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Getting Started with the

GAINS • MITIGATION EFFORTS CALCULATOR

…estimating GHG mitigation opportunities and costs in Annex I countries

http://gains.iiasa.ac.at/MEC/

Tutorial (Version 1.3 - August 2010)

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PURPOSE

This user manual provides a brief introduction into IIASA's Mitigation Efforts Calculator (MEC). The MEC is an interactive web application that can be used to compare mitigation efforts for Annex I countries in the year 2020, both in terms of emission reductions and per-capita . It is based on the Greenhouse gas - Air pollution Interactions and Synergies (GAINS) model[1]. GAINS is currently[2] implemented for 36 Annex I Parties, representing 98% of 1990 emissions in all Annex I Parties.

In the guide you will also find a short description on the data fact sheets on greenhouse gas mitigation potentials for each of the Annex I countries. These data sheets are complimentary to the MEC.

[1] available at: http://gains.iiasa.ac.at/gains/Annex1.html
[2] as of April 2010

1 Introduction

Mitigation efforts and investments over the next two to three decades are critical for the future development of greenhouse gas emission levels. Opportunities exist to achieve low stabilization levels of greenhouse gases. However, it will be a formidable challenge to negotiating Parties to arrive at a generally accepted scheme for sharing efforts among Annex 1 countries that achieves the necessary emission reductions.

This user's guide presents the Mitigation Efforts Calculator online tool based on a comparison of greenhouse gas mitigation potentials and costs for Annex 1 countries. In brief, the methodology (i) adopts exogenous projections of future economic activities as a starting point, (ii) develops a corresponding baseline projection of greenhouse gas emissions for 2020 with information derived from the national GHG inventories that have been reported by Parties to the UNFCCC for 2005, (iii) estimates, with a bottom-up approach, for each economic sector in each country the potential emission reductions that could be achieved through application of the available mitigation measures, and (iv) quantifies the associated costs required for these measures under the specific national conditions.

The approach includes all six gases that are included in the Kyoto protocol (i.e., CO_2, CH_4, N_2O, HFCs, PFCs, SF_6) and covers all anthropogenic sources that are included in the emission inventories of Annex I countries to the UNFCCC (i.e., Energy, Industrial Processes, Agriculture, Waste, and from LULUCF). In addition, the analysis quantifies the co-benefits of GHG mitigation strategies for air pollution.

The Mitigation Efforts Calculator (MEC) currently provides three different baseline scenarios, each based on a World Energy Outlook (WEO). The most recent of these baseline scenarios includes the effects of the economic crisis and sees GHG emissions in 2020 that are more than 6% below 1990 levels (without LULUCF). With the above assumptions, a technical mitigation potential of approximately 38.7 percent (7.1 Gt CO_2eq) in relation to 1990 is estimated. The economic potential, e.g., for a carbon price of €100 /t CO_2eq (as calculated with a four percent interest rate) is estimated at a 33 percent reduction compared to 1990. It is worth noting that, because of measures with negative costs, total costs to the economy turn positive only beyond a 22 percent GHG reduction compared to 1990.

Note that the GAINS model only considers currently available technologies, takes into account the turnover rate of capital stock and does not assume premature scrapping of existing equipment. GAINS itself assesses the domestic mitigation potentials, but excludes behavioral changes; the implications of international carbon trading regimes can be analyzed with the MEC. All data that enter the model were derived from publicly available sources, and all input assumptions, including technological specifications, are freely available online.

In the following you will find a brief overview on how to get access to and use the Annex I online calculator data and the fact sheets.

2 Accessing the online calculator

The GAINS GHG mitigation effort calculator (MEC) allows an interactive comparison of mitigation potentials and costs via the Internet (http://gains.iiasa.ac.at/MEC).
The information on the data sheets is compiled together on the web into an online tool. The calculator can be accessed from: http://gains.iiasa.ac.at/MEC/

Registration is necessary to obtain free access to the calculator (see Figure 1). We require registration in order to be able to assist you should you encounter any problem. Click the icon *register* and follow the process as will be indicated.

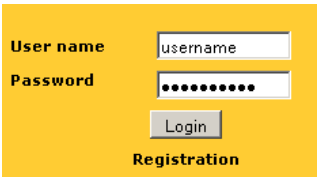

Figure 1 Login field

3 How to use the mitigation calculator

Once you have logged in, you see the following screen:

