sustained poverty incidence reduction, and improved access to energy services.
Environmental	Enhanced environment quality, strengthened resilience and adaptive capacity to climate change and enhanced sustainable energy resource management.

Status of technology in the Philippines	No system in place.
Barriers	Institutional: • Lack of one-stop-shop to cater the market needs of project developers and investors. • Lack of solar energy institute that will cater the capacity building needs of the sector. • Concerned government agencies have inadequate technical knowledge in the evaluation of the solar energy related projects for the faster issuance of permits and clearances Legal: • Absence of specific administrative and regulatory requirements and procedures in the development of solar energy utilizing water surface resource. Technical: • The technology entails high investment since it is new in the country and relies on foreign expertise, equipment and materials • Capital marker barrier because of limited access to capital and high interest rate • Intermittent source of power • Lack of technical standards. Social: • Lack of consumer awareness about the technology. Cultural: • Acceptance of the community that the technology will not affect their customary way of living.
Acceptability to local stakeholders	Interest in solar thermal system is expanding in the country and companies driven by the following: • rising prices for power and fuel • concerns about grid power reliability • industry commitment to and government support for sustainable development.
Endorsement by experts	The technology is among those being considered in the National Renewable Energy Program of the government through the DOE. The Program has undergone public consultation process.
Timeframe	The solar thermal system depending on the size can be implemented within one (1) year subject to the availability of all components.
Institutional capacity	Technical know-how, both among the project developers implementing solar thermal system and local industries providing services is important for the success of the implementation and operation of solar thermal system projects. Thus, additional Research, Development and Demonstration and Capacity

	Building on Concentrating Solar Thermal Power (CSP) and solar thermal cooling/heating technology are recommended.
Adequacy for current climate	There are no negative consequences of the mitigation option in the current climate.
Size of beneficiaries group	End-users of solar thermal system, developers, financing institutions, foreign and local manufacturers, policy makers/ government agencies, local consultants and service providers.
References	• Energy Information Administration. • https://science.howstuffworks.com/environmental/green-tech/energy-production/solar-thermal-power1.htm

3. Technology: Waste Heat Recovery (WHR) System	
Introduction	Industrial waste heat refers to energy that is generated in industrial processes without being put to practical use. Sources of waste heat include hot combustion gases discharged to the atmosphere, heated products exiting industrial processes, and heat transfer from hot equipment surfaces. Efforts to improve industrial energy efficiency focus on reducing the energy consumed by the equipment used in manufacturing (e.g., boilers, furnaces, dryers, reactors, separators, motors, and pumps) or changing the processes or techniques to manufacture products. A valuable alternative approach to improving overall energy efficiency is to capture and reuse the lost or "waste heat" that is intrinsic to all industrial manufacturing. During these manufacturing processes, as much as 20 to 50% of the energy consumed is ultimately lost via waste heat contained in streams of hot exhaust gases and liquids, as well as through heat conduction, convection, and radiation from hot equipment surfaces and from heated product streams. In some cases, such as industrial furnaces, efficiency improvements resulting from waste heat recovery can improve energy efficiency by 10% to as much as 50%. Captured and reused waste heat is an emission free substitute for costly purchased fuels or electricity. Numerous technologies are available for transferring waste heat to a productive end-use. Currently, there are a range of commercially-proven and mature waste heat recovery (WHR) power systems ranging from classic Rankine-cycle steam-based installations to Organic Rankine Cycle (ORC) and Kalina cycle systems.
Technology characteristics	Heat recovery involves processing the waste heat produced by existing processes so it can be used to power the same process or a different one. Waste heat recovery system entails capturing and

