

GACMO model. Solution to applied exercises.

Training workshop for Anglophone African countries:
Deep dive into tracking NDC mitigation commitments
under the Paris Agreement

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Exercises 1 and 2 Assumptions

Grid Emission Factor and Electricity prices

24	Electricity	Isolated grids	Grid 1	Grid 2
25	US\$/kWh		0.12	
26	Grid Emissions Factor	tCO2/MWh (=kCO2/kWh)		
27	Operating margin (OM)			
28	Build Margin (BM)			
29	Combined Margin (CM) Solar & Wind		0.8000	
30	Combined Margin (CM) Other		0.8000	
31				

Exercise 3 Offshore wind

1	Total GHG mitigation in Mauritius		Investment	Annual costs	Units penetrating in 2030	Emission reduction in 2030		
2			Million US\$	MUS\$/year		Per option	Added	
3						kt/year	kt/year	Frac.of total
4	Type	Reduction option						
121	Wind	Wind turbines, on-shore	0.0	0.0	50	0.00	289	5.4%
122		Wind turbines, on-shore with 24 storage	0.0	0.0		0.00	289	5.4%
123		Wind turbines, off-shore	99.3	-8.3		128.00	417	7.8%

Emissions reduction
128 kt/year

1 MW Wind turbines connected to main grid (off-shore) in 2030			
Costs in US\$	Reduction Option	Reference Option	Increase (Red.-Ref.)
Total investment	1986000		
Project life	20		
Lev. investment	187464		187464
Annual O&M	29790		29790
Annual fuelcost		384000	-384000
Total annual cost	217254	384000	-166746
Annual emissions (tons)	Tons	Tons	Reduction
Fuel CO2-eq. emission		2560.0	2560.0
Other			
Total CO2-eq. emission	0.0	2560.0	2560.0
US\$/ton CO2-eq.			-65.1

General inputs:		
Discount rate	7%	
Reference electricity price	0.12	US\$/kWh
CO2-eq. emission coefficient	0.80	tCO2/MWh
Reduction option: Wind Power		
O&M	1.50%	
Activity	1	MW
Investment in Activity	1986	US\$/kW
Capacity factor	3200	Full time hours
Electricity production	3200	MWh/ year
Cost of electricity produced	0.068	US\$/kWh
Reference option: No wind turbines		

Exercise 4 Renewable Energy Hybrid Facilities

Solar + battery storage

1	Total GHG mitigation in	Mauritius	Investment	Annual costs	Units	Emission reduction in 2030		
2			Million US\$	MUS\$/year	penetrating	Per option	Added	
3					in 2030	kt/year	kt/year	Frac.of total
4	Type	Reduction option						
90	Solar	Solar water heater, residential	0.0	0.0		0.00	0	0.0%
91		Solar water heater, large	0.0	0.0		0.00	0	0.0%
92		Solar PVs, large grid	0.0	0.0		0.00	0	0.0%
93		Solar PVs, large grid with 24h storage	0.0	0.0		0.00	0	0.0%
94		Solar house PVs	0.0	0.0		0.00	0	0.0%
95		Solar cottage PVs	0.0	0.0		0.00	0	0.0%
96		Solar/diesel mini-grid	0.0	0.0		0.00	0	0.0%
97		Solar LED lamps	0.0	0.0		0.00	0	0.0%
98		Solar PVs, small isolated grid, 100% solar	1302.5	83.5	100	262.80	263	4.9%
99		Solar street lights	0.0	0.0		0.00	263	4.9%
100		Parabolic through CSP, no storage	0.0	0.0		0.00	263	4.9%
101		Solar tower CSP, with storage	0.0	0.0		0.00	263	4.9%

Emissions reduction
262.8 kt/year

202 Solar PVs, small isolated grid, 2 MW, 100% solar			
203 Costs in	Reduction	Reference	Increase
204 US\$	Option	Option	(Red.-Ref.)
205 Total investment	13,025,000		
206 Project life	20		
207 Lev. investment	1,229,468		1,229,468
208 Annual O&M	35		35
209 Annual fuelcost		394,200	-394,200
210 Total annual cost	1,229,503	394,200	835,303
211			
212 Annual emissions (tons)	Tons	Tons	Reduction
213 Fuel CO2-eq. emission	0	2,628	2,628
214 Other			
215 Total CO2-eq. emission	0	2,628	2,628
216			
217 US\$/ton CO2-eq.			318
218			
219			
220			
221			
222			