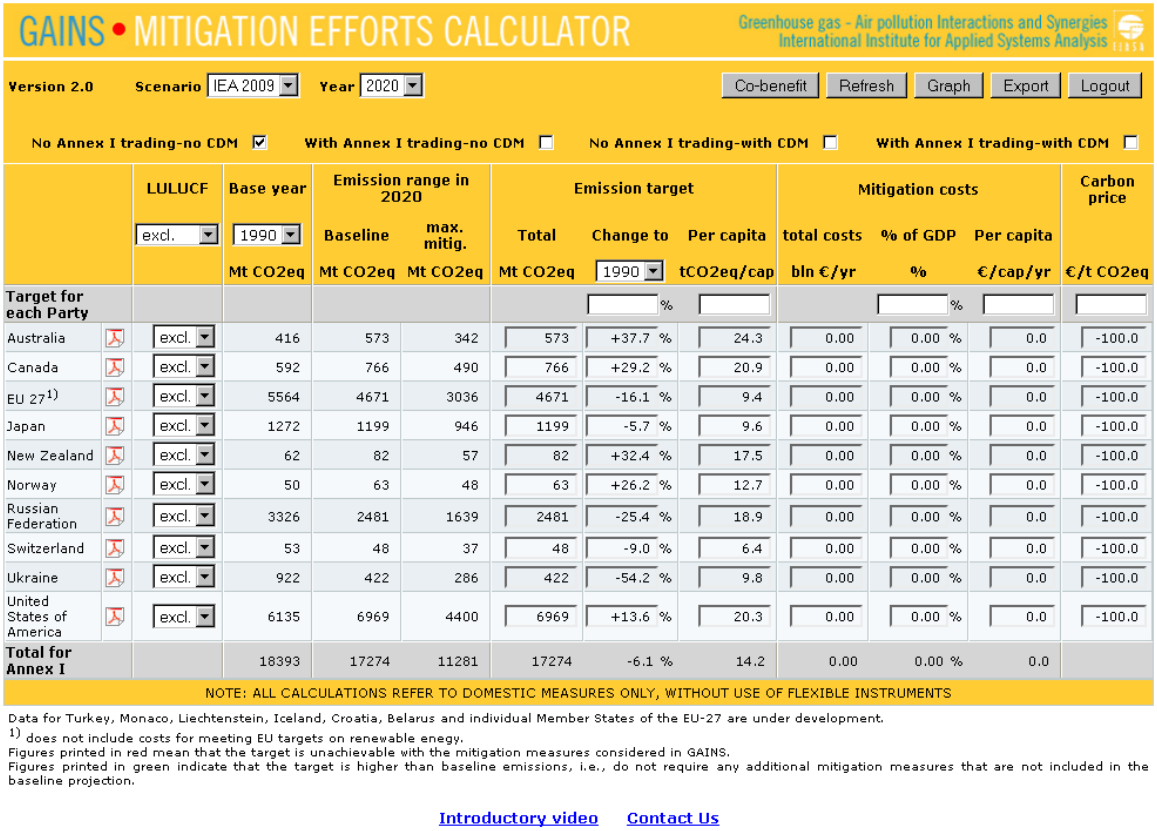

Figure 2 Start page of the mitigation efforts calculator

To get the most benefit out of the calculator you should essentially follow four steps:

1. Select the scenario and the future year, as well as the trading regime for the analysis;
2. Select target values
3. View numerical results
4. Assess co-benefits, export results and view results graphically

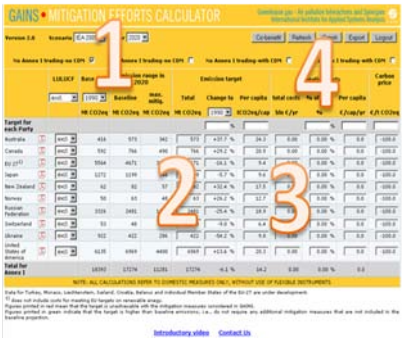

Figure 3 Following four steps

We now illustrate these individual elements of the calculator in detail.

3.1 The MEC calculator in detail

1. As a first step, you should configure the scenario. At the very top of the page you will find two *scroll-down boxes*: in the first you choose the baseline ***scenario***, in the second the target ***year***. You can also select the international carbon trading regime (for details see Section 4 below).

Figure 4. First parameters of the calculation

2. The calculator currently displays data for 10 Annex I Parties, including EU27 as an aggregate[3] as you see in the very first column. Next to the name of each party you will find the icon: that refers to a PDF document that belongs to the party. If you click it, a data sheet on GHG mitigation potentials will open in a new window. These data sheets contain graphic information on the macro-economic drivers, GHG intensities, mitigation potentials and costs in 2020 and finally the list of mitigation measures that applies to the party for increasing marginal costs, as discussed in Section 3.3 below.

Figure 5
Annex I Parties

[3] Analysis for individual EU27 countries has not been finalized yet

3. At the top of the next column, as shown in Figure 6, you select the base year to be either 1990 or 2005. The numbers shown in this column are the emission values of the UNFCCC inventories, as of submission year 2008.

Base year 1990 Mt CO2eq
416
592
5568
1272
62
50
3326
53
922
6135
18396

Figure 6 Base Year Emissions

4. The two columns show the range of possible emissions for 2020 going from projected emissions if business as usual continues to the lowest emission level possible in the model (Figure 7). In the first column you see the ***baseline emissions*** for the year 2020. The second column shows the lowest emission level that could be reached in the GAINS model starting with the selected baseline scenario and applying all mitigation measures to the maximum extent possible (when the ***maximum mitigation*** potential is reached).

Emission range in 2020	
Baseline Mt CO2eq	max. mitig. Mt CO2eq
611	385
796	536
5653	3757
1315	970
85	60
58	49
2831	1743
60	43
442	237
7153	4953
19004	12733

Figure 7 Emission range

5. In the next step (Figure 8) you have various options to specify ***emission targets*** for 2020: either as absolute targets in million tons of CO_2 equivalent, or as a percentage reduction relative to 1990 or 2005 emissions, or as an emissions per capita target figure. Percentage reductions have to be entered with a (-) sign, increases over the base year with a (+) sign. After you have specified a number, press ENTER and observe the fields in the calculator change. Percentage targets and per capita targets can be entered for each Party individually or for all Parties simultaneously.

Emission target		
Total Mt CO2eq	Change to 1990	Per capita tCO2eq/cap
	%	
611	+46.9 %	26.1
796	+34.4 %	21.8
5653	+1.5 %	11.4
1315	+3.4 %	10.6
85	+37.5 %	18.4
58	+17.5 %	12.3
2831	-14.9 %	20.1
60	+12.8 %	8.2
442	-52.0 %	10.7
7153	+16.6 %	20.9
19004	+3.3 %	15.5

Figure 8 Setting emission targets

6. You can insert targets for individual countries or global targets depending on the international carbon market selected. For example, insert a -10% emission target in the top row (i.e. for each Party) and press enter. You will notice the effect this will have for the data in the other fields.

7. As a result of the target setting emission figures will change, but also the total costs, costs expressed as a percentage of gross domestic product (GDP), costs per capita, and the marginal mitigation cost, i.e. the cost of reducing emissions by an extra ton of CO_2 equivalent.

In the first column you will find ***total cost*** for reaching the mitigation target for each Party. This is also expressed as a share of the ***Party's projected GDP in 2020***, and as a cost per person (total cost divided by the projected population in 2020).

The last column shows the marginal abatement cost at the mitigation target specified. The initial value is set to -100 Euros/tCO_2eq, and it changes as different targets are set.

Mitigation costs			Carbon price
total costs	% of GDP	Per capita	
bln €/yr	%	€/cap/yr	€/t CO2eq
	%		
21.15	2.76 %	896.7	20000.0
3.48	0.28 %	95.0	89.3
-4.71	-0.04 %	-9.5	-4.8
2.75	0.07 %	22.1	86.7
2.80	2.49 %	598.4	20000.0
1.70	0.88 %	357.9	20000.0
0.00	0.00 %	0.0	-100.0
-0.02	-0.01 %	-2.2	-14.4
0.00	0.00 %	0.0	-100.0
43.48	0.32 %	126.4	57.2
70.64	0.20 %	58.0	

Figure 9 Reading off and comparing mitigation costs

Results shown in **red** indicate that target you selected cannot be achieved with mitigation measures from current technology, it exceeds the technical potential. Results shown in **green** indicate that the target will already be achieved in the baseline scenario.

