The GACMO model.

A simple tool to calculate

the mitigation contribution of INDC's

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GACMO is a simple tool

You do not have much time to prepare your INDC. You therefore need a simple tool.

The tool should be able to make Business As Usual (BAU) projection to 2020/2025/2030 if you want to make an INDC that pledge a reduction of a percentage reduction of the GHG emission compared to the BAU.

The tool should be able to calculate the GHG reduction and the cost for each mitigation option compared to the technology used in the baseline. The tool should be able to scale the size of the mitigations option up and down.

The tool should give a clear overview of the total mitigation effort: total GHG reduction, total investment, and total annual cost.

The calculation should be transparent and easy to follow.

The GACMO model can now be downloaded from www.cdmpipeline.org or www.namapipeline.org

Start year balance:
2010 Energy Balance for Country X

Unit : ktoe	Total	LPG	Gasoline	Jet Fuel	Diesel	HFO	Kerosene and other	Total oil products	Coal	Lignite	Gas	Electricity consumption Gwh
Total consumption	130352	10069.38	36254.74	2705.14	20574.90	11596.81	32.07	81233	0.00	6551.95	42566.54	
Fossil power plants	44034	112.97	0.00	0.00	448.74	8706.49	0.00	9268	0.00	6455.79	28310.15	63103
Refineries	2880	0.00	374.51	0.00	979.08	1526.28	0.00	2880	0.00	0.00	0.00	
FINAL CONSUMPTION	83438	9956.41	35880.23	2705.14	19147.08	1364.05	32.07	69085	0.00	96.16	14256.39	207947
Industry - steel	2331	0.00	0.00	0.00	32.64	132.47	0.00	165	0.00	0.00	2165.73	7237
Industry - chemical	2588	15.82	0.00	0.00	109.13	140.15	0.00	265	0.00	0.00	2322.52	9160
Industry - non metallic mineral	1785	2.26	0.00	0.00	11.22	521.24	0.00	535	0.00	96.16	1154.10	6664
Industry - food and tobacco	661	39.54	0.00	0.00	107.09	200.62	0.00	347	0.00	0.00	313.46	3391
Industry - construction	257	0.00	0.00	0.00	257.01	0.00	0.00	257	0.00	0.00	0.00	549
Industry - mining	1117	119.75	0.00	0.00	97.91	101.75	0.00	319	0.00	0.00	797.89	5603
Industry - machinery	6	5.65	0.00	0.00	0.00	0.00	0.00	6	0.00	0.00	0.00	0
Industry - non ferrous metals	41	1.13	0.00	0.00	0.00	0.00	0.00	1	0.00	0.00	39.89	709
Industry - paper and pulp	992	7.91	0.00	0.00	32.64	182.39	0.00	223	0.00	0.00	769.40	4758
Industry - transport equipment	57	0.00	0.00	0.00	14.28	0.00	0.00	14	0.00	0.00	42.75	1983
Industry - textile and leather	0	0.00	0.00	0.00	0.00	0.00	0.00	0	0.00	0.00	0.00	67
Industry - miscellaneous	4067	816.80	0.00	0.00	756.75	14.40	0.00	1588	0.00	0.00	2478.65	75008
Transport - road	50477	858.60	35878.09	0.00	13727.48	0.00	0.00	50464	0.00	0.00	13.12	
Transport - rail	581	0.00	0.00	0.00	581.33	0.00	0.00	581	0.00	0.00	0.00	1191
Transport - air	2705	0.00	0.00	2705.14	0.00	0.00	0.00	2705	0.00	0.00	0.00	
Transport - navigation	714	0.00	0.00	0.00	642.52	71.03	0.00	714	0.00	0.00	0.00	
Households	7426	6563.80	2.14	0.00	3.06	0.00	32.07	6601	0.00	0.00	824.51	49407
Services	1758	1389.58	0.00	0.00	112.19	0.00	0.00	1502	0.00	0.00	256.14	33620
Agriculture	2797	135.57	0.00	0.00	2661.87	0.00	0.00	2797	0.00	0.00	0.00	8600
Non energy - chemical feedstocs	3078	0.00	0.00	0.00	0.00	0.00	0.00	0	0.00	0.00	3078.23	