General inputs:	
Discount rate	7%
Reference electricity price	0.12 US\$/kWh
CO2-eq. emission coefficient	0.80 tCO2/MWh
Activity: Solar PV with battery	
Investment in PV	1450 US\$/kW
O&M	35 US\$/kW
Capacity factor	1642.5 Full time hours
Electricity production/kW	1642.5 kWh/year
Electricity production/kW	4.5 kWh/day
Electricity consumption whitout sun/kW	2.3 kWh/day
Unit cost of batteries	187 US\$/kWh
Max. battery load	20%
Reinvestment in batteries	3 Times
Cost of batteries	5063 US\$/kW
Size of PV	2 MW
Electrici produced	3285 MWh/year
Cost of electricity produced	0.374 US\$/kWh

Notes:	
220	Project on the Maldives: SREP report: To convert 10 small islands
221	Each using 250-350 MWh/yr Assuming 5 h/day gives a total for 10
222	Islands of 2 MW Cost of a lithium-ion battery: 450 US\$/kWh (Pike

Exercise 5 Electric vehicles

Total GHG mitigation in Mauritius		Investment	Annual costs	Units penetrating in 2030	Emission reduction in 2030		
		Million US\$	MUS\$/year		Per option	Added	Frac. of tot
Type	Reduction option				kt/year	kt/year	
02	20% Biodiesel blend in all diesel	0.0	0.0		0.00	263	4.9
03	15% Bioethanol blend in all gasoline	0.0	0.0		0.00	263	4.9
04	Bus Rapid Transit (BRT)	0.0	0.0		0.00	263	4.9
05	More efficient gasoline cars	0.0	0.0		0.00	263	4.9
06	More efficient diesel cars	0.0	0.0		0.00	263	4.9
07	Natural Gas cars	0.0	0.0		0.00	263	4.9
08	Electric cars	230.1	38.0	26	25.70	289	5.4

Emissions reduction
25.7 kt/year

Electric cars (1000 cars) in 2030			
Costs in US\$	Reduction Option	Reference Option	Increase (Red.-Ref.)
Total investment	28,850,000	20,000,000	8,850,000
Project life	15	15	
Lev. investment	3,167,575	2,195,892	971,682
Annual O&M	144,250	200,000	-55,750
Annual fuel cost	331,500	1,330,431	-998,931
Total annual cost	3,643,325	3,726,323	-82,998
Annual emissions (tons)	Tons	Tons	Reduction
Fuel CO2-eq. emission	1,878	3,198	1,321
Other			
Total CO2-eq. emission	1,878	3,198	1,321
US\$/ton CO2-eq.			-63

General inputs:	
Discount rate	7%
Annual distance	25,000 km
Activity	1,000 Cars
Reduction option: Electric cars	
Investment in vehicle	25,450 US\$
Investment in charging station	1,000 US\$
Size of battery	40 kWh
Investment in battery	60 US\$/kWh
Annual O&M	0.5% of investment
Electricity consumption	9.0 km/kWh
Total electricity consumption	2,763 MWh
Reference electricity price	0.12 US\$/kWh
CO2-eq. emission coefficient	0.68 tCO2/MWh
Emissions from electricity	1,878 tCO2
Economic efficiency	0.15 US\$/km
Reference option: Normal gasoline cars	
Energy consumption	18.2 km/l
Investment in vehicle	20,000 US\$
Annual O&M	1.0% of investment
Gasoline price	0.97 US\$/liter

Notes: Batteries: Bloomer new energy Finance 2019

Exercise 6 Growth rates

2	Start year:	2021			
3	Growth from the start year	Annual % increase in the period			
4	Growth and multiplication factors	2021 to 2025	2025 to 2030	2030 to 2035	2035 to 2050
5	Population growth	0.34%	0.34%	0.34%	0.34%
6	GDP growth	3.00%	3.00%	2.00%	2.00%

Exercise 7 Mitigation actions in the Forestry sector

File Home Insert Page Layout Formulas Data Review View Automate Help ArcGIS						
H59 $= (5*5+20*5+(1.25*5+2.5*5+1.25*5)+(5*5+10*5+5*5))/1000$						
	A	B	H	I	J	K
1	Total GHG mitigation in	Mauritius				
2			Units penetrating in 2030	Emission reduction in 2030		
3				Per option	Added	
4	Type	Reduction option		kt/year	kt/year	Frac.of total
59	Forestry	Reforestation	0.250	0.92	1	0.0%
60		REDD: Avoided deforestation		0.00	1	0.0%
61		Assisted forest regeneration		0.00	1	0.0%
62		Reforestation with agroforestry		0.00	1	0.0%
63		Reforestation with Silvopasture		0.00	1	0.0%

