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Cloud Business Intelligent Services to explore the synergies and interactions among climate change, air quality objectives

Outline

- GAINS concepts and modeling
  - Concepts and requirements
  - Modeling and Interaction with other models
- Gains cloud based multi dimensional data model
  - Cloud based Multi Dimensional Data Model
  - Dimensions and Variables (facts)
  - Application Services
- Cloud-based gains data warehousing application framework
  - Multi Dimensional Modeling Services
  - Application Services
- Conclusions and Future Works

GAINS CONCEPTUAL MODEL

GAINS Concepts

- To identify portfolios of measures that improve air quality and reduce greenhouse gas emissions at least cost.
- To bring together scientific knowledge and quality-controlled data on future socio-economic driving forces of emissions:
  - on the technical and economic features of the available emission control options,
  - on the chemical transformation and dispersion of pollutants in the atmosphere, and the resulting impacts on human health and the environment.

The multi-pollutant/multi-effect approach

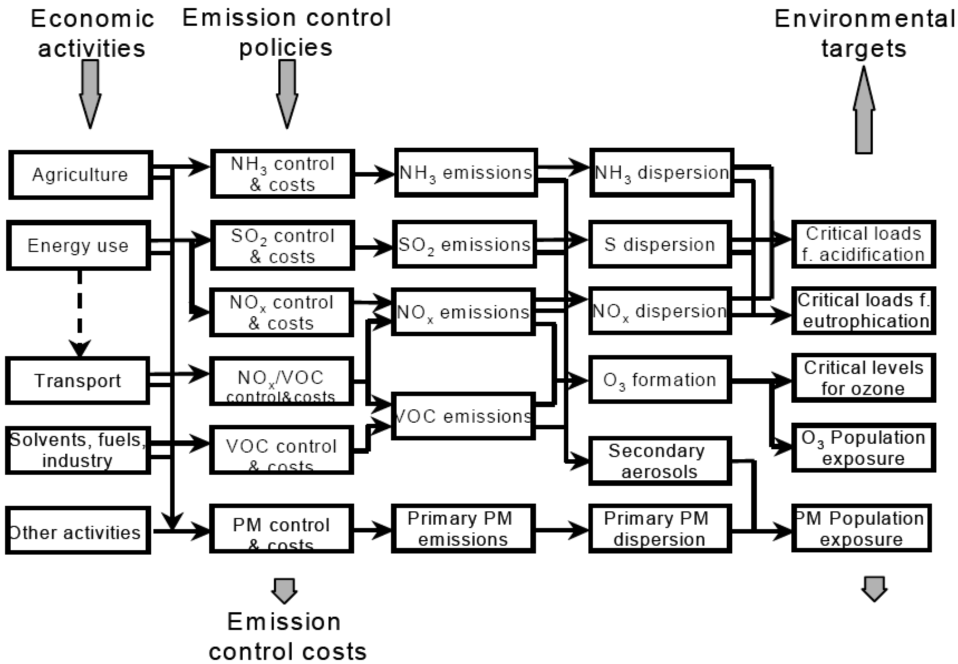
addresses impacts of air pollution on:
- human health,
- vegetation and
- aquatic ecosystems

	PM	SO_2	NO_x	VOC	NH_3	CO_2	CH_4	N_2O	HFCs PFCs SF_6
Health impacts: PM	√	√	√	√	√				
O_3			√	√			√		
Vegetation damage: O_3			√	√			√		
Acidification		√	√		√				
Eutrophication			√		√				
Radiative forcing: - direct						√	√	√	√
- via aerosols	√	√	√	√	√				
- via OH			√	√			√		

