BUILDING LOW EMISSION ALTERNATIVES TO DEVELOP ECONOMIC RESILIENCE AND SUSTAINABILITY PROJECT (B-LEADERS)

PHILIPPINES MITIGATION COST-BENEFIT ANALYSIS

-

November 2015

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Integrated Report

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I. EXECUTIVE SUMMARY

As the Philippine economy continues to expand, the Government of the Philippines is working to address the sustainability and greenhouse gas (GHG) emission challenges related to sustaining this growth. As a part of this effort, the Climate Change Commission (CCC) partnered with the United States Agency for International Development (USAID) to develop the quantitative evidence base for prioritizing climate change mitigation by conducting a cost-benefit analysis (CBA) of climate change mitigation options. An economy-wide CBA is a systematic and transparent process that can be used to evaluate the impact of potential government interventions on the welfare of a country's citizens. Thus, the CBA is well-suited for the identification of socially-beneficial climate change mitigation opportunities in the Philippines.

The CBA Study is conducted under the USAID-funded Building Low Emission Alternatives to Develop Economic Resilience and Sustainability (B-LEADERS) Project managed by Engility Corporation. The scope of the CBA covers all GHG emitting sectors in the Philippines, including agriculture, energy, forestry, industry, transport, and waste. The assessment is carried out relative to a 2010-2050 baseline projection of the sector-specific GHG emissions levels. The evaluation of the mitigation options covers the period spanning 2015-2050, except for the forestry where costs are assessed starting in 2010.

For each sector, the CBA evaluates a collection of nationally-appropriate mitigation options. To this end, each option is characterized in terms of:

- **The direct benefits** that are measured by the expected amount of GHG emissions reduced via the option. These GHG emission benefits are quantified, but not monetized;
- **The costs** associated with the mitigation option that can be quantified and monetized; and
- **The co-benefits** associated with the mitigation option that can be quantified and monetized. Depending on the option, the co-benefits may include beneficial economic/market impacts and non-market impacts.

The CBA employs two tools that are already being used by stakeholders in the country:

- **The Long-range Energy Alternatives Planning (LEAP) Tool** – LEAP is a flexible, widely used software tool for optimizing energy demand and supply and for modeling mitigation technologies and policies across the energy and transport sectors, as well as other sectors.
- **The Agriculture and Land Use Greenhouse Gas Inventory (ALU)** Software which was developed to guide a GHG inventory compiler through the process of estimating GHG emissions and removals related to agriculture, land use, land-use change, and forestry (LULUCF) activities.

The CBA is performed predominantly in the LEAP tool. The estimates of the agriculture and forestry sector GHG emissions are computed in the ALU tool and subsequently fed to LEAP. For some of the mitigation options, the estimates of costs and benefits are developed externally, with the LEAP model linking to the relevant datasets.

This Report represents the second update on the CBA model development work. It is structured to integrate stand-alone sectoral reports that contains:

- A description of methods and sector-specific GHG emissions for the base year of 2010 and for the baseline projection spanning 2010-2050;
- A description of mitigation options evaluated for each sector;
- Estimates of the option/activity-specific direct benefits (i.e., the amount of GHG emissions reduced) as well as costs and economic co-benefits of the mitigation options for 2015-2050 time period, for which the Study Team already obtained data;
- Where relevant, estimates of indirect economic impacts (i.e., power sector impacts from mitigation activities in other sectors) and non-market co-benefits (congestion and public health) for those mitigation options where data are available;
- Where relevant, estimates of quantifiable energy security, employment, and public health-related gender impacts for the analyzed mitigation options;
- The development of a marginal abatement cost curve (MACC) which illustrates the cumulative abatement potential and costs per tonne of the mitigation options analyzed in this report; and
- A summary of next steps and specific areas for stakeholder involvement, including additional support for data sharing and review of proposed methodologies (Section **Error! Reference source not found.**).

This study builds on the output of the series of consultations conducted from February until July of 2015. The results of these consultations were vetted by CCC and stakeholders in each of the relevant sectors. As such, this does not include results of discussions, new assumptions and data collected after July 2015. An updated version of this report shall be done in consultation with the relevant national government agencies led by the CCC and hopefully will reflect outcome of the Conference of Parties (COP) in Paris where CCC played a key role in the Philippine Delegation.

I.1 2010 BASELINE GHG EMISSIONS AND REMOVALS

The 2010 base year GHG inventory for the Philippines is organized according to the standard categories used by the Intergovernmental Panel on Climate Change (IPCC) in the 2006 Inventory Guidelines (IPCC, 2006), except in the case of the IPCC category of energy. In this study, the energy category is split into "energy" and "transport." The energy sector in this CBA predominantly covers the power sector-related activities. The categories are as follows: agriculture, energy, forestry, industry (process emissions), transport, and waste. Figure I. 1 on the next page summarizes the results for the 2010 base year GHG emissions.

Figure I. 1. 2010 Base Year GHG Emissions and Removals for All Sectors (MtCO2e)

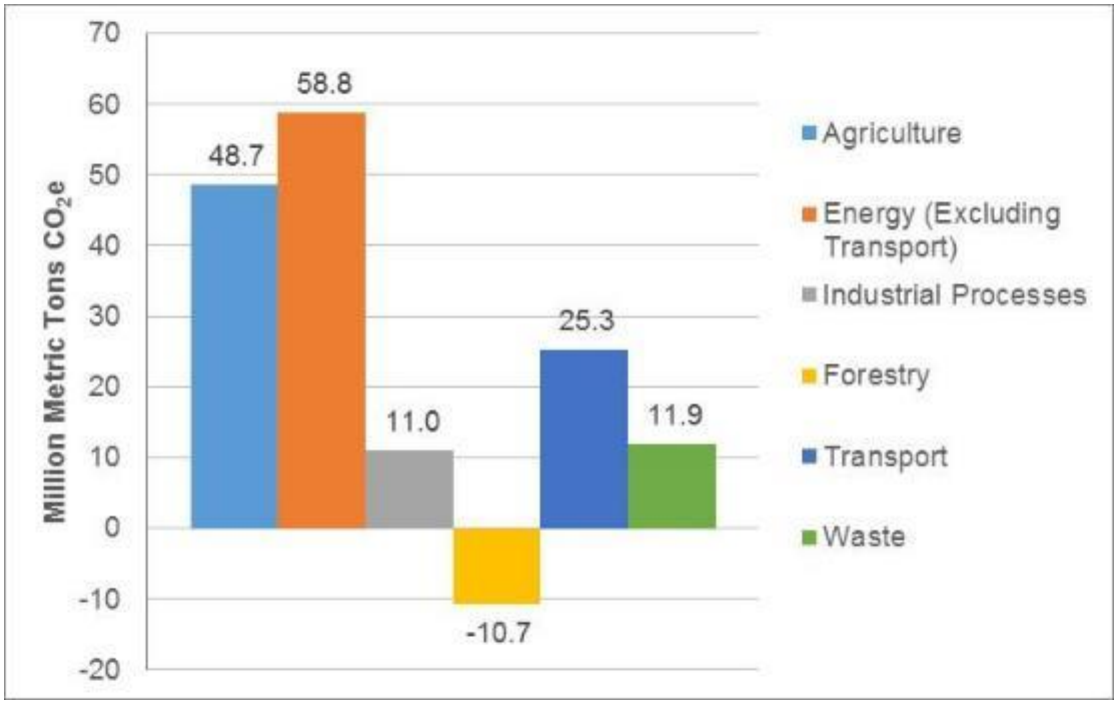


Table I. 1. SNC 2000 and CBA 2010 GHG Emissions and Removals for All Sectors ($MtCO_2e$)

Sector	2000	2010	Change (%)
Agriculture	37	48.7	31.5
Energy (Excluding Transport)	43.7	58.8	34.6
Forestry	-105.1	-10.7	-89.8
Industrial Processes	8.6	11.0	27.5
Transport	25.9	25.3	-2.5
Waste	11.6	11.9	2.4
Total	**21.7**	**144.9**	**567.7**

Table I. 1 compares the 2010 base year estimate with the year 2000 GHG inventory from the Philippines Second National Communication (SNC). The Table shows over a 500% increase in GHG emissions between 2000 and 2010. However, the numbers in Table I. 1 should be interpreted with care, because the 2010 estimates for each of the sectors relied on new data sources and/or methodologies. In some cases, such as the agriculture, energy and industrial process sectors, the addition of new source categories led to an increase in GHG emissions, while for sectors such as transport and waste, GHG emissions are lower in 2010 than would otherwise have been expected had the same methods been used as those in the SNC.

