The Greenhouse Gas Abatement Cost Model GACMO

GACMO as a tool for establishing mitigation scenarios

3 December 2020

Denis Desgain - Head of Mitigation Analysis and Data Management Section, UNEP DTU Partnership

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UNEP DTU Partnership (UDP - https://unepdtu.org/**):** Technical centre based in Denmark. We provide support to developing countries in in the context of the Paris Agreement and the Sustainable Development Goals

What is GACMO ?

- Model GACMO = Greenhouse Gas Abatement Cost Model
- Bottom-up modelling tool for greenhouse gas emissions based on Excel
- IPCC / CDM Methodologies
- Developed by Jørgen Fenhann at UNEP DTU Partnership
- Available for free on the UDP website https://unepdtu.org/publications/the-greenhouse-gas-abatement-cost-model-gacmo/

Que es GACMO ?

GACMO allows to analyze the mitigation options of a region, a country or a city and evaluate its impacts from the point of view of the GHG emissions reductions

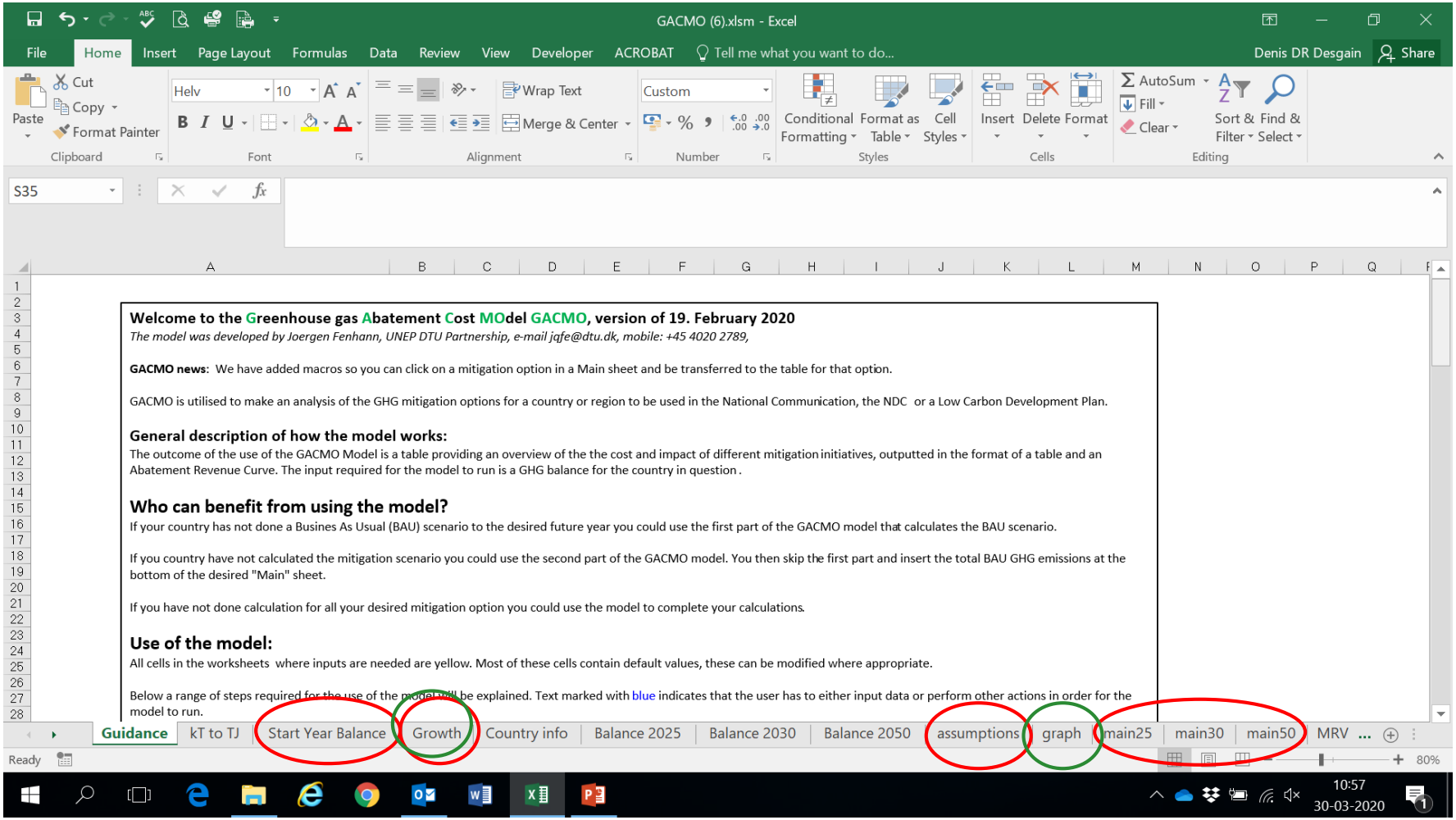
a) Establish the **BAU scenario** for emissions of a region / country

b) Select **mitigation options** from a list of options included in the model. For each of these options, the model will **calculate the potential for emission reduction**, as well as the **additional cost (or savings)** for inversion and implementation in comparison with a reference option

a) Establish a **mitigation scenario** based on the list of attenuation options for the different sectors (2025, 2030, 2050)

b) Establishes a marginal abatement curve that compares the different attenuation options.

Structure of GACMO?



