SUSTAINABLE, LOW EMISSION, HIGH RENEWABLE

ENERGY SCENARIOS FOR EUROPE

Mark Barrett
Mark.Barrett@ucl.ac.uk
Complex Built Environment Systems
University College London

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Contents

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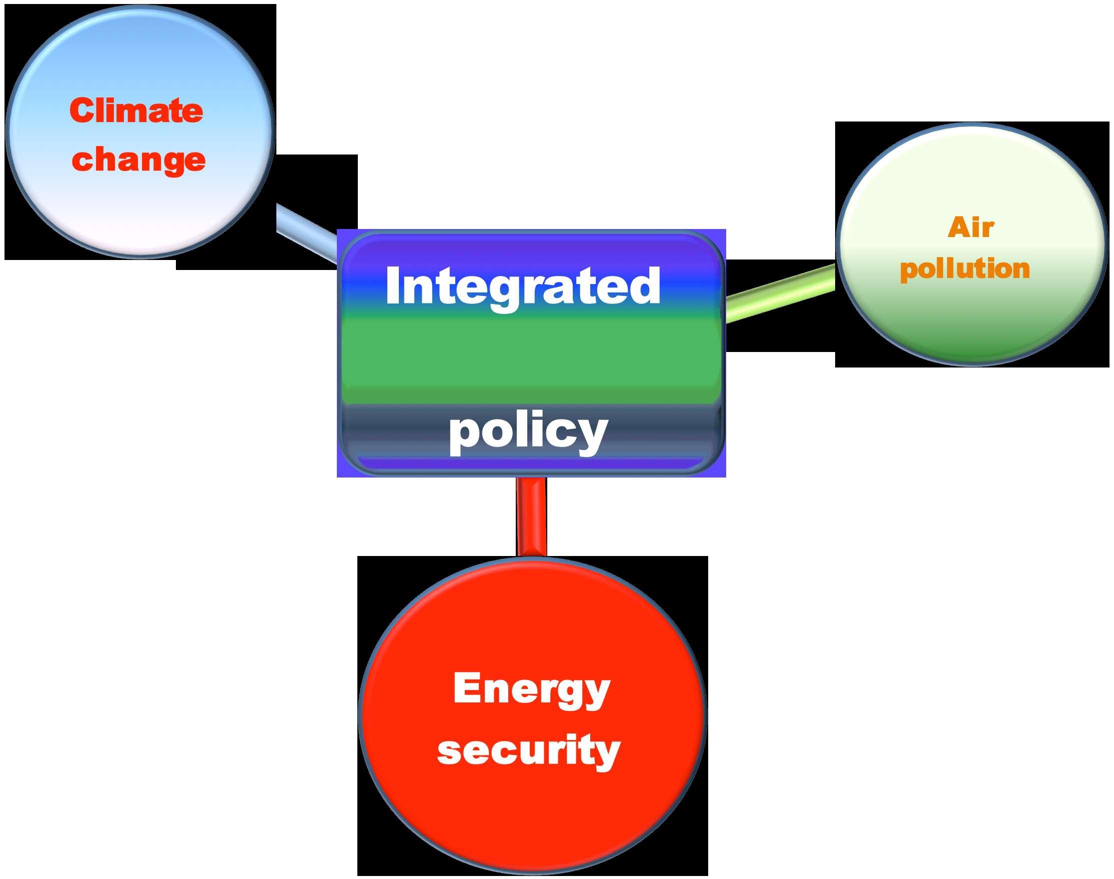
The challenge

Develop EU integrated policy that achieves environmental and energy goals at least overall cost.



European policy targets

Energy security

- 20 % share of renewable energy in overall EU energy consumption by 2020;
- 10 % minimum target share of biofuels in petrol and diesel consumption by 2020

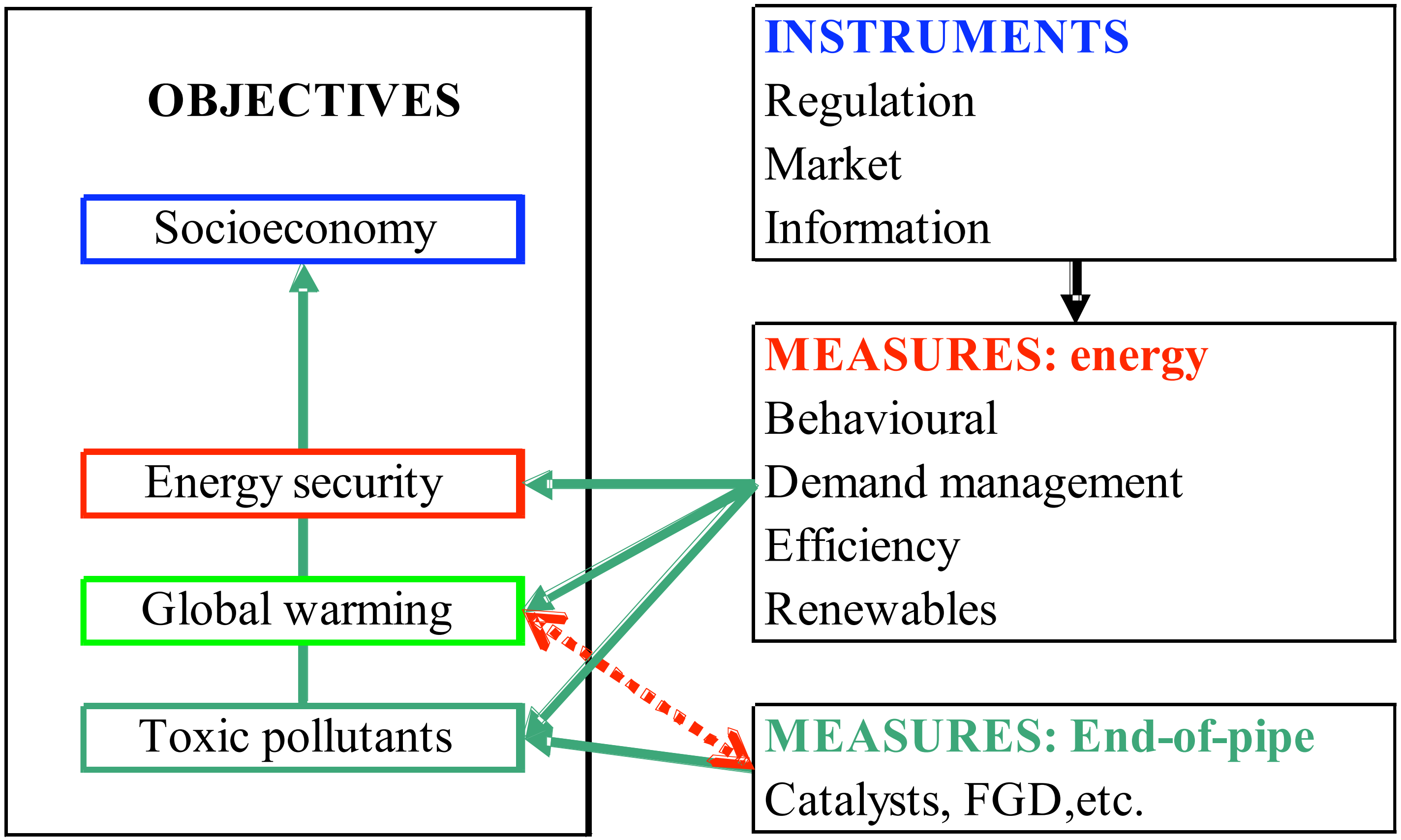
Climate change

- Kyoto; 8% reduction in greenhouse gases 1990-2010
- Council commitment 20 % reduction 1990-2020

Air pollution

- Air quality standards, biodiversity
- National Emission Ceilings
- Emission standards for vehicles, combustion plant etc

Objectives, instruments and measures



Energy : physical measures

Measures that reduce finite fuel consumption and atmospheric emissions. Mix of measures can be applied to different degrees at a 'natural' rate (years); note the general rapid rate of introduction of behavioural/operational measures which helps meet near term targets (e.g. 2020).