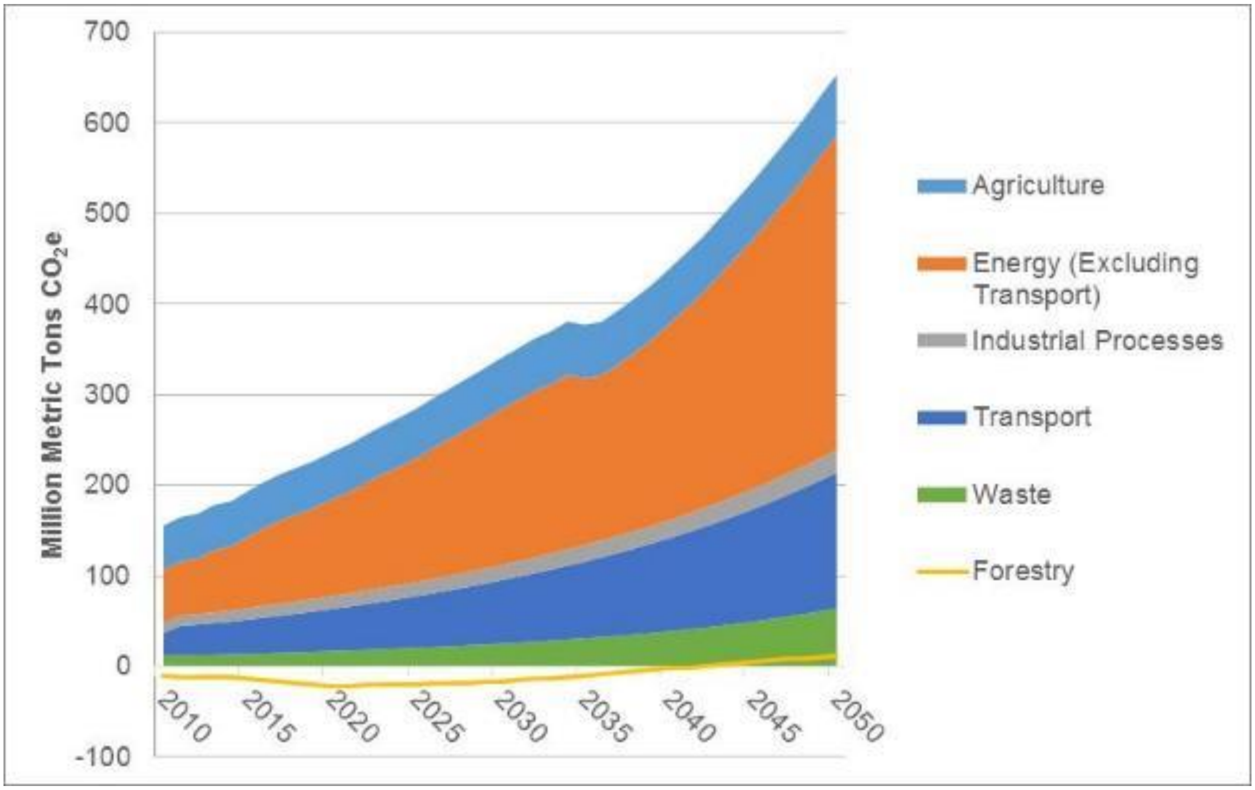
In the forestry sector, the use of the ALU tool means that entirely new accounting methods and assumptions have been used. As these are still being reviewed by stakeholders, the 2010 base year results may change.

I.2 BASELINE PROJECTION FOR 2010 TO 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. The goal of this CBA is to quantify the GHG emissions impact, costs and benefits of existing and proposed mitigation actions, regulations, and policies in the Philippines. Therefore, the baseline excludes some of the existing policies that contribute to GHG mitigation, even though these policies have already been passed into law and are being implemented in the Philippines. Instead, these policies and measures are analyzed as the sector-specific mitigation options. This approach enables stakeholders to assess the future GHG impact, costs and co-benefits of the many recent initiatives that are being implemented to reduce GHG emissions, such as the National Renewable Energy Program and the National Greening Program.

Figure I. 2 describes the results for the 2010-2050 baseline, which indicates that emissions will almost triple by 2050. 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. Based on the initial assumptions for the forestry sector agreed to with stakeholders in April 2015, the results indicate that the Philippines will no longer remain a carbon sink by 2050.

Figure I. 2. 2010-2050 Baseline Projection for All Sectors (MtCO_2e)



I.3 MITIGATION COST-BENEFIT AND CO-BENEFIT ANALYSIS

This section presents estimates of costs and benefits for those mitigation options for which data and assumptions have already been made available by stakeholders. The mitigation options were selected and analyzed based on the following considerations:

- The mitigation options are reflected in national policies, regulations and development plans for the Philippines and/or options that are being considered for future adoption;
- The options are included in prior mitigation studies and reports for the Philippines (such as efforts by the UNDP and ADB) to prioritize and/or analyze mitigation options for various sectors;
- The options have the potential to reduce and/or avoid GHG emissions in the Philippines; and/or
- Stakeholders recommended inclusion of the options in this study.

Table I. 2 summarizes the abatement potentials and costs for the mitigation options analyzed in the CBA, including changes in capital, operating and maintenance (O&M), implementation, and fueling costs as well as GHG emissions. The assessment is based on cumulative costs expected during the 2015-2050 time period, except for the forestry sector where costs are estimated starting in 2010. Many of the mitigation options have a negative cumulative net cost which means that they will be cost-effective to implement simply from a perspective of direct cost and GHG reduction potential.

The GHG mitigation potential of the options analyzed are compared individually against the baseline scenario. As a result, there is overlap between some of the emission sources covered by the mitigation options. The GHG mitigation potentials of all of the options should therefore not be “summed up” as it would overestimate the GHG mitigation that can be achieved by their implementation.

Table I. 2. Mitigation Options for All Sectors – Potential and Net Cost

Sector	Mitigation Option	Costs Compared to Baseline (Cumulative 2015-2050) [Billion 2010 USD] Discounted at 5%			GHG Mitigation Potential (2015-2050) [MtCO2e]	Cost per Ton Mitigation (2015-2050) [2010 USD] *without co-benefits*
		Capital, O&M, Implementation Costs	Cost of Fuel and Other Inputs	**Total Net Cost**		
Symbol		*A*	*B*	*C*	*D*	*E*
Formula				*(A+B)=C*		*C/D=E*
Energy	Biodiesel Blending Target	0.00	6.94	6.94	84.4	82.2
	Biodigesters	2.51	-1.16	1.35	1.0	1,287.2
	Biomass Co-firing in Coal Plants	1.05	-1.53	-0.48	70.6	-6.8
	Biomass for Cement Production	0.00	-2.35	-2.35	115.5	-20.4
	Cement Clinker Reduction	-0.39	-29.48	-29.86	120.5	-247.8
	Cement Waste Heat Recovery	-0.20	-0.36	-0.56	10.5	-53.9
	Energy Efficient Street Lighting with HPS Technology	0.18	-0.52	-0.33	11.3	-29.6
	Energy Efficient Street Lighting with LED Technology	0.30	-0.60	-0.31	13.7	-22.4
	Forest Protection	1.94	3.19	5.13	516.9	9.9
	Forest Restoration and Reforestation	1.80	-0.94	0.86	405.9	2.1
	Home Appliance Improvements	-2.57	-3.29	-5.86	81.3	-72.0
	Home Lighting Improvements	-0.32	-0.41	-0.73	9.0	-81.5
	Methane Recovery from Dumpsites for Electricity	0.14	-0.29	-0.14	79.3	-1.8
	Methane Recovery from Sanitary Landfills for Electricity	0.12	-0.27	-0.15	81.5	-1.9
	MSW Combustion	0.59	-0.21	0.38	N/A[a]	N/A[a]
	MSW Digestion	0.21	-0.39	-0.18	25.5	-7.1
	NREP Biomass	0.21	-0.44	-0.24	15.6	-15.2
	NREP Geothermal	16.03	-7.72	8.31	179.0	46.4
	NREP Large Hydro	10.17	-6.41	3.76	137.9	27.3