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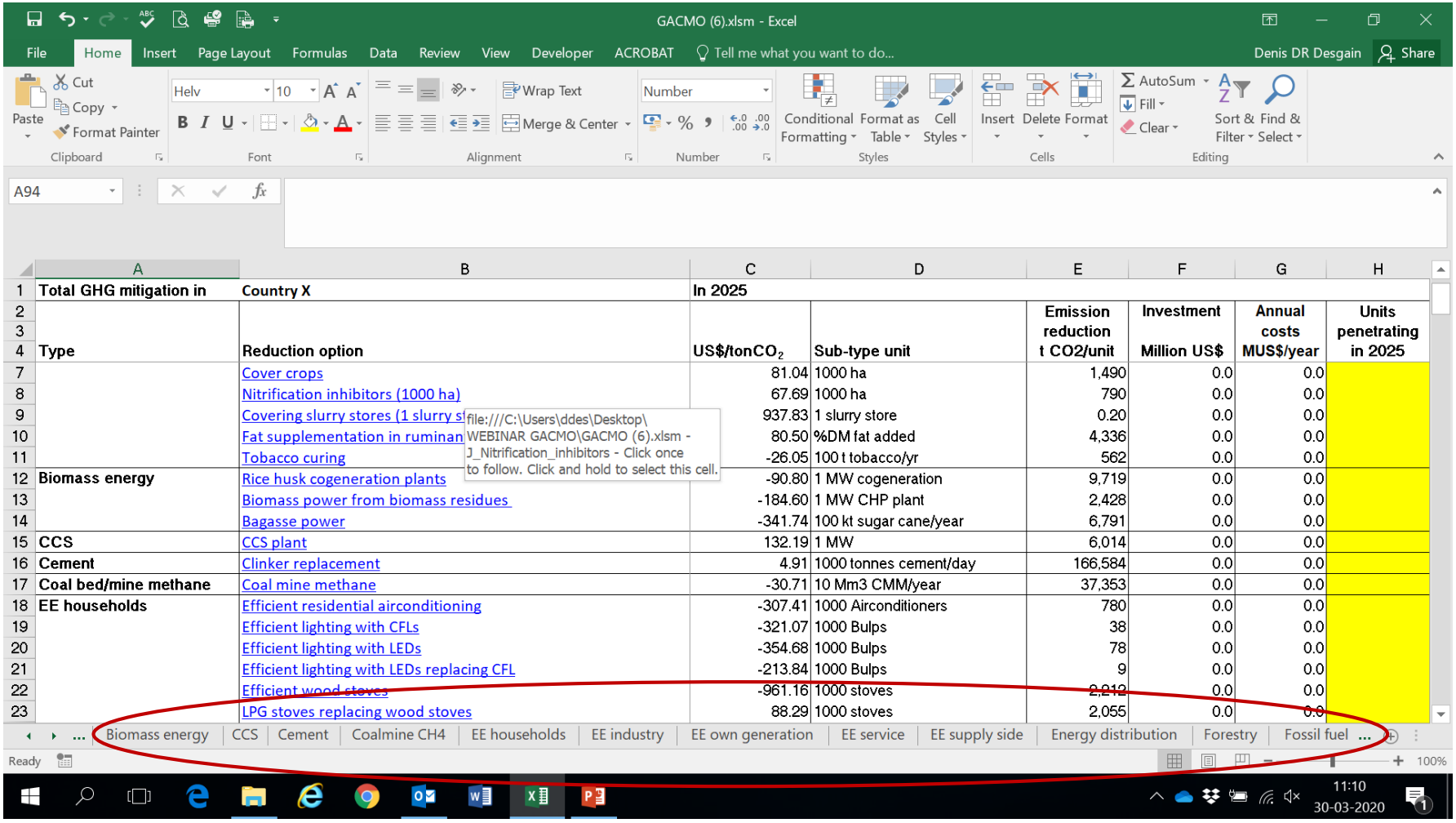
Structure of GACMO?



	A	B	C	D	E	F	G	H
1	**Total GHG mitigation in**	**Country X**	**In 2025**					
2								
3								
4	**Type**	**Reduction option**	**US$/tonCO$_2$**	**Sub-type unit**	**Emission reduction t CO2/unit**	**Investment Million US$**	**Annual costs MUS$/year**	**Units penetrating in 2025**
7		Cover crops	81.04	1000 ha	1,490	0.0	0.0	
8		Nitrification inhibitors (1000 ha)	67.69	1000 ha	790	0.0	0.0	
9		Covering slurry stores (1 slurry s	937.83	1 slurry store	0.20	0.0	0.0	
10		Fat supplementation in ruminan	80.50	%DM fat added	4,336	0.0	0.0	
11		Tobacco curing	-26.05	100 t tobacco/yr	562	0.0	0.0	
12	**Biomass energy**	Rice husk cogeneration plants	-90.80	1 MW cogeneration	9,719	0.0	0.0	
13		Biomass power from biomass residues	-184.60	1 MW CHP plant	2,428	0.0	0.0	
14		Bagasse power	-341.74	100 kt sugar cane/year	6,791	0.0	0.0	
15	**CCS**	CCS plant	132.19	1 MW	6,014	0.0	0.0	
16	**Cement**	Clinker replacement	4.91	1000 tonnes cement/day	166,584	0.0	0.0	
17	**Coal bed/mine methane**	Coal mine methane	-30.71	10 Mm3 CMM/year	37,353	0.0	0.0	
18	**EE households**	Efficient residential airconditioning	-307.41	1000 Airconditioners	780	0.0	0.0	
19		Efficient lighting with CFLs	-321.07	1000 Bulps	38	0.0	0.0	
20		Efficient lighting with LEDs	-354.68	1000 Bulps	78	0.0	0.0	
21		Efficient lighting with LEDs replacing CFL	-213.84	1000 Bulps	9	0.0	0.0	
22		Efficient wood stoves	-961.16	1000 stoves	2,012	0.0	0.0	
23		LPG stoves replacing wood stoves	88.29	1000 stoves	2,055	0.0	0.0	