Norway		50	62	48	48	-2.6 %	10.2	1.70	0.88 %	357.9	20000.0
Russian Federation		3326	2672	1603	2672	-19.7 %	20.3	0.00	0.00 %	0.0	-100.0
Switzerland		53	49	37	48	-10.0 %	5.8	-0.02	-0.01 %	-2.2	-14.4
Ukraine		922	460	318	460	-50.1 %	10.7	0.00	0.00 %	0.0	-100.0
United States of America		6135	7244	4597	5522	-10.0 %	16.1	43.48	0.32 %	126.4	57.2

Figure 10 Results in green indicate that this target is already achieved in the baseline

EU 27[1)]		5568	5407	3493	5011	-10.0 %	10.1	-4.71	-0.04 %	-9.5	-4.8
Japan		1272	1332	1058	1145	-10.0 %	9.2	2.75	0.07 %	22.1	86.7
New Zealand		62	83	59	59	-4.6 %	12.6	2.80	2.49 %	598.4	20000.0
Norway		50	62	48	48	-2.6 %	10.2	1.70	0.88 %	357.9	20000.0
Russian Federation		3326	2672	1603	2672	-19.7 %	20.3	0.00	0.00 %	0.0	-100.0

Figure 11 Results in red indicate that this target cannot be achieved only with the mitigation options in the GAINS model, starting from the baseline selected

Alternatively to setting an emission target you can also specify a target on the cost side and watch its implication on the emission side. For example, you can enter a target marginal abatement cost for a Party, or a target total cost figure for a Party, or a target value for all Annex I Parties, expressed as a percentage of GDP. This allows a full comparison of efforts in terms of costs, per capita emissions, and percentage reduction. Note, however, that the costs for GHG mitigation measures already included in the baseline are not taken into account in the MEC.

8. In a fourth step you can turn to the ***Co*-benefit**s of the GHG mitigation target on the emissions of local air pollutants; you can ***Refresh*** the interface, i.e. reset to the initial value; you can view the results ***Graph***ically; you can ***Export*** the current settings to Excel; and you can ***Logout***.

Figure 12 The additional features of the MEC

Co-benefits here is the reduction of the emissions of three major air pollutants (sulfur dioxide (SO_2), nitrogen oxides (NO_x) and fine particulate matter ($PM_{2.5}$)) as a result of the emissions of GHGs. The co-benefits are expressed in absolute emission numbers (kt), and as a percentage reduction **relative to the baseline** selected.

Version 2.0 Export Close

Co-benefits of GHG mitigation on Air pollutants emission

Party	Carbon Price	GHG emissions		SO2		NOx		PM2.5	
	€/t CO2	Mt CO2 eq	Change comp. to 1990	kt SO2	Change comp. to Baseline 2020	kt NOx	Change comp. to Baseline 2020	kt PM2.5	Change comp. to Baseline 2020
Australia	20000.0	378	-9.25%	873	-36.90%	556	-39.20%	91	-37.35%
Canada	89.3	533	-10.00%	1319	-22.44%	838	-17.14%	104	-13.18%
EU 27	-4.8	5011	-10.00%	3238	-4.28%	5692	-5.23%	1247	-2.15%
Japan	86.7	1145	-10.00%	686	-17.18%	1197	-8.45%	137	-7.85%
New Zealand	20000.0	59	-4.61%	28	-48.34%	74	-19.53%	10	-18.09%
Norway	20000.0	48	-2.57%	23	-26.51%	133	-7.94%	54	-1.02%
Russian Federation	-100.0	2672	-19.68%	6676	-0.21%	4290	-0.02%	1844	0.00%
Switzerland	-14.4	48	-10.00%	13	-1.74%	39	-2.82%	7	-0.28%
Ukraine	-100.0	460	-50.07%	1416	0.00%	766	0.00%	341	0.01%
United States of America	57.2	5522	-10.00%	3834	-20.19%	6773	-11.39%	622	-13.22%

Figure 13 Example output for co-benefits

Use the ***Refresh*** button to return to the initial values and use the ***Export*** button when you are ready to export your query results in Excel (Figure 14).

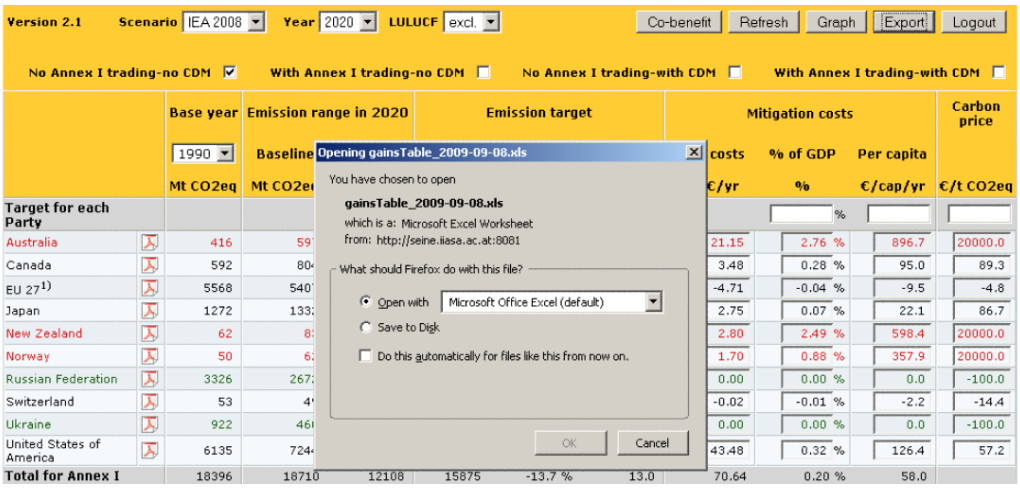

Figure 14 Export your results into Excel

Finally, you can also display results graphically for your further analysis by clicking the ***Graph*** button (Figure 15).