	NREP Ocean	0.43	-0.40	0.03	8.1	3.7
	NREP Small Hydro	1.71	-1.03	0.67	17.1	39.4
	NREP Solar	0.39	-0.38	0.01	11.0	0.9
	NREP Wind	3.85	-4.08	-0.23	85.5	-2.7
	Nuclear Power	2.64	-2.84	-0.20	91.5	-2.2
	Substituting Natural Gas for Coal	-8.23	5.89	-2.34	608.9	-3.8
Transport	Biofuels	0.0	19.9	19.9	[1]	63
	Buses and BRT	6.4	-2.4	4.0	10.5	377
	CNG Buses	0.1	-0.3	-0.2	0.5	-483
	Congestion Charging	0.1	-6.0	-5.9	46	-129
	Driver Training	1.5	-5.7	-4.2	40	-105
	Jeepney Modernization	-0.3	-23.3	-23.6	172	-137
	Electric LDV	1.2	-4.0	-2.7	14	-192
	Electric MCTC	0.8	-1.4	-0.6	1.2	-483
	Euro 4/IV and MVIS	2.3	83.6	85.9	55	1575
	Euro 6/VI and MVIS	4.1	180.5	184.6	55	3363
	LDV Efficiency	6.7	-10.8	-4.1	71	-57
	MVIS	0.4	-7.3	-6.9	46	-150
	Rail	9.1	-1.9	7.2	8.5	849
	Road Maintenance	13.2	-13.9	-0.6	85	-7
	Two-Stroke Replacement	0.2	-0.1	0.1	0.1	939
Waste	MSW Digestion	0.21	-0.39	-0.18	25.53	-7.08
	Methane Recovery from Sanitary Landfills	0.12	-0.27	-0.15	81.51	-1.85
	Methane Flaring	0.46	–	0.46	76.89	5.95
	Composting	6.05	–	6.05	169.88	35.60
	Eco-Efficient Cover	2.51	–	2.51	77.75	32.30
Forestry	(M2) Forest Restoration and Reforestation	1.80	-0.94	0.859	405.87	2.12
	(M1) Forest Protection	1.94	3.19	5.133	516.91	9.93
Industry	Increase Glass Cullet Use	□	-0.13	-0.13	0.2	-564.5
	Cement Clinker Reduction	-0.39	-29.48	-29.86	120.5	-247.8
	Cement Waste Heat Recovery	-0.20	-0.36	-0.56	10.5	-53.9
	Biomass in Cement	0.00	-2.35	-2.35	115.6	-20.4
	Biomass Co-firing	1.05	-1.53	-0.48	70.6	-6.8
Agriculture	Organic fertilizers	–	-1.0	-1.0	48.1	-2.0
	AWD	0.1	–	0.1	91.2	0.1
	Crop diversification	–	0.4	0.4	8.5	4.6
	Bio-digesters	2.51	-1.16	1.35	1.1	1,287.2

Notes:

[1] This study estimates the GHG mitigation potential of transport biofuels to be 366 $MtCO_2e$, assuming no biogenic emissions from fuel combustion and not accounting for increased upstream emissions beyond domestic borders. This figure represents the potential to reduce emissions listed in the domestic emissions inventory, but excludes the considerable increase in upstream emissions that is likely in countries that export biofuels to the Philippines.
[2] Unlike cumulative costs of mitigation options in other sectors, cumulative costs of forestry sector mitigation options cover 2010-2015.
[3] The energy benefits of the glass mitigation option will be added at a later date.
Abbreviations:
CNG = Compressed natural gas; LDV = light-duty vehicle; MCTC = motorcycle/tricycle; MVIS = motor vehicle inspection system; SLF = sanitary landfill; OD = open dump; CDF = controlled disposal facility; MRF = material recycling facility
Column Definitions:
[A] Capital, O&M, and Implementation Costs: Includes capital, O&M, and implementation costs compared to the Baseline scenario.
[B] Cost of Fuel and Other Inputs: Includes the cost of delivered fuels, and plus the cost of fertilizer for the agriculture sector, all relative to the Baseline scenario. Fuel savings or reductions in fertilizer use are reflected as negative costs (co-benefits).
[C] Total Net Cost: Equal to the sum of capital, O&M, implementation, fuel, and input costs compared to the Baseline. Represents the net change in costs with implementation of the mitigation option. Negative costs indicate cost savings compared to the Baseline (e.g., fuel savings).
[D] GHG Mitigation Potential: Potential change in cumulative GHG emissions from 2015-2050 with implementation of the mitigation option. Positive values indicate GHG emissions benefits.
[E] Cost per Tonne Mitigation without co-benefits: Equal to the total net cost divided by the mitigation potential. Represents the cumulative cost per tonne of a mitigation option if implemented relative to the Baseline. Negative values indicate cost savings as well as GHG emissions benefits.

There are several non-market and market co-benefits which can add to the cost-effectiveness of a mitigation option. For this report we have estimated the following co-benefits:

- *Non-market co-benefits*: the value of air quality-related improvements in public health as well as the value of congestion relief; and

- *Market co-benefits*: the value of timber and agroforestry commodities obtainable from reforested areas (designated for production) as well as the income generated from recyclables and composting.

Table I. 3 summarizes the co-benefits that can be monetized for the mitigation options included in this CBA. The estimates are cumulative and cover the time period of 2015-2050 for mitigation options in all sectors.

Table I. 3. Monetized Co-Benefits of Mitigation Options in all Sectors

Sector	Mitigation Option	Co-benefits Compared to Baseline (Cumulative 2015-2050) [Billion 2010 USD] Discounted at 5%				Cost per Ton Mitigation (2015-2050) [2010 USD] *co-benefits only*
		Health	Congestion	Income Generation	**Total Co-benefit**	
Symbol		*F*	*G*	*H*	*I*	*J*
Formula					sum(F,G,H)=I	-I/D=J

Sector	Mitigation Option	Co-benefits Compared to Baseline (Cumulative 2015-2050) [Billion 2010 USD] Discounted at 5%				Cost per Ton Mitigation (2015-2050) [2010 USD] *co-benefits only*
		Health	Congestion	Income Generation	**Total Co-benefit**	
Energy	Biodiesel Blending Target	0.00	N/A[a]	N/A[a]	0.00	0.0
	Biodigesters	-0.36	N/A[a]	N/A[a]	-0.36	348.0
	Biomass Co-firing in Coal Plants	4.74	N/A[a]	N/A[a]	4.74	-67.2
	Biomass for Cement Production	0.00	N/A[a]	N/A[a]	0.00	0.0
	Cement Clinker Reduction	0.04	N/A[a]	N/A[a]	0.04	-0.3
	Cement Waste Heat Recovery	0.23	N/A[a]	N/A[a]	0.23	-22.0
	Energy Efficient Street Lighting with HPS Technology	N/A[b]	N/A[a]	N/A[a]	N/A[b]	N/A[b]
	Energy Efficient Street Lighting with LED Technology	0.16	N/A[a]	N/A[a]	0.16	-11.7
	Forest Protection	0.16	N/A[a]	N/A[a]	0.16	-0.3
	Forest Restoration and Reforestation	-0.19	N/A[a]	N/A[a]	-0.19	0.5
	Home Appliance Improvements	0.01	N/A[a]	N/A[a]	0.01	-0.2
	Home Lighting Improvements	0.19	N/A[a]	N/A[a]	0.19	-21.6
	Methane Recovery from Dumpsites for Electricity	N/A[b]	N/A[a]	N/A[a]	N/A[b]	N/A[b]
	Methane Recovery from Sanitary Landfills for Electricity	-0.13	N/A[a]	N/A[a]	-0.13	1.6
	MSW Combustion	0.07	N/A[a]	N/A[a]	0.07	N/A[c]
	MSW Digestion	0.18	N/A[a]	N/A[a]	0.18	-7.2
	NREP Biomass	0.22	N/A[a]	N/A[a]	0.22	-14.0
	NREP Geothermal	5.13	N/A[a]	N/A[a]	5.13	-28.7
	NREP Large Hydro	3.38	N/A[a]	N/A[a]	3.38	-24.5
	NREP Ocean	0.13	N/A[a]	N/A[a]	0.13	-16.0
	NREP Small Hydro	0.24	N/A[a]	N/A[a]	0.24	-14.2
	NREP Solar	0.37	N/A[a]	N/A[a]	0.37	-33.6
	NREP Wind	1.27	N/A[a]	N/A[a]	1.27	-14.8
	Nuclear Power	1.44	N/A[a]	N/A[a]	1.44	-15.7
	Substituting Natural Gas for Coal	18.30	N/A[a]	N/A[a]	18.30	-30.1
	Biofuels					
	Buses and BRT	13.7	9		22.7	-2162

