



ETSAP semi-annual Workshop, Oxford, UK
Models and Studies

Analysing Long Term Strategies of the Electric Sector
in the Italian Regions

Rocco De Miglio, Maurizio Gargiulo, Evasio Lavagno
Laboratorio di Analisi e Modelli Energetici - Dipartimento di Energetica - Politecnico di Torino

Oxford (UK) November 2005

LAME - POLITO



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Main activities of the LAME Team on energy analysis and modelling sectors:

- Analysis of Long Term Strategies of the Electric Sector in Italian Regions
- Local Energy System Modeling (Piemonte Region, Provinces, Metropolitan Areas, ..)
- TIMES-UK for NEEDS Integrated Project
- LCA and externalities studies on Hydrogen and Fuel Cells technologies

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The project

The activity has been developed with reference to a project, called SCESEL

cooperation among **LAME** (POLITO), **AIEE** (Italian Association of Energy Economists) and **CESI** (Italian Electrical System Research Centre, project leader), in the framework of a wider SCENARI National Project, which includes other five sub-projects:

- * EDEN aimed to analyse the evolution of the electricity demand
- * OFFGEN aimed to analyse the generation options
- * EVAMB and MONAMB on the environmental impacts and their monitoring
- * STRUDEL aimed to assess the sustainability analysis methodology

SCESEL is intended to built and evaluate, with TIMES, developing scenarios (time horizon 2000-2030) for the whole Italian electricity system.

Steps:

Structure of the RES with inter-regional links
(detail level, spatial resolution, grid voltage)

Technologies
(base year situation, past investments, new plants and devices available in the future, national and regional Energy Plans)

Demand
(base year situation and evolution in the time horizon)

Fuel
(cost and availability for coal, oil, natural gas and electricity import, base year situation and evolution in the time horizon)

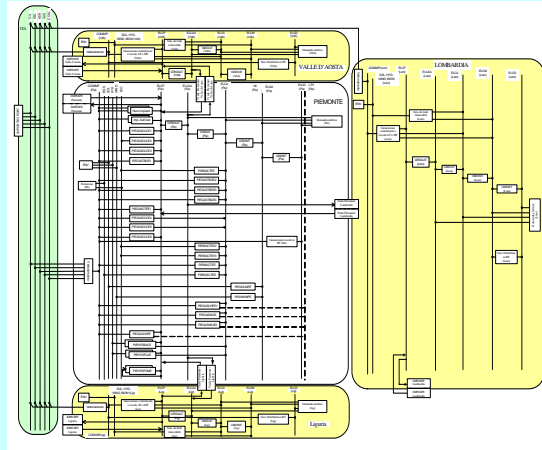
Scenario Constraint
(base year situation and evolution in the time horizon)

The functional scheme for the Model of the Electricity System presents

- 40 Segments of electrical services demand
- 150 End use technologies supplied with different voltage levels
- 400 Supply technologies (thermal, hydro and other renewables power plants, combined heat and power plants)
- 8 Time-slices (Winter, Spring, Summer, Fall and D/N)
- 5 Voltage levels

The figure represents (in a simplified way) the typical **RES structure** inside a generic region, with electricity import/export and trade with neighbouring regions.

The other energy vectors which supply the power plants are described as in-flows coming from a virtual region representing the **aggregated Italian Energy scheme**.



The **grids** are represented through

5 voltage levels

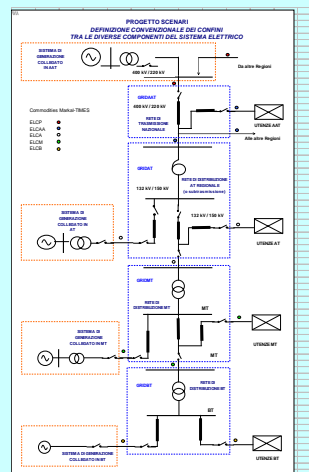
- AAT produced & imported
- AAT national grid
- AT
- MT
- BT distribution

5 electricity commodities

- ELCP
- ECLAA
- ECLA
- ECLM
- ELCD

4 GRID technologies

- GRIDAAT
- GRIDAT
- GRIDMT
- GRIDBT



plant typologies

The plant typologies taken into consideration are listed in the table:

Medium size and large plants are spatially identified and characterised.