	reusing the waste heat in industrial processes for heating or for generating mechanical or electrical energy. Waste heat recovery system reduces the operating costs for facilities by increasing their energy productivity. It has three essential components: 1) an accessible source of waste heat, 2) a recovery technology, and 3) a use for the recovered energy.
Costs, including	
cost to implement mitigation options	Installation Cost ranges from US $ 3,800 to US $ 5,000 per kW depending upon WHR power technology type and installed capacity Annual operation and maintenance costs: 2.5% of the capital cost; Auxiliary power requirements of 7%.
cost of not modifying the project	N/A
Potential development impacts, benefits	
Economic	• Reduced purchased power consumption and/or reliance on fossil-fuel based captive power plants • Mitigated impact of future electric price increases • Enhanced plant power reliability • Improved plant competitive position in the market.
Social	Job creation
Environmental	Lowers plant specific energy consumption, reducing greenhouse gas emissions (GHG) and air pollutants emissions. Estimated CO_2 emission reduction is 11,800 tons/year (e.g. Lafarge Teresa Plant).
Status of technology in the Philippines	The Philippine cement industry has installed three (3) waste heat recovery power generation systems with a total capacity of 17.5 MW in the following: • Cemex Antipolo Plant (6 MW) • Lafarge Teresa Plant (4.5 MW) • Eagle Cement Corporation (7 MW)
Barriers	Many WHR technologies are already well developed and technically proven, however, there are numerous applications where heat is not recovered due to a combination of market and technical barriers: 1) **Costs**: i) Long payback periods - Costs of heat recovery equipment, auxiliary systems, and design services lead to long payback periods in certain applications. Additionally, several industry subsectors with highquality waste heat sources (e.g., metal casting,) are renowned for small profit margins and intense internal competition for limited capital resources. ii) Material constraints and costs - Certain applications require advanced and more costly materials. Costly materials are

	required for high temperature streams, streams with high chemical activity, and exhaust streams cooled below condensation temperatures. Overall material costs per energy unit recovered increase as larger surface areas are required for moreefficient, lowertemperature heat recovery systems. 2) **Economies of Scale** - Equipment costs favor large scale heat recovery systems and create challenges for small scale operations. i) Operation and maintenance costs – Corrosion, scaling and fouling of heat exchange materials lead to higher maintenance costs and lost productivity. 3) **Temperature Restrictions** i) Lack of an end-use – Many industrial facilities do not have an onsite use for low temperature heat. Meanwhile, technologies that create end-use options (e.g., low temperature power generation) are currently less developed and more costly. ii) Material constraints and costs: (a) High temperature – Materials that retain mechanical and chemical properties at high temperatures are costly. Therefore, waste heat is often diluted with outside air to reduce temperatures. This reduces the quality of energy available for recovery. (b) Low temperature – Liquid and solid components can condense as hot streams cool in recovery equipment, leading to corrosive and fouling conditions. The additional cost of materials that can withstand corrosive environments often prevents low temperature recovery. (c) Thermal cycling – The heat flow in some industrial processes can vary dramatically and create mechanical and chemical stress in equipment. iii) Heat transfer rates - Smaller temperature differences between the heat source and heat sink lead to reduced heat transfer rates and require larger surface areas. 4) **Chemical Composition** i) Temperature restrictions – Waste heat stream chemical compatibility with recovery equipment materials will be limited both at high and low temperatures. ii) Heat transfer rates – Deposition of substances on the recovery equipment surface will reduce heat transfer rates and efficiency. iii) Material constraints and costs – Streams with high chemical activity require more advanced recovery equipment materials to withstand corrosive environments. iv) Operation and maintenance costs – Streams with high chemical activity that damage equipment surfaces will lead to