Sector	Mitigation Option	Co-benefits Compared to Baseline (Cumulative 2015-2050) [Billion 2010 USD] Discounted at 5%				Cost per Ton Mitigation (2015-2050) [2010 USD]
		Health	Congestion	Income Generation	**Total Co-benefit**	*co-benefits only*
	CNG Buses					
	Congestion Charging	24	8.5		32.5	-707
	Driver Training					
	Jeepney Modernization	96.4			96.4	-560
	Electric LDV	0.8			0.8	-59
	Electric MCTC	0.1			0.1	-100
	Euro 4/IV and MVIS	101.4			101.4	-1860
	Euro 6/VI and MVIS [1]	140 to 308			140 to 308	-5603 to -2554
	LDV Efficiency					
	MVIS	125.1			125.1	-2720
	Rail	5.2	3.3		8.5	-1000
	Road Maintenance					
	Two-Stroke Replacement	0.019			0.019	-194
Waste	MSW Digestion	0.183	–	–	0.183	-7.17
	Methane Recovery from Sanitary Landfills	-0.127	–	–	-0.127	1.56
	Methane Flaring	–	–	–	0.00	0.00
	Composting	–	–	6.5	6.5	-38.26
	MSW Digestion	–	–	–	0.00	0.00
Forestry	(M2) Forest Restoration and Reforestation	-0.195	–	7.19	6.995	-17.23
	(M1) Forest Protection	0.158	–	–	0.158	0.31
Industry	Increase Glass Cullet Use	□	□	□	0	0
	Cement Clinker Reduction	0.038	□	□	0.038	-0.3
	Cement Waste Heat Recovery	0.231	□	□	0.231	-21.9
	Biomass in Cement	□	□	□	0	0
	Biomass Co-firing	4.738	□	□	4.738	-67.1
Agriculture	Organic fertilizers	–	–	–	0.0	0.0
	AWD	–	–	–	0.0	0.0
	Crop diversification	–	–	–	0.0	0.0
	Bio-digesters	-0.364	–	–	-0.364	348.0

Notes:

[1] The range of health co-benefits reflects uncertainty regarding the level of reduction in $PM_{2.5}$ emissions from diesel jeepneys running on cleaner (10ppm sulfur) fuel. Studies in the U.S. (MECA, 1999) and Japan (WWFC, 2000) have found 10-50% reductions in $PM_{2.5}$ from uncontrolled diesel trucks (Walsh & Blumberg, 2003) switching from 300-500ppm to ultra-low sulfur fuel.

[2] The energy benefits of the glass mitigation option will be added at a later date.

Abbreviations:

CNG = Compressed natural gas; LDV = light-duty vehicle; MCTC = motorcycle/tricycle; MVIS = motor vehicle inspection system; SLF = sanitary landfill; OD = open dump; CDF = controlled disposal facility; MRF = material recycling facility.

Column Definitions:

[F] Co-benefits: Health: Monetized public health benefits reflect the reduced risk of premature death from exposure to air pollution exposure. For the transport sector, these are based on reduced emissions of fine particles from vehicle tailpipes. For the energy sector, these are based on the reduced power plant emissions of SO_2, fine particulates, and NO_X.

[G] Co-benefits: Congestion: Monetized congestion benefits reflect less time wasted on congested roadways. These are specific to the transport sector.

[H] Co-benefits: Income Generation: Economic co-benefits from creation of new markets and/or expansion of productive capacity. For forestry, these include timber and fruit production from re-forested areas. For waste, these include recyclables and composting from waste diverted from landfills.

[I] Total Co-benefits: Sum of valuation of monetized co-benefits. Co-benefits that were quantified but not monetized (i.e. energy security) are summarized in **Error! Reference source not found.**.

[J] Cost per Tonne Mitigation: co-benefits only: Value of monetized co-benefits (represented as a negative cost) divided by mitigation potential.

Table I. 4 combines the net cost per tonne that reflects the difference between costs and co-benefits of fuel/other input savings (Column E in Table I. 2) with the total value of other market and non-market co-benefits per tonne (Column J in Table I. 3). Column L of Table I. 4 indicates the present value of net benefit stream, which is the difference between discounted value of cumulative co-benefits (the value of fuel savings, income generation, public health improvements, and traffic congestion) and discounted value of cumulative costs of a mitigation option. A positive value indicates a mitigation option has net benefits to society in addition to its potential to mitigate GHG emissions.

Table I. 4. Net Present Value of Mitigation Options in All Sectors

Sequence Number of Mitigation Option	Mitigation Option	Incremental GHG Mitigation Potential (2010-2050) [$MtCO_2e$]	Incremental Cost per Ton Mitigation [2010 USD / tCO_2e]		Net Present Value Excluding Value of GHG Reduction (2010-2050) [Billion 2010 USD] *with co-benefits*
			without co-benefits	with co-benefits	
Symbol		*D*	*E*	*K*	*L*
Formula			*C/D=E*	*E+J*	*D * -K*
Energy	Biodiesel Blending Target	84.4	82.2	82.2	-6.94
	Biodigesters	1.0	1,287.2	1,635.2	-1.71
	Biomass Co-firing in Coal Plants	70.6	-6.8	-74.0	5.22
	Biomass for Cement Production	115.5	-20.4	-20.4	2.35
	Cement Clinker Reduction	120.5	-247.8	-248.1	29.90
	Cement Waste Heat Recovery	10.5	-53.9	-75.9	0.80
	Energy Efficient Street Lighting with HPS Technology	11.3	-29.6	N/A[a]	N/A[a]
	Energy Efficient Street Lighting with LED Technology	13.7	-22.4	-34.2	0.47
	Forest Protection	516.9	9.9	9.6	-4.97

Sequence Number of Mitigation Option	Mitigation Option	Incremental GHG Mitigation Potential (2010-2050) [$MtCO_2e$]	Incremental Cost per Ton Mitigation [2010 USD / tCO_2e] without co-benefits	with co-benefits	Net Present Value Excluding Value of GHG Reduction (2010-2050) [Billion 2010 USD] *with co-benefits*
	Forest Restoration and Reforestation	405.9	2.1	2.6	-1.05
	Home Appliance Improvements	81.3	-72.0	-72.2	5.87
	Home Lighting Improvements	9.0	-81.5	-103.0	0.92
	Methane Recovery from Dumpsites for Electricity	79.3	-1.8	N/A[a]	N/A[a]
	Methane Recovery from Sanitary Landfills for Electricity	81.5	-1.9	-0.3	0.02
	MSW Combustion	N/A[b]	N/A[b]	N/A[b]	-0.30[c]
	MSW Digestion	25.5	-7.1	-14.3	0.36
	NREP Biomass	15.6	-15.2	-29.1	0.45
	NREP Geothermal	179.0	46.4	17.8	-3.18
	NREP Large Hydro	137.9	27.3	2.7	-0.38
	NREP Ocean	8.1	3.7	-12.3	0.10
	NREP Small Hydro	17.1	39.4	25.2	-0.43
	NREP Solar	11.0	0.9	-32.7	0.36
	NREP Wind	85.5	-2.7	-17.5	1.50
	Nuclear Power	91.5	-2.2	-17.9	1.64
	Substituting Natural Gas for Coal	608.9	-3.8	-33.9	20.64
Transport	Biofuels	[1]	63	63	-23
	Buses and BRT	10.5	377	-1136	12
	CNG Buses	0.5	-483	-483	0.2
	Congestion Charging	46	-129	-766	35
	Driver Training	40	-105	-105	4.2
	Jeepney Modernization	172	-137	-679	117
	Electric LDV	14	-192	-251	3.5
	Electric MCTC	1.2	-483	-583	0.7
	Euro 4/IV and MVIS	55	1575	-285	16
	Euro 6/VI and MVIS	55	3363	-2240 to 810	-44 to 123
	LDV Efficiency	71	-57	-57	4.0
	MVIS	46	-150	-2870	132
	Rail	8.5	849	90	-0.8
	Road Maintenance	85	-7	-7	0.6
	Two-Stroke Replacement	0.1	939	745	-0.1
Waste	MSW Digestion	25.53	-7.08	-14.25	0.36
	Methane Recovery from Sanitary Landfills	81.51	-1.85	-0.29	0.02
	Methane Flaring	76.89	5.95	5.95	-0.46
	Composting	169.88	35.60	-2.66	0.45
	Eco-Efficient Cover	77.75	32.30	32.30	-2.51