Only small plants are aggregated (minihydro, mni-chp, ...).

steam cycle/condensation	gas
steam cycle/condensation	oil
steam cycle/condensation	coal
new coal fuelled steam plants	coal
turbogas	gas
turbogas	diesel oil
steam cycle with repowered turbogas	gas
steam cycle with repowered turbogas	oil
combined cycle	gas
natural gas derivate fuelled combined cycle	gas derivate
internal combustion engine	diesel oil
incinerator	usw
biomass combustion plant	biomass
combined cycle integrated with gasification	heavy oils
natural gas fuelled small thermal plant	gas
wind plant	wind
solar plant	solar
hydro plant	hydro
geothermal plant	geothermal
diesel oil fuelled combined	diesel oil
oil fuelled combined cycle	oil
oil fuelled turbogas	oil
diesel oil fuelled small thermal plant	diesel oil
biogas combustion plant	biogas
combined cycle chp	gas
natural gas turbogas chp	gas
steam cycle chp	oil
oil fuelled turbogas chp	oil
steam cycle/condensation chp	gas
steam cycle/condensation chp	oil
combined cycle chp	diesel oil
steam cycle/condensation chp	coal

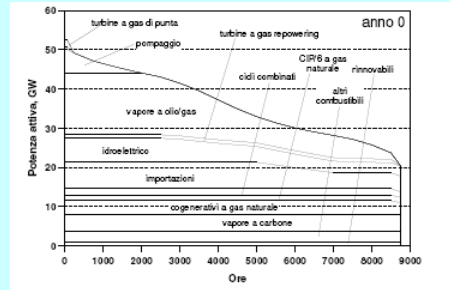
new technologies

TechName	TechDesc	Comm-IN
ENGNATG1A	Gas turbine < 80 MW - High Voltage	ELCGNATG
ENGNATG1P	Gas turbine < 300 MW - Very High Voltage	ELCGNATG
ENGNATV1P	Gas turbine < 2500 MW - Very High Voltage	ELCGNACV
ENOLITV1P	Steam turbine USC-FGD < 2500 MW oil - Very High Voltage	ELCOLICV
ENGSLC11M	Internal Combustion Engine < 20 MW - Intermediate Voltage	ELCGSLCI
ENGNACCI1A	Combined Cycle (turbogas) < 200 MW - High Voltage	ELCGNACC
ENGNACCI1P	Combined Cycle (turbogas) < 3000 MW - Very High Tens	ELCGNACC
ENSOLIM1B	PV plant (urban areas) - Low Voltage	ELCSOLRI
ENSOLIM2B	PV plant (rural areas) - Low Voltage	ELCSOLRI
ENGNAMT1M	Micro-turbine < 0.5 MW - Intermediate Voltage	ELCGNATG
ENCARTV1P	Steam turbine cycle USC >500 MW coal - (AAT)	ELCCARCN
ENWINIMAA	Wind plant type A	ELCWINRI
ENWINIMBA	Wind plant type B	ELCWINRI
ENWINIMCA	Wind plant type C	ELCWINRI
ENWINIMDA	Wind plant type D	ELCWINRI
ENBIOIM1M	Biomass plants - Media Tens	ELCBIORI
ENBIOIM1A	Biomass plants - High Voltage	ELCBIORI
ENHYDMIN	Mini hydro	ELCHYDRI
ENGEIOM1A	Geothermal plant - High Voltage	ELCGEORI
ENSOLIM1B	PV plants (PV roofs) - Low Voltage	ELCSOLRI
ENSOLIM1M	PV plants (multi MW) - Intermediate Voltage	ELCSOLRI
ENGNAMCG1	Residential micro-chp North - Intermediate Voltage	ELCGNAMC
ENGNAMCG2	Residential micro-chp Centre - Intermediate Voltage	ELCGNAMC
ENGNAMCG3	Residential micro-chp South - Intermediate Voltage	ELCGNAMC
ENGNACKN1	Combine cycle Plant (CG)	ELCGNACK