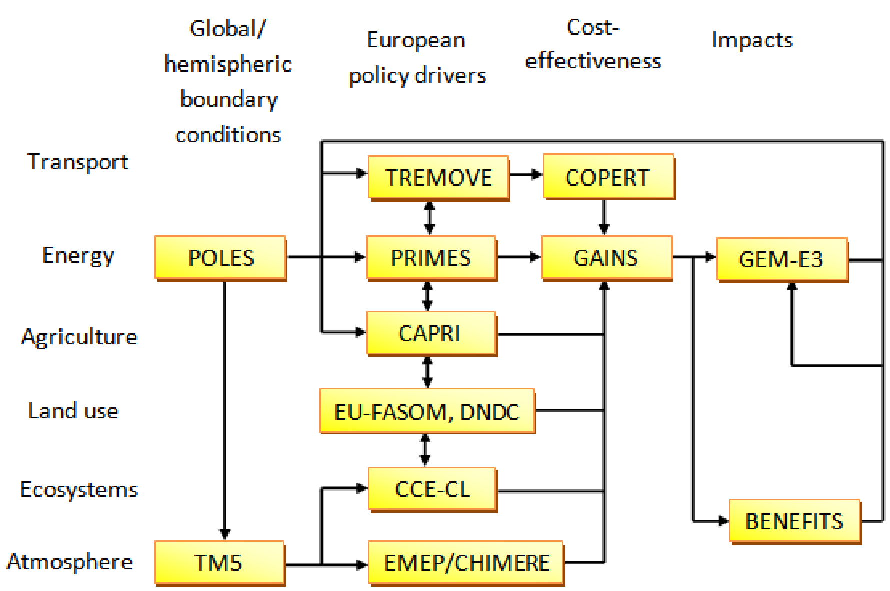
Requirements

- accessible, i.e. both the typically inputs and outputs of the analysis need to be publically available at all times;
- transparent, i.e. in addition the model rationale and mathematical relations need to be comprehensible even to non-experts;
- participatory, i.e. national experts need to be able to have an influence on the model design;
- able to deliver results promptly as needed;
- able to store large amounts of data and produce them even after years;
- able to interact with a variety of other, specialized modeling tools.