Sequence Number of Mitigation Option	Mitigation Option	Incremental GHG Mitigation Potential (2010-2050) [$MtCO_2e$]	Incremental Cost per Ton Mitigation [2010 USD / tCO_2e]		Net Present Value Excluding Value of GHG Reduction (2010-2050) [Billion 2010 USD] *with co-benefits*
			without co-benefits	with co-benefits	
Forestry	(M2) Forest Restoration and Reforestation	405.87	2.12	-15.11	6.13
	(M1) Forest Protection	516.91	9.93	9.62	-4.97
Industry	Increase Glass Cullet Use	0.2	-564.5	-564.5	0.11
	Cement Clinker Reduction	120.5	-247.8	-248.1	29.9
	Cement Waste Heat Recovery	10.5	-53.9	-75.8	0.80
	Biomass in Cement	115.6	-20.4	-20.4	2.36
	Biomass Co-firing	70.6	-6.8	-73.9	5.22
Agriculture	Organic fertilizers	48.1	-2.0	-2.0	0.10
	AWD	91.2	0.1	0.1	-0.01
	Crop diversification	8.5	4.6	4.6	-0.04
	Bio-digesters	1.1	1,287.2	1,635.2	-1.71

Notes:
[1] This study estimates the GHG mitigation potential of transport biofuels to be 366 $MtCO_2e$, assuming no biogenic emissions from fuel combustion and not accounting for increased upstream emissions beyond domestic borders. This figure represents the potential to reduce emissions listed in the domestic emissions inventory, but excludes the considerable increase in upstream emissions that is likely in countries that export biofuels to the Philippines.
[2] The range of health co-benefits reflects uncertainty regarding the level of reduction in $PM_{2.5}$ emissions from diesel jeepneys running on cleaner (10ppm sulfur) fuel. Studies in the U.S. (MECA, 1999) and Japan (WWFC, 2000) have found 10-50% reductions in $PM_{2.5}$ from uncontrolled diesel trucks (Walsh & Blumberg, 2003) switching from 300-500ppm to ultra-low sulfur fuel.
[3] Unlike cumulative costs of mitigation options in other sectors, cumulative costs of forestry sector mitigation options cover 2010-2015.
[4] The energy benefits of the glass mitigation option will be added at a later date.
Abbreviations:
CNG = Compressed natural gas; LDV = light-duty vehicle; MCTC = motorcycle/tricycle; MVIS = motor vehicle inspection system; SLF = sanitary landfill; OD = open dump; CDF = controlled disposal facility; MRF = material recycling facility.
Column Definitions:
[D] GHG Mitigation Potential: Potential change in cumulative GHG emissions from 2015-2050 with implementation of the mitigation option. Positive values indicate GHG emissions benefits.
[E] Cost per Tonne Mitigation without co-benefits: Equal to the total net cost divided by the mitigation potential. Represents the cumulative cost per tonne of a mitigation option if implemented relative to the Baseline. Negative values indicate cost savings as well as GHG emissions benefits.
[J] Cost per Tonne Mitigation: co-benefits only: Value of monetized co-benefits (represented as a negative cost) divided by mitigation potential.
[K] Cost per Tonne Mitigation with co-benefits: Equal to the total net cost minus valuation of co-benefits, divided by mitigation potential.
[L] Net Present Value Excluding Value of GHG Reduction: Total co-benefits minus total net cost. Reflects the present value to society of a mitigation option relative to the baseline, including changes in costs (e.g. capital, fuel, and other inputs) and co-benefits such as public health, but excluding climate benefits. A true net present value would include a valuation of climate benefits based on the social cost of carbon dioxide-equivalent in the Philippines times the mitigation potential (**Error! Reference source not found.**, column D).

I.4 MARGINAL ABATEMENT COST CURVE

Figure I. 4 on the next page provides the marginal abatement cost curve (MACC) for the mitigation options analyzed in the CBA.[1] The MACC visually illustrates the cumulative abatement potential and costs per ton if all the mitigation options are implemented. It is designed to take into account interactions between mitigation options. Implementing certain options together can lower (or raise) their total effectiveness. The CBA follows the retrospective systems approach in Sathaye and Meyers (1995) whereby the final emission reduction potential and cost per ton of CO_2e for each option are calculated using the marginal emission reductions and costs incurred after the option was added to prior mitigation option. Thus, the first option is evaluated in comparison to the BAU scenario only, the second option in comparison to the BAU plus the first option, and so forth.

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[1] The MACC is based on the direct costs and benefits summarized in The GHG mitigation potential of the options analyzed are compared individually against the baseline scenario. As a result, there is overlap between some of the emission sources covered by the mitigation options. The GHG mitigation potentials of all of the options should therefore not be "summed up" as it would overestimate the GHG mitigation that can be achieved by their implementation.

Table I. 2. It does not capture the indirect market effects highlighted in Table I. 3 on co-benefits.

II. INTRODUCTION

II.1 PURPOSE

The Philippines ranks among the fastest-growing and dynamic economies in the Asia-Pacific region. However, the Philippines is also one of the globe's most vulnerable countries to climate change. 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. In turn, as the Philippines economy continues to grow, the government is working to address the growth-related sustainability challenges that may slow down the pace of improvement in quality of life for its citizens. As a part of this effort, the Climate Change Commission (CCC) partnered with the United States Agency for International Development (USAID) to develop the quantitative evidence base for prioritizing climate change mitigation options by conducting a cost-benefit analysis (CBA) of mitigation options. The CCC is interested in using this CBA to develop Nationally Appropriate Mitigation Actions (NAMAs), and, potentially, formulate the country's intended nationally determined contribution (INDC) submission to the United Nations Framework Convention on Climate Change (UNFCCC).

An economy-wide cost-benefit analysis (CBA) is a systematic and transparent process that can be used to evaluate the impact of potential government interventions on the welfare of a country's citizens. Thus, the CBA is well-suited for the identification of socially-beneficial climate change mitigation opportunities in the Philippines. The CBA findings can also support the national planning of low emissions development strategies and preparation of the national communication to the UNFCCC.

The Study is conducted under the USAID-funded Building Low Emission Alternatives to Development, Economic Resilience, and Sustainability (B-LEADERS) Project managed by Engility Corporation. The Study is being implemented by a consortium of local and international experts from Abt Associates, the Stockholm Environment Institute (SEI), and the International Council on Clean Transportation (ICCT).

- **Abt Associates Inc. (Abt).** Founded in 1965, Abt Associates Inc. is a mission-driven, global leader in research and program implementation in the fields of health, social and environmental policy, and international development. Abt is dedicated to providing its partners with sound information and empirical analysis as the foundation for effective decision-making. With a professional staff of more than 2,700 US and international full-time experts – working on projects in over 60 countries – Abt specializes in fields such as climate change mitigation and adaptation, clean energy finance, economics, public administration and institutional strengthening. Abt Associates is one of the premier providers of analytic support to key environmental agencies in the United States and more than 20 developing and transition countries. Currently, Abt supports economic analyses for the US Environmental Protection Agency's lead division for climate change and implements numerous capacity building programs for USAID, the Inter-American Development Bank (IADB), the World Bank and the Asian Development Bank (ADB) to strengthen capacity for low emissions economic analysis and investment worldwide.