	increased maintenance costs. v) Environmental concerns – Waste heat recovery from exhaust stream may complicate or alter the performance of environmental control and abatement equipment. vi) Product/Process control – Chemically active exhaust streams may require additional efforts to prevent crosscontamination between streams. 5**) Application Specific Constraints** i) Process specific constraints – Equipment designs are processspecific and must be adapted to the needs of a given process. ii) Product/ Process control – Heat recovery can complicate and compromise process/quality control systems. 6) **Inaccessibility/Transportability** i) Limited space – Many facilities have limited physical space in which to access waste heat streams (i.e., limited floor or overhead space) ii) Transportability – Many waste heat gaseous streams are discharged near atmospheric pressure (limiting the ability to transport them to and through equipment without additional energy input). iii) Inaccessibility – It is difficult to access and recover heat from unconventional sources such as hot solid product streams (e.g., ingots) and hot equipment surfaces (e.g., sidewalls of primary aluminum cells). Safety and operational demands that require egress/access around/above most melting furnaces, boilers, heaters, and other high temperature equipment.
Acceptability to local stakeholders	Interest in waste heat recovery system is expanding in the country and companies driven by the following: • rising prices for power and fuel • concerns about grid power reliability • industry commitment to and government support for sustainable development.
Endorsement by experts	Yes, the need for experts is highly considered in order to: 1) conduct capacity building activities to develop local expertise, 2) provide expert advice and support to potential developers, and 3) partnerships between foreign equipment suppliers and local manufacturers and visit and study tours to successful installations in a similar environment.
Timeframe	For new industries, the WHR system can be integrated in the system and can be implemented any time.
Institutional capacity	Technical know-how, both among the project developers implementing WHR system and local industries providing services, is important for the success of the implementation and operation of waste heat recovery system projects.

Adequacy for current climate	There are no negative consequences of the mitigation option in the current climate.
Size of beneficiaries group	Stakeholders: End-users of waste heat recovery, developers, financing institutions, foreign and local manufacturers, policy makers/government agencies, local consultants and service providers.

B. Waste

1. Technology: Use of eco-efficient/methane-oxidizing soil cover	
Introduction	Use of microbially mediated methane oxidation in smaller dumpsite covers by using methanotrophic micro-organisms to counter the rise in methane emissions.
Technology characteristics	Requires compost to be mixed with soil as covering for the closed dumpsites in which microorganisms will decompose methane into carbon dioxide.
Costs, including	
cost to implement mitigation options	Costs would be around 1/3 lower compared to the cost of conventional reactive barrier cover
cost of not modifying the project	Higher cost/investment
Potential development impacts, benefits	Ensures utilization of compost Easy to implement by small LGUs Will increase disposal site closure/rehabilitation rates
Economic	Lower cost
Social	Enhanced training and capacity building of stakeholders
Environmental	Lower methane (GHG) emission
Status of technology in the Philippines	At the research and development stage
Barriers	• Only applicable to small disposal sites • Requires revision of DAO 2006-09 or the Closure and Rehabilitation of Disposal Sites specifically the soil cover and gas management sections • Need to have further studies on the feasibility and cost-effectiveness of the technology
Acceptability to local stakeholders	Although this is cheaper and easy to implement, there is lack of knowledge and understanding of local stakeholders on the use of the technology.
Endorsement by experts	An initial study has been conducted by GIZ which shows positive results in terms of reducing methane emission in a dumpsite.
Timeframe	2020-2030
Institutional capacity	Need to have trainings and capacity building within the EMB,

	NSWMC and other relevant agencies/offices and also studies to support the development of policies for the implementation of the technology.
Adequacy for current climate	One negative impact of the technology is soil erosion/siltation as this technology would require to have the soil/compost cover to be loose
Size of beneficiaries group	– This would benefit a large number of LGUs on cost reduction in the rehabilitation and closure of open and close dumpsites that is prohibited by the law (RA 9003)

2. Technology: Anaerobic digestion with methane recovery	
Introduction	Organic waste management through aerobic composting is already an accepted practice in the Philippines. However, aerobic composting is a relatively slow process and requires space/land. For urban LGUs with high waste generation rates and limited space for organic waste processing, anaerobic digestion seems to provide a sustainable solution.
Technology characteristics	Technology includes diversion and collection of biodegradable waste for anaerobic digestion using anaerobic digester wherein methane is capture and use for power generation.
Costs, including	
cost to implement mitigation options	Depend on the size and type but basic anaerobic digester cost about PHP1 million.
cost of not modifying the project	N/A
Potential development impacts, benefits	
Economic	Employment
Social	Does not require a big space compare to aerobic composting
Environmental	Capture methane for electricity generation, Less waste going to landfill
Status of technology in the Philippines	Limited implementation/adoption
Barriers	Kitchen wastes are highly hydrolyzable and its operation needs high degree of technical expertise and capitalization (high cost).
Acceptability to local stakeholders	This technology is already implemented but not at a larger scale due to cost and inadequate technical capability.
Endorsement by experts	The technology is among mitigation options in the country's INDC that were subjected to stakeholders' consultation.
Timeframe	2019-2030
Institutional capacity	Need to have further trainings and capacity building within the EMB, NSWMC, LGUs and other relevant agencies/institutions.