Emissions reduction
0.92 kt/year

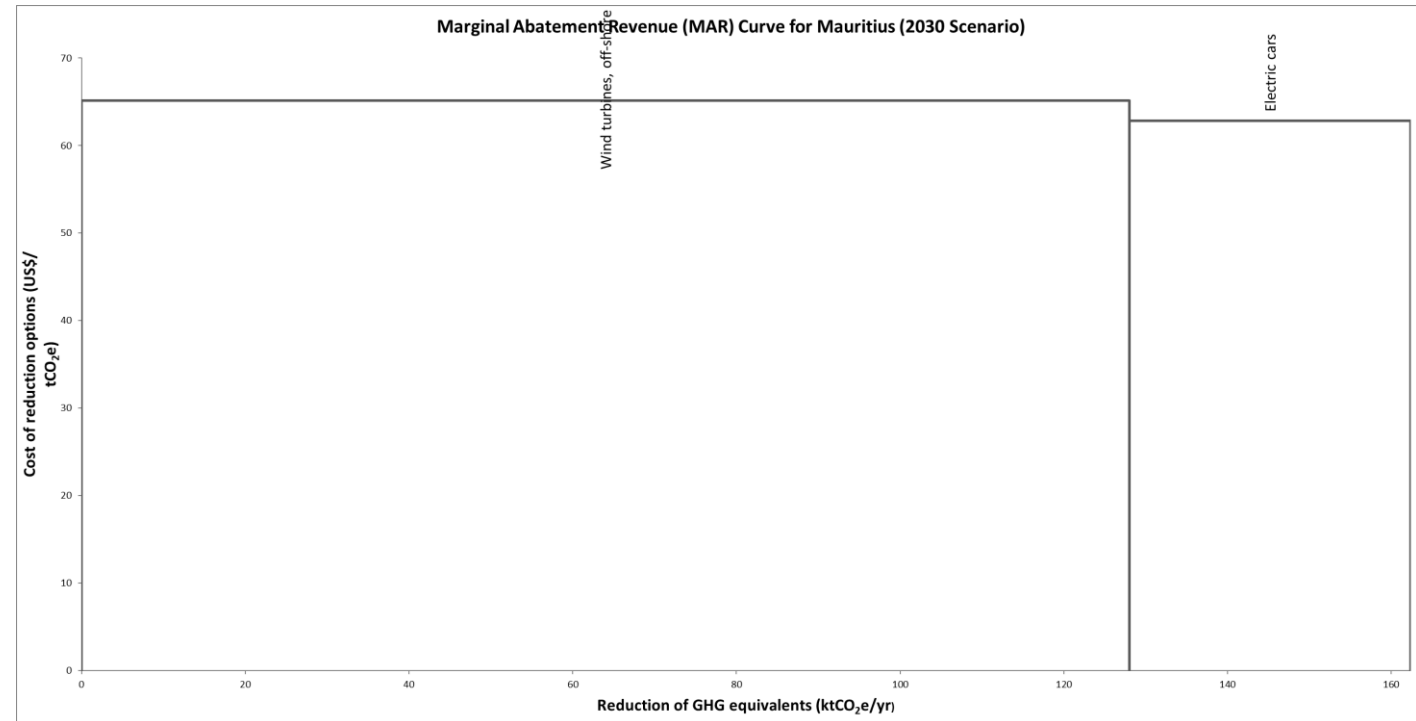
Exercise 8 Comparison of mitigation actions

Marginal Abatement Revenue Curve

Comparison of mitigation options available in the “Graph” sheet

From the MARC curve it can be seen that wind turbines and electric cars are effective options

Wind turbines provide most emissions reductions



Exercise 8 Comparison of mitigation actions

Options included in MAR Curve		
Reduction option	US\$/tonCO2	Emission reduction in 2030 per option kt/year
Wind turbines, off-shore	65.14	128.00
Electric cars	62.84	34.34

Options excluded in MAR Curve		
Reduction option	US\$/tonCO2	Emission reduction in 2020 per option kt/year
Reforestation	-15.45	0.92
Solar PVs, small isolated grid, 100% solar	-317.85	262.80