- **Stockholm Environment Institute (SEI).** SEI is an independent, international not-for-profit research institute based in Stockholm, Sweden, and with offices in the USA, UK, Estonia, Thailand and Kenya. SEI has been engaged in environment and development issues at local, national, regional and global policy levels for over twenty years and now has a staff of approximately 200 people. Since its establishment in 1989, it has earned a reputation for rigorous and objective scientific analyses of complex environmental, developmental, social and institutional issues. SEI's work on scenarios, sustainability modeling, vulnerability assessments and analysis of natural resources and environmental systems is particularly well known. SEI works all around the world, conducting integrated analyses that support decision-makers and build capacity for integrated sustainability planning through training and collaboration on projects. SEI is also the developer of the Long Range Energy Alternatives Planning System.

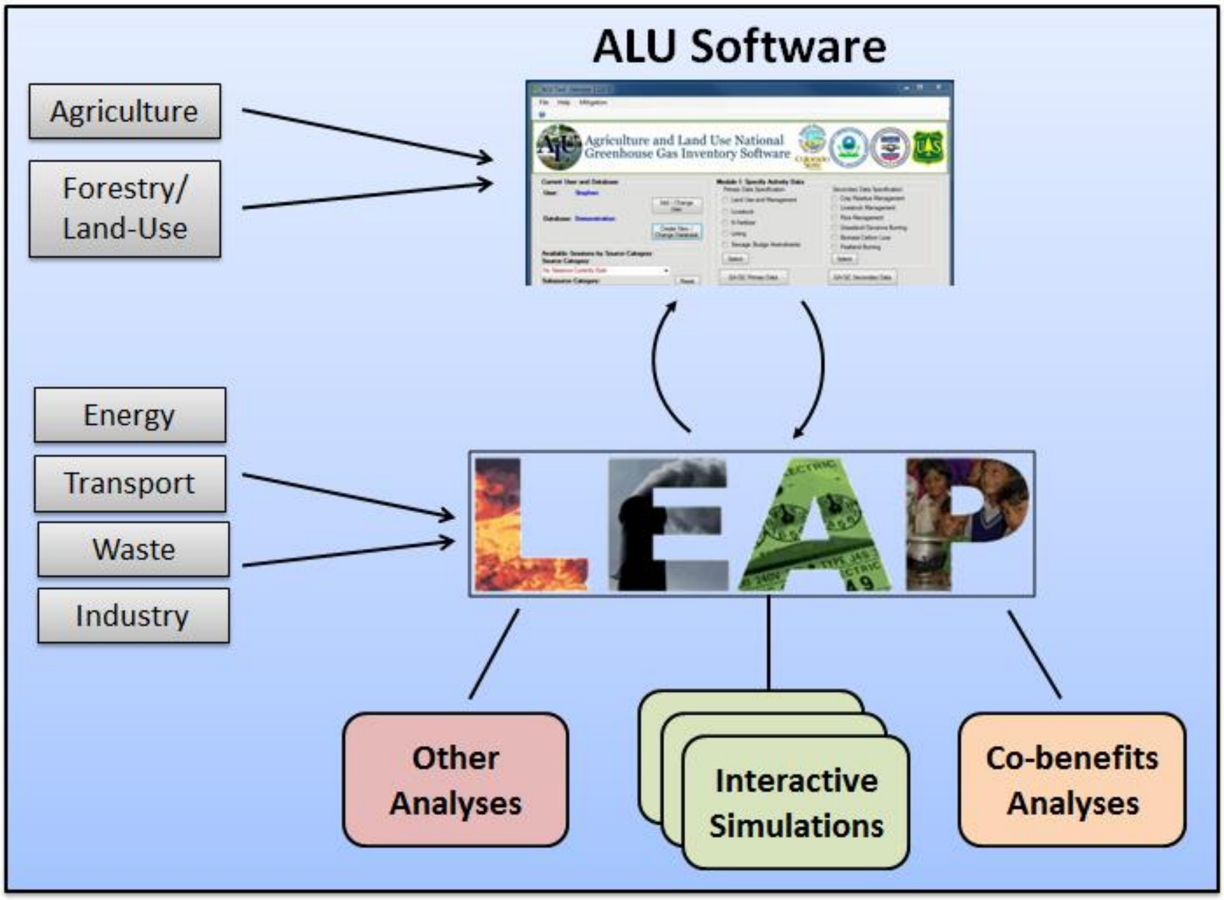
- **The International Council on Clean Transportation (ICCT)** is a non-profit research organization dedicated to improving the environmental performance and energy efficiency of transportation to improve air quality and address climate change. The ICCT provides national and local policymakers with technical analysis of regulations, fiscal incentives, and other technology-based measures for clean vehicles and fuels. The ICCT works across modes including passenger cars, light commercial vehicles, heavy-duty trucks and buses, two- and three-wheelers, international aviation and marine, conducting global outreach with a focus on major and growing vehicle markets. The ICCT maintains a staff of about 30 technical and policy experts, and a network of Council Members who provide input on regulatory and research priorities.

II.2 ORGANIZATION OF THE ANALYSIS

The scope of the CBA performed in this Study covers all greenhouse gas (GHG) emitting sectors in the Philippines, including agriculture, energy, forestry, industry, transport, and waste. The mitigation assessment is carried out relative to a 2010-2050 baseline projection of the sector-specific GHG emissions levels. The evaluation period for the mitigation options spans 2015-2050 unless otherwise specified for each mitigation option.[2] All monetary estimates reported in the analysis are in 2010 United States Dollars (USD) and rely on 5% discount rate, where appropriate.

[2] The evaluation of the mitigation options assumes a start-year of 2015 and is carried out to 2050, unless the options are tied to a mitigation policy or program with a specific end year. In the case of the forestry sector, the evaluation of mitigation costs goes back to 2010.

Figure I. 3.Mitigation Cost Benefit Modeling Framework for the Philippines



B-LEADERS will deliver the next iteration of the Report to the CCC in August 2015. The August 2015 deliverable will:

- Incorporate the comments and feedback received on this Update Report as well as additional data which the study team expects to obtain by then;
- Include a cost-benefit analysis of the additional mitigation options proposed in Section **Error! Reference source not found.** on next steps as well as an evaluation of additional co-benefits that can be quantified and monetized;
- Summarize the results of the CBA study and document all data, methods, and assumptions; and

- Include a toolkit developed in LEAP that enables stakeholders to develop, modify and visualize mitigation scenarios using the CBA model.

In the last quarter of 2015, B-LEADERS will provide a training manual on how to use and update the national model once this study is completed.

In addition to these written reports, the B-LEADERS project will provide hands-on training and capacity building to stakeholders on the methods for:

- Conducting cost-benefit analysis of mitigation; and
- Updating and revising the CBA model and toolkit developed for this analysis.

This will ensure that the CCC and USAID are provided with the complete and current information and that the government is able to apply the model for future planning purposes even after the project is completed.

II.2.1 Cross-Cutting Assumptions

The levels of sector-specific GHG emissions generating activities are expected to evolve over time and are dependent on the changes in several fundamental characteristics of the country's economy. In the context of this CBA, the relevant economy characteristics include: population size, GDP (i.e., the total value added by all productive activity in the country over a year), relative contributions of various economic sectors[3] to the total value added, and fuel prices. To ensure internal consistency of the CBA, the Study Team developed a set of projections for these economic characteristics for the Philippines during 2010-2050. The Team then used this projection set to build the sector-specific baseline activity and GHG projections.

