Updated Energy Sector’s Marginal Abatement Cost Curve Analysis – Sri Lanka

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Updating the Energy Sector Marginal Abatement Cost Curve

Introduction

The Marginal Abatement Cost Curve (MACC) of the Sri Lanka Energy Sector prepared by the Energy Sector Nationally Appropriate Mitigation Action (NAMA) Project supported by the United Nations Development Programme (UNDP) comprised 46 Green House Gas (GHG) abatement technologies. The objective of the assignment is to assess the validity/relevance of each of the 46 technologies, eliminate irrelevant technologies, verify and update inputs of each technology, and include any new technologies that have been identified suitable for implementation in Sri Lanka since the energy sector MACC was published.

Technologies captured in the energy sector MACC developed by the UNDP supported Energy Sector NAMA Project are provided in

Energy Sector Nationally Determined Contributions (NDC) of Sri Lanka comprise an unconditional reduction of 5% and a conditional reduction of 20% of emissions in 2030 from the business-as-usual scenario. For the electricity sector, the Long Term Generation Expansion Plan 2013-2032 provides the business-as-usual scenario, and emissions of the business-as-usual scenario is 25,023 $ktCO_{2e}$. The unconditional commitment of 5% GHG emission reduction requires 1,298 $ktCO_{2e}$, well below the GHG emission abatement potential with negative abatement costs. The conditional commitment of 20% requires an emission reduction of 7,834 $ktCO_{2e.}$ Table 3 provides the GHG emission abatement potential at various abatement cost levels.

Table 3 – GHG Emission Abatement Potential at Various Abatement Cost Levels

Range of Abatement Cost (US $ per tCO_{2e})	**Abatement Potential ($ktCO_{2e}$)**
Less than 0	12,129
0 to 50	652
50 to 100	1,160
More than 100	805

ANNEX 1.

Reassessment of Technologies Included in the MACC

Reassessment of technologies included in the MACC was carried out following four criteria (i) implementation potential of the technology, (ii) maturity of the proposed technology, (iii) existence of the technology, meaning whether the proposed technology has been outdated or will be outdated soon[1], and (iv) availability of relevant data. Technologies assessed to be 'No' for any of the criteria were decided to be removed from MACC.

Technologies with no/less implementation potential in Sri Lanka are;

(i) roof solar PV - 2 kW (since the introduction of the net-accounting scheme household rooftop solar PV systems are designed for higher capacities such as 4 kW or 5 kW);
(ii) HEM in tea factories - 5-8 kW (as proven by the UNDP pilot projects);
(iii) HEM in tea factories - 8-20 kW (as proven by the UNDP pilot projects);
(iv) efficient refrigerators - 700 litres (refrigerators of high capacities available in the market are inverter type and are energy efficient);
(v) advanced filtering replacing water boiling; and
(vi) mini hydro power plants 1 – 10 MW (almost all potential sites of this capacity range have already been developed)

Technologies that have not matured as yet are;

(i) wave energy.

Wave energy is a technology that is still under development, and it is not available for commercial implementation immediately. Hence, the implementation potential is uncertain. However, instead of removing the technology the development potential was reduced to 1 project of 5 MW capacity.

Technologies that have become irrelevant are:

(i) use of efficient ballasts and conversion of T8 linear fluorescent lamps to T5 fluorescent lamps.

Technologies that don't have sufficient data available are;

(i) rainwater collection tanks;
(ii) energy efficiency measures in house construction (ventilation, roof improvements);
(iii) building management systems;
(iv) efficiency improvement - KIS irrigation; and
(v) efficiency improvement - Polgolla diversion irrigation system.

Furthermore, several technologies were revised to improve their applicability due to various technological, economical and regulatory changes that have taken place recently. They are provided in Table 1.

Table 1 – Technologies that were Revised

Technology in the MACC	Revision Proposed
Rooftop solar PV - 3-4 kW	Rooftop solar PV - 3-5 kW

[1] Change of T8 linear fluorescent lamps to T5 linear fluorescent lamps with electronic ballasts was included in the MACC as an abatement technology. However, now the trend is replacing T8 linear fluorescent lamps with linear LED lamos.