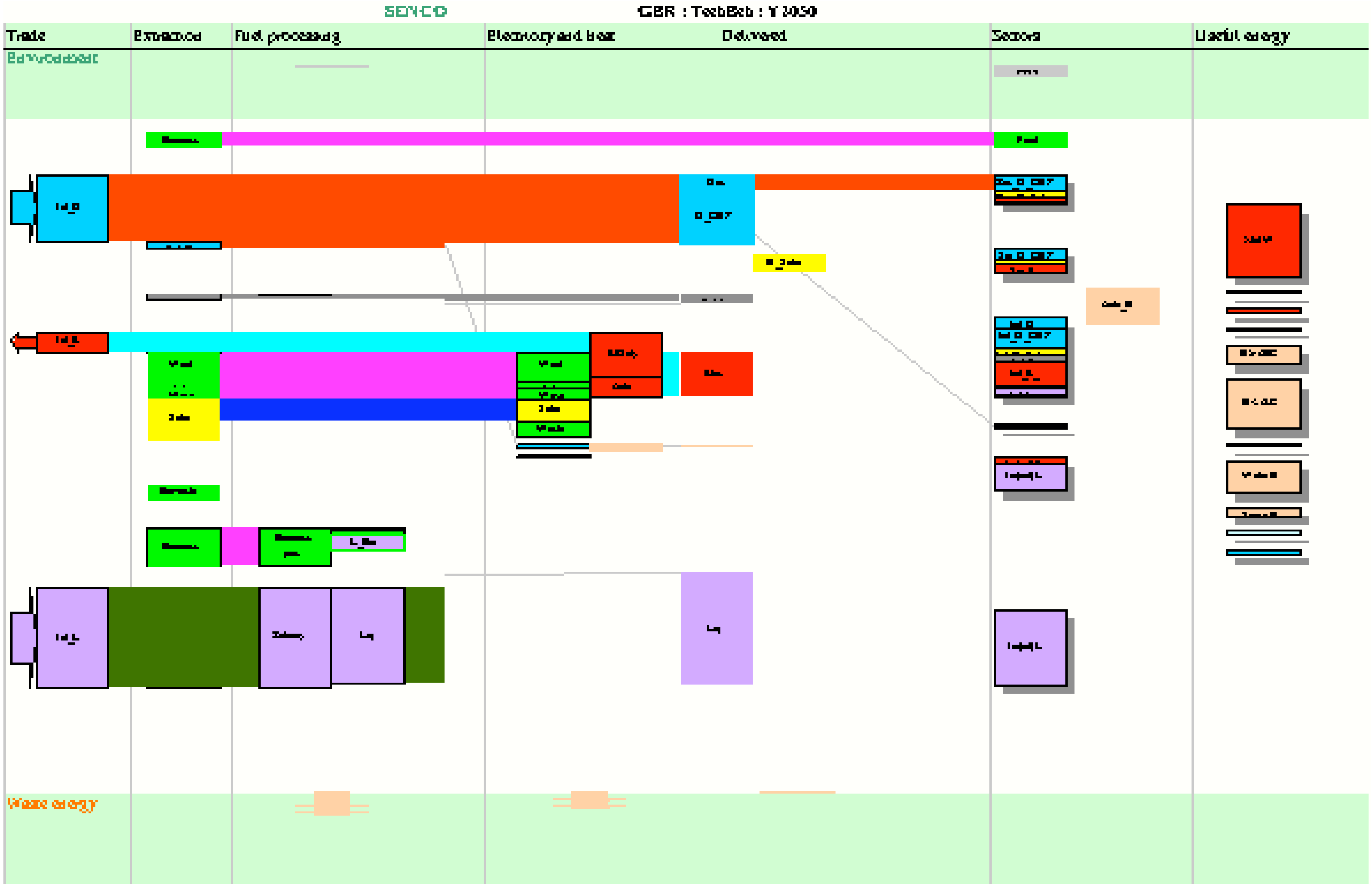
Class	Examples of options	Rate yrs	Decision variable
Behaviour	Effective comfort temperature in buildings	10	BeTi
	Passenger transport demand control	20	BeTPass
	Aviation transport demand control	15	BeAvi
	Passenger mode; from car to bus/rail	20	BePMod
	Freight mode; from truck to rail	25	BeFMod
	Downsizing cars	15	BeCar
	Speed control on motorways, aircraft	5	BeSpeed
Demand management	Transport load factor	20	DMTLF
	Demand management in transport	30	DMTra
	Building insulation and ventilation control	40	DMBui
	Demand management in non-residential sectors	30	DMInd
Fuel mix	Shift to electric vehicles, CHP and renewables in end use sectors	35	FMDel
	Shift to CHP and renewables in supply sectors	40	FMSup
Efficiency	Improved efficiency of boilers, heat pumps, etc	35	EFDel

Scenarios

Six scenarios for each EU25 country were constructed to reach these objectives using different combinations of NEOP measures implemented to different degrees.

Label	Target: % CO_2 reduction	Target: Reduction date	Nuclear	NEOPs
EU30pc20N	**30**	**2020**	**New**	**Mix**
EU40pc20N	40	2020	New	Mix
EU30pc20NN	30	2020	No new	Mix
TecNN			No new	Maximum technology
BehNN			No new	Maximum behavioural
TecBehNN			No new	Maximum technology and behaviour

The system modelled : UK : sample energy flow chart for 2050

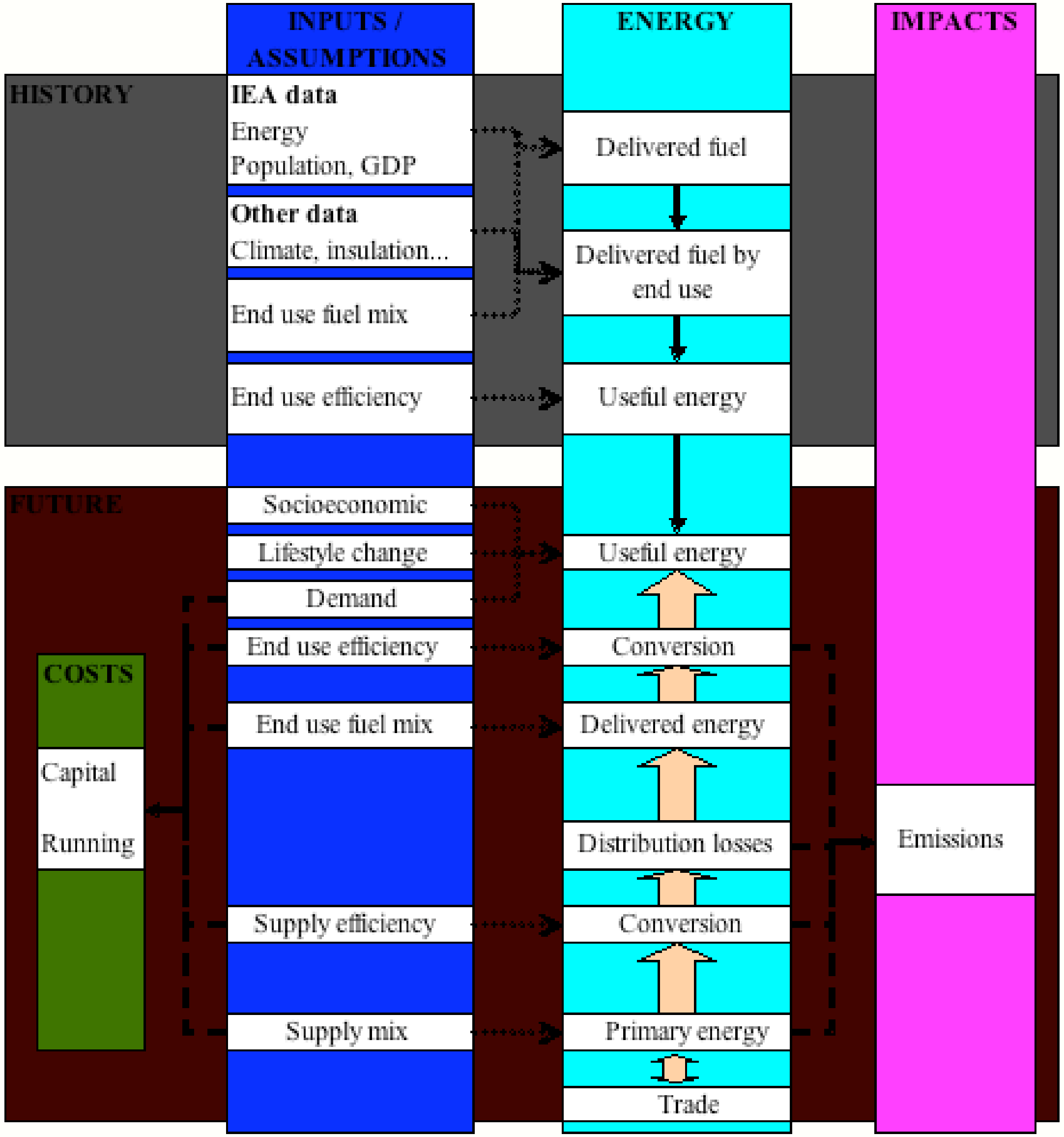


SEEScen: Society, Energy, Environment Scenario model

- SEEScen is applicable to any large country having IEA energy statistics
- SEEScen calculates energy flows in the demand and suppl sectors, and the microeconomic costs of demand management and energy conversion technologie and fuels
- SEEScen is a national energy model that does not address detailed issues in any demand or supply sector.