The following data and assumptions were used to project the economy characteristics of interest:

- **Population size**: We used historical population size estimate for 2010 and population size projections for 2011–2045 from Philippine Statistics Authority. For 2046–2050, population size was projected using annual average population size growth rate during 2035–2045.
- **GDP**: We used historical GDP data for 2010–2014 from Philippine Statistics Authority. For 2015–2050, GDP was projected using similar assumptions as those used by the Asian Development Bank in the study on Low-Carbon Scenario and Development Pathways for the Philippines (ADB, 2015).
- **Distribution of value added by economic sector**: We used historical data on economic sector-specific value added for 2010–2014 from the Philippine Statistics Authority. For each year in 2015–2050, economic sector-specific value added was projected by multiplying the GDP projection with the projected economic sector-specific share of value added. Economic

[3] Note that the economic sectors are not equivalent to the GHG emissions sectors. The economic sectors characterize distinct sets of productive activities that generate value added. They include industry (e.g., manufacturing or food processing), commerce, agriculture, forestry, and fishing.

sector-specific value added shares were projected using their historical annual average growth rates during 1998–2014.

- **Fuel prices**: For 2010–2014, we used historical data on fuel prices from various sources, which included DOE, DENR (biomass), IPCC AR5 WG3 Annex III (nuclear), and own calculation based energy balances and imports data. For the majority of fuels, we projected 2015–2050 prices based on the World Energy Outlook 2014 (Current Policies scenario). Prices for biomass and nuclear fuels were held constant. CNG price held constant until 2016 (Velasco 2014); during 2017–2050, CNG price was based on price of natural gas plus the additional cost for compression, distribution, refining, taxes, and retail mark-up.

All data sources supporting the projection development are further detailed in ANNEX B.

II.3 MITIGATION COST-BENEFIT ANALYSIS

This subsection presents estimates of costs and benefits for those mitigation options for which data and assumptions have already been made available by stakeholders.

II.3.1 Process for Selecting the Mitigation Options

The mitigation options proposed for this analysis were selected based on the following considerations:

- The mitigation options are reflected in national policies, regulations and development plans for the Philippines and/or options that are being considered for future adoption;
- The options are included in prior mitigation studies and reports for the Philippines (such as efforts by the UNDP and ADB) to prioritize and/or analyze mitigation options for various sectors;
- The options have the potential to reduce and/or avoid GHG emissions in the Philippines; and/or
- Stakeholders recommended inclusion of the options in this study.

In 2014, the UNDP supported by the CCC developed a list of mitigation options for the waste, industry, transport, and agriculture sectors that could be included in future Nationally Appropriate Mitigation Actions (NAMAs) (Mejia, 2014). At the request of the CCC, B-LEADERS built upon the mitigation options listed in the UNDP study to develop a list of mitigation options for this study. Some of the mitigation options on the UNDP list consist of general policies that could include more than one mitigation option. Those general policies are not included in this CBA study, since the CBA is targeted towards distinct mitigation options, technologies, or processes that can be individually quantified, monetized, and compared for cost effectiveness.

The Study Team supplemented the initial list with additional mitigation options identified through the stakeholder consultations outlined in Section **Error! Reference source not found.**, existing national policies and regulatory documents, and the Philippines' Second National Communication to the UNFCCC. The UNDP study did not cover the energy and forestry sectors. Instead, the sector experts on the study team proposed a menu of options and confirmed these during consultations with the

Department of Energy and the Forest Management Bureau, respectively. Key to the development of the list of mitigation options was their applicability to the Philippines and existing support by the government.

II.3.2 Cross-Cutting Variables

A number of common variables were used for analyzing costs and benefits across all sectors, including:

- Exchange rate,
- 5% discount rate, and
- Currency unit and monetary year (2010 USD).

In addition to the co-benefits that were monetized there are several other indicators that can help assess the mitigation options, but cannot be expressed in monetary terms. These are reported in Table I. 5 and include energy security, power sector employment generation, and public health-related gender impacts

Table I. 5. Additional Quantified Indicators for All Sectors

Sector	Mitigation Option	Change in Indicator						
		Energy Intensity	GHG Intensity	Share of Imports	Share of Renewables	Power Sector Employment Generated	Public Health	Gender Health
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
Transport	Biofuels	-0.047	-13.297	-0.502	2.418	0		
	CNG Buses	-0.001	-0.065	-0.004	0.003	0	684	37
	Congestion Charging	-0.031	-2.155	-0.189	0.136	0	43,688	37
	Driver Training	-0.022	-1.491	-0.133	0.098	0		
	Electric LDV	-0.007	-0.378	-0.041	0.031	3,200	1,799	37
	Electric MCTC	-0.003	-0.132	-0.016	0.012	790	244	36
	Euro 6/VI Standards	-0.025	-1.952	-0.148	0.109	0	287,200 to 619,896	37 to 48
	Euro 4/IV Standards	-0.025	-1.939	-0.148	0.109	0	209,537	37
	E-Jeepneys	-0.074	-5.214	-0.486	0.362	10,000	153,310	37
	LPG Taxis	0	-0.005	0	0	0		
	MVIS	-0.025	-1.659	-0.148	0.109	0	178,153	38
	Public Transport	-0.004	-0.299	-0.024	0.015	0	11,425	37
	Road Maintenance	-0.050	-3.261	-0.273	0.216	0		
	Two-Stroke Replacement	0	-0.013	-0.001	0.001	40	28	36
	Vehicle Efficiency	-0.028	-1.813	-0.158	0.121	0		
Energy	Agricultural Waste Digestion	Modeled in conjunction with agricultural biodigesters scenario.						
	Biodiesel Blending Target	-0.0043	-3.0434	-0.0716	0.5827	0		
	Biomass Co-firing		-2.9636	-0.3714	0.4286	0	4,808	39

Sector	Mitigation Option	Change in Indicator						
		Energy Intensity	GHG Intensity	Share of Imports	Share of Renewables	Power Sector Employment Generated	Public Health	Gender Health
	Biomass in Cement		-4.9269	-0.6541	0.7411	0		
	Cement Clinker Reduction	Modeled in conjunction with industry cement clinker reduction scenario.						
	Cement Waste Heat Recovery	-0.0053	-0.3655	-0.0156	0.0094	-2,500	66	37
	Gas for Coal	-0.0395	-4.9782	-0.1083	0.0674	-3,400	15,095	39
	Landfill Gas	Modeled in conjunction with solid waste scenario 2.						
	Municipal Solid Waste Incineration and Digestion	-0.0004	-0.3642	-0.0567	0.0642	1,700	58	37
	National Renewable Energy Program - All Technologies	0.4197	-26.4432	-5.7301	7.7926	160,000	10,178	38
	NREP Biomass	0.0023	-0.5512	-0.1055	0.12	2,400	107	38
	NREP Geothermal	0.3930	-7.7879	-3.0005	4.5959	44,000	3,226	38
	NREP Large Hydro	0.0539	-11.8497	-2.0801	2.4982	82,000	3,861	38
	NREP Ocean	-0.0031	-0.3620	-0.0316	0.0321	750	171	39
	NREP Small Hydro	0.0079	-1.9888	-0.2301	0.3818	12,000	777	38
	NREP Solar	-0.0031	-0.4056	-0.0091	0.0374	12,000	133	38
	NREP Wind	-0.0329	-4.0894	-0.3873	0.3825	8,200	1,943	38
	Street Lighting - Efficient High Pressure Sodium	-0.0060	-0.4062	-0.017	0.0106	-2,700	71	37
	Street Lighting - Light Emitting Diode	-0.0077	-0.5372	-0.0202	0.0125	-3,200	169	38
Agriculture	AWD	0	-0.1524	0	0	0		
	Organic fertilizer	0	-3.1609	0	0	0		
	Crop diversification	0	-1.8576	0	0	0		

Sector	Mitigation Option	Change in Indicator						
		Energy Intensity	GHG Intensity	Share of Imports	Share of Renewables	Power Sector Employment Generated	Public Health	Gender Health
	Biodigesters	0.0064	-1.0965	-0.1305	0.1617	2,300	228	38
Forestry	Forest protection (M1)	-0.1836	-33.9227	2.5226	-2.9639	31,000	-418	38
	Forest restoration and reforestation (M2)	0.0214	-9.2999	-0.2305	0.3077	-3,100	204	38
Waste	Scenario 1: Substitute dumpsites for landfills, 100% diversion of biodegradable waste							
	Scenario 2: Scenario 1 with methane recovery	0.0055	-6.314	-0.153	0.1649	22,000	70	37
	Scenario 3: Scenario 2 but 40% diversion of biodegradable waste	0.0044	-9.191	-0.1229	0.1288	18,000	-19	45
Industry	Cement Clinker Reduction	-0.0207	-4.0824	-0.1068	0.0857	-1,700	-31	42
	Glass	0	-0.0138	0	0			

Abbreviations:

CNG = Compressed natural gas; LDV = light-duty vehicle; MCTC = motorcycle/tricycle; MVIS = motor vehicle inspection system; SLF = sanitary landfill; OD = open dump; CDF = controlled disposal facility; MRF = material recycling facility.