Roofop solar PV with battery storage - 3-4 kW	Rooftop solar PV with battery storage - 3-5 kW
Rooftop solar PV – 5-10 kW	Rooftop solar PV – 5-15 kW
Biomass power plant 1 -10 MW	Biomass power plant 0.5 -3 MW
Waste-to-energy - AD - 600 tonnes MSW/d	Waste-to-energy - 600 tonnes MSW/d
Efficient ballasts (T8 to T5)	Linear fluorescent to LED
Waste incineration	Same as 'Waste-to-energy - 600 tonnes MSW/d'. Hence, combine

In addition, the following technologies were included into the MACC as they have been identified as abatements options with implementation potential in Sri Lanka.

(i) Solar PV farms 10 – 25 MW (Average size 10MW)
(ii) Replacing LPG/electricity water heaters with biomass in hotels
(iii) Absorption chillers for apparel and hotel sectors
(iv) Tri generation at industrial zones
(v) Efficient chillers - apparel sector
(vi) Biodigester - 50 - 100 cubic meters
(vii) Renewal of expiring mini-hydro power plants 1 - 10 MW

Technologies included in the MACC can be categorised as;

(i) power generation technologies with reduced/no GHG emissions;
(ii) energy efficiency improvement technologies in electricity end-use sectors resulting GHG emission reductions in electricity generation;
(iii) efficiency improvements in other energy end-use sectors;
(iv) switching to energy types with less GHG emissions; and
(v) technologies reducing waste disposal and related GHG emissions.

Updating Input Data

Input data of the MACC were updated based on information available with the following information sources.

(i) Sri Lanka Energy Balance published by the Sri Lanka Sustainable Energy Authority
(ii) Household appliance survey carried out by the Department of Census and Statistics
(iii) Long Term Generation Expansion Plan 2020-2039 by the Ceylon Electricity Board
(iv) Statistical Digests 2018, 2019 and 2020 of Ceylon Electricity Board
(v) Socio-economic data published by the Central Bank of Sri Lanka
(vi) Global economic data and published by the World Bank
(vii) Fuel prices and specifications published by the Ceylon Petroleum Corporation
(viii) Equipment prices and related information based on market information.

Information updated are available for review in the updated MACC provided together with this report.

GHG Emission Abatement Potential

The analysis estimates the GHG emission abatement potential of technologies included in the MACC as 14,746 $ktCO_{2e}$. The GHG emission abatement potential with a negative abatement cost (technologies which derive a cost saving throughout the lifetime of the technology in