The figure shows the Power Plants contribution to the load curve:

gas fuelled Combined Cycle Plants
 ⇒ base-load

oil and gas fuelled Steam Cycle Plants
 ⇒ modulation



A detailed analysis of the evolution of the

inter-regional electricity exchange

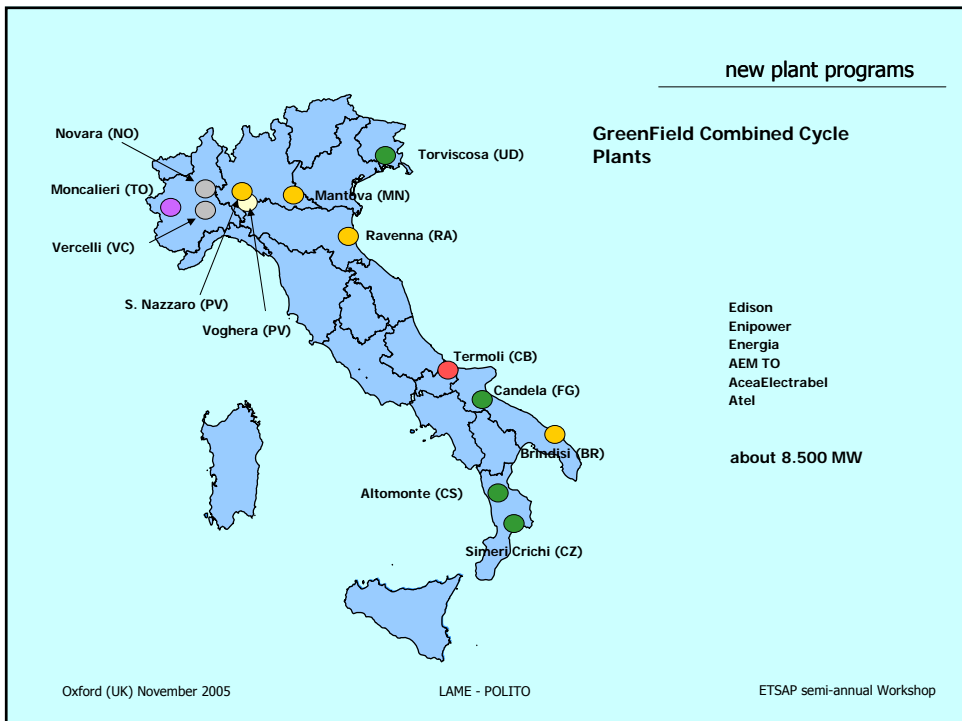
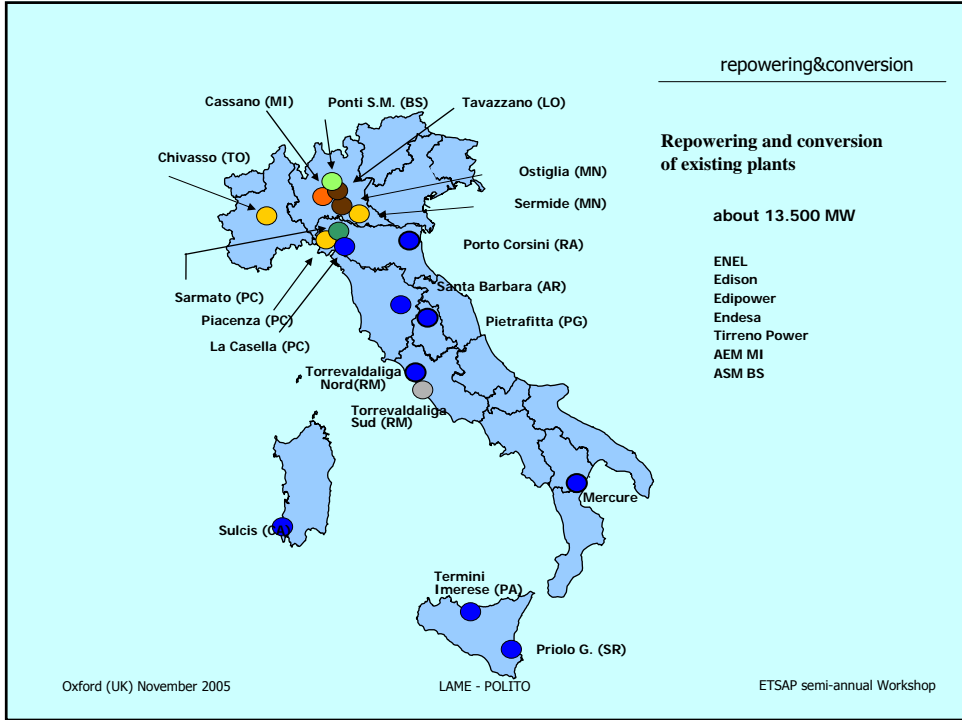
under