Adequacy for current climate	
Size of beneficiaries group	This would benefit a large number of LGUs particularly in urban areas that have limited space and also increase the lifetime of the landfills by reducing or diverting significant volume of waste

C. Transport

1. Technology: Motor Vehicle Inspection System	
Introduction	Motor Vehicle Inspection System (MVIS) is a system in which a vehicle for inspection is driven into a lane of equipment ("MVIS lane") that allows an automated check of the vehicle's mechanics for roadworthiness. The MVIS (Implementation) Program is to establish computerized motor vehicle inspection stations all over the country. The program called for at least one MVIS Center to be operational in each Land Transportation Office (LTO) district office to test the roadworthiness of vehicles prior to registration. The Goal is to enhance road safety and reduce the traffic accidents through an integrated and comprehensive program on Motor Vehicle Inspection. The Objectives are as follows: • To develop and promote an integrated and comprehensive program on Motor Vehicle Inspection; • To provide a systematic, reliable and effective testing of motor vehicle through computerization and automation for compliance with safety and emission requirements; • To comply with existing motor vehicle standards, provision of national laws and international agreements; • To integrate all motor vehicle inspection reports into a central motor vehicle database. It involves the establishment of infrastructure, equipment and software to implement Motor Vehicle Inspection Centers (MVICs).
Technology characteristics	Automated emission and roadworthiness inspection

Costs, including	Total project cost Php 2.22B; Number of Lanes: Light Duty- 21 lanes; Heavy Duty- 22 lanes; Motorcycle- 29 lanes
cost to implement mitigation options	
cost of not modifying the project	
Potential development impacts, benefits	The mobile-sourced air pollution will be lessen by setting air quality standards and management guidelines and the setting of emission thresholds for vehicles
Economic	The additional cost to be paid by the vehicle owner is a profit of the government
Social	Improve human health
Environmental	Less air pollution
Status	Pending procurement of MVIF and establishment of MVICs; There are five (5) MVIS in the country which are located in NCR (North & South MVIS), San Fernando City, Cebu City and Alaminos, Laguna which are need to maintain and upgrade
Barriers	Accreditation and authorization guidelines not yet issued
Acceptability to local stakeholders	It will add additional cost to the vehicle owner, but in general will help in the emission standards
Endorsement by experts	Previous studies conducted by Korea International Cooperation Agency (KOICA) in cooperation with Korea Transportation Safety Authority (TS) finalized the Development of a Master Plan of the Motor Vehicle Inspection and Management System (MVIS) in the Philippines
Timeframe	2019 onwards
Institutional capacity	There is a need to capacitate the MVIS technicians
Adequacy for current climate	High
Size of beneficiaries group	Nationwide coverage

2. Technology: Biogas for Transport	
Introduction	Biogas are produced through microbiological process from different kinds of biomass (as feedstock) such as: (1) wastewater from wastewater treatment sludge; (2) manure from animal production; (3) industrial and municipal organic waste from landfill;