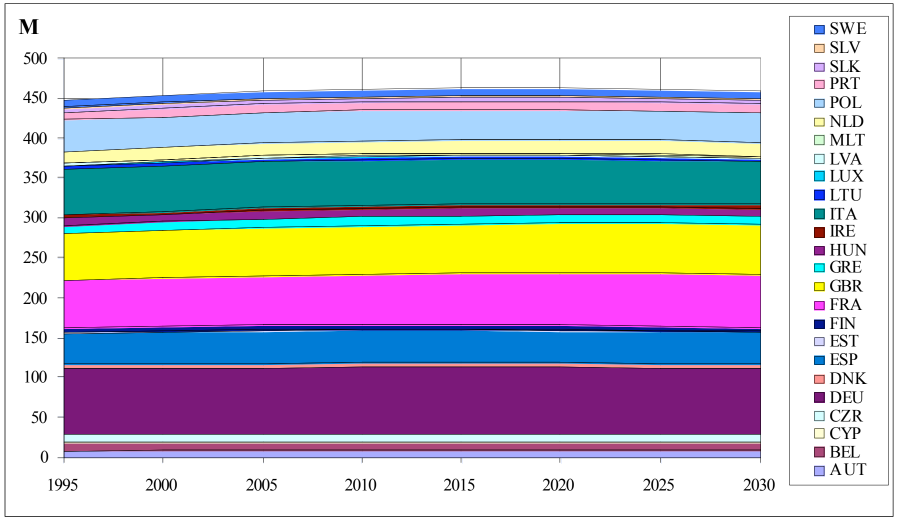
Method

- Simulates system over years, or hours given assumptions about the four classes of policy option
- Optimisation under development

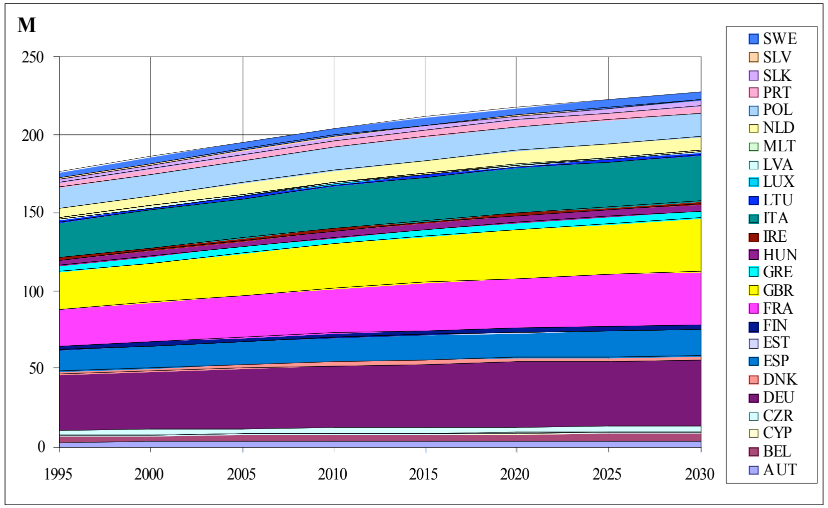


Exogenous assumptions (from PRIMES WCLP scenario): basic drivers

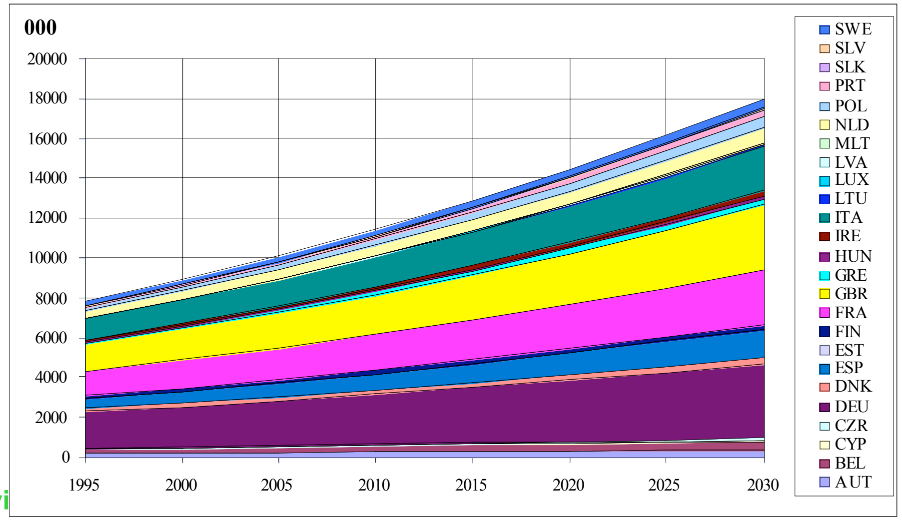
Population peaks and declines



More households

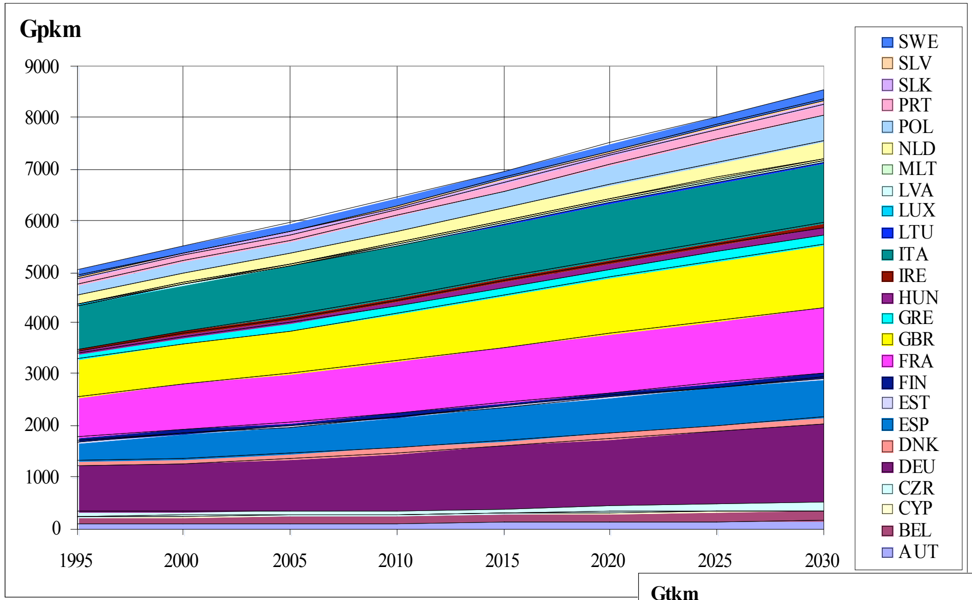


GDP growth

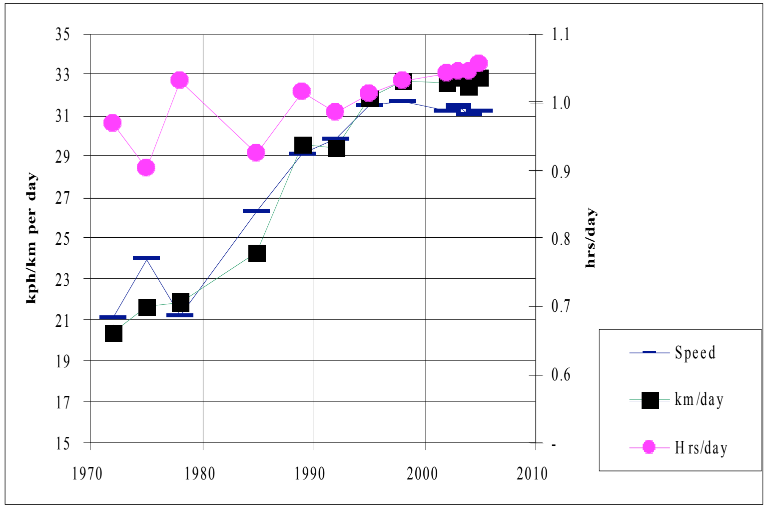


Exogenous assumptions (from PRIMES): transport demand

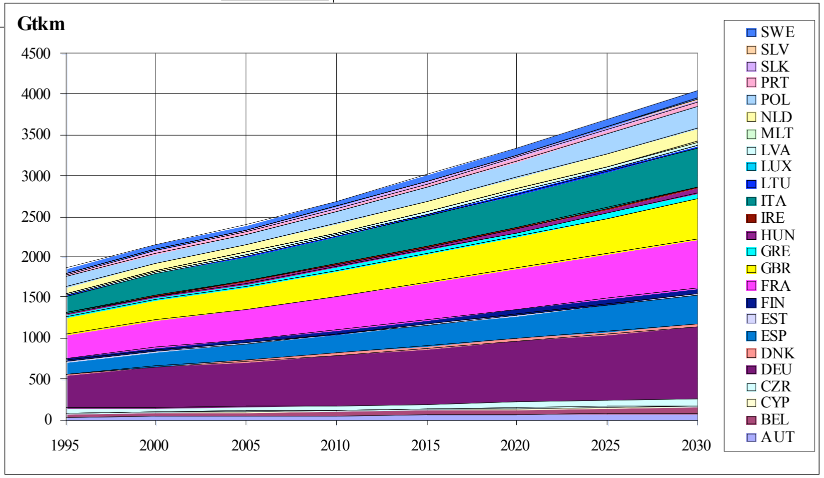
More passenger travel



But is saturation occurring, e.g. UK?