different scenarios

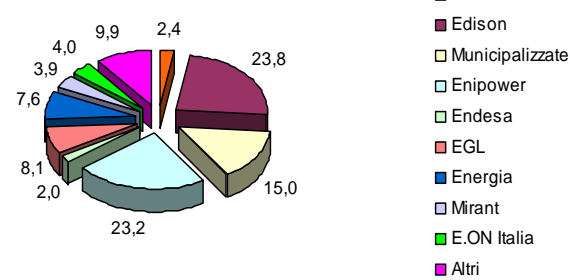
and

plant siting policies (national, regional, utilities)

has been required for evaluate planning alternatives for the development of National and Regional transport/distribution grids.

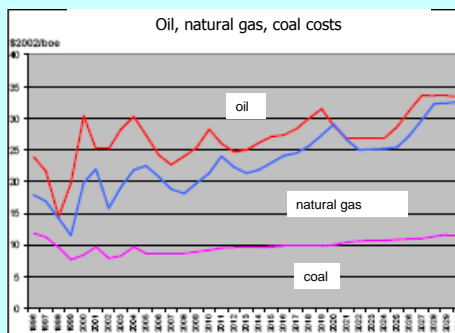


new Power Plants approved by MAP



About **20.000 MW**.
 North Italy 44%
 Central-South Italy 8%
 South Italy 48%

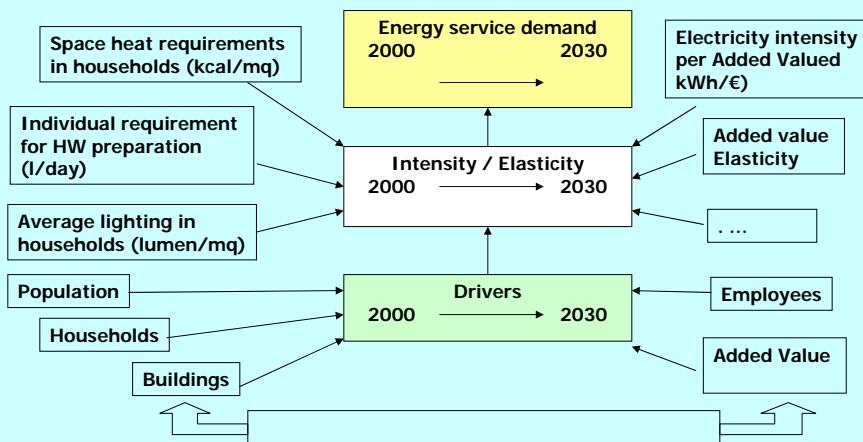
Fuel costs
 (from AIEE Team)



Demand of energy services

	GRTN		AIEE	
	TWh/year	Δ	TWh/year	Δ
2005	329,0	+ 2,0 %	329,1	+ 2,0 %
2006	338,0	+ 2,7 %	335,7	+ 2,0 %
2007	347,5	+ 2,8 %		
2008	357,6	+ 2,9 %		
2009	368,3	+ 3,0 %		
2010				
2014	379,3	+ 3,0 % + 1,0 %	362,4	
2015	427,0		396,9	

Energy Services Demand Evaluation Procedure



Assessment of the demand for energy services

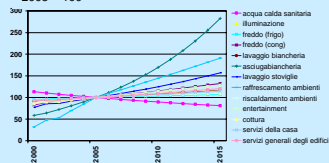
(input from AIEE Team)