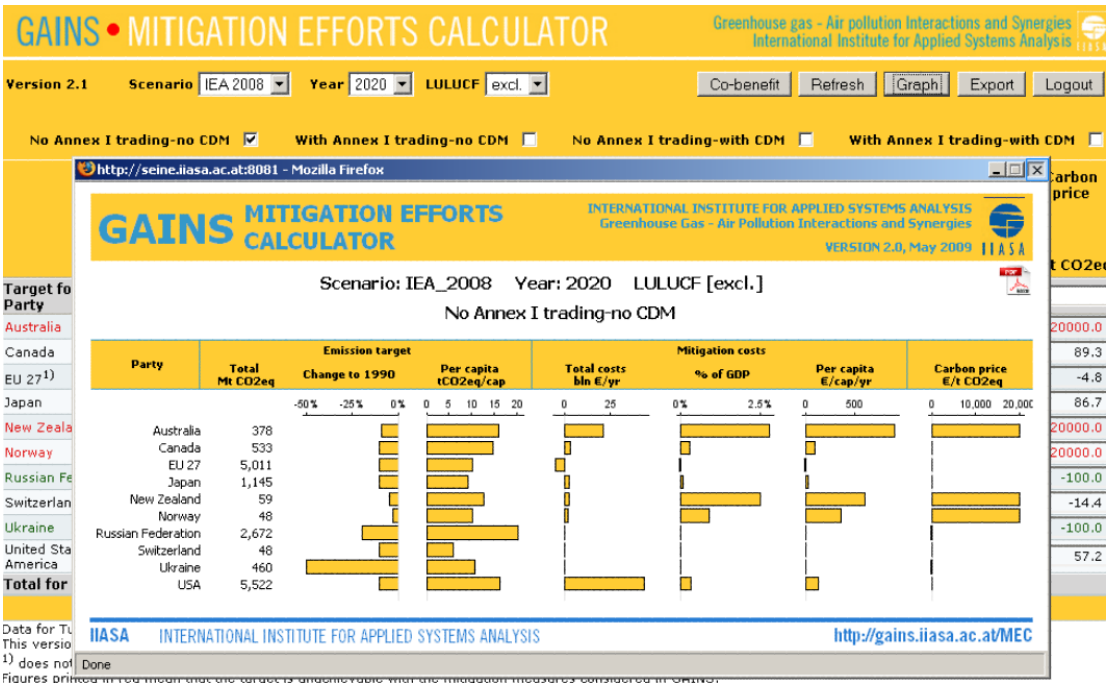

Figure 15 Graphical representation of results

Similarly to the previous column, you can enter a unified per cent of GDP for all parties in the blank box at the top of the column or you can enter individual values for the parties.

3.2 GAINS data fact sheets

GAINS ***data fact sheets*** on greenhouse gas mitigation potentials are complimentary to the mitigation calculator and are prepared for each Annex I Party. The fact sheets can be accessed from the mitigation calculator. Next to each Annex I party there is a (.pdf) symbol. By clicking the symbol, the fact sheet of a particular country will open. You can also choose to include or exclude the LULUCF sector from your calculations. By selecting a LULUCF option, the corresponding fact sheets change, as well (Figure 16).

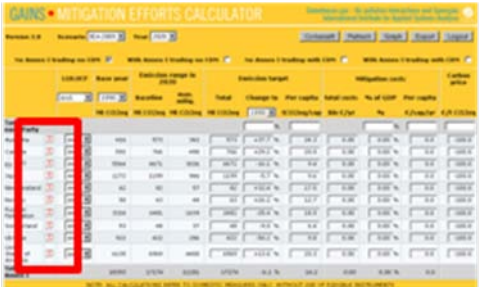

Figure 16 Location of Fact Sheets on the MEC page

In the following, we will look into the information provided in the sheets through the example of Australia. Select LULUCF sector excluded and click the icon. The sheet that will appear on your screen consists of a series of graphs, which we will discuss in groups. The first three graphs (Figure 17) display macro-economic drivers and baseline emissions scenarios.

The left hand graph shows assumed increase in population, GDP, primary energy and livestock unit until 220 relative to 1990. In the middle you can see the sectoral contribution to GHG emissions, and from the third graph you can read off the relative role of the individual greenhouse gases.

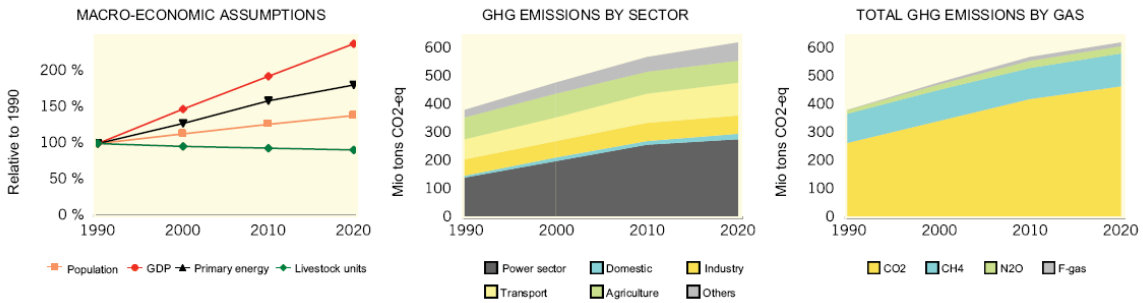

Figure 17 Macro-economic drivers and baseline GHG emissions for Australia

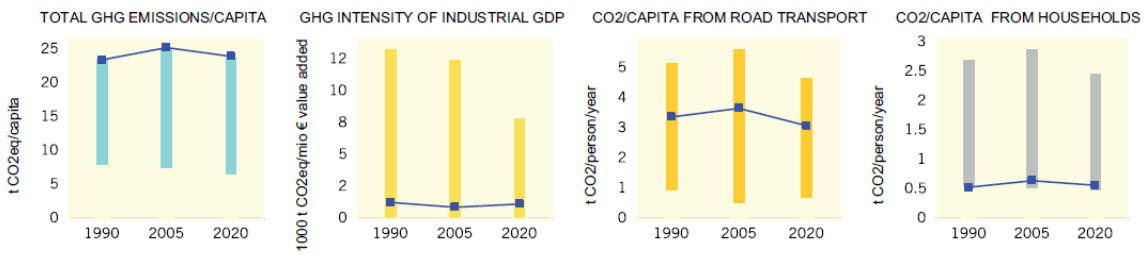

Figure 18 GHG intensities for Australia

The second set of graphs in the GAINS data fact sheets shows GHG intensities. Take a look at the first graph, where blue bars represent the range of GHG emissions per capita in all

Annex I countries and the dark-blue squares represent the per capita emissions for the country of your choice, in our case Australia. Notice that per capita emissions in Australia are among the highest within Annex I.

You will see on the second graph that Australia's intensity of industrial GDP is at the lower end of Annex I countries. The third graph tells you that Australia's CO_2 emissions per capita from road transport are significantly higher than the average. Finally, per capita emissions in Australia from direct fuel use in households are in the bottom range of all Annex I, due to the low number of heating days in the country.