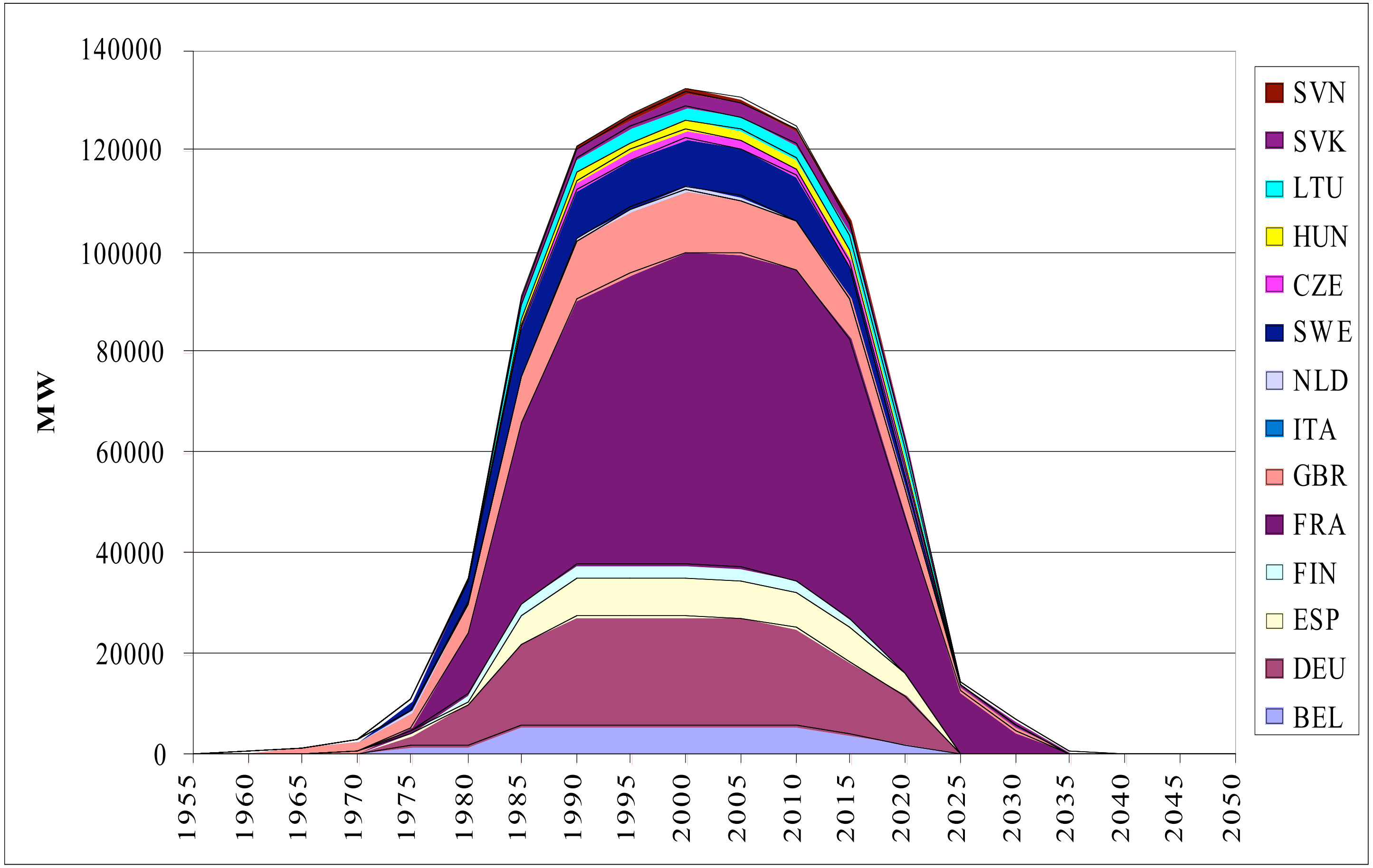


More freight transport



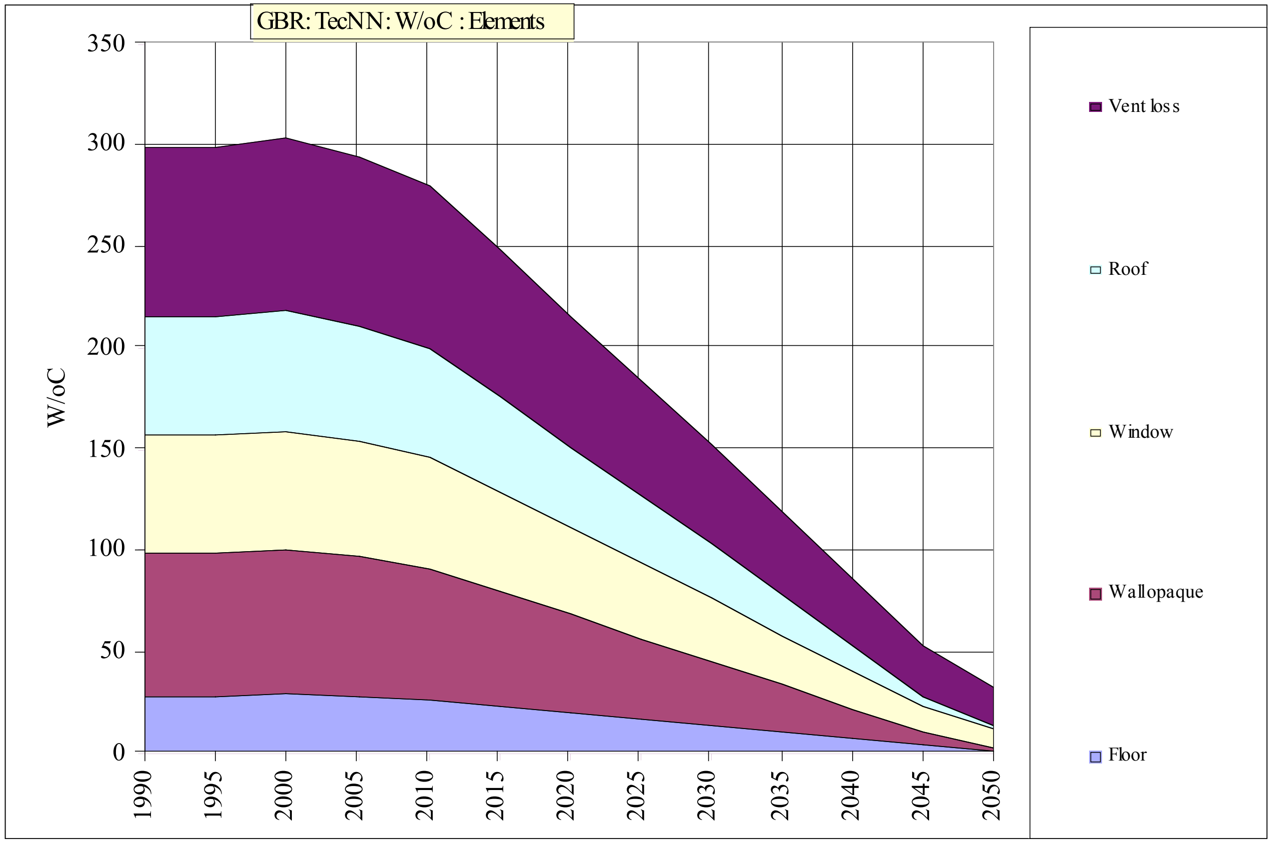
Exogenous assumptions: nuclear power

Profile with 35 years life



SEEScen sample: Domestic sector: house heat loss factors

Implementation of space heat demand management (insulation, ventilation control) depends on housing needs and stock types, replacement rates, and applicability of technologies. Insulation of the building envelope and ventilation control can reduce house heat losses to minimal levels.



Transport: measures

- Demand management, especially in aviation sector

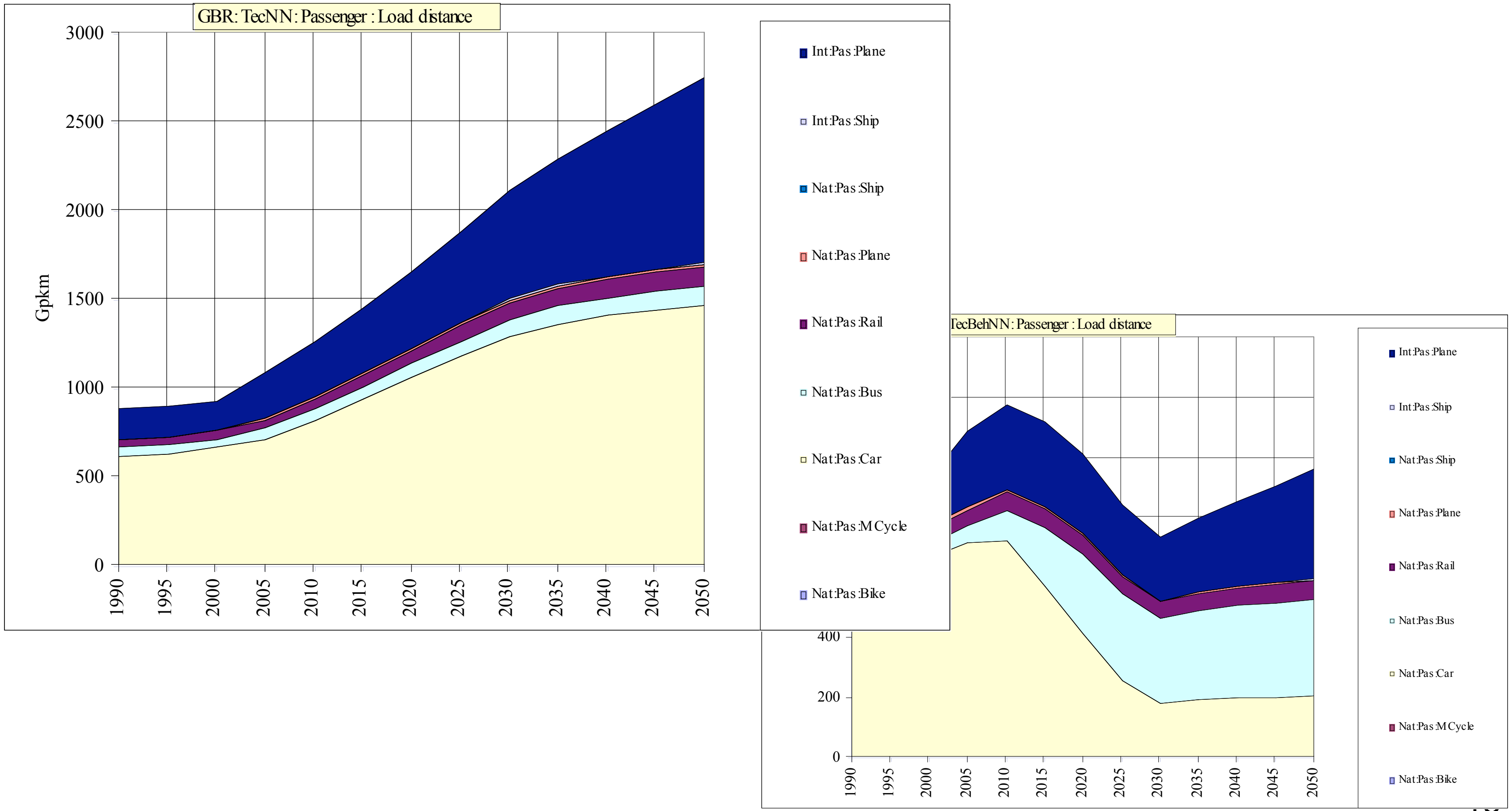
- Reduction in car power and top speed
- Increase in vehicle efficiency
  - light, low drag body
  - improved motor efficiency