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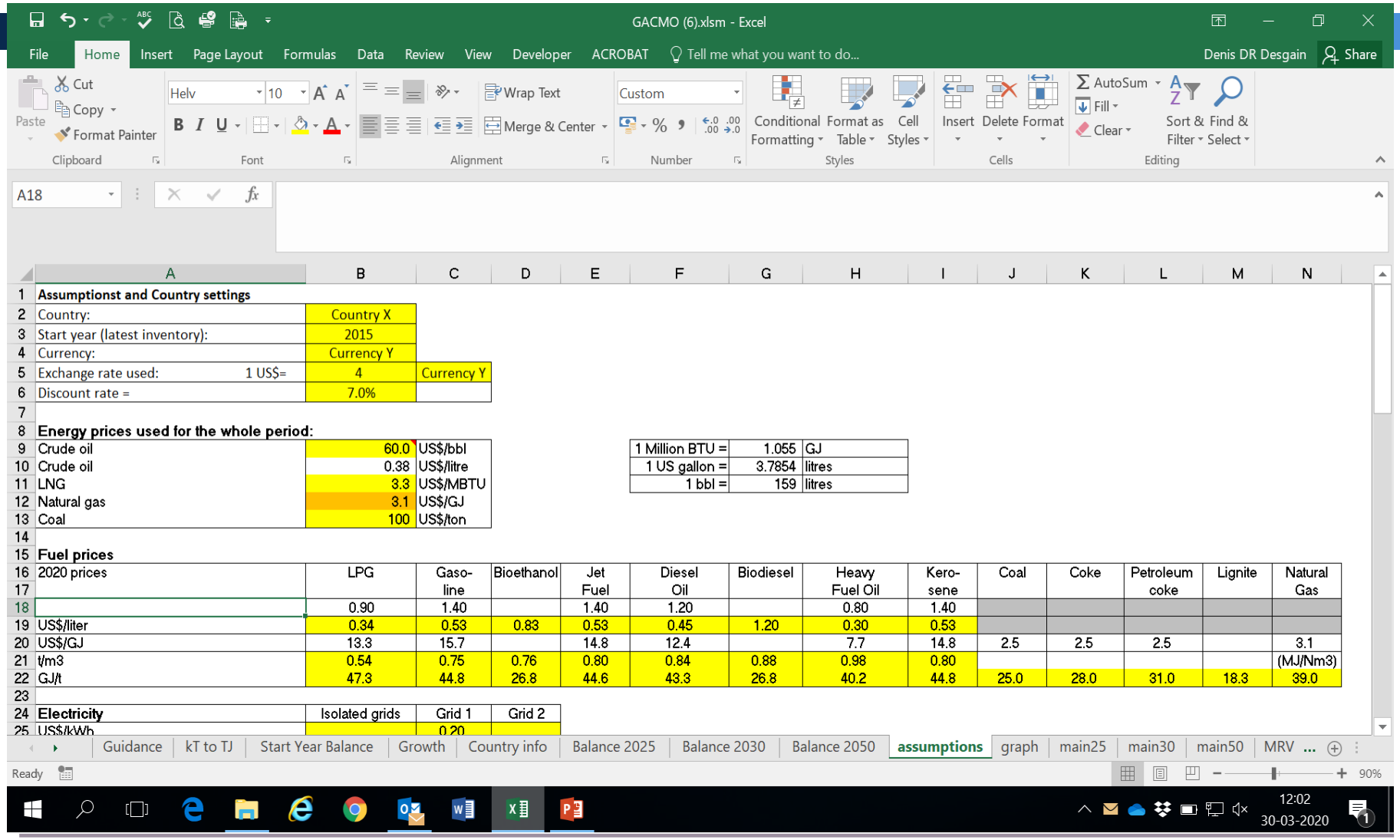
Data needed to use GACMO?

The data needed are those of the energy balance of the country and the growth projections for the different subcategories of activities.

Inputs



GACMO (6).xlsm - Excel

	A	B	C
1	**Assumptionst and Country settings**		
2	Country:	Country X	
3	Start year (latest inventory):	2015	
4	Currency:	Currency Y	
5	Exchange rate used: 1 US$=	4	Currency Y
6	Discount rate =	7.0%	
7			
8	**Energy prices used for the whole period:**		
9	Crude oil	60.0	US$/bbl
10	Crude oil	0.38	US$/litre
11	LNG	3.3	US$/MBTU
12	Natural gas	3.1	US$/GJ
13	Coal	100	US$/ton

1 Million BTU =	1.055	GJ
1 US gallon =	3.7854	litres
1 bbl =	159	litres

	A	LPG	Gaso-line	Bioethanol	Jet Fuel	Diesel Oil	Biodiesel	Heavy Fuel Oil	Kero-sene	Coal	Coke	Petroleum coke	Lignite	Natural Gas
15	**Fuel prices**													
16	2020 prices													
17														
18		0.90	1.40		1.40	1.20		0.80	1.40					
19	US$/liter	0.34	0.53	0.83	0.53	0.45	1.20	0.30	0.53					
20	US$/GJ	13.3	15.7		14.8	12.4		7.7	14.8	2.5	2.5	2.5		3.1
21	t/m3	0.54	0.75	0.76	0.80	0.84	0.88	0.98	0.80					(MJ/Nm3)
22	GJ/t	47.3	44.8	26.8	44.6	43.3	26.8	40.2	44.8	25.0	28.0	31.0	18.3	39.0
23														
24	**Electricity**	Isolated grids	Grid 1	Grid 2										
25	US$/kWh		0.20											

Guidance | kT to TJ | Start Year Balance | Growth | Country info | Balance 2025 | Balance 2030 | Balance 2050 | assumptions | graph | main25 | main30 | main50 | MRV ...