	and (4) crops. When biogas is purified or upgraded to natural gas quality, it can be used as vehicle fuel.
Technology characteristics	Biogas (as raw biogas) is a product of anaerobic digestion of biomass, without upgrading (CO_2-removal); 50% to 70% CH_4. Biogas consists mainly of methane (CH_4, 50%-70%) and carbon dioxide (CO_2, 25% to 45%) and small quantities of impurities (mostly H_2S and H_2O, with different shares depending on the feedstock being used. In order to use biogas as vehicle fuel, purification and upgrading (CO_2 removal) are necessary to reduce contamination with hazardous components and increase the calorific value of the gas, i.e. to make it interchangeable with conventional fuels (especially natural gas). Biomethane is an upgraded biogas to natural gas quality, with a high CH_4 content (at least 90%, commonly 96% to 99%) and low share of impurities.
Costs, including	
cost to implement mitigation options	Total cost for the supply of biomethane as vehicle fuel ranges: • US$ 0.75 to 1.94 per m^3 CH_4 (from energy crops); • US$ 0.40 to 1.63 per m^3 CH_4 (from manure); • US$ 0.28 to 1.63 per m^3 CH_4 (from industrial waste) Biogas production (anaerobic digestion) costs: • Energy crops (e.g. corn silage, sugar beet, wheat grain): US$ 9/GJ to US$ 14/GJ • Agricultural waste products (mainly slurry and manure): US$ 0/GJ to US$ 6/GJ • Industrial waste products (e.g. distillery stillage): US$ 3/GJ to US$ 6/GJ • Municipal waste (municipal solid waste or sewage sludge): US$ 20/GJ to US$ 9/GJ Biogas upgrading costs ranges: • from US$ 0.17/m^3 CH_4 to US$ 2.50/m^3 CH_4 (500m^3/hour upgrading capacity) • from US$ 0.14/m^3 CH_4 to US$ 0.18/m^3 CH_4 (1,000 m^3/hour upgrading capacity) • from US$ 0.09/m^3 CH_4 to US$ 0.16/m^3 CH_4 (2,000 m^3/hour upgrading capacity) Biomethane distribution costs ranges from US$0.09/$m^3$ CH_4 to US$0.22 per m^3 CH_4 Overall cost for fast-filling fuelling station with a capacity of 3,500m^3/day is about US$ 0.5/m^3 CH_4

cost of not modifying the project	Biogas production (anaerobic digestion) costs: • Energy crops (e.g. corn silage, sugar beet, wheat grain): US$ 9/GJ to US$ 14/GJ • Agricultural waste products (mainly slurry and manure): US$ 0/GJ to US$ 6/GJ • Industrial waste products (e.g. distillery stillage): US$ 3/GJ to US$ 6/GJ • Municipal waste (municipal solid waste or sewage sludge): US$ 20/GJ to US$ 9/GJ
Potential development impacts, benefits	
Economic	• Substitution of import fuels and reduction of import dependency • Savings in health and welfare costs/benefits due to less air pollution • Contributes to energy security and sustainability • Tax income
Social	• Offers job creation/employment opportunities
Environmental	• Lower emissions in comparison to diesel and gasoline driven vehicles • Contribution to municipal or company's targets on GHG emissions reduction • The utilization and treatment of waste and residues and therefore the reduction of ecological damage and closing of material cycles
Status of technology in the Philippines	Currently, there are no companies who are engaged in the biomethane production in the country.
Barriers	Potential barriers of biogas production and use as vehicle fuel (biomethane production and use) and/or establishment of biogas-to-fuel market are as follows: • Vehicle company operators have to make a major decision with some economic risk • Drivers may have prejudices against the new vehicle technology • Higher standards on fleet depots and maintenance garages (e.g. gas warning system) • The high initial investment is more visible for customers than economic advantage (costs for fuel) over the car's lifetime • Technical limitations: driving distance, less space in the car because of gas cylinder with large volume in comparison to liquid fuel storages • A lot of "clean" alternatives (e.g. liquid biofuels, electric vehicles) are available • Lack of centralized biomass availability • Relatively high costs in comparison with fossil fuels

	• Lack of awareness about the advantages of biogas as an energy carrier • Regulatory frameworks often do not give stakeholders a reliable basis for investing in biogas project • Lack of rules with regard to the access to gas grid; • Existing structures and stakeholders in the waste business often do not allow for new solutions od waste treatment • Lack of natural gas vehicle (NGV) infrastructure (e.g. gas grid, filling stations and NGV) makes biogas use as fuel for transport • The economic advantages of NGV are often not known by the customers.
Acceptability to local stakeholders	Highly acceptable to local stakeholders because biogas (raw biogas) has been used in domestic and agricultural applications for electricity and cooking. Low acceptability to transport sector due to high cost
Endorsement by experts	Yes, the need for experts is highly considered in order to: • conduct capacity building activities to develop local expertise • provide expert advice and support to potential developers • partnerships between foreign equipment suppliers and local manufacturers and visit and study tours to successful installations in a similar environment.
Timeframe	A biomethane project can be implemented from 1 to 5 years with the assumptions that the project is feasible/viable.
Institutional capacity	Technical know-how, both among the project developers implementing biogas (raw) and biomethane and local industries providing services is important for the success of the implementation and operation of biogas projects.
Adequacy for current climate	There are no negative consequences of the mitigation option in the current climate.
Size of beneficiaries group	End-users of biogas/biomethane, developers, financing institutions, foreign and local manufacturers, policy makers/government agencies, local consultants and service providers