2000		
Acqua calda sanitaria	mld l/a	277,7
Illuminazione	mld lumen/a	410,7
Frigorifero	mld litri	5,93
Congelatore	mld litri	2,01
Domanda lavaggio biancheria	mld lavaggi/a	6,22
Domanda lavaggio stoviglie	mld lavaggi/a	1,87
Domanda condizionamento	TWh fr / a	3,1
Domanda riscaldamento	MMcald/a	618,3
Domanda entertainment		
Televisore	n. televisori	38239841
Videoregistratori	n. videoregistratori	14441216
Videocamera	n. videocamere	4456835
Hi-Fi	n. Hi-Fi	12046110
PC	n. PC	7608926
Modem	n. modem	5480523
Segreteria	n. segreterie	3260755
Fax	n. fax	1592224
Videogame	n. videogames	3664633
Domanda cottura		
Forno elettrico	n. forni elettrici	14659173
Forno a microonde	n. forni a microonde	2449908
Fornello elettrico	n. fornelli elettrici	432488
Domanda servizi per la casa	GWh/a	5683
Domanda servizi generali edifici	GWh/a	6864

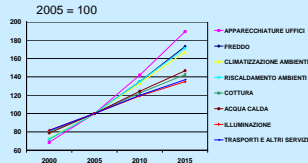
Demand for energy services

(input from AIEE reports)

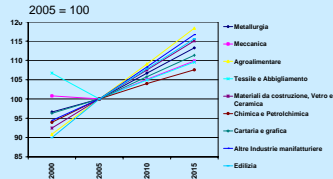
Residential sector - Energy service demand
2005 = 100

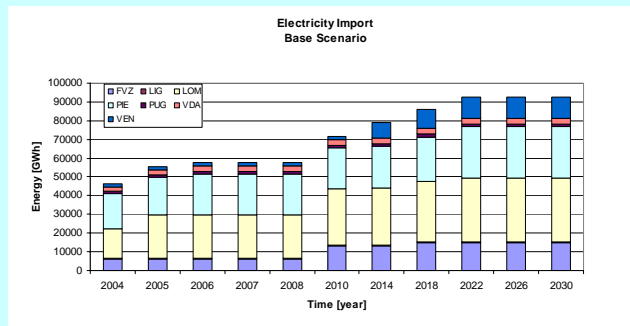
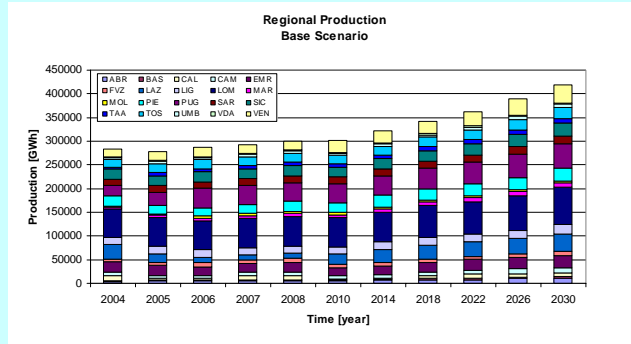


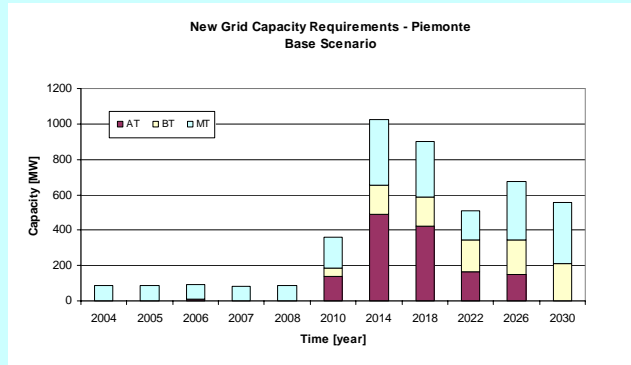
Service sector - Energy service demand
2005 = 100