The last section of the data fact sheets deal with mitigation potentials and costs. The first graph displays marginal abatement cost curve for Australia (Figure 19). At the very top of the graph you see emissions relative to 2005 and on the bottom emissions relative to 1990. On the left side of the horizontal axis are emissions of the baseline scenario and on the right side is the maximum mitigation case.

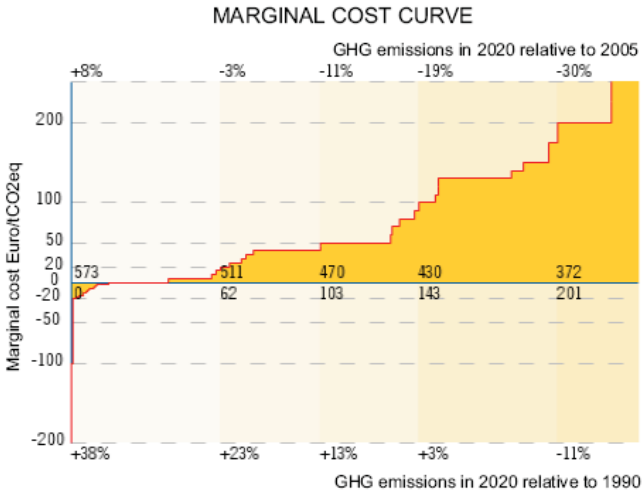

Figure 19 Marginal abatement cost curve for Australia

The red line in the graph indicates how the marginal costs (carbon price expressed in EUR/tCO_2eq.) is increasing with different mitigation levels. At the left bottom corner of the graph costs are negative representing measures that pay for themselves over their lifetime. Such negative cost measures include the insulation of newly built apartments. These are examples where GHG mitigation can result in cost savings as well.

Note that the starting and end points, as well as the shape of the curves is different for each individual party because they reflect national circumstances, such as different population densities, different climatic conditions, behavioral and consumption patterns, as well as industrial structures.

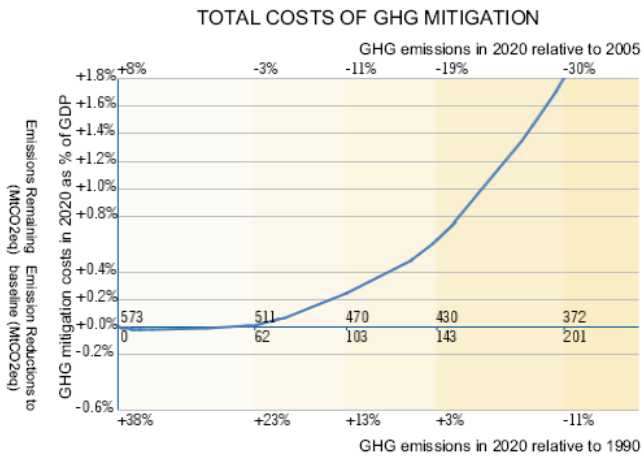

Figure 20 Total GHG mitigation cost for Australia

Finally the last graph on the sheet (Figure 20) shows the total mitigation cost as a function of the GHG emissions relative to 1990 (lower axis) and 2005 (upper axis).

The curve starts on the left at zero and first falls below zero due to the negative cost options mentioned above. The curve then rises as the marginal cost turns positive. Note that total costs here are scaled to the projected GDP in 2020 on the vertical axes in order to make this indicator comparable across Annex I parties.

The costs for mitigation measures in the baseline are not taken into account.

3.3 List of mitigation measures

The Fact Sheet discussed above is followed by pages that list cost-effective mitigation measures for Annex I Parties for increasing marginal costs. The list was obtained by comparing GAINS model results at consecutive marginal cost values. Thus, this table (Figure 21) provides a list of incremental steps of measures.

The GAINS model identifies cost-effective mitigation measures using an optimization method. It takes into account the fact that the combination of mitigation measures may not be as effective as the sum of the measures taken individually. For example, from a systems perspective reducing electricity consumption is a less effective mitigation measure *per se* if it is accompanied with a decarbonisation of the supply fuel mix.

As you can see from Figure 21 below, the first two columns display the country name and the marginal cost expressed in EUR/tCO_2eq. The column ***More of*** describes the measures that would be taken ***in addition*** to those taken at the previous marginal cost. Likewise the activities under the heading ***Less of*** are being reduced relative to the previous marginal cost. Thus, this list can be used to identify the marginal measures. Naturally, GAINS can also produce, for a given marginal cost, the total set of measures relative to the baseline.

Party	Marginal Cost Euro/CO2eq	More of	Less of	Remaining Emissions (MtCO2eq)	Cumulative Reductions rel. to baseline (MtCO2eq)	Change rel. to 1990
Australia						
Australia	-20	DOM - standard efficiency - commercial heating and cooling - existing buildings in Victoria DOM - Efficiency measures stage 1 - commercial heating and cooling - new buildings in New South Wales CH4: Gas distribution networks -doubling of leak control frequency TRA - Highest efficiency heavy duty diesel trucks TRA - Highest efficiency heavy duty gasoline trucks	DOM - Efficiency measures stage 1 - commercial heating and cooling - existing buildings in Victoria DOM -standard efficiency - commercial heating and cooling - new buildings in New South Wales DOM - Efficiency measures stage 2 - commercial heating and cooling - new buildings in Victoria CH4: Gas distribution networks -replacement grey cast iron networks TRA - Heavy duty diesel trucks with standard efficiency TRA - Heavy duty gasoline trucks with standard efficiency	572.5	-1.0	38%
Australia	-18	TRA - Gasoline cars with advanced internal combustion engines TRA - Light duty diesel trucks with advanced internal combustion engine	TRA - Gasoline cars with standard efficiency TRA - Light duty diesel trucks with standard efficiency	571.3	-2.1	37%

Figure 21. **Snapshot from the list of incremental mitigation measure steps of Australia**

The last three columns of the list also show at each marginal cost:

1. The remaining GHG emissions (in Mt CO_2eq)
2. The amount of GHG emissions reduced relative to the baseline (in MtCO_2eq)
3. The resulting percentage change relative to the 1990 emissions reported to the UNFCCC.