ANNEX II: ENERGY SECTOR TECHNOLOGIES FOR TNA STUDY

Subsector	Technology (Brief Description)
Renewable Energy, electricity generation	Hydropower, Dam Type
	Hydropower, Run-of-River
	Geothermal Power
	Wind turbine, On-Shore
	Wind turbine, Off-Shore
	Biomass Fueled Cogeneration
	Biomass Gasification
	Biogas Plant
	Landfill Gas Plant
	Biofuels (Bioethanol and Biodiesel) – for transport
	Solar Photovoltaics
	Solar Thermal power
	Floating Solar is a solar PV Facility which utilizes the water surface in lieu of roof and ground/land
	Ocean Power
Renewable Energy, thermal energy	Solar Water Heating System
	Solar Water Pumping System
	Biomass Combustion for Water Heating/Drying
Renewable Energy (commercial and residential sector)	Solar Dryers
	Solar Cookers
Renewable Energy, mechanical energy	Wind-Powered Mechanical Water Pumps
Renewable Energy (Energy Storage)	Lithium-Iron Phosphate (LiFePO4)- a revolutionary energy storage with three times power density of conventional battery that could be used to store excess energy from RE generating facilities such as solar PV Power to Gas Storage - utilizing excess energy from RE facility such as Solar Energy Facility to produce Natural gas (CH_4) through the combination of Carbon Dioxide (CO_2) and Hydrogen (H_2)
Renewable Energy (Policy)	A policy mandating all government agencies to have Solar PV rooftop installations within their building facilities

Renewable Energy (IEC)	A nationwide campaign to fast track the implementation and approval of Solar PV grid-connected facilities
Supply side and demand side: power industries/other manufacturing industries/commercial establishments/ households/ transport	Electricity Transmission and Distribution Efficiency Improvement
	Power Plant Efficiency Improvement
	Energy-Efficient Lighting System
	Energy-Efficient Refrigerators
	Energy-Efficient Freezers
	Energy-Efficient Washing Machine e.g. inverter type
	Energy-Efficient Electric Fans
	Energy-Efficient Pumps
	Energy-Efficient Air Compressors
	Energy-Efficient Air-Conditioning System
	Energy- Efficient Chillers – e.g. Magnetic Bearing Chiller with environment safe refrigerant
	Energy-Efficient Electric Motors
	Variable Speed Drive/Variable Frequency Drive
	Alternative Fuel Refuse (AFR) for Fuel Replacement
	Waste Heat Recovery System
	Insulations, Cladding and Steam traps
	Energy Management System (EMS)
	Building Management System (BMS)
	Supervisory Control and Data Acquisition (SCADA)
	Next generation vehicle testing laboratory for hybrid, plug-in hybrid and electric vehicles- will be used for validating the vehicle parts performance such as motor, battery and engine
	Training and Software for the conduct of environmental life cycle analysis of next generation vehicles
	Smart Energy Control for energy efficiency and conservation-designed of web-based and communication device interactive application to enhance energy efficiency and conservation practices in household
Coal Mines	Coal -Bed Methane Recovery
Reduce in GHG emission	High efficiency low emission mine mouth power plant using lignitic coal deposit

Oil and Gas Production Fields	Capture and Flaring of Oil and Gas
Non-Renewable Energy	High-Efficient Coal Power Plant: subcritical and supercritical with pollution control system and carbon capture and storage
	Natural Gas Combined Cycle Power Plant
	Natural Gas Open Cycle Power Plant
	High-Efficient Oil Power Plant
	Nuclear Power Plant, Heavy Water Reactor
	Nuclear Power Plant, Light Water Reactor
Renewable Energy	Promotion and development of RE (solar-greenhouse, floating solar, very low-head hydropower project)
Energy Efficiency	Promotion and installation of energy efficient lighting and own-use solar rooftop installation