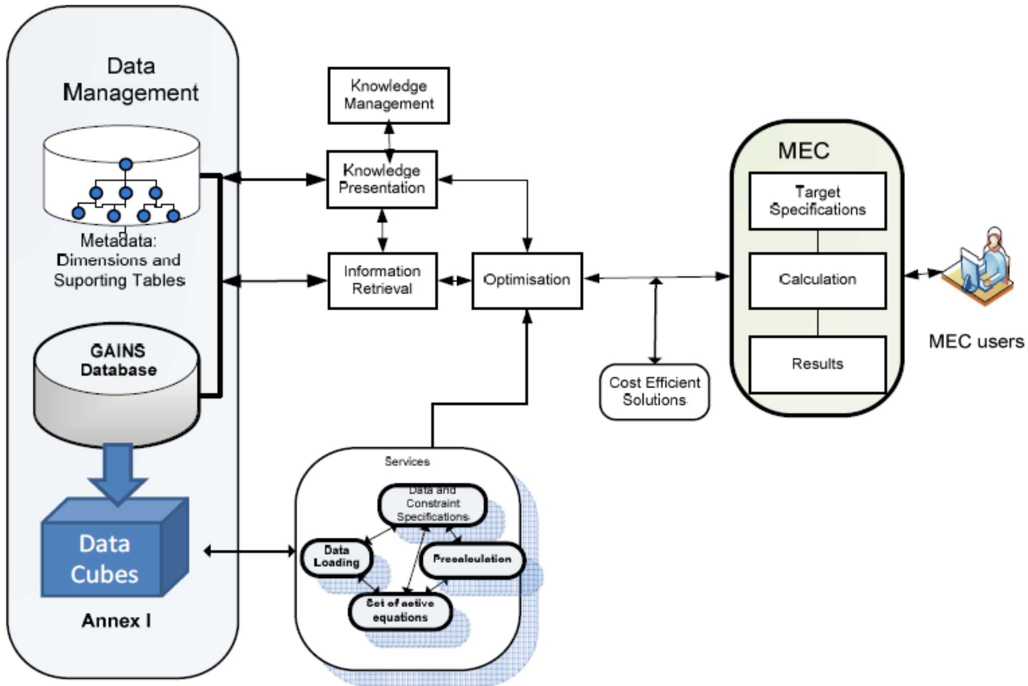
Information Flow



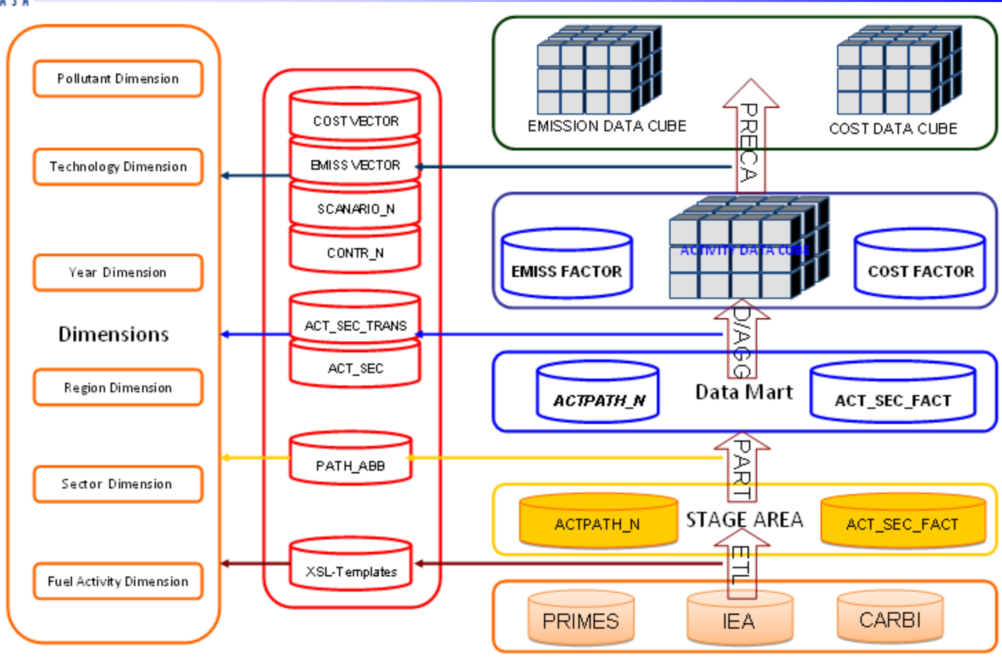
Interaction with other models



GAINS System Architecture



GAINS DWH system architecture



GAINS CLOUD BASED MULTIDIMENSIONAL DATA MODEL

$$G = \langle D,V,A \rangle$$

- D = {R,F,S,P,T,Y} is a set of dimensions.
- V is a set of variables or facts.
- A is a set of application services in the context of GAINS cloud intelligent framework and used to build, manage as well as analysis data in GAINS data ware- house.

Dimensions

- six main dimensions D={R,F,S,P,T,Y}. Specifically:
  - R is dimension region, and r ∈ R is a region.
  - F is dimension fuel activity, f ∈ F is a fuel activity. For example, natural gas is a fuel activity.
  - S is dimension sector, s ∈ S is a sector. For example,
  - P is dimension pollutant, i.e. air pollutants (SO_2, NO_x, $PM_{2.5}$, NH_3 and VOC) as well as the greenhouse gases CO_2, CH_4, N_2O and FGAS
  - T is dimension technology, t ∈ T is a technology, specifically an emission control technology, for exam- ple a catalytic converter.
  - Y is dimension year, y ∈ Y is a year. GAINS covers the period 1990-2050 in 5-year steps.

Variables or Facts

- Activity data specified by a combination of a fuel activity f with a sector s ,in a region r,of a year y.

$$0 \leq a_{r,s,f,y}, \quad \forall r \in R, \forall s \in S, \forall y \in Y, \forall f \in F_{r,s}$$

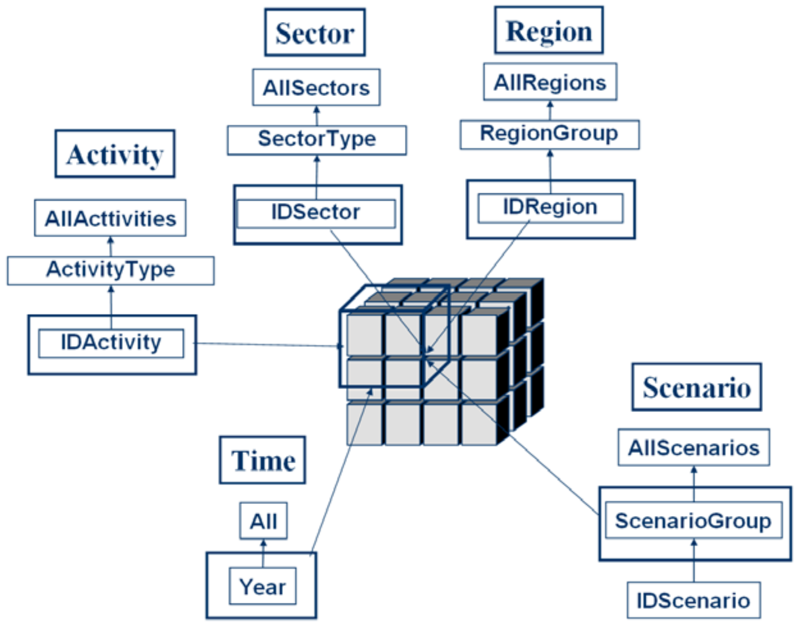
- Technology-specific Activity data describes the extent to which a certain control technology t is applied in a given sector s and region r to a given fuel activity f.