4 MEC Examples in different carbon trading regimes

The MEC allows the user to assess mitigation targets in the context of four different carbon trading regimes: on the one hand the user can choose whether or not trading **amongst Annex I parties** is allowed. If trading is allowed there is a common market with a single carbon price at which carbon can be traded. On the other hand the user can choose whether trading **between Annex I and Non-Annex I parties** is allowed. This type of trading is representing a CDM-like mechanism, and here the relevant aspect is that offsets can be purchased by Annex I parties. Since the MEC currently does not include Non-Annex I parties there is no explicit representation of the supply of offsets or CDM certificates: the MEC thus requires the carbon trading price as input by the user.

In the following four examples are discussed that illustrate the functionality of the MEC with the help of some specific examples.

4.1 No Annex I trading and no CDM

Select the first trading option in the top left corner of the MEC. This is actually the default setting when you login.

You can now enter targets either as targets for individual Parties, or for all Parties simultaneously. For example, for Australia set the total emission target to 500 $MtCO_2eq$, and press ENTER.

	LULUCF	Base year	Emission range in 2020		Emission target			Mitigation costs			Carbon price
	excl.	1990	Baseline	max. mitig.	Total	Change to	Per capita	total costs	% of GDP	Per capita	
		Mt CO2eq	Mt CO2eq	Mt CO2eq	Mt CO2eq	1990	tCO2eq/cap	bln €/yr	%	€/cap/yr	€/t CO2eq
Target for each Party						%			%		
Australia	excl.	416	573	342	500	+20.1 %	21.2	0.41	0.06 %	17.2	36.3
Canada	excl.	592	766	490	500	-15.6 %	13.6	5.02	0.41 %	137.0	128.5

Figure 22 Example result: setting a absolute targets

The calculator translates this target not only in a percentage change relative to 1990 and a resulting per capita emission, but also calculates the total costs and a marginal cost. Repeating this exercise for, say, Canada at an absolute emission level of also 500 $MtCO_2eq$ results in different values for the indicators. In particular, note that the marginal cost is different in the two countries because there is no trading of AAUs between the Parties that could lead to an equilibrium carbon price.

Similarly you can set targets on the costs, or on the carbon price, either by individual Annex I Party or for the whole group of Parties.

4.2 Annex I trading is allowed, but no CDM

Select the second trading option in the specifications at the top of the screen. A slightly different screen will appear.

GAINS • MITIGATION EFFORTS CALCULATOR

Greenhouse gas - Air pollution Interactions and Synergies
International Institute for Applied Systems Analysis

Version 2.0 Scenario IEA 2009 Year 2020 Co-benefit Refresh Graph Export Logout

No Annex I trading-no CDM ☐ With Annex I trading-no CDM ☑ No Annex I trading-with CDM ☐ With Annex I trading-with CDM ☐

	LULUCF	Emissions					Mitigation costs					Carbon price
		Base year	Target 2020		Allocation							
	excl.	1990	Total	Change to	Domestic emissions	for permits	for domestic measures	for permits	total costs	% of GDP	Per capita	
		Mt CO2eq	Mt CO2eq	1990 %	Mt CO2eq	Mt CO2eq	bln €/yr	bln €/yr	bln €/yr	%	€/cap/yr	€/t CO2eq
Total for Annex I				%								
Target for each Party				%						%		
Australia	excl.	416	573	+37.7 %	573	0	0.00	0.00	0.00	0.00 %	0.0	-100.0
Canada	excl.	592	766	+29.2 %	766	0	0.00	0.00	0.00	0.00 %	0.0	-100.0
EU 27[1)]	excl.	5564	4671	-16.1 %	4671	0	0.00	0.00	0.00	0.00 %	0.0	-100.0
Japan	excl.	1272	1199	-5.7 %	1199	0	0.00	0.00	0.00	0.00 %	0.0	-100.0
New Zealand	excl.	62	82	+32.4 %	82	0	0.00	0.00	0.00	0.00 %	0.0	-100.0
Norway	excl.	50	63	+26.2 %	63	0	0.00	0.00	0.00	0.00 %	0.0	-100.0
Russian Federation	excl.	3326	2481	-25.4 %	2481	0	0.00	0.00	0.00	0.00 %	0.0	-100.0
Switzerland	excl.	53	48	-9.0 %	48	0	0.00	0.00	0.00	0.00 %	0.0	-100.0
Ukraine	excl.	922	422	-54.2 %	422	0	0.00	0.00	0.00	0.00 %	0.0	-100.0
United States of America	excl.	6135	6969	+13.6 %	6969	0	0.00	0.00	0.00	0.00 %	0.0	-100.0
Total for Annex I		18393	17274	-6.1 %	17274	0	0.00	0	0.00	0.00 %	0.0	

Figure 23 Initial configuration when the second trading regime is selected

Initially it seems that there are fewer options for specifying targets: you have to provide a target that either applies to the Annex I region as a whole or to each individual Annex I party. Note that the target that you set has to be more ambitious than the baseline, i.e. in the above example a reduction of more than 6.1% relative to 1990.

As a first example, set a target of -25% in the *Total for Annex I* cell. The result will be this:

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	LULUCF	Emissions					Mitigation costs					Carbon price
		Base year	Target 2020		Allocation							
	excl.	1990	Total	Change to	Domestic emissions	for permits	for domestic measures	for permits	total costs	% of GDP	Per capita	
		Mt CO2eq	Mt CO2eq	1990 %	Mt CO2eq	Mt CO2eq	bln €/yr	bln €/yr	bln €/yr	%	€/cap/yr	€/t CO2eq
Total for Annex I				-25 %								
Target for each Party				%						%		
Australia	excl.	416	498	+19.7 %	498	0	0.46	0.00	0.46	0.06 %	19.7	39.3
Canada	excl.	592	559	-5.6 %	559	0	0.52	0.00	0.52	0.04 %	14.2	39.3
EU 27[1)]	excl.	5564	3772	-32.2 %	3772	0	5.88	0.00	5.88	0.04 %	11.8	39.3
Japan	excl.	1272	1072	-15.8 %	1072	0	-0.07	0.00	-0.07	-0.00 %	-0.6	39.3
New Zealand	excl.	62	70	+13.9 %	70	0	0.04	0.00	0.04	0.04 %	9.6	39.3
Norway	excl.	50	55	+11.2 %	55	0	-0.01	0.00	-0.01	-0.00 %	-1.5	39.3
Russian Federation	excl.	3326	1914	-42.4 %	1914	0	1.49	0.00	1.49	0.06 %	11.3	39.3
Switzerland	excl.	53	42	-19.9 %	42	0	-0.03	0.00	-0.03	-0.01 %	-4.3	39.3
Ukraine	excl.	922	345	-62.5 %	345	0	1.11	0.00	1.11	0.31 %	25.7	39.3
United States of America	excl.	6135	5466	-10.9 %	5466	0	6.99	0.00	6.99	0.05 %	20.3	39.3
Total for Annex I		18393	13795	-25.0 %	13795	0	16.38	0	16.38	0.05 %	13.5	

Figure 24 Setting an overall target

The overall target of -25% is achieved (last row), but each Party takes a different share in this reduction, because in this configuration the most cost-effective distribution of emission reductions is chosen. As you can see in the *Allocation* column, there is actually no trading occurring (i.e. no allocation for permits), in each country all mitigation measures up to a marginal cost of 39 Euros are implemented (cf. last column) and the implementation of these measures results in the emissions and costs as displayed.