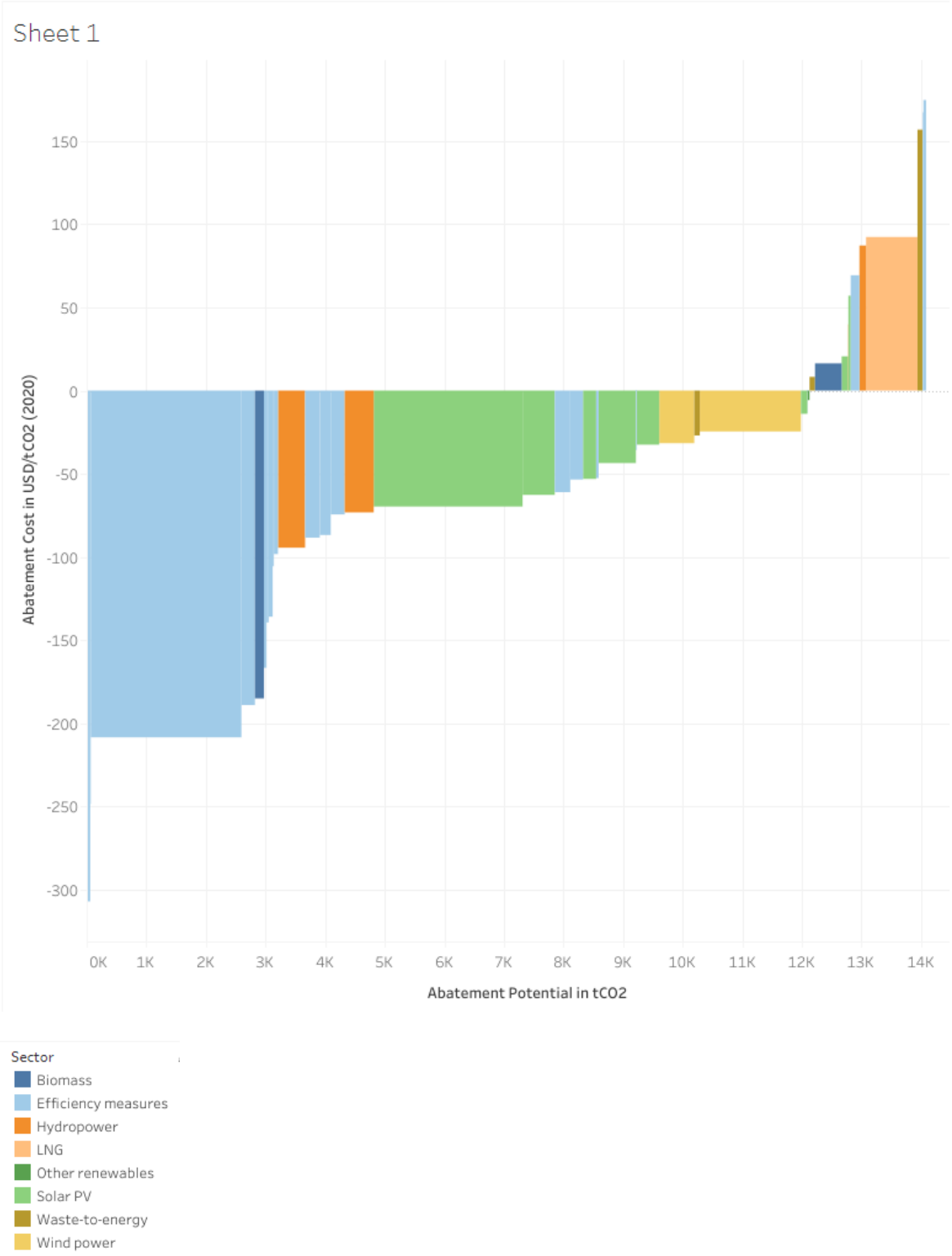
addition to a reduction in GHG emission) is estimated as 12,129 $ktCO_{2e}$. Abatement technologies with abatement costs and abatement potential is provided in Table 2 and the MACC is depicted in Figure 1.