$$a_{r,s,f,y} \equiv a_{r,s,f,y,p} = \sum_{t \in T_{s,f,p}} a_{r,s,f,y,t}$$

- Application rates/Control strategies $\quad q_{r,s,f,y,t} = \dfrac{a_{r,s,f,y,t}}{a_{r,s,f,y}},$

$\forall r \in R, \forall s \in S, \forall y \in Y, \forall f \in F_{r,s}, \forall t \in T_{s,f,p}$ so that
$0\% \leq q_{r,s,f,t} \leq 100\%$

Activity Pathway Data Cube Schema



Application Services-Dimension constraints

- Fuel activity and Sector constraint. $\forall f \in F_s, \forall s \in S$
- Fuel activity, Sector, and Region constraint

  $\forall f \in F_{r,s} \subset F_s, \forall r \in R, \forall s \in S$
- Sector-Fuel Activity and Pollutant constraints.

  $\forall p \in P_{s,f}, \forall s \in S, \forall r \in R, f \in F_s$
- Sector-Fuel activity and Technology constraints

  $\forall t \in T_{s,f}, \forall s \in S, \forall f \in F_s$
- Fuel activity, Sector, Technology and Pollutant constraint

  $\forall p \in P_{s,f}, \forall s \in S, \forall r \in R, f \in F_s$

Emission and Cost Calculations

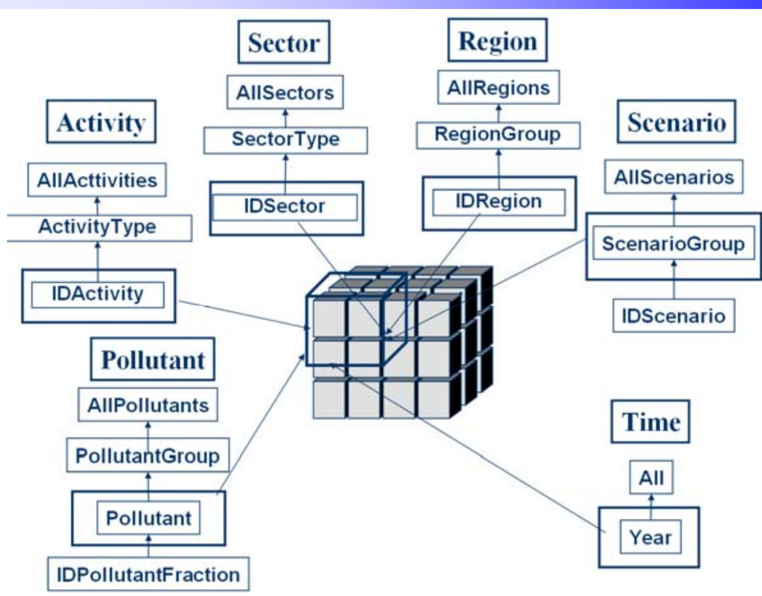
- Emissions Calculation

$$E_{r,p,y} = \left(\sum_{s \in S} \sum_{f \in F_{r,s}} \sum_{t \in T_{s,f,p}} a_{r,s,f,y,t} \cdot q_{r,s,f,y,t} \cdot ef_{r,s,f,t,p} \right)$$