Industrial sector - Electrical service demand
2005 = 100

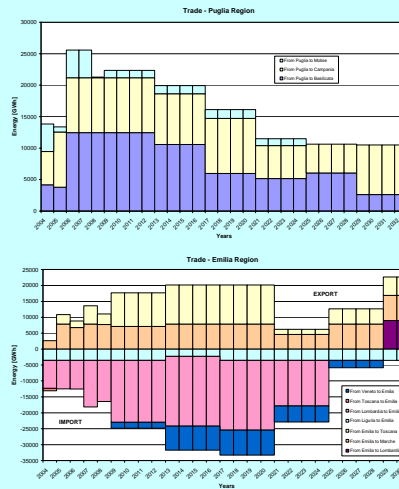






Some results: TRADE

The figures represent two examples of the trade mechanism with neighboring regions, the situations for Emilia and Puglia in the BASE Scenario.



results: electricity flows

Lombardia Region
Balance
2010 year

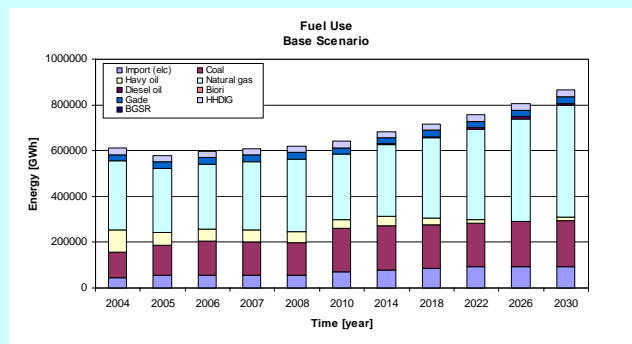
production	ELCP									49165.8	
	ELCA									11571.0	
	ELCM									26.5	
	ELCD									0.6	
	TOT									60764.0	
	IMP	30046.8	IRE-in	10618.2							
											ELCP
			89830.8								
	PP	49165.8	GRIDAAT	IRE-out	20688.55047						
											ELCAA
			89020.7								
			64889.5		64889.5						
	PP		GRIDAT								
											ELCA
			63617.2								
			66938.9								
	PP	11571.0	GRIDMT								
											ELCM
			65658.6								
			32892.6								
	PP	26.5	GRIDBT								
											ELCD
			31148.3								
	PP	0.6	31148.9	32792.5	8249.3	3442.7				75633.4	
	AGR			535.8	260.1					795.8	
	COM	tot	60764.0	10589.6	5332.7	93.9				16016.2	
	IND			6331.6	26874.7	8155.4	137.7			41499.4	
	RES			13467.5	8.0					13475.5	
	PUMP									3305.0	
	TRA			224.5	317.0					541.5	

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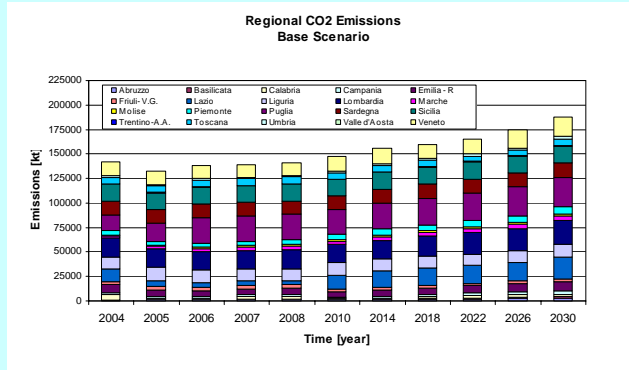
results: fuel use