ANNEX III: List of Stakeholders

Consultation with stakeholders
Training Room, Energy Center, Rizal Drive, Taguig
06 February 2018

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Prioritization Workshop with Stakeholders

PNOC Building

19 March 2018

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National Consultation
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ANNEX IV: Highlights of Workshops/Consultation Meetings

TECHNOLOGY NEEDS ASSESSMENT CONSULTATIONS
February 2017 – April 2018

I. BACKGROUND

The Climate Change Commission (CCC) is spearheading the Technology Needs Assessment (TNA) Project with support from UN Environment and Technical University of Denmark (UN–DTU) to identify needs for new technologies, capacities and skills to mitigate greenhouse gas emissions and enhance adaptive capacity of vulnerable sectors to climate change.

II. OBJECTIVES

Series of consultation with relevant agencies were conducted to come up with a long-list of technology needs and identify technology barriers to guide subsequent technology prioritization for climate change adaptation and mitigation. The list of technologies will then become the basis for subsequent technical and financial assistance to increase efforts on climate change adaptation and mitigation.

Activity	Date	Objective
Consultation with stakeholders	6 February 2018 19 March 2018	- Provide overview of the project - identify initial technology needs of stakeholders - Validate the submission of stakeholders
National Consultation	24 April 2018	- Present the initial TNA for adaptation and mitigation report relevant in the implementation of the NCCAP and the NDC - Finalize and consolidate climate change related technology needs and technology providers and industries - Prioritize technology needs per sector using multi-criteria analysis tool

III. HIGHLIGHTS OF CONSULTATIONS

Mr. Belver with Dr. Rosa and Mr. Francis moderated the forum and solicited updates from the offices/agencies on the current technologies available and needed for climate change adaptation and mitigation.

1. Categorization of Technologies

   Prior to prioritization of technologies, variants of technologies must be noted. These include hard and soft, or a combination of both and orgware technologies. Hard technologies could include goods and hardware while soft technologies may use "knowledge of methods and techniques that enable "hard technologies to be applied". Orgware may involve the re-organization or establishment of social networks and/or institutions (*UNFCCC definition).*

2. Prioritizing Sectors

   In prioritizing sectors for mitigation, the development priorities and/or the potential for greenhouse gas reduction may be given considerations. For that matter, the stakeholder grounded its prioritization based on the AWIT-FE (agriculture, waste, industry, transport, forestry and energy) sectors.

3. Alignment of Mitigation actions on NCCAP and INDC

   The TNA aims to align its mitigation technologies to support for the attainment of the actions stated in the county's National Climate Change Action Plan and the Intended Nationally Determined Contributions, and other development plan and frameworks, among others.

   The Philippines' climate change vulnerabilities are strategically being addressed by the National Climate Change Action Plan (NCCAP), pursuant to Republic Act 9729 or the Climate Change Act, consistent with the Philippine Development Plan and other national and sectoral plans as well as the 2030 Sustainable Development Goal (SDG) targets and the Paris Agreement, among other international frameworks.

   The NCCAP also aims to build the adaptive capacities of women and men in their communities, (1) increase the resilience of vulnerable sectors and natural ecosystems to climate change and; (2) optimize mitigation opportunities towards gender responsive and rights-based sustainable development. It provides key climate actions, clustered into seven thematic priorities: food security, water sufficiency, environmental and ecological

stability, human security, sustainable energy, climate-smart industries and service and knowledge and capacity development[50]

The Philippine climate change policies are geared towards the attainment of the Philippine targets for greenhouse gas emissions reduction, and climate change adaptation, while duly considering intergenerational equity.

The Department of Energy as well as the relevant agencies were trained in conducting cost-benefit analysis last August 2017 where the mitigation options in the INDC were revisited to determine whether these options are realistic and attainable. Some of the identified options for the energy sector are energy efficient street lighting (LED and HPS); and NREP biomass, small hydro, large hydro, wind, solar, ocean and geothermal.