Growth factors used for BAU projections

Start year:	2005					
Growth from the start year	**Annual % increase in the period**			**% increase from start year values**		
Growth and multiplication factors	2005 to 2020	2020 to 2025	2025 to 2030	2020	2025	2030
Industry - fuel in steel	0.7%	0.7%	0.7%	11%	15%	19%
Industry - fuel in chemical	0.7%	0.7%	0.7%	11%	15%	19%
Industry - fuel in non metallic mineral	0.7%	0.7%	0.7%	11%	15%	19%
Industry - fuel in food and tobacco	0.7%	0.7%	0.7%	11%	15%	19%
Industry - fuel in construction	0.7%	0.7%	0.7%	11%	15%	19%
Industry - fuel in mining	0.7%	0.7%	0.7%	11%	15%	19%
Industry - fuel in machinery	0.7%	0.7%	0.7%	11%	15%	19%
Industry - fuel in non ferrous metals	0.7%	0.7%	0.7%	11%	15%	19%
Industry - fuel in paper and pulp	0.7%	0.7%	0.7%	11%	15%	19%
Industry - fuel in transport equipment	0.7%	0.7%	0.7%	11%	15%	19%
Industry - fuel in textile and leather	0.7%	0.7%	0.7%	11%	15%	19%
Industry - fuel in miscellaneous	0.7%	0.7%	0.7%	11%	15%	19%
Industry - electricity consumption	1.0%	1.0%	1.0%	16%	22%	28%
Transport - fuel in road	3.0%	3.0%	3.0%	56%	81%	109%
Transport - fuel in rail	3.0%	3.0%	3.0%	56%	81%	109%
Transport - fuel in air	3.0%	3.0%	3.0%	56%	81%	109%
Transport - fuel in navigation	3.0%	3.0%	3.0%	56%	81%	109%
Transport - electricity consumption	2.0%	2.0%	2.0%	35%	49%	64%
Households - fuel	1.7%	1.7%	1.7%	29%	40%	52%
Households - electricity consumption	9.6%	5.0%	2.0%	296%	405%	457%
Services - fuel	1.7%	1.7%	1.7%	29%	40%	52%
Services - electricity consumption	9.6%	5.0%	2.0%	296%	405%	457%
Agriculture - fuel	0.9%	0.9%	0.9%	14%	20%	25%
Agriculture - electricity consumption	2.0%	2.0%	2.0%	35%	49%	64%
Non energy - fuel in chemical feedstocs	0.7%	0.7%	0.7%	11%	15%	19%
Forestry emission	0.0%	0.0%	0.0%	0%	0%	0%
Waste emission	1.5%	1.5%	1.5%	25%	35%	45%
Industrial processes	0.7%	0.7%	0.7%	11%	15%	19%

2020 GHG Balance for Country X

GHG Balance - country X - 2020											
Ton CO2/Toe (IPCC):		2.64	2.90	2.99	3.10	3.24	3.01		3.96	4.24	2.35
Unit : ktCO2	Total	LPG	Gasoline	Jet Fuel	Diesel	HFO	Kerosene and other	Total oil products	Coal	Lignite	Gas
Total	**582927**	**42878**	**155210**	**17483**	**90196**	**61145**	**153**	**367065**	**0**	**47254**	**168608**
Power plants	209763	0	0	0	2365	47923	0	50288	0	46481	112994
Refineries	9250	0	1109	0	3097	5044	0	9250	0	0	0
FINAL CONSUMPTION	363914	42878	154101	17483	84734	8178	153	307527	0	772	55614
Industry - steel	10644	0	0	0	192	813	0	1005	0	0	9639
Industry - chemical	11917	79	0	0	641	860	0	1581	0	0	10337
Industry - non metallic mineral	9185	11	0	0	66	3199	0	3276	0	772	5136
Industry - food and tobacco	3454	198	0	0	629	1231	0	2058	0	0	1395
Industry - construction	1510	0	0	0	1510	0	0	1510	0	0	0
Industry - mining	5350	599	0	0	575	625	0	1799	0	0	3551
Industry - machinery	28	28	0	0	0	0	0	28	0	0	0
Industry - non ferrous metals	183	6	0	0	0	0	0	6	0	0	178
Industry - paper and pulp	4775	40	0	0	192	1119	0	1351	0	0	3424
Industry - transport equipment	274	0	0	0	84	0	0	84	0	0	190
Industry - textile and leather	0	0	0	0	0	0	0	0	0	0	0
Industry - miscellaneous	16895	3513	0	0	3823	76	0	7412	0	0	9483
Transport - road	220506	3356	154091	0	63013	0	0	220460	0	0	46
Transport - rail	1991	0	0	0	1991	0	0	1991	0	0	0
Transport - air	17483	0	0	17483	0	0	0	17483	0	0	0
Transport - navigation	2455	0	0	0	2201	254	0	2455	0	0	0
Households	30678	27435	10	0	15	0	153	27613	0	0	3066
Services	9086	7218	0	0	684	0	0	7902	0	0	1183
Agriculture	9514	395	0	0	9118	0	0	9514	0	0	0
Non energy uses	7987	0	0	0	0	0	0	0	0	0	7987