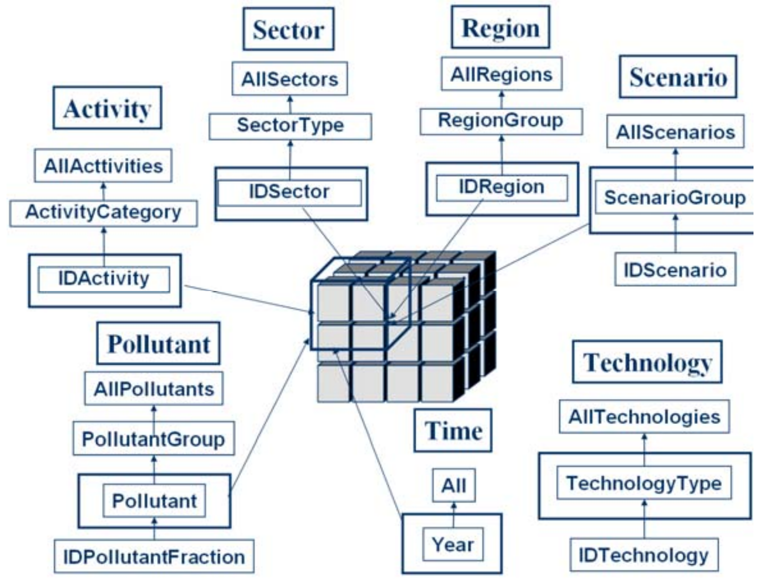
- Cost Calculation

$$C_{r,p,y,t} = \left(\sum_{s \in S} \sum_{f \in F_{r,s}} \sum_{t \in T_{s,f,p}} a_{r,s,f,y,t} \cdot q_{r,s,f,y,t} \cdot cf_{r,s,f,t} \right)$$

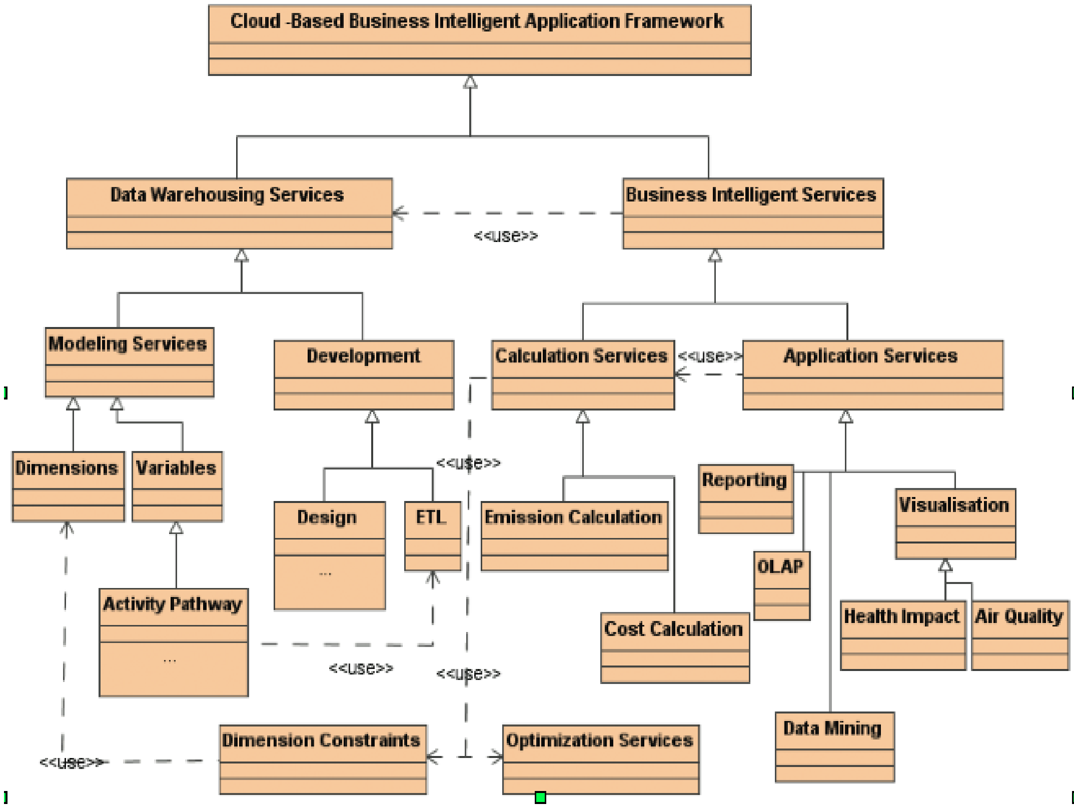
Emission Data Cube Schema



Cost Data Cube Schema



CLOUD-BASED GAINS DATA WAREHOUSING APPLICATION FRAMEWORK



GAINS Portal

ON-LINE ACCESS TO GAINS

This web site provides interactive access to the on-line implementations of the GAINS model.

Annex I	Europe
South Asia	China
Russia *	Rest of World *
Mitigation Efforts Calculator	

* Version not yet publicly available - access currently restricted to project collaborators

Current Models and Applications

GAINS DWH: developed by collecting data from available data sources and used to build regional data warehouse(s) as required.

MEC: developed under United Nations Framework Convention on Climate Change (UNFCCC), interactive tool to compare the relative climate change mitigation efforts of all industrialized (Annex I) countries.