Table 2 – GHG Abatement Cost and the Abatement Potential of Technologies

	Technology	Abatement cost in USD/tonne CO_{2e}	Abatement potential, in '000 tonnes CO_{2e}
1	LED Replacing CFL	-307	59
2	Electric Water Pumps – Agriculture	-248	9
3	Change of Linear Fluorescent Lamps to LED	-208	2528
4	LED Replacing Incandescent Lights	-189	227
5	Biomass Replacing Diesel/Oil - in Industrial Boilers	-185	152
6	Efficient Chillers - Hotel Sector	-167	43
7	District cooling systems	-139	36
8	Efficient Air Conditioning - Domestic	-136	68
9	VFDs for Tea Factories - 5-10 kW	-106	20
10	Efficient Chillers - Hotel Sector	-98	69
11	Mini Hydro - 0.1-1 MW	-94	455
12	Building management systems	-88	246
13	Energy efficiency measures (ventilation, roof improvements)	-87	184
14	Solar Water Heater - New	-74	234
15	Renewal of Expiring Mini-hydro SPPAs	-73	487
16	Solar PV Farm 10 - 25 MW	-70	2498
17	Rooftop Solar PV - 50-1000 kW	-63	540
18	Biomass Chillers for Hotels and Apparel Factories	-61	260
19	Efficient Fans	-53	214
20	Solar PV Farm -100 MW	-53	221
21	Efficient Chillers - Commercial Sector - New	-53	41
22	Solar PV Farm - 1 MW	-44	626
23	Efficient air compressors - New	-35	14
24	Roof solar PV - 3 - 5 kW	-33	378
25	Wind Farm -100 MW	-32	588
26	Waste-to-energy - AD - 600 tonnes MSW/d	-27	92
27	Wind Farms - 10 – 30 MW	-25	1698
28	Roof solar PV – 5-15 kW	-14	108
29	Solar Water Pumps - Agriculture	-14	7
30	Efficiency improvement - KIS irrigation	-6	29
31	Waste-to-energy - AD - 100 tonnes MSW/d	8	92
32	Biomass Power Plant 1 -3 MW	16	447
33	Roof solar PV with battery storage - 3 - 5 kW	21	108
34	Micro Hydro - 5-100 kW	40	4
35	Roof solar PV - 2 kW	57	40
36	Efficient Refrigerators - 258 liters - New	69	146
37	Hydro Power Plants 10 – 50 MW	87	112
38	LNG plant - 300-600 MW	92	863
39	Waste incineration	157	87
40	Efficient air compressors - Retrofit	167	13
41	Efficient Chillers - Commercial Sector - Retrofit	175	44

42	Advanced filtering replacing water boiling - New	292	69
43	Efficient Refrigerators - 258 liters - Retrofit	417	119
44	Efficient refrigerators - 700 liters	493	132
45	Efficient refrigerators - 700 liters	567	241
46	Efficiency improvement - Polgolla diversion irrigation system	615	27
47	Wave Energy	938	5
48	Rainwater collection tanks	1196	46
49	Efficient Washing Machines - New	2341	22

Figure 1 – Energy Sector MACC



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ANNEX 1 – GHG Abatement Options Included in the Existing MACC

1 Biodigester - 8 -20 cubic meters
2 Roof solar PV - 2 kW
3 Roof solar PV - 3-4 kW
4 Roof solar PV with battery storage - 3-4 kW
5 Solar PV farm - 1 MW
6 Solar PV farm -100 MW
7 Wind farm -100 MW
8 LNG plant - 300-600 MW
9 HEM in tea factories - 5-8 kW
10 HEM in tea factories - 8-20 kW
11 Efficient refrigerators - 258 liters
12 LED replacing incandescent lights
13 Waste-to-energy - AD - 100 tonnes MSW/d
14 Mini hydro - 0.1-1 MW
15 Biomass replacing diesel/oil - industry
16 Efficient chillers - commercial sector
17 Solar pumps - agriculture
18 Roof solar PV – 5-10 kW
19 Roof solar PV - 50-300 kW
20 Wind farms - 10 – 30 MW
21 Wave energy
22 Micro hydro - 5-100 kW
23 Hydro 1 -10 MW
24 Hydro 10 – 50 MW
25 Biomass power plant 1 -10 MW
26 Waste-to-energy - AD - 600 tonnes MSW/d
27 Electric pumps – agriculture
28 Efficient ballasts (T8 to T5)
29 Rainwater collection tanks
30 Efficient refrigerators - 700 liters
31 Efficient washing machines
32 LED replacing CFL
33 Efficient air conditioning - domestic
34 Efficient fans

35 Energy efficiency measures (ventilation, roof improvements)

36 Building management systems

37 Advanced filtering replacing water boiling

38 Biomass chillers

39 Efficient air compressors

40 Solar water heater

41 VFDs for tea factories - 5-8 kW

42 Efficiency improvement - KIS irrigation

43 Efficiency improvement - Polgolla diversion irrigation system

44 Efficient chillers - hotel sector

45 Waste incineration

46 District cooling systems