- Speed reduction for all transport
- Shift to modes that use less energy per passenger or freight carried:
  - passengers from car to bus and train
  - freight from truck to train and ship
- Increased load factor, especially in the aviation sector

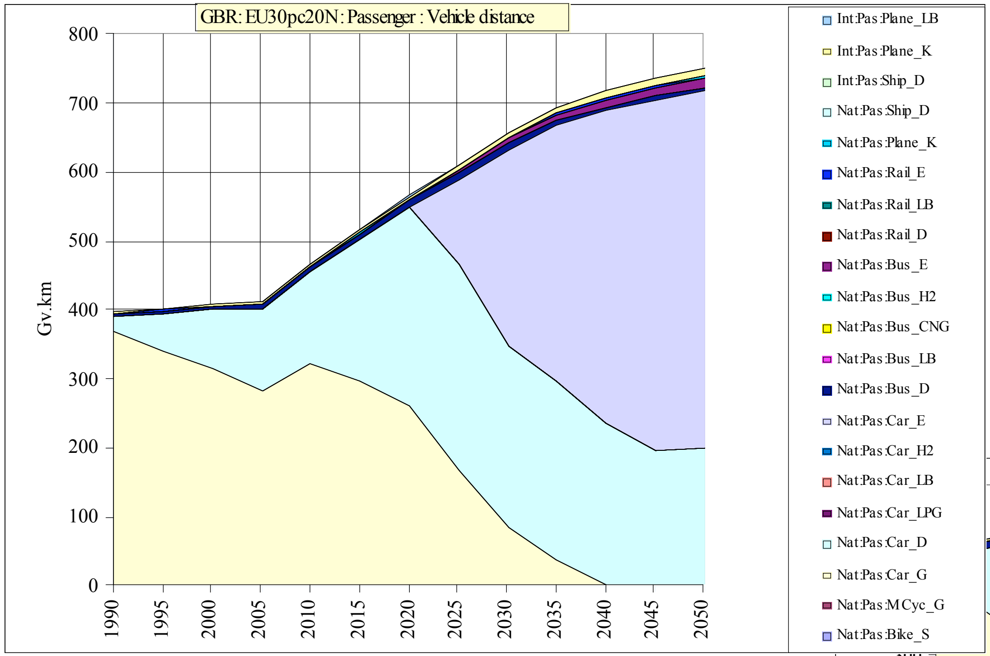
- Some penetration of vehicles using alternative fuels:
  - electricity for car and vans
  - biofuels principally for longer haul trucks and aircraft

SEEScen sample: Transport: passenger demand by mode and vehicle type

Demand depends on complex of factors: demographics, wealth, land use patterns, employment, leisure travel. National surface demand is limited by time and space, but aviation is not so limited by these factors.

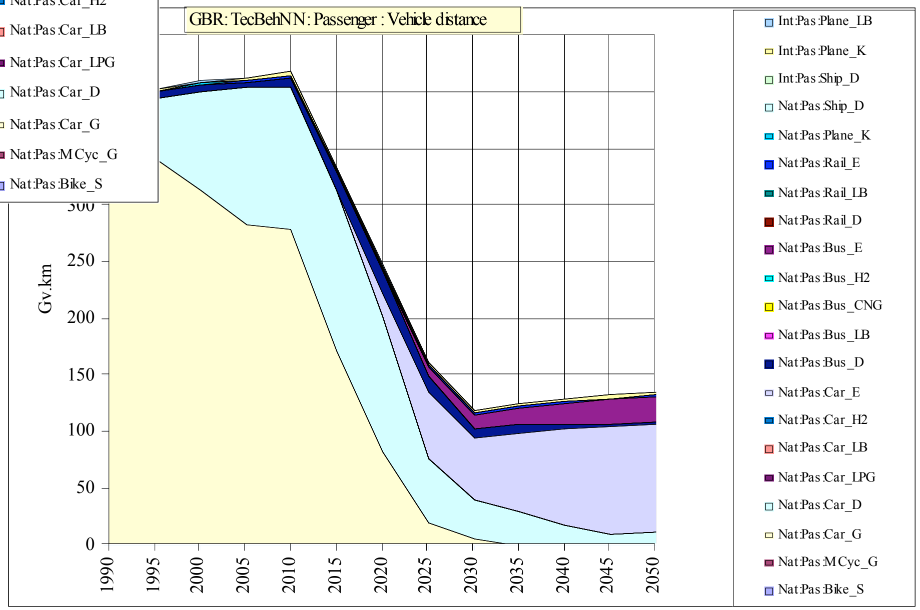


SEEScen sample: Transport: passenger vehicle distance



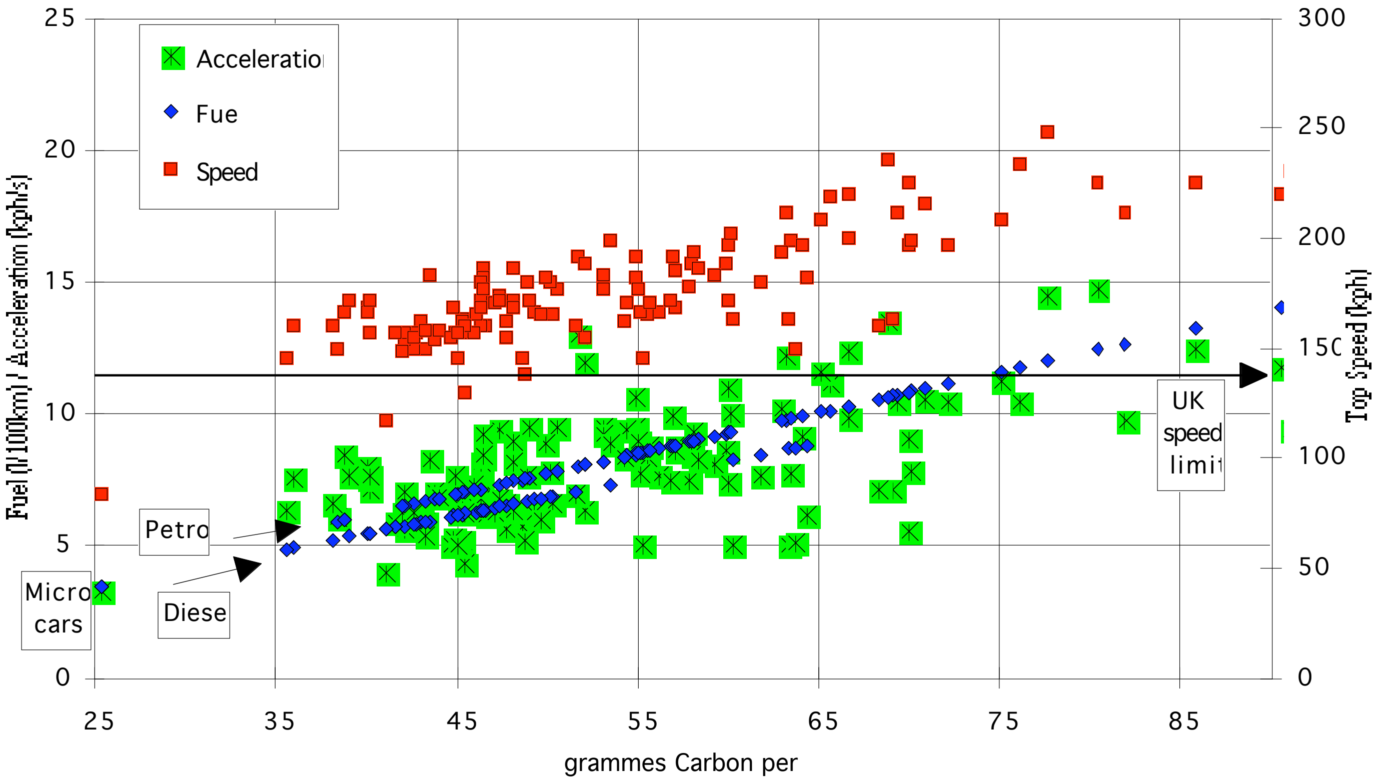
Demand management and modal shift can produce a large reduction in road traffic reduces congestion which gives benefits of less energy, pollution and travel time.