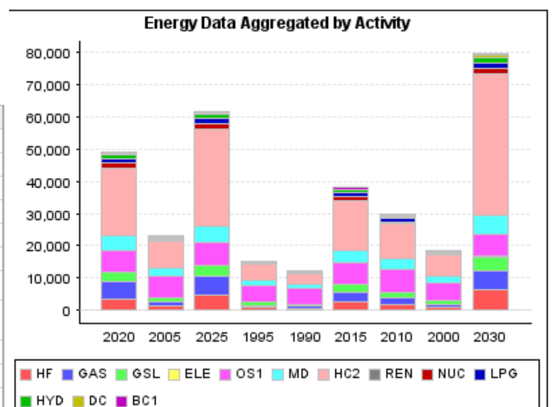
GAINS_EUROPE: used extensively by EU Member States and the Commission to develop cost-effective strategies to reduce the environmental impact of air pollutions

GAINS_China and South Asia, including India: used to explore sustainable development pathways for the future.

An example of using Activity Data Cube to generate Energy Data aggregated by Activity

Activity Type: ENE
Scenario: IEA WEO2009_450;curr. AP polic. (ID: 450_WEO_2009_CCS)
Region: Austria
Unit: [PJ]
UserID: ntbinh

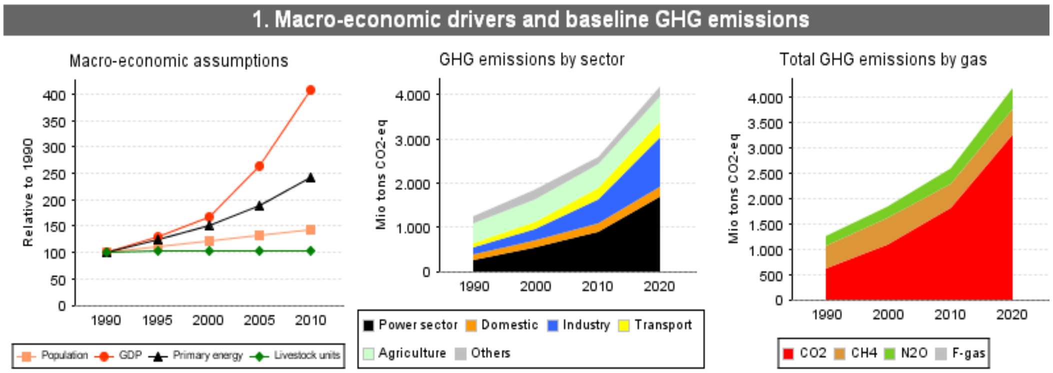
Activity	abbr.	2005	2020	2030
Brown coal/lignite, grade 1	BC1	10.92	0.40	0.18
Hard coal, grade 1	HC1	67.31	66.59	45.57
Derived coal (coke, briquettes)	DC	48.69	24.59	22.13
Biomass fuels	OS1	144.70	244.27	358.46
Other biomass and waste fuels	OS2	2.57	10.73	13.83
Heavy fuel oil	HF	108.44	71.42	45.56
Medium distillates (diesel, light fuel oil)	MD	354.83	292.36	267.54
Gasoline and other light fractions of oil (includes kerosene)	GSL	124.18	116.53	112.93
Liquefied petroleum gas	LPG	25.62	15.43	15.55
Natural gas (incl. other gases)	GAS	376.86	367.56	334.09
Hydrogen	H2	0.00	0.00	0.00
Renewable energy other than biomass	REN	9.65	38.77	80.46
Hydro	HYD	127.81	164.21	184.79
Electricity	ELE	8.23	-23.06	-15.83
Heat (steam, hot water)	HT	0.00	0.00	...
Sum		1409.81	1389.79	1465.29