Example of the calculations in the GACMO model in the Maldives

1 kW grid connected PVs in Greater Malé Region versus diesel fuelled power			
Costs in US$	Mitigation option	Baseline	Difference
Investment	3000		
Lifetime in years	20		
Levelized investment	283		283
Annual O&M	30		30
Annual fuel costs		453	-453
Total annual costs	313	453	**-139**
Annual emissions			Abatement
Fuel in tCO_2e	0.0	1.1	1.1
Other			
Total in tCO_2e	0.0	1.1	**1.1**
US$/tCO2e			**-133**

General inputs:		
Discount rate	7%	
Baseline electricity generation costs	0.31	US$/kWh
Emissions factor	0.72	tCO2e/MWh electricity
Mitigation option: Solar PVs		
Investment in PVs	3000	US$/kW
Capacity factor	1825	full load hours
Efficiency factor	0.8	
Electricity production	1460	kWh/year
Annual O&M	1%	of capital costs
Baseline: Electricity from diesel generators		
Electricity production	1460	kWh

Electricity generation costs	**0.21**	**US$/kWh**

Comments:

11 MW for the capital island of Male and 4 MW on Hulhumale along with inter-island grid connection through submarine cable.

Due to higher temperatures in the Maldives the output of the PVs will be reduced by the efficiency factor of 0.8.

The GACMO model contain sheets like this for the each GHG reduction options

GACMO summary table for the 71 GHG mitigation options available (1)

Type	Reduction option	Sort reduction options: US$/tonCO2	Sub-type unit	Emission reduction t CO2/unit	Investment Million US$	Annual costs MUS$/year	Units penetrating in 2020
Agriculture	Rice crop CH4 reduction	0.00	Rice crop CH4 red.(1000 ha)	2,566	0.0	0.0	100
Biomass energy	Rice husk cogeneration plants	-89.60	1 MW cogeneration	11,877	4.9	-5.3	5
	Biomass power from other biomass residues	-149.27	1 MW CHP plant	6,126	3.6	-3.7	4
	Bagasse power	-247.89	100 kt sugar cane/year	10,491	24.3	-26.0	10
CCS	CCS plant	132.19	1 MW	6,014	5895.4	556.5	700
Cement	Clinker replacement	7.33	1000 tonnes cement	167,896	35.7	6.2	5
Coal bed/mine methane	Coal mine methane	-32.91	10 Mm3 CMM/year	39,278	2.4	0.1	2
EE households	Efficient residential airconditioning	-241.93	1000 Airconditioners	1,099	650.0	-1329.5	5,000
	Efficient domestic lighting with CFLs	-314.73	1000 Bulps	65	316.0	-4068.9	200,000
	Efficient domestic lighting with LEDs	-63.71	1000 Bulps	9	256.0	-11.7	20,000
	Efficient wood stoves	0.25	1000 stoves	5,836	2.9	0.1	100
	LPG stoves replacing wood stoves	23.04	1000 stoves	7,816	9.0	54.0	300
	Efficient refrigerators	-154.25	1000 refrigerators	343.6	1297.0	-265.0	5,000
EE industry	Efficient electric motors	-235.61	1 kW	0.7	324.0	-415.9	2,700,000
	Energy efficiency in industry	27.01	100 TJ reduction	6,765	1858.7	182.7	1,000
	Building materials	-27.37	1 million bricks	937	0.2	-0.3	10
EE own generation	Waste heat recovery at cement plant	-269.82	1 Cement plant	61,565	11.1	-16.6	1
	Waste heat recovery at steel plant	-279.64	1 Steel plant	56,700	6.0	-15.9	1
EE service	Efficient electric motors	-261.86	1 kW	0.6	0.1	-0.2	1,000
	Efficient office lighting with CFLs	-238.47	1000 lights	60	0.1	-0.1	10
	Efficient street lights	-230.72	1000 lights	552	7.1	-12.7	100
	Efficient water pumping	-244.19	4 Million m3 water	1,076	2.0	-2.6	10
	HVAC	-285.34	100,000 m2 floor area	7,039	5.9	-30.1	15
	New office building with central cooling	-209.18	1000 m2	49	0.0	0.0	
EE supply side	New high efficiency coal power plant	-2.85	1 MW	31,340	1388.0	-89.3	1,000
	New natural gas power plant	-439.71	1 MW	1,746	5526.8	-4606.4	6,000
	Switch from fuel oil to diesel	1,448.20	1 MW	124	0.0	0.0	0
	Cogeneration in industry	-471.25	1 MW	4,452	3839.0	-23076.1	11,000
	Single cycle to combined cycle	19.79	100 MW increase	210,600	0.0	0.0	
Energy distribution	Efficient electric grids	139.82	1 GWh loss reduction	490	0.0	0.0	
	Connection of isolated grid to central grid	-39.72	1 GWh consumption	490	2.7	-1.9	100