4. Workshops and consultations

4.1 Coordination with stakeholders

The Climate Change Commission (CCC) prepared a template for needs identification indicating the sector, subsector, brief description of technology, category (soft or hard), NCCAP priority, scale of application, life span and estimated cost. Another template is used to gather detailed description of technology needs (e.g. potential development impacts/benefits, barriers, acceptability to local stakeholders, endorsement by experts, timeframe, and institutional capacity). The concerned agencies were requested to fill up the templates and the CCC collated all submissions in preparation for the prioritization process.

The CCC conducted a series of house-to-house consultations with agencies to validate their submissions. A national consultation/workshop was conducted to present the long list of technologies and to prioritize the submissions.

4.2 Screening long-list of technologies

In a national workshop with participants from the national government agencies, non-government organizations, and civil society organizations, the group decided to have a shortlist of technologies for easier prioritization. With over 70 technologies submitted for climate mitigation, the shortlist of technologies should capture the needs and priorities of the country as per NCCAP and INDC, and other development plans and international frameworks. Although there were overwhelming submissions, the shortlist only accommodated the following

[50] National Climate Change Action Plan 2011-2028. Climate Change Commission.

considerations: (1) emerging or new technologies; and (2) hardware technologies. Other technologies under software and orgware categories and those that are considered "matured" technologies are still included as part of the long list. However, in consideration with the capacity of the country to fund a technology, emerging or new hardware technologies were prioritized for possible technical and financial assistance from the financing facility.

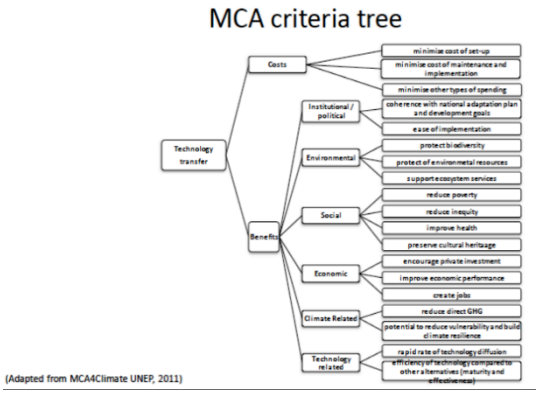
Shortlisted technologies will be subjected to the technology prioritization process using the Multi-Criteria Analysis (MCA) Tool.

4.3 Assigning weights

From the shortlisted technologies, two main factors were considered: (1) cost of technology and (2) its benefits. The CCC set a criteria to standardize the prioritization, that is, 30% for cost and 70% for benefit. Aside from the relevance of mitigation technologies to INDC mitigation options and the potential for greenhouse gas reduction, the following sub-factors with corresponding criteria were established:

1. Cost of technology
   a. Capital cost (85%)
   b. Operational and maintenance cost (15%)

2. Benefit
   a. Environmental and climate impacts (30%)
   b. Social acceptability (20%)
   c. Institutional/ Political (10%)
   d. Economic relevance (20%)
   e. Technology-relatedness (20%)



The mitigation group, which is composed of NGAs, CSOs, development partners and private sector, assigned weights per technology in parallel to the criteria set by the CCC and with approval from the stakeholders. The formula used to come up with priority technologies on energy, transport and waste sectors is shown below.

$$\left((\sum weighted\ cost\ x\ 0.3) + (\sum weighted\ benefit\ x\ .70)\right) x\ 100$$

4.4 Result of MCA

The table below shows the result of participatory prioritization of technologies for mitigation using the MCA tool.

Sector	Technology	Ranking
Energy	Next generation vehicle testing laboratory for hybrid, plug-in hybrid and electric vehicles	1st
	Solar thermal System	2nd
	Waste Heat Recovery System	3rd
Waste	Eco-efficient Soil Cover using compost	1st
	Anaerobic digester	2nd
Transport	Motor Vehicle Inspection System (MVIS)	1st
	Biogas	2nd