Assumed introduction of electric vehicles to replace liquid fuels, and reduce urban air pollution.



Cars: carbon emission by performance

Car carbon emissions are strongly related to top speed, acceleration and weight. Most cars sold can exceed the maximum legal speed limit by a large margin. Switching to small cars would reduce car carbon emissions by some 50% in 15 years in the UK (about 7% of total UK emission). Switching to micro cars and the best liquid fuelled cars would reduce emissions by 80% and more in the longer term. In general, for a given technology, the emissions of pollutants are roughly related to fuel use, so the emission of these would decrease by a similar fraction to CO2.

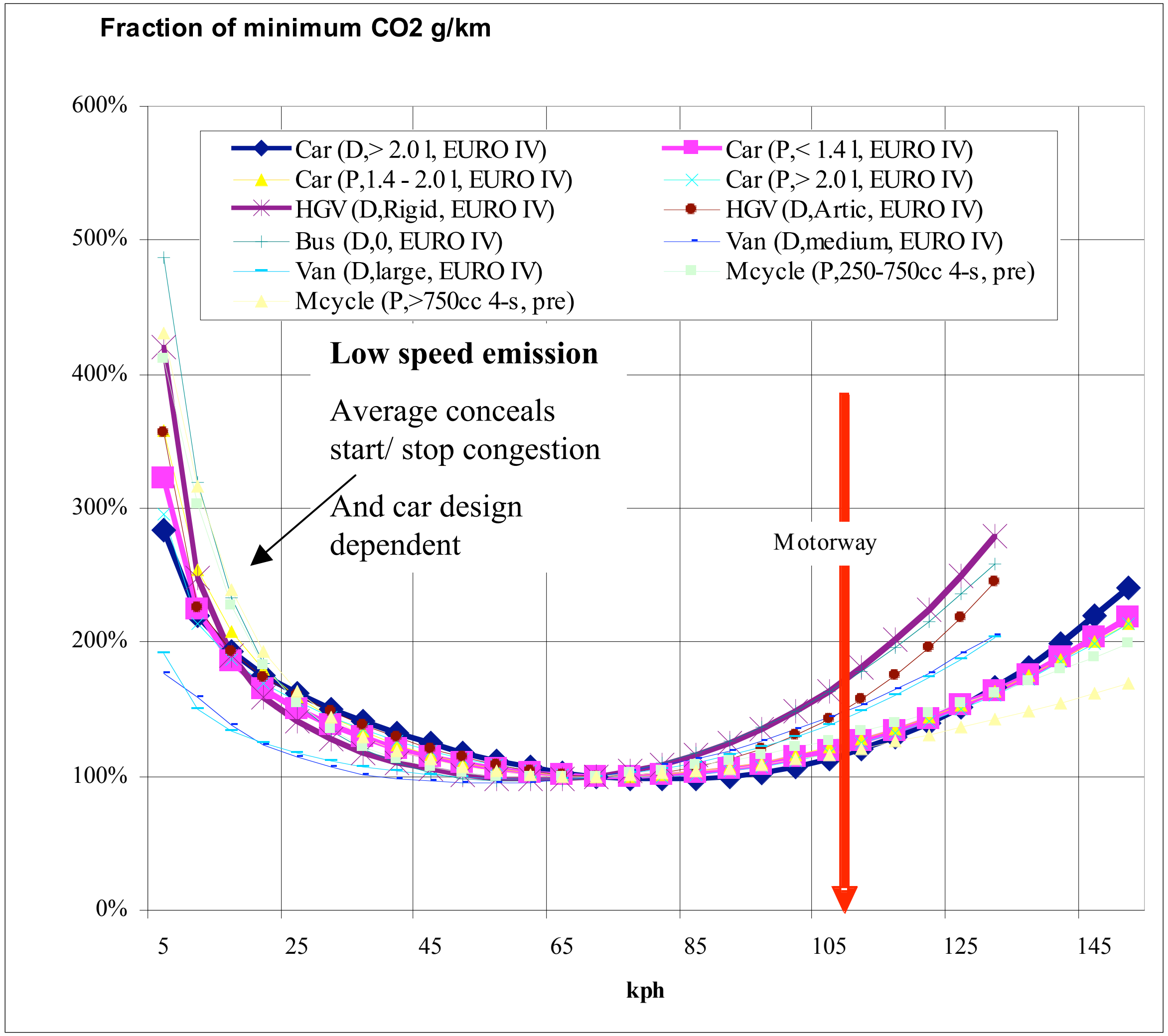


Transport: road speed and CO2 emission

Energy use and carbon emissions increase strongly at higher speeds. Curves for other pollutants generally similar, because emission is strongly related to fuel consumption.

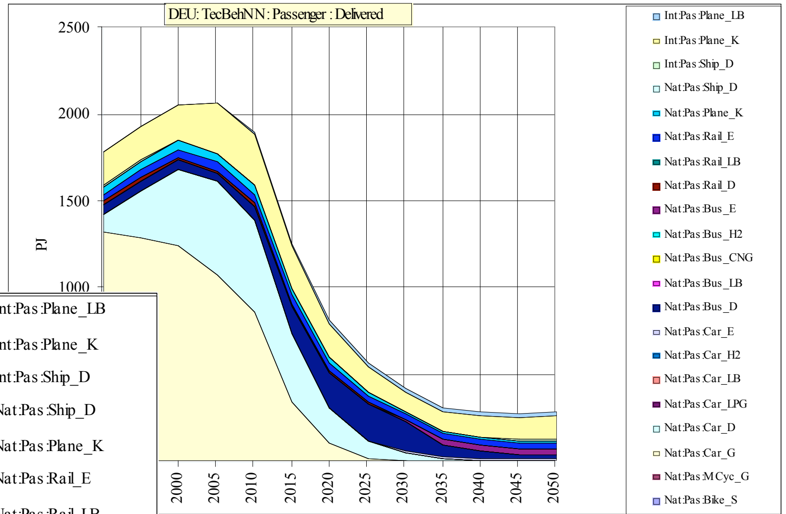
These curves are only applicable to current vehicles. The characteristics of future vehicles (e.g. urban internal combustion and electric powered) would be different. Minimum emission would probably be at a lower speed, and the fuel consumption and emissions at low speeds would not show the same increase.

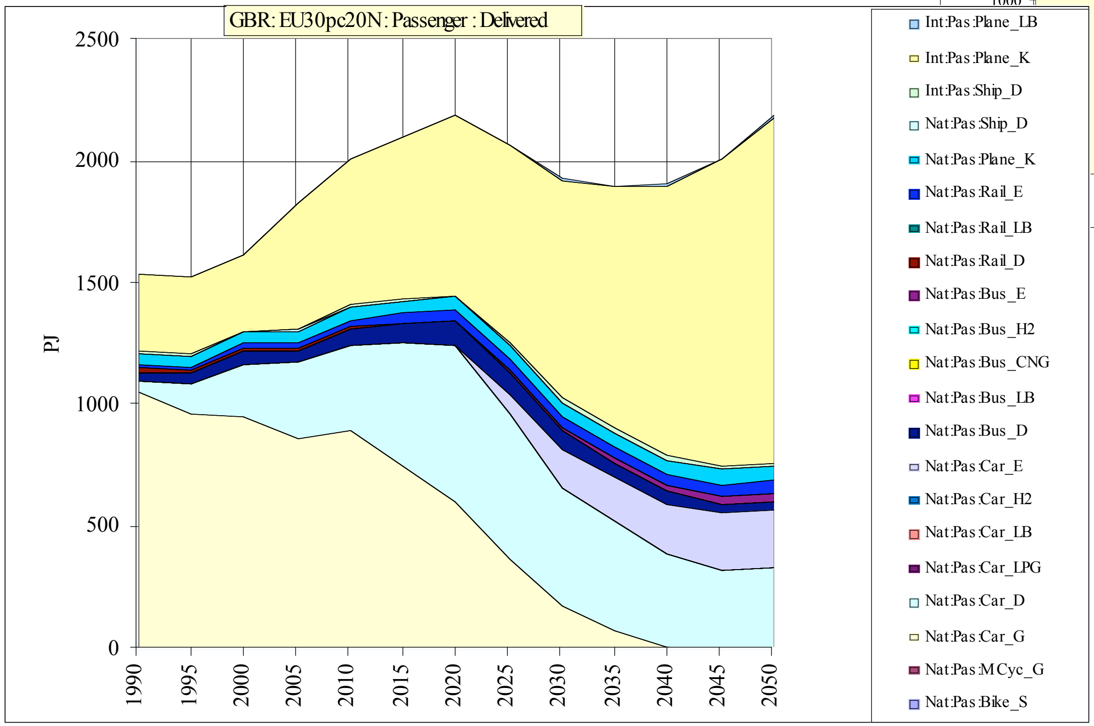
Potentially, the lowering of actual speeds on fast roads might reduce emissions on those roads by perhaps 10-20%.