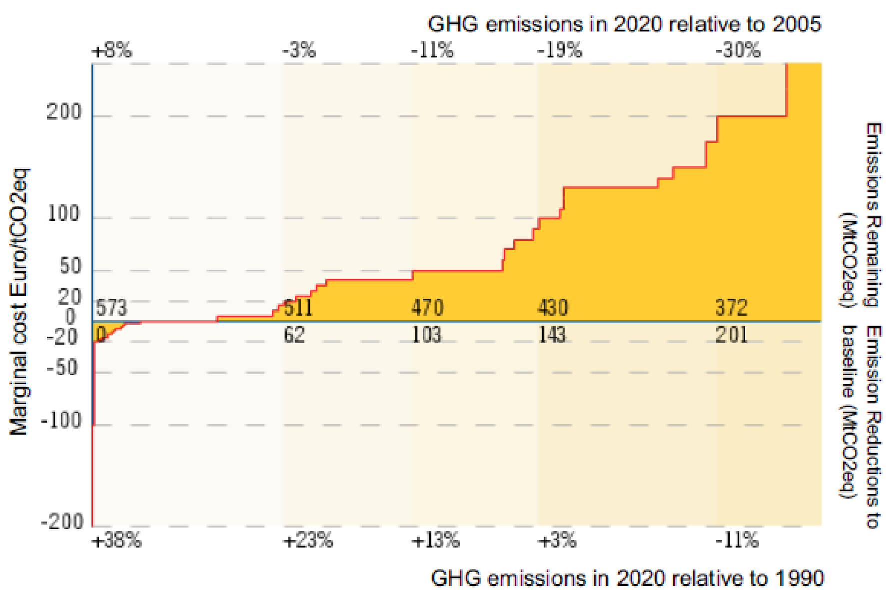
Scenario Definition

Austria			Energy	Agriculture	VOC sources	Process	Mobile
Country	Emission Vector	Control Strategy	ENE	AGR	VOCP	PROC	MOB
Austria	Jun08	EUVI_NEC_austV5ip	WEO09_450_CCS	NEC_NATV1_M8	NEC_NATV2	WEO09_450	WEO09_450