Ready

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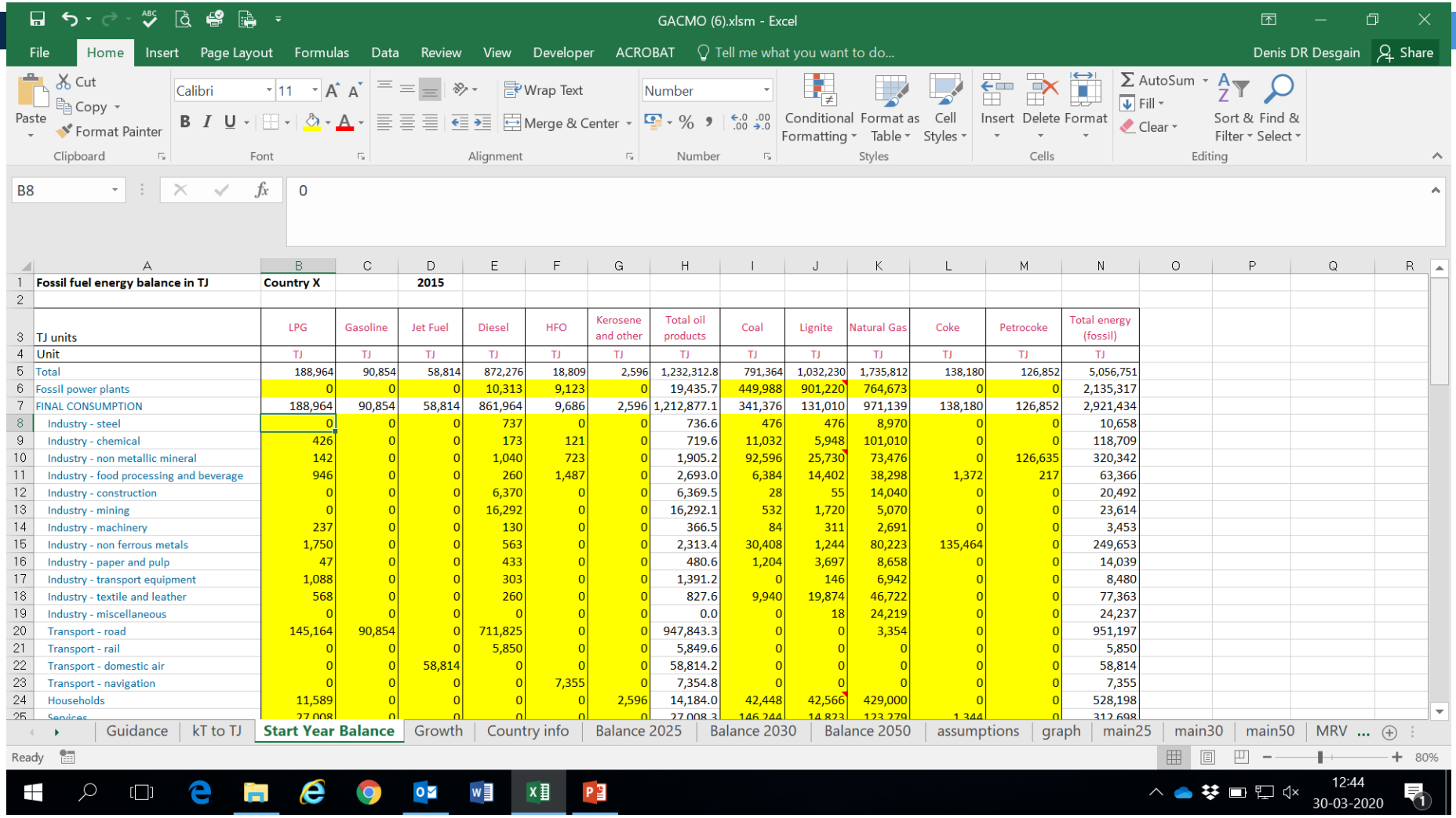
Inputs