Column definitions:

(3) Energy Intensity: Energy intensity is measured as total primary energy supply (indigenous production of primary energy + energy imports - energy exports) divided by GDP. The reported quantity is energy intensity with mitigation option minus energy intensity in the baseline scenario, averaged over 2015-2050. The data output for this metric is derived from the LEAP model. For the methods and data used to determine primary energy supply and GDP, please refer to Section 4 Energy.

(4) GHG Intensity: Greenhouse (GHG) intensity is measured as CO_2e emissions (economy-wide, including from energy and non-energy sources) per unit of GDP. The reported quantity is carbon intensity with mitigation option minus GHG intensity in baseline scenario, averaged over 2015-2050.

(5) Share of Imports: Percentage share of imports in total primary energy supply. The reported quantity is percentage share of energy imports with mitigation option minus percentage share of energy imports in baseline scenario, averaged over 2015-2050. The data output for this metric is derived from the LEAP model. For the methods and data used to determine energy imports and GDP, please refer to Section 4 Energy.

(6) Share of Renewables: Percentage share of renewable energy in total primary energy supply. Renewable energy sources include biomass, geothermal, hydro, solar, wind, and ocean. The reported quantity is percentage share of renewables with mitigation option minus percentage share of renewables in reference scenario, averaged over 2015-2050. For the data and methods used to determine renewable energy supply please refer to Section 4 Energy.

(7) Power Sector Employment Generated: Cumulative number of job-years created in the power sector under a mitigation option over 2015-2050. Please refer to Annex B for a more detailed description of how these are estimated. NOTES: i) This indicator does not account for employment gains or losses due to the mitigation option elsewhere in the economy; ii) In the future, this indicator may be expanded to include employment gains from mitigation options in other sectors beyond power generation.
(8) Public Health: Cumulative number of outdoor air pollution-related deaths avoided due to a mitigation option. Please refer to Annex B for a more detailed description of how these are estimated.

II.3.3 Marginal Abatement Cost Curve

Figure I. 4 on the next page provides the marginal abatement cost curve (MACC) for the mitigation options analyzed in the CBA.

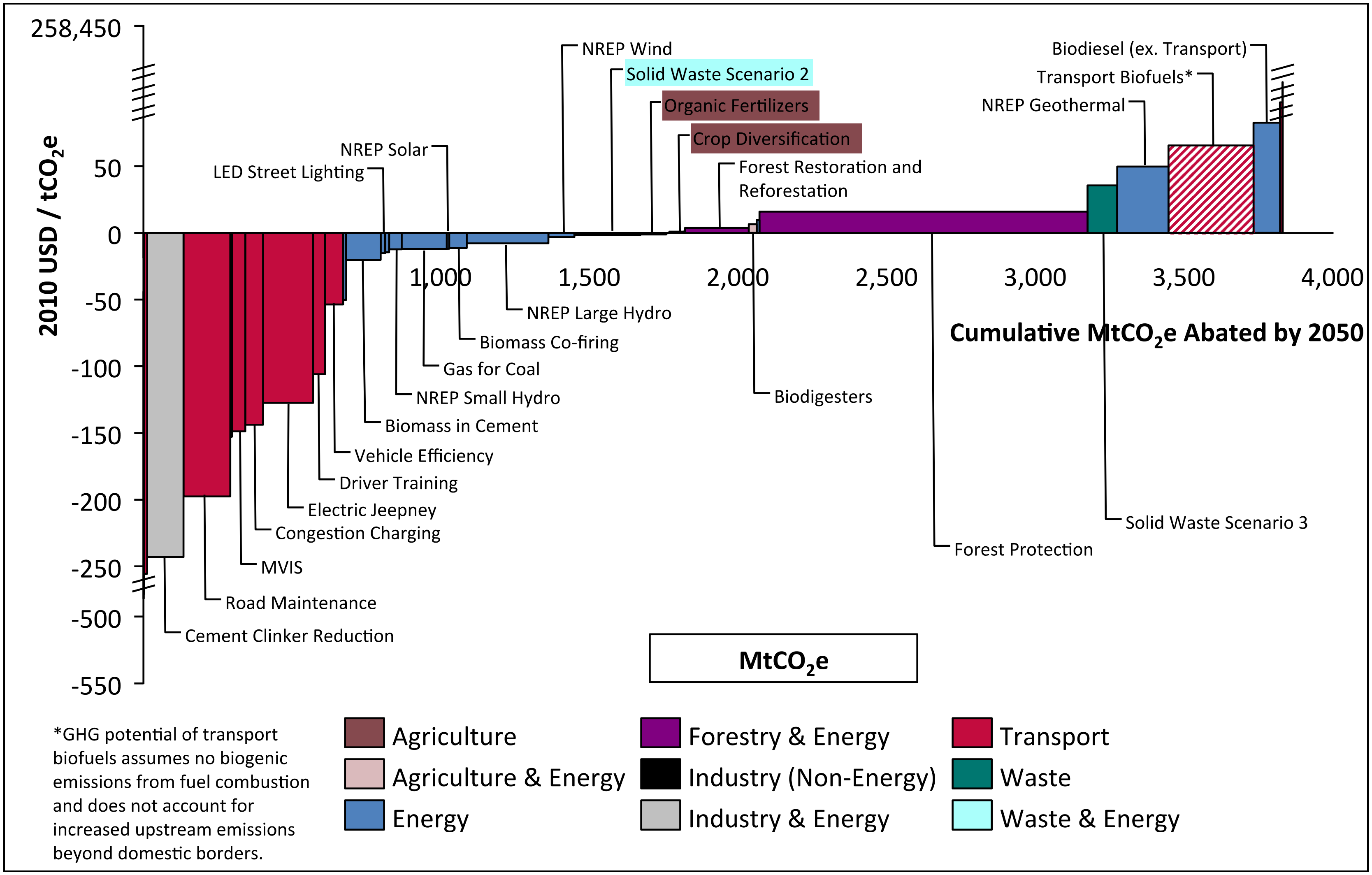
A key issue in the estimation of mitigation potential and costs per ton is how to account for interactions between mitigation options. Implementing certain options together can lower (or raise) their total effectiveness—for example, an electric efficiency measure will result in greater abatement when the power system is carbon intensive, but less if a renewable power measure is deployed concurrently. Similarly, in the transport sector, some mitigation options address the same GHG emission source categories (i.e., Euro 4 and Euro 6 emission standards), leading to a potential overestimation of total GHG emission reductions if all the mitigation options analyzed in this report are simply summed up. The CBA addresses this issue by following the retrospective systems approach in Sathaye and Meyers (1995). In brief, this method involves four steps:

- Each mitigation option is first evaluated individually (compared to the BAU case), and an initial cost per ton for each is recorded;
- The options are sorted according to their initial costs per ton in ascending order;
- The options are added one at a time and in order to a new combined mitigation scenario, and emissions and costs for the combined scenario are recorded after each addition; and
- The final abatement potential and cost per ton for each option are calculated using the marginal emission reductions and costs incurred after the option was added to the combined scenario. Thus, the first option is evaluated in comparison to the 2010-2050 baseline only, the second option in comparison to the baseline plus the first option, and so forth.

The MACC visually illustrates the cumulative abatement potential and costs per ton if all the mitigation options are implemented. It shows that implementation of all the mitigation options analyzed in the study could result in total cumulative emission reductions of 3,832 $MtCO_2e$ compared with the baseline scenario. If all the negative cost mitigation options are implemented (i.e., all those below the horizontal axis), the Philippines can achieve reductions of 1,769 $MtCO_2e$ by 2050 compared to the baseline.

The MACC presented in Figure I. 4 is based on the direct costs and benefits. It does not capture the indirect market effects.

Figure I. 4. Marginal Abatement Cost Curve for All Sectors



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