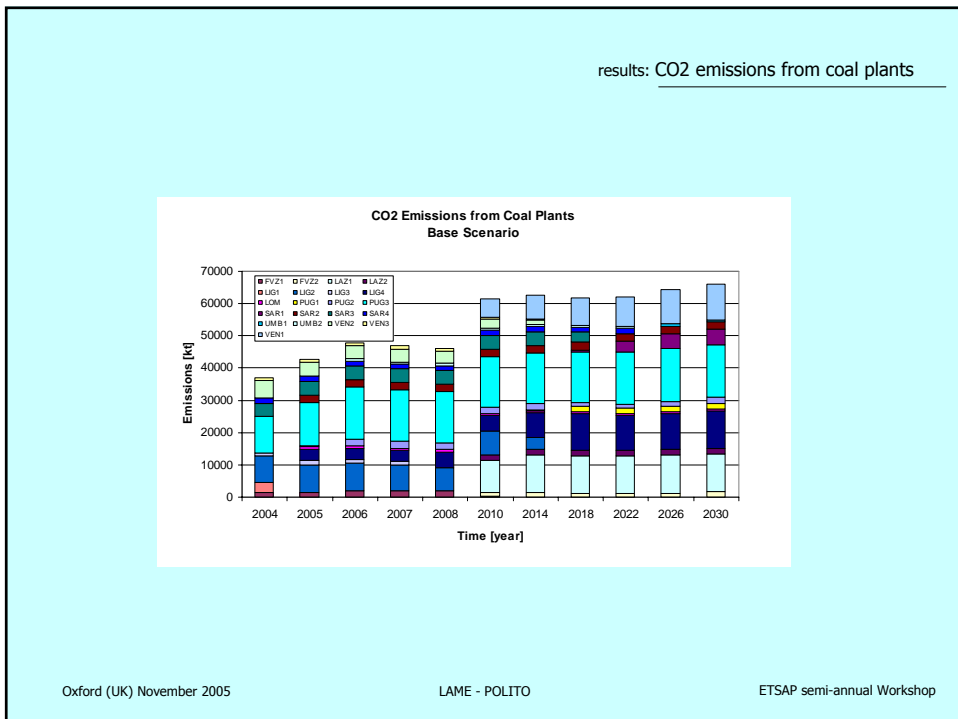
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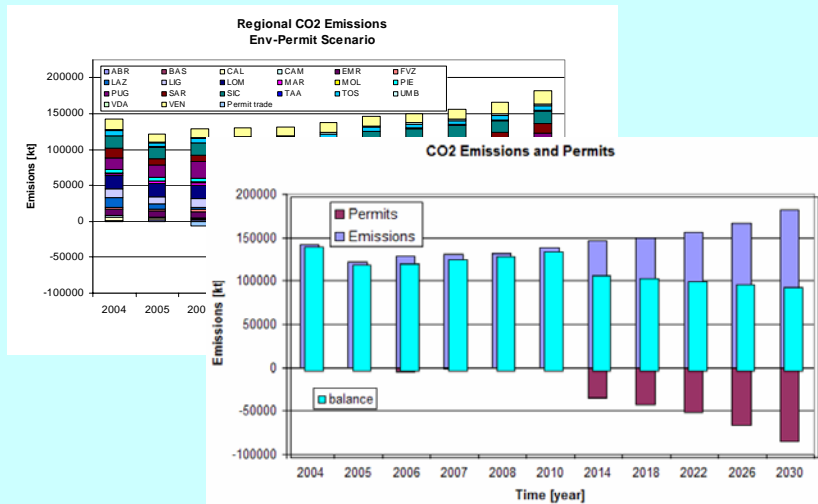
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	VDA	PIE	LIG	LOM	TAA	VEN	PVZ	EHR	TOS	UMB	MAR	LAZ	ABR	MOL	CAM	PUG	BAS	CAL	SIC	SAR
VDA	0	3982																		
PIE	-3982	0	1523	10618																
LIG		-1523	0					2655	4636											
LOM		-10618		0	0	4098		16591												
TAA				0	0	129														
VEN				-4098	-129	0	-7892	5973												
PVZ						7892	0													
EHR			-2655	-16591		-5973	0	6388		2689										
TOS			-4636				-6388	0	664		5383									122
UMB								-664	0		-374	-738								
MAR							-2689			0										
LAZ								-5383	374		0				885					105
ABR										738			0							
MOL													0			-3105				
CAM														0	0	-6636	-6195			
PUG															3105	6636	0	12802		
BAS																6195	-12802	0	5479	
CAL																	-5479	0	1404	
SIC																		-1404	0	
SAR								-122				-105								0





A Phase II of the Project is planned, in the following two directions :

- **Scenario analyses**

(in addition to Base, Kyoto and K+permit trade already done)

specific constraints in IRE and import
 plant siting,
 fuel mix,
 distr/conc electricity production,
 regional plans
 LNG terminals siting
 pipeline terminals,

effects of taxation and subsidy policies
 effects of externalities

- **Modelling improvement**

industry demand
 cogeneration plants
 peak behaviour
 trade tch (not only exchange)
 CO2 limits as national (not regional) level
 links with GIS representations

Thank you

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