GACMO summary table for the 71 GHG mitigation options available (2)

Type	Reduction option	Sort reduction options: US$/tonCO2	Sub-type unit	Emission reduction t CO2/unit	Investment Million US$	Annual costs MUS$/year	Units penetrating in 2020
Forestry	Reforestation	11.83	Reforestation of 1000 ha	7,181	2700.0	254.9	3,000
	REDD: Avoided deforestation	0.47	No deforestation for 1000 ha	10,313	206.3	19.5	4,000
	Assisted forest regeneration	-4.06	Reforestation of 1000 ha	3,483	1200.0	-4.8	2,000
	Reforestation with agroforestry	-1.16	Reforestation of 1000 ha	2,090	1350.0	-2.4	1,000
	Reforestation with Silvopasture	-0.69	Reforestation of 1000 ha	3,483	1350.0	-2.4	1,000
Fossil fuel switch	Switch from coal to natural gas in industry	176.50	100 TJ fuel use/year	3,850	0.0	0.0	0
	Switch from fuel oil to natural gas in industry	120.26	100 TJ fuel use/year	2,127	0.0	0.0	0
Fugitive	Reduced flaring at oil field	-104.38	1 MMSCF/day	22,613	3531.5	-767.2	325
	Reduced flaring at oil refineries	53.20	1 MMSCF/day	20,797	52.0	2.2	2
	Leak reduction in natural gas pipelines	-22.13	1 Mm3 CH4/year leaking	15,078	47.4	6.9	190
	Charcoal production	1.61	100,000 ton charcoal/yr	141,005	12.0	1.1	5
Geothermal	Geothermal power	-210.40	1 MW	5,250	3325.0	-1049.4	950
	Geothermal heat						
HFCs, PFCs, SF6	Reduced PFCs from aluminum production	0.02	100,000 ton Aluminium/yr	208,091	0.2	0.0	10
Hydro	Hydro power connected to main grid	-276.09	1 MW	2,971	0.0	0.0	0
	Mini hydro power connected to main grid	-210.83	1 MW	3,000	9900.0	-1391.5	2,200
	Mini hydro power connected to main grid	-44.96	1 MW	3,232	20.0	-0.7	5
Landfills	Landfill gas plant with power production	-47.54	200 t/day plant	124,415	561.4	-680.2	115
	Landfill gas flaring	1.12	200 t/day plant	124,415	61.5	9.8	70
	Composting of Municipal Solid Waste	-9.54	1000 t/day plant	121,184	365.7	-10.4	9
Methane avoidance	Biogas at rural farms	1.21	1000 units	11,274	2.7	0.1	10
	Biogas at big farms	-5.823	1 plant	280,957	14.4	-8.2	5
	Biogas from industrial waste water	-185.34	1 plant	32,029	745.3	-890.5	150
N2O	Nitric acid plant (N2O destruction)	1.10	100 ton HNO3/day	91,652	14.1	2.0	20
Solar	Solar water heater, residential	-247.70	1000 locations	1,242	0.5	-0.3	1,000
	Solar water heater, large	-253.43	1 unit	47	1.6	-1.2	100
	Solar PVs, large grid	-160.86	1 MW	1,273	144.0	-19.7	96
	Solar PVs, small isolated grid, 100% solar	615.11	2 MW	2,628	0.0	0.0	0
	Concentration Solar Power (CSP)	-129.12	1 MW	1,759	26520.0	-1930.8	8,500
Transport	20% Biodiesel blend in all diesel	341.38	15% blend in transport	9,270,669	0.0	3164.9	1
	15% Bioethanol blend in all gasoline	369.53	20% blend in transport	24,138,571	0.0	8920.0	1
	Bus Rapid Transit (BRT)	92.03	1 km BRT line	1,976	63.3	3.6	20
	More efficient gasoline cars	-248.36	1000 cars	409	0.0	-304.7	3,000
	More efficient diesel cars	-186.52	1000 cars	180	0.0	-838.1	25,000
	Restriction on import of used cars	-248.36	1000 cars	931	0.0	0.0	20,000
	Better maintenance and use of motor bikes	-226.89	1000 bikes	310	0.0	-7.0	100
Wind	Wind turbines, on-shore	-200.46	1 MW	1,705	5460.0	-1435.5	4,200
	Wind turbines, off-shore	-131.27	1 MW	2,700	2000.0	-177.2	500
				Totals:	**59648.8**	**2862.9**	**BAU emiss**

Marginal Revenue Abatement (MAR) Curve