In an alternative configuration, apply the -25% target **to each Party** and obtain this:

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	LULUCF	Emissions					Mitigation costs					Carbon price
		Base year	Target 2020		Allocation							
	excl.	1990	Total	Change to	Domestic emissions	for permits	for domestic measures	for permits	total costs	% of GDP	Per capita	
		Mt CO2eq	Mt CO2eq	1990	Mt CO2eq	Mt CO2eq	bln €/yr	bln €/yr	bln €/yr	%	€/cap/yr	€/t CO2eq
Total for Annex I				%								
Target for each Party				-25 %						%		
Australia	excl.	416	312	-25.0 %	498	186	0.46	7.32	7.79	1.08 %	330.1	39.3
Canada	excl.	592	444	-25.0 %	559	115	0.52	4.53	5.05	0.42 %	137.7	39.3
EU 27[1)]	excl.	5564	4173	-25.0 %	3772	-401	5.88	-15.78	-9.90	-0.07 %	-19.9	39.3
Japan	excl.	1272	954	-25.0 %	1072	117	-0.07	4.62	4.55	0.13 %	36.6	39.3
New Zealand	excl.	62	46	-25.0 %	70	24	0.04	0.95	0.99	0.94 %	211.5	39.3
Norway	excl.	50	37	-25.0 %	55	18	-0.01	0.71	0.70	0.36 %	141.6	39.3
Russian Federation	excl.	3326	2495	-25.0 %	1914	-580	1.49	-22.82	-21.33	-0.86 %	-162.1	39.3
Switzerland	excl.	53	40	-25.0 %	42	3	-0.03	0.11	0.07	0.03 %	9.8	39.3
Ukraine	excl.	922	692	-25.0 %	345	-346	1.11	-13.61	-12.50	-3.48 %	-290.1	39.3
United States of America	excl.	6135	4601	-25.0 %	5466	864	6.99	33.98	40.97	0.30 %	119.1	39.3
Total for Annex I		18393	13794	-25.0 %	13794	0	16.39	0	16.39	0.05 %	13.5	

Figure 25 Setting a *Target for each Party*

You will observe the following changes: first, now each Party achieves the -25% target individually, but not by domestic measures alone. This means that, though the domestic emissions in the allocation column is the same as above, the amounts of AAUs bought (+) and sold (-) are different. The marginal cost is still 39 Euros/tCO_2eq., which in this case also corresponds to the carbon trading price. Second, the mitigation costs now have a domestic component and a trading component. The domestic costs are the same as in the previous case, but now parties pay for (+) or have revenues from selling AAUs (-), so that the total costs for each Party are different from the previous case (Figure 24). Third, once you have set a target for each Party, the MEC also now allows you to set percentage targets for individual Parties.

For example, in Figure 26 below we have increased the target for the USA to -30% while leaving the targets for all other Parties the same. It can be observed that not only does this imply an increase of the overall Annex I target to -26.7%, but also it has increased the carbon price to 47.6 Euro/tCO_2eq., and therefore also the costs for each Party have changed: now domestic mitigation measures up to 47.6 Euro/tCO_2eq. are implemented, and the trading costs changes as a result of the higher carbon price.

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	LULUCF	Emissions					Mitigation costs					Carbon price
		Base year	Target 2020		Allocation							
	excl.	1990	Total	Change to	Domestic emissions	for permits	for domestic measures	for permits	total costs	% of GDP	Per capita	
		Mt CO2eq	Mt CO2eq	1990 %	Mt CO2eq	Mt CO2eq	bln €/yr	bln €/yr	bln €/yr	%	€/cap/yr	€/t CO2eq
Total for Annex I				%								
Target for each Party				%						%		
Australia	excl.	416	312	-25.0 %	470	158	1.70	7.52	9.22	1.28 %	390.8	47.6
Canada	excl.	592	444	-25.0 %	547	103	1.04	4.89	5.93	0.49 %	161.9	47.6
EU 27[1)]	excl.	5564	4173	-25.0 %	3718	-455	8.16	-21.68	-13.52	-0.10 %	-27.2	47.6
Japan	excl.	1272	954	-25.0 %	1070	116	-0.03	5.54	5.52	0.15 %	44.4	47.6
New Zealand	excl.	62	46	-25.0 %	70	23	0.07	1.12	1.19	1.12 %	253.8	47.6
Norway	excl.	50	37	-25.0 %	55	18	-0.00	0.85	0.85	0.44 %	171.7	47.6
Russian Federation	excl.	3326	2495	-25.0 %	1853	-642	4.04	-30.57	-26.53	-1.07 %	-201.6	47.6
Switzerland	excl.	53	40	-25.0 %	42	3	-0.03	0.12	0.10	0.04 %	12.8	47.6
Ukraine	excl.	922	692	-25.0 %	327	-365	1.94	-17.39	-15.45	-4.30 %	-358.6	47.6
United States of America	excl.	6135	4295	-30.0 %	5335	1041	12.68	49.59	62.27	0.46 %	181.1	47.6
Total for Annex I		18393	13488	-26.7 %	13488	0	29.57	0	29.57	0.08 %	24.3	

Figure 26 Increasing the target for the USA to -30%.

Finally the overall cost has also increased from 16.4 bln Euros per year to 29.6 bln Euros per year.

Similar analyses can be carried out by setting an overall cost target for Annex I, either expressed as a percentage of GDP or as costs per capita. Once an overall target has been selected, the MEC allows you to also set targets for individual Parties.

A scenario with a desired carbon price can be generated by iteratively setting overall targets for Annex I Parties until the carbon price is reached.