GACMO (6).xlsm - Excel

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	**Fossil fuel energy balance in TJ**	**Country X**		**2015**										
2														
3	TJ units	LPG	Gasoline	Jet Fuel	Diesel	HFO	Kerosene and other	Total oil products	Coal	Lignite	Natural Gas	Coke	Petrocoke	Total energy (fossil)
4	Unit	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ
5	Total	188,964	90,854	58,814	872,276	18,809	2,596	1,232,312.8	791,364	1,032,230	1,735,812	138,180	126,852	5,056,751
6	Fossil power plants	0	0	0	10,313	9,123	0	19,435.7	449,988	901,220	764,673	0	0	2,135,317
7	FINAL CONSUMPTION	188,964	90,854	58,814	861,964	9,686	2,596	1,212,877.1	341,376	131,010	971,139	138,180	126,852	2,921,434
8	Industry - steel	0	0	0	737	0	0	736.6	476	476	8,970	0	0	10,658
9	Industry - chemical	426	0	0	173	121	0	719.6	11,032	5,948	101,010	0	0	118,709
10	Industry - non metallic mineral	142	0	0	1,040	723	0	1,905.2	92,596	25,730	73,476	0	126,635	320,342
11	Industry - food processing and beverage	946	0	0	260	1,487	0	2,693.0	6,384	14,402	38,298	1,372	217	63,366
12	Industry - construction	0	0	0	6,370	0	0	6,369.5	28	55	14,040	0	0	20,492
13	Industry - mining	0	0	0	16,292	0	0	16,292.1	532	1,720	5,070	0	0	23,614
14	Industry - machinery	237	0	0	130	0	0	366.5	84	311	2,691	0	0	3,453
15	Industry - non ferrous metals	1,750	0	0	563	0	0	2,313.4	30,408	1,244	80,223	135,464	0	249,653
16	Industry - paper and pulp	47	0	0	433	0	0	480.6	1,204	3,697	8,658	0	0	14,039
17	Industry - transport equipment	1,088	0	0	303	0	0	1,391.2	0	146	6,942	0	0	8,480
18	Industry - textile and leather	568	0	0	260	0	0	827.6	9,940	19,874	46,722	0	0	77,363
19	Industry - miscellaneous	0	0	0	0	0	0	0.0	0	18	24,219	0	0	24,237
20	Transport - road	145,164	90,854	0	711,825	0	0	947,843.3	0	0	3,354	0	0	951,197
21	Transport - rail	0	0	0	5,850	0	0	5,849.6	0	0	0	0	0	5,850
22	Transport - domestic air	0	0	58,814	0	0	0	58,814.2	0	0	0	0	0	58,814
23	Transport - navigation	0	0	0	0	7,355	0	7,354.8	0	0	0	0	0	7,355
24	Households	11,589	0	0	0	0	2,596	14,184.0	42,448	42,566	429,000	0	0	528,198
25	Services	27,008	0	0	0	0	0	27,008.3	146,244	14,823	123,279	1,344	0	312,698

Guidance | kT to TJ | **Start Year Balance** | Growth | Country info | Balance 2025 | Balance 2030 | Balance 2050 | assumptions | graph | main25 | main30 | main50 | MRV ...

Ready

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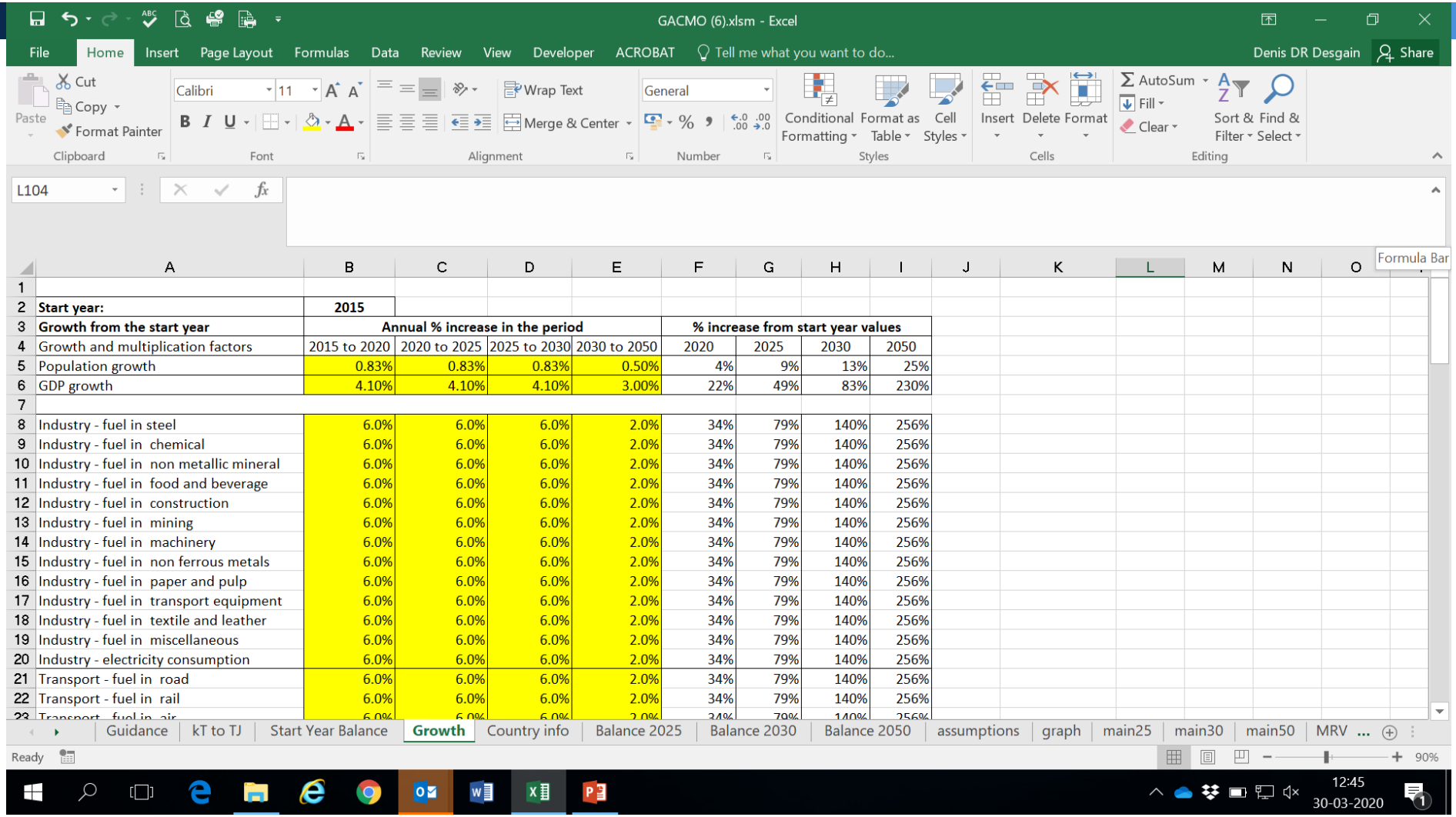
Inputs