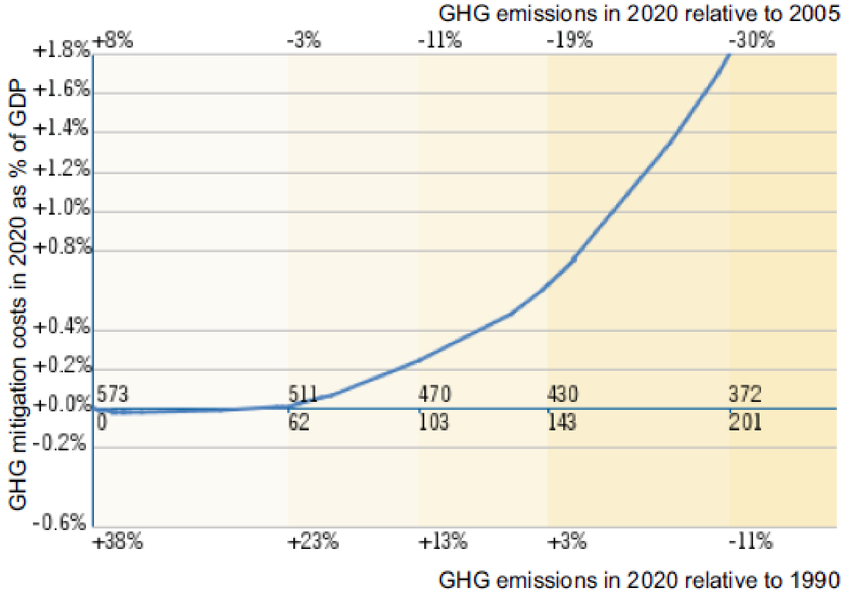
Emission Calculation



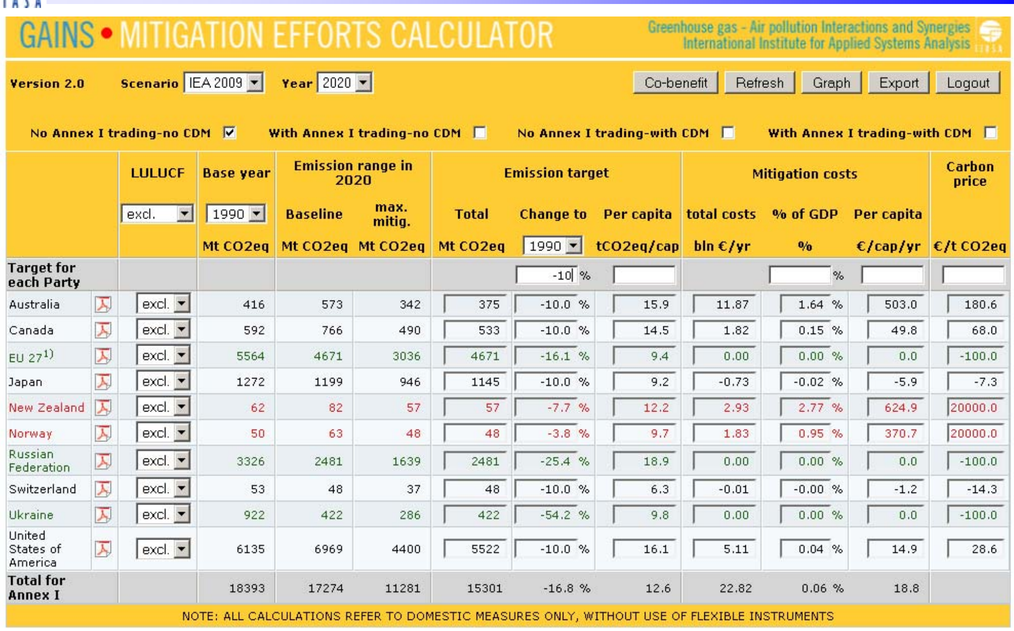
Marginal Cost Curve



Total Cost of GHG Emission



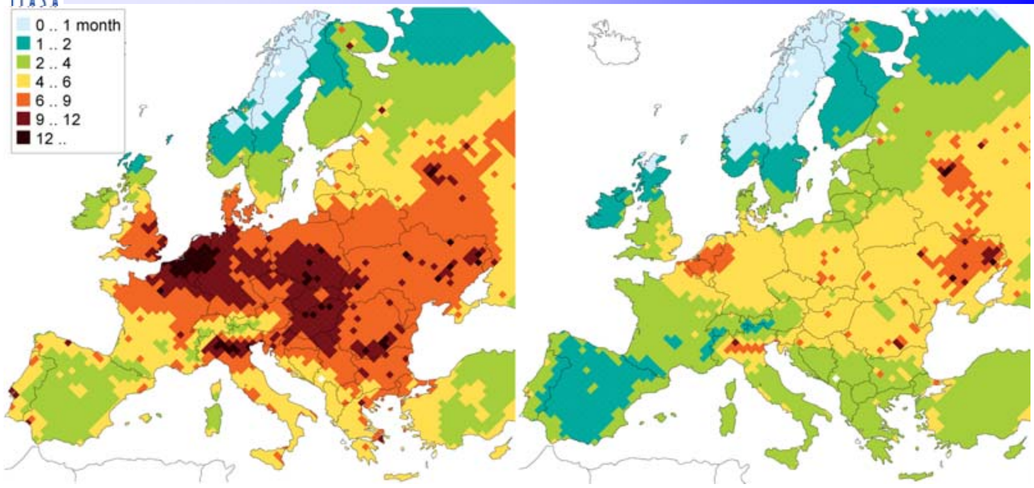
MEC Calculator- Demo



	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						-10 %			%		
Australia	excl.	416	573	342	375	-10.0 %	15.9	11.87	1.64 %	503.0	180.6
Canada	excl.	592	766	490	533	-10.0 %	14.5	1.82	0.15 %	49.8	68.0
EU 27[1)]	excl.	5564	4671	3036	4671	-16.1 %	9.4	0.00	0.00 %	0.0	-100.0
Japan	excl.	1272	1199	946	1145	-10.0 %	9.2	-0.73	-0.02 %	-5.9	-7.3
New Zealand	excl.	62	82	57	57	-7.7 %	12.2	2.93	2.77 %	624.9	20000.0
Norway	excl.	50	63	48	48	-3.8 %	9.7	1.83	0.95 %	370.7	20000.0
Russian Federation	excl.	3326	2481	1639	2481	-25.4 %	18.9	0.00	0.00 %	0.0	-100.0
Switzerland	excl.	53	48	37	48	-10.0 %	6.3	-0.01	-0.00 %	-1.2	-14.3
Ukraine	excl.	922	422	286	422	-54.2 %	9.8	0.00	0.00 %	0.0	-100.0
United States of America	excl.	6135	6969	4400	5522	-10.0 %	16.1	5.11	0.04 %	14.9	28.6
Total for Annex I		18393	17274	11281	15301	-16.8 %	12.6	22.82	0.06 %	18.8	

NOTE: ALL CALCULATIONS REFER TO DOMESTIC MEASURES ONLY, WITHOUT USE OF FLEXIBLE INSTRUMENTS

Modeling Air quality



CONCLUSION AND FUTURE WORK

- conceptual data model to design and build a Cloud-based Data warehousing Framework.
- Cloud based data warehouse and semantic technologies - such as representation of data combination and constraints - to enhance the efficiency and agility of the GAINS/MEC system.
- continue to improve the transparency of strategic decision making in the international context on the basis of scientific analysis with multiple levels of information requirements.

THANK YOU !!!!!