4.3 Annex I trading is not allowed, but CDM is

In this trading regime Annex I parties cannot trade amongst themselves, but each Party has access to CDM certificates from a global pool. Since this is a not a very realistic trading regime, we prefer to discuss the new features that the possibility of trading with Non-Annex I Parties introduces only in the next subsection.

4.4 Both Annex I trading and CDM are allowed

Select the *With Annex I trading-with CDM* option on the upper right of the MEC interface. In this trading regime Annex I parties can both trade amongst themselves and also buy CDM type certificates from an otherwise unspecified Non-Annex I region. The interface looks very much like the one discussed in Section 4.2. The difference is that, once you enter an Annex I emission target (either for *Total for Annex I* or *Target for each Party*), the MEC gives you the option to provide an assumption for a carbon price for the trading between Annex I and non-Annex I parties:

	18393	13795	-25.0 %	13795	0	16.38	0.000	16.38	0.05	%

Please select your best guess about equilibrium price in global CDM market No CONFIRM

echtenstein, Iceland, Croatia, Belarus and individual Member States of the EU-27 are under development.

Figure 27 The interface to provide a carbon price in the CDM market

Since this Annex I MEC does not include cost curve information for the Non-Annex I parties, the users have to make their own assumptions about the net volumes of CERs that can be traded at which price. The default value is "No", i.e. there is no trading between Annex I and non-Annex I Parties assumed. Specifying a positive numerical value results in a redistribution of emission reductions and costs. For example, starting from a -25% reduction for each Party (like in Figure 25 above), and entering a carbon price of 30 Euros/tCO_2eq. (+ENTER) results in the following:

No Annex I trading-no CDM ☐ With Annex I trading-no CDM ☐ No Annex I trading-with CDM ☐ With Annex I trading-with CDM ☑

	LULUCF	Emissions					Mitigation costs					Carbon price
		Base year	Target 2020		Allocation							
	excl.	1990	Total	Change to	Domestic emissions	Credits (bought +) (sold -)	for domestic measures	Credits (bought +) (sold -)	total costs	% of GDP	Per capita	
		Mt CO2eq	Mt CO2eq	1990	Mt CO2eq	Mt CO2eq	bln €/yr	bln €/yr	bln €/yr	%	€/cap/yr	€/t CO2eq
Total for Annex I				%								
Target for each Party				%						%		
Australia	excl.	416	312	-25.0 %	503	191	0.31	5.72	6.03	0.83 %	255.6	30.0
Canada	excl.	592	444	-25.0 %	577	133	-0.16	3.98	3.82	0.31 %	104.4	30.0
EU 27[1)]	excl.	5564	4173	-25.0 %	3905	-268	1.20	-8.05	-6.84	-0.05 %	-13.8	30.0
Japan	excl.	1272	954	-25.0 %	1081	127	-0.41	3.82	3.40	0.09 %	27.4	30.0
New Zealand	excl.	62	46	-25.0 %	71	24	0.03	0.73	0.77	0.72 %	163.3	30.0
Norway	excl.	50	37	-25.0 %	56	19	-0.03	0.56	0.53	0.27 %	107.1	30.0
Russian Federation	excl.	3326	2495	-25.0 %	1958	-536	-0.08	-16.09	-16.17	-0.65 %	-122.9	30.0
Switzerland	excl.	53	40	-25.0 %	42	3	-0.04	0.08	0.05	0.02 %	6.4	30.0
Ukraine	excl.	922	692	-25.0 %	369	-322	0.36	-9.66	-9.30	-2.59 %	-215.9	30.0
United States of America	excl.	6135	4601	-25.0 %	5502	901	5.66	27.03	32.69	0.24 %	95.0	30.0
Total for Annex I		18393	13794	-25.0 %	14065	270	6.86	8.110	14.97	0.04 %	12.3	

Please select your best guess about equilibrium price in global CDM market 30 CONFIRM

Data for Turkey, Monaco, Liechtenstein, Iceland, Croatia, Belarus and individual Member States of the EU-27 are under development.

Figure 28 Full trading regime in the presence of a carbon price of 30 Euro/tCO_2eq.

Note that the -25% target is reached and now the equilibrium carbon price (last column) is indeed 30 Euros/tCO_2eq. Compared to Figure 25, however, the allocation of domestic emissions and credits has changed: here we observed that 270 MtCO_2eq. are actually purchased in the form of credits from Non-Annex I Parties, amounting to a revenue of 8.1 bln Euros. Since the carbon price of 30 Euros/tCO_2eq. is lower than the Annex I equilibrium price of 39 Euros/tCO_2eq. (Figure 25), the overall mitigation cost is now also lower (12.3 instead of 13.5 bln Euros). The negative figures in the allocation column for credits (in the center of Figure 28) indicate that some Annex I Parties are still selling credits to other Annex I parties.

In this analysis we have assumed that the Non-Annex I region can indeed supply 270 MtCO_2eq. at a carbon price of 30 Euros/tCO_2eq. In an alternative scenario, we may assume that the supply at this carbon price is actually higher. In this case we have to assume a lower trading price (e.g. 20 Euros/tCO_2eq.) and observe a higher trading volume. Similarly, we may explore a scenario in which the supply curve lies higher, i.e. the equilibrium price is higher than 30 Euros/tCO_2eq and the trading volume lower. However, when the assumed carbon price exceeds the Annex I equilibrium price (here 39.3 Euros/tCO_2eq., cf. Figure 25), no trading between Annex I and Non-Annex I Parties occurs.

5 Appendix

Additional information to the interactive online calculator can be found at the APD web site on the Comparison of GHG Mitigation Efforts for Annex 1 Parties: http://gains.iiasa.ac.at/gains/Annex1.html.

This web site provides access to the following resources:

- Initial results of the analysis:
  - Report on initial results
  - The interactive Mitigation Efforts Calculator
  - Data sets for Annex 1 Parties, by default excluding LULUCF sector: Australia - Canada - EU27 - Japan - New Zealand - Norway - Russia - Switzerland - Ukraine - USA
- Documentation of the approach:
  - Methodology
  - Energy-related and industrial GHG emissions
  - Transport
  - Non-CO_2 emissions
  - GHG emissions from LULUCF
- Interactive access to all input data:
  - For Annex I countries in Europe and for other Annex I countries
- Presentations at the IIASA side event at COP14: (these are mostly outdated)
  - Introduction
  - Methodology
  - Initial results for energy and industrial emissions
  - Estimates for the LULUCF sector
  - Access to information

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