	A	B	C	D	E	F	G	H	I
2	**Start year:**	**2015**							
3	**Growth from the start year**	**Annual % increase in the period**				**% increase from start year values**			
4	Growth and multiplication factors	2015 to 2020	2020 to 2025	2025 to 2030	2030 to 2050	2020	2025	2030	2050
5	Population growth	0.83%	0.83%	0.83%	0.50%	4%	9%	13%	25%
6	GDP growth	4.10%	4.10%	4.10%	3.00%	22%	49%	83%	230%
8	Industry - fuel in steel	6.0%	6.0%	6.0%	2.0%	34%	79%	140%	256%
9	Industry - fuel in chemical	6.0%	6.0%	6.0%	2.0%	34%	79%	140%	256%
10	Industry - fuel in non metallic mineral	6.0%	6.0%	6.0%	2.0%	34%	79%	140%	256%
11	Industry - fuel in food and beverage	6.0%	6.0%	6.0%	2.0%	34%	79%	140%	256%
12	Industry - fuel in construction	6.0%	6.0%	6.0%	2.0%	34%	79%	140%	256%
13	Industry - fuel in mining	6.0%	6.0%	6.0%	2.0%	34%	79%	140%	256%
14	Industry - fuel in machinery	6.0%	6.0%	6.0%	2.0%	34%	79%	140%	256%
15	Industry - fuel in non ferrous metals	6.0%	6.0%	6.0%	2.0%	34%	79%	140%	256%
16	Industry - fuel in paper and pulp	6.0%	6.0%	6.0%	2.0%	34%	79%	140%	256%
17	Industry - fuel in transport equipment	6.0%	6.0%	6.0%	2.0%	34%	79%	140%	256%
18	Industry - fuel in textile and leather	6.0%	6.0%	6.0%	2.0%	34%	79%	140%	256%
19	Industry - fuel in miscellaneous	6.0%	6.0%	6.0%	2.0%	34%	79%	140%	256%
20	Industry - electricity consumption	6.0%	6.0%	6.0%	2.0%	34%	79%	140%	256%
21	Transport - fuel in road	6.0%	6.0%	6.0%	2.0%	34%	79%	140%	256%
22	Transport - fuel in rail	6.0%	6.0%	6.0%	2.0%	34%	79%	140%	256%
23	Transport - fuel in air	6.0%	6.0%	6.0%	2.0%	34%	79%	140%	256%

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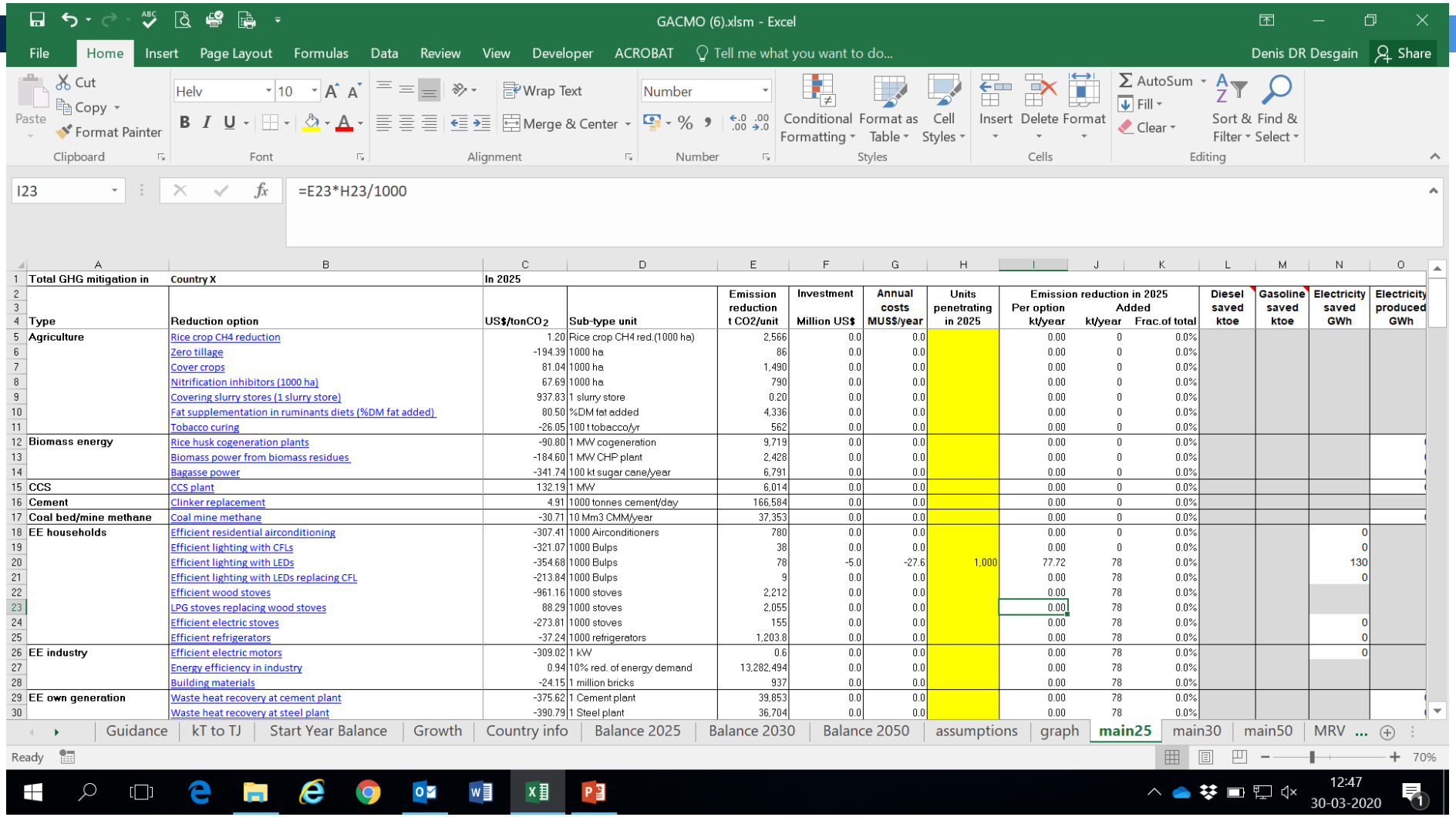
Inputs



GACMO (6).xlsm - Excel

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I23 =E23*H23/1000

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	Total GHG mitigation in	Country X	In 2025												
2									Emission reduction in 2025						
3					Emission reduction	Investment	Annual costs	Units penetrating	Per option	Added		Diesel saved	Gasoline saved	Electricity saved	Electricity produced
4	Type	Reduction option	US$/tonCO2	Sub-type unit	t CO2/unit	Million US$	MUS$/year	in 2025	kt/year	kt/year	Frac.of total	ktoe	ktoe	GWh	GWh
5	Agriculture	Rice crop CH4 reduction	1.20	Rice crop CH4 red.(1000 ha)	2,566	0.0	0.0		0.00	0	0.0%				
6		Zero tillage	-194.39	1000 ha	86	0.0	0.0		0.00	0	0.0%				
7		Cover crops	81.04	1000 ha	1,490	0.0	0.0		0.00	0	0.0%				
8		Nitrification inhibitors (1000 ha)	67.69	1000 ha	790	0.0	0.0		0.00	0	0.0%				
9		Covering slurry stores (1 slurry store)	937.83	1 slurry store	0.20	0.0	0.0		0.00	0	0.0%				
10		Fat supplementation in ruminants diets (%DM fat added)	80.50	%DM fat added	4,336	0.0	0.0		0.00	0	0.0%				
11		Tobacco curing	-26.05	100 t tobacco/yr	562	0.0	0.0		0.00	0	0.0%				
12	Biomass energy	Rice husk cogeneration plants	-90.80	1 MW cogeneration	9,719	0.0	0.0		0.00	0	0.0%				
13		Biomass power from biomass residues	-184.60	1 MW CHP plant	2,428	0.0	0.0		0.00	0	0.0%				
14		Bagasse power	-341.74	100 kt sugar cane/year	6,791	0.0	0.0		0.00	0	0.0%				
15	CCS	CCS plant	132.19	1 MW	6,014	0.0	0.0		0.00	0	0.0%				
16	Cement	Clinker replacement	4.91	1000 tonnes cement/day	166,584	0.0	0.0		0.00	0	0.0%				
17	Coal bed/mine methane	Coal mine methane	-30.71	10 Mm3 CMM/year	37,353	0.0	0.0		0.00	0	0.0%				
18	EE households	Efficient residential airconditioning	-307.41	1000 Airconditioners	780	0.0	0.0		0.00	0	0.0%			0	
19		Efficient lighting with CFLs	-321.07	1000 Bulps	38	0.0	0.0		0.00	0	0.0%			0	
20		Efficient lighting with LEDs	-354.68	1000 Bulps	78	-5.0	-27.6	1,000	77.72	78	0.0%			130	
21		Efficient lighting with LEDs replacing CFL	-213.84	1000 Bulps	9	0.0	0.0		0.00	78	0.0%			0	
22		Efficient wood stoves	-961.16	1000 stoves	2,212	0.0	0.0		0.00	78	0.0%				
23		LPG stoves replacing wood stoves	88.29	1000 stoves	2,055	0.0	0.0		0.00	78	0.0%				
24		Efficient electric stoves	-273.81	1000 stoves	155	0.0	0.0		0.00	78	0.0%			0	
25		Efficient refrigerators	-37.24	1000 refrigerators	1,203.8	0.0	0.0		0.00	78	0.0%			0	
26	EE industry	Efficient electric motors	-309.02	1 kW	0.6	0.0	0.0		0.00	78	0.0%			0	
27		Energy efficiency in industry	0.94	10% red. of energy demand	13,282,494	0.0	0.0		0.00	78	0.0%				
28		Building materials	-24.15	1 million bricks	937	0.0	0.0		0.00	78	0.0%				
29	EE own generation	Waste heat recovery at cement plant	-375.62	1 Cement plant	39,853	0.0	0.0		0.00	78	0.0%				
30		Waste heat recovery at steel plant	-390.79	1 Steel plant	36,704	0.0	0.0		0.00	78	0.0%				

Guidance | kT to TJ | Start Year Balance | Growth | Country info | Balance 2025 | Balance 2030 | Balance 2050 | assumptions | graph | main25 | main30 | main50 | MRV ...

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Technology sheet

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$/kWh
Emissions factor	0.72	tCO_2e/MWh electricity
Mitigation option: Solar PVs		
Investment in PVs	3000	US$/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**

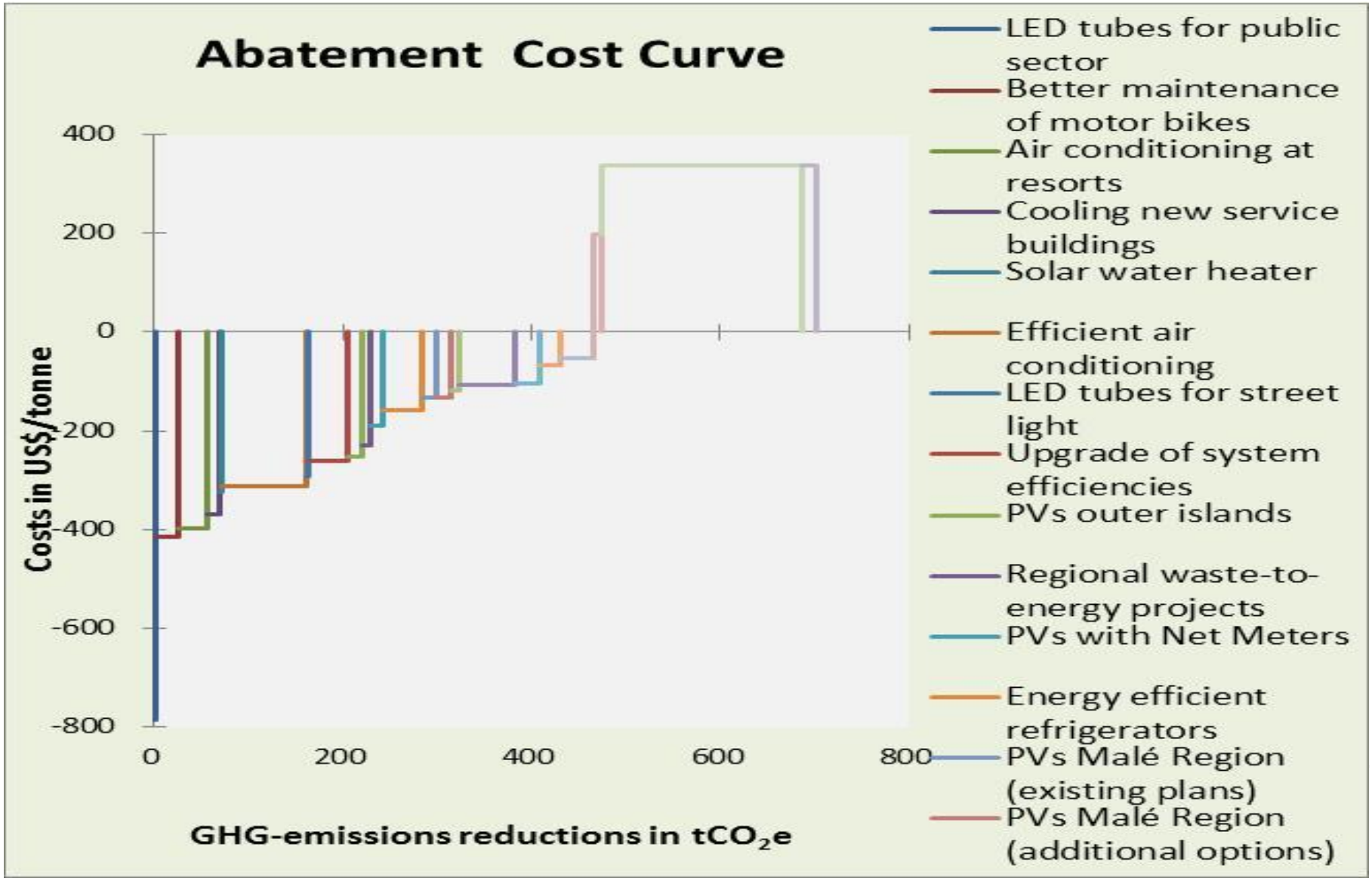
Comments:

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.

GACMO incluye hojas idénticas para cada opción de mitigación incluida en el modelo

Marginal Abatement Cost (MAC) curve - Maldives



Conclusions GACMO

GACMO is a **simple tool, easily adaptable** to a specific national context used to make analysis of mitigation options and their effects in terms of GHG emissions reduction in the context of NDC preparation or update

The GACMO calculations are transparent and easy to follow, in line with the methodologies established by the IPCC and CDM

GACMO allows to establish a Business As Usual (BAU) project 2025/2030/2050

GACMO allows to establish a mitigation scenario projection (percentage of reduction of GHG emissions in comparison with BAU)

GACMO allows you to calculate the reduction of GHG and the cost related to each mitigation option compared to a technology used as a reference

GACMO allows to "play" with the scale of application of any mitigation option to reach a global reduction target

GACMO offers a clear description of the total reduction of GHG emissions, total inversion and total annual cost

available at
https://unepdtu.org/publications/the-greenhouse-gas-abatement-cost-model-gacmo/

UNEP DTU Partnership (UDP)
https://unepdtu.org/

Denis Desgain, UDP (ddes@dtu.dk)
Jørgen Fenhann, UDP (jqfe@dtu.dk)