SEEScen sample: Transport: passenger: delivered energy

International air travel will become a large fraction of future passenger energy use

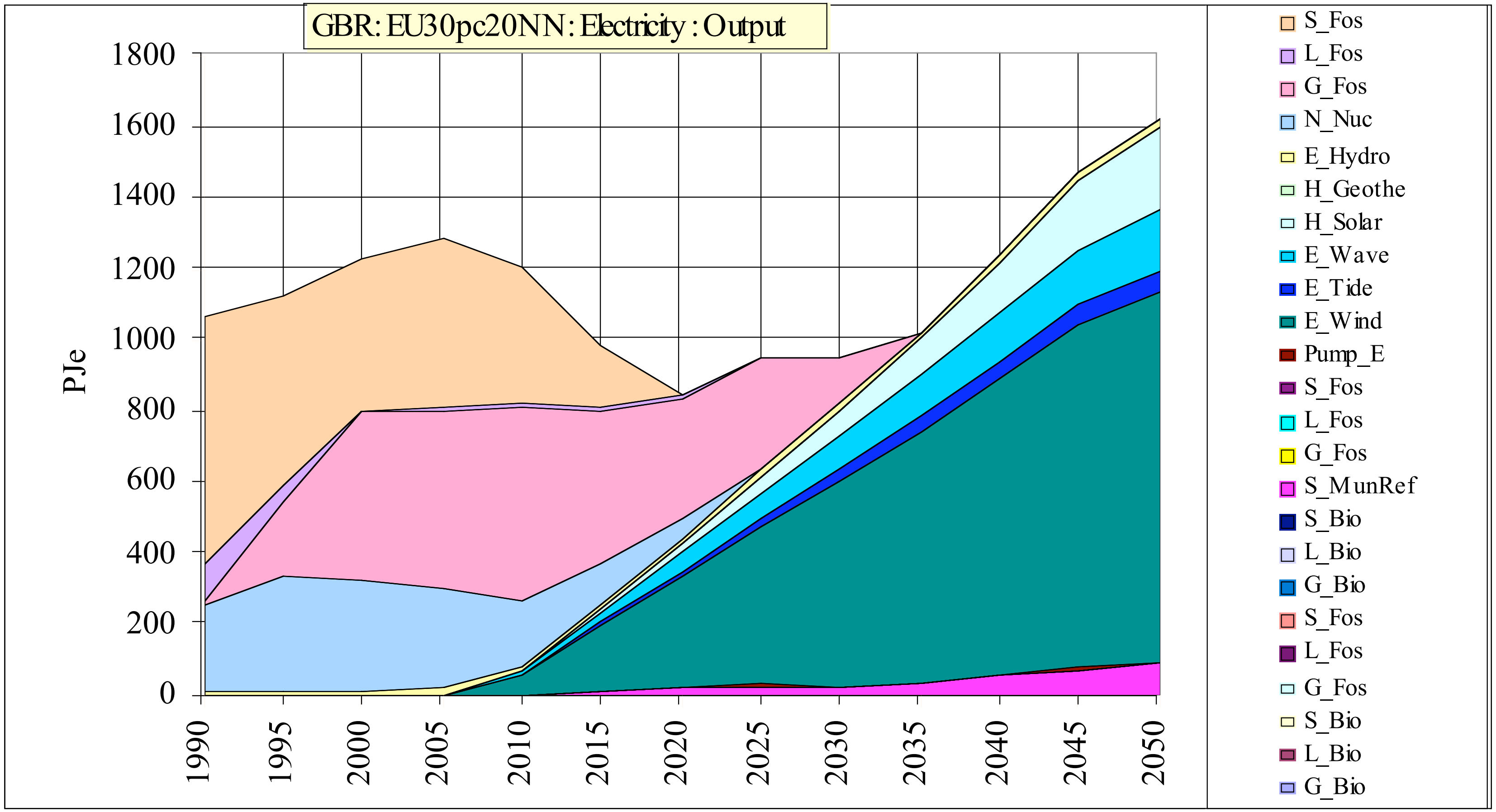




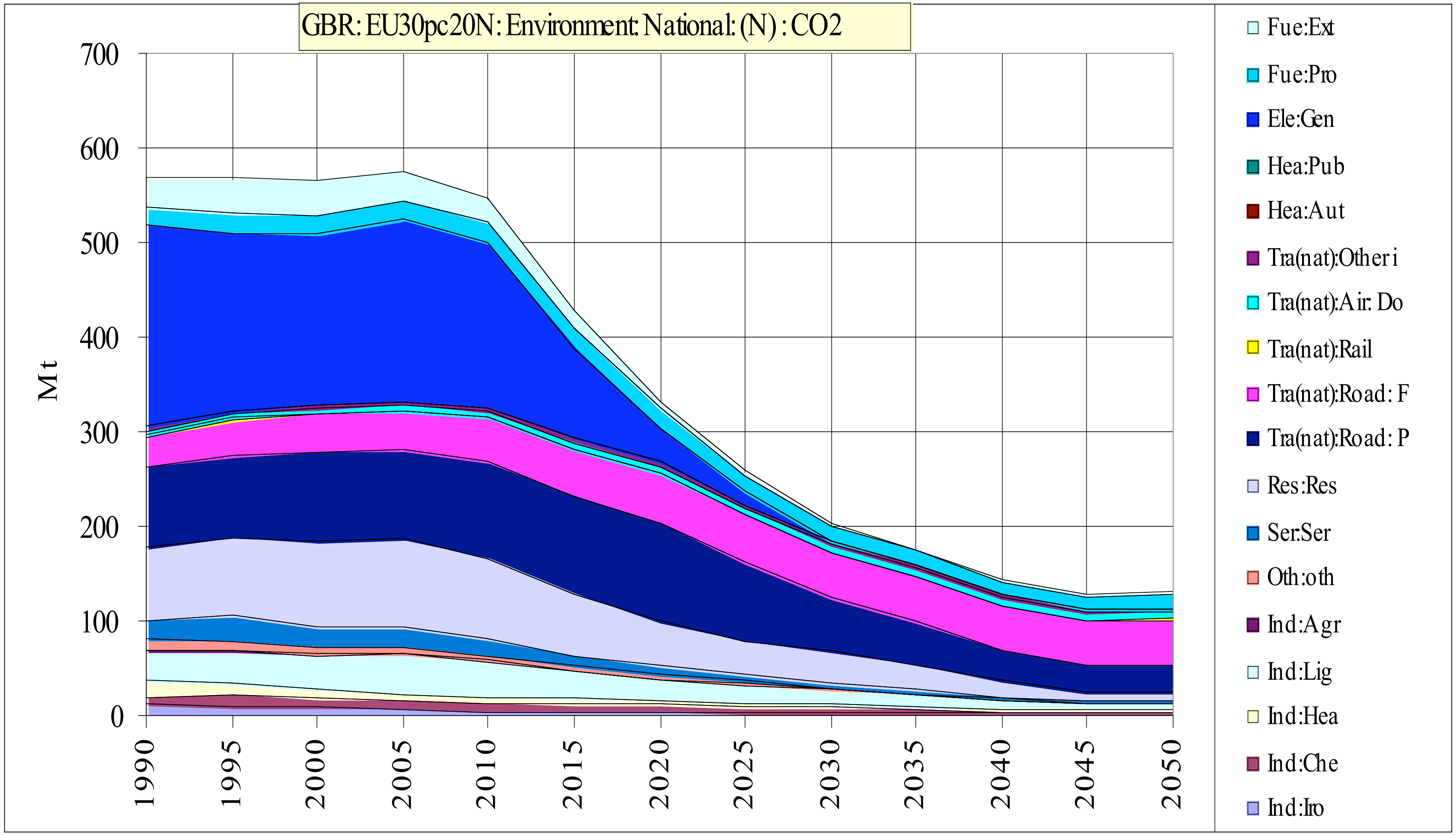
SEEScen sample: UK : electricity generation (not consumption)

Switch from electricity only fossil and nuclear generation to:

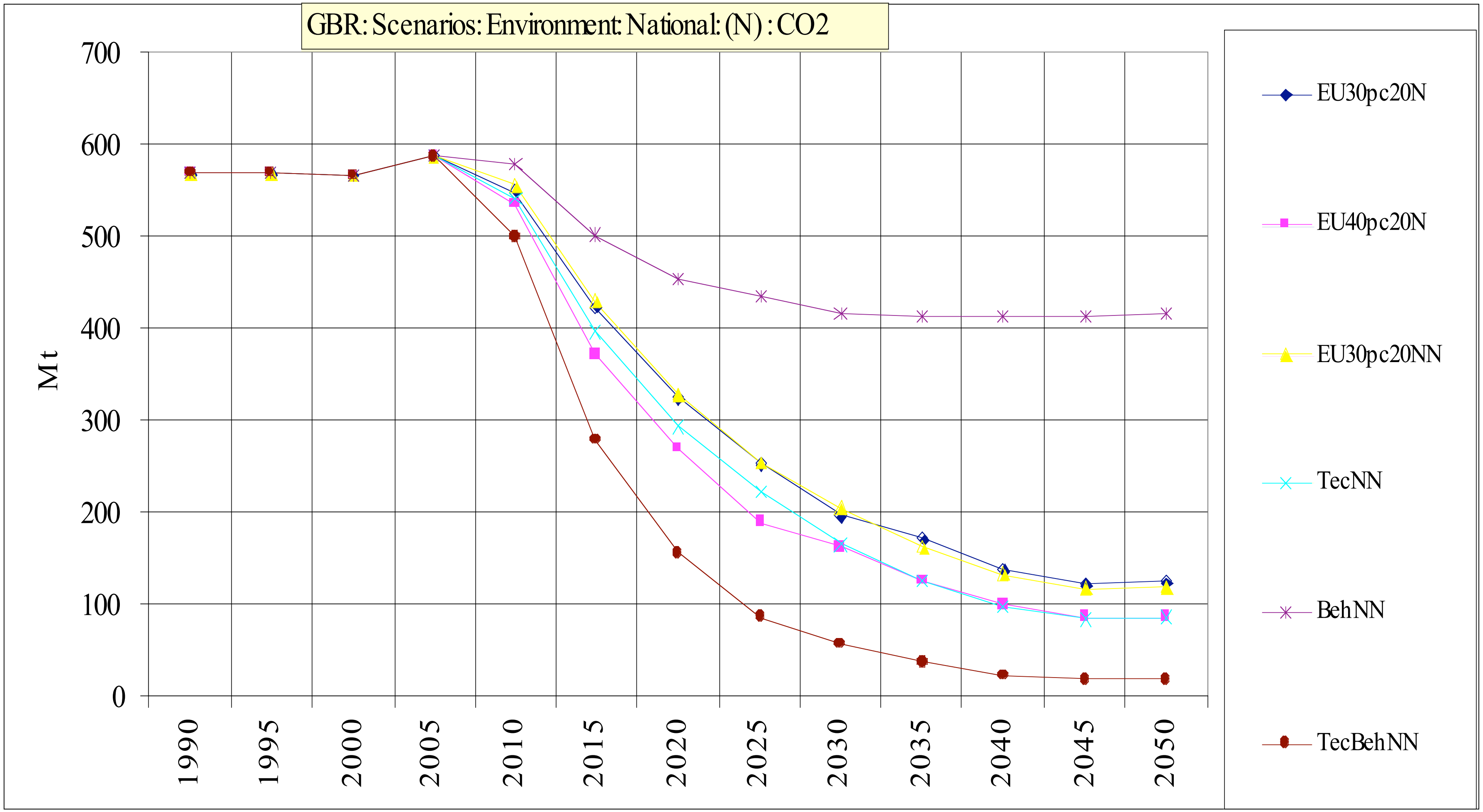
- Fossil CHP for medium term, and biomass CHP
- Renewable sources



SEEScen sample: UK : CO2 excluding international transport

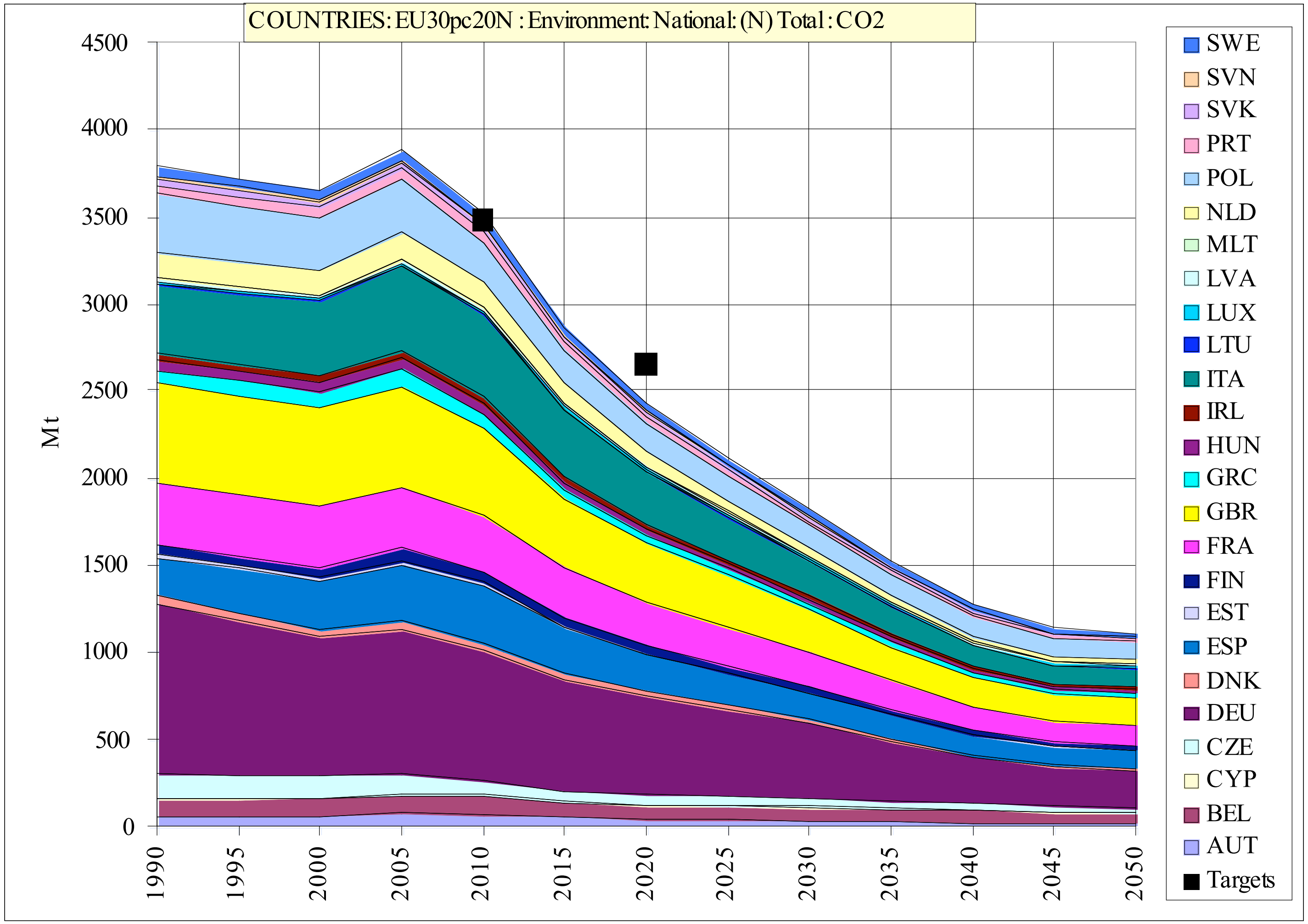


SEEScen sample: UK CO2 by scenario

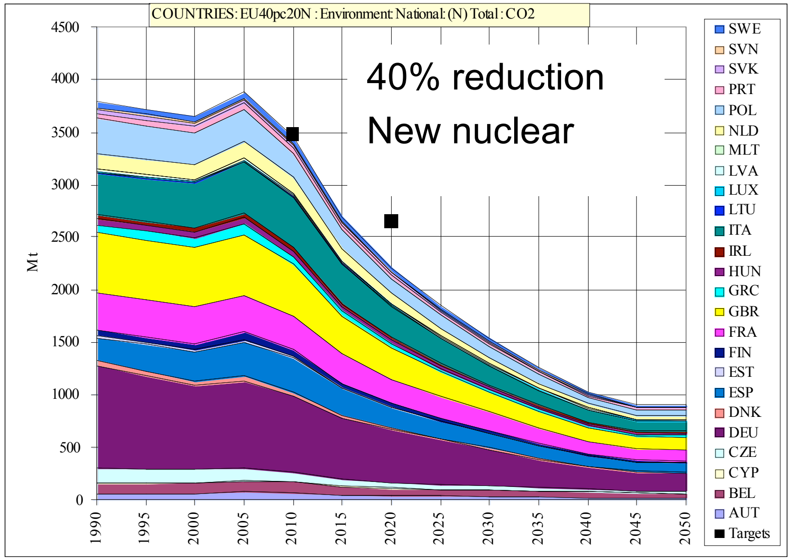


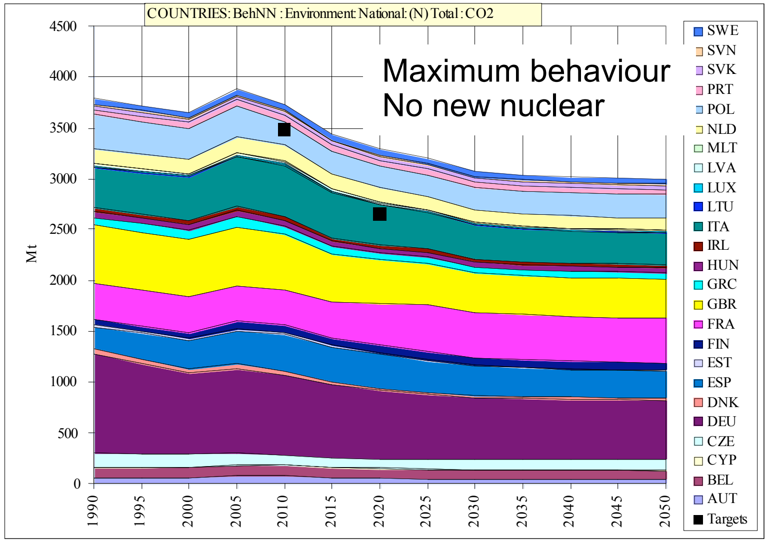
SEEScen sample: EU25 CO2 emissions by country : EU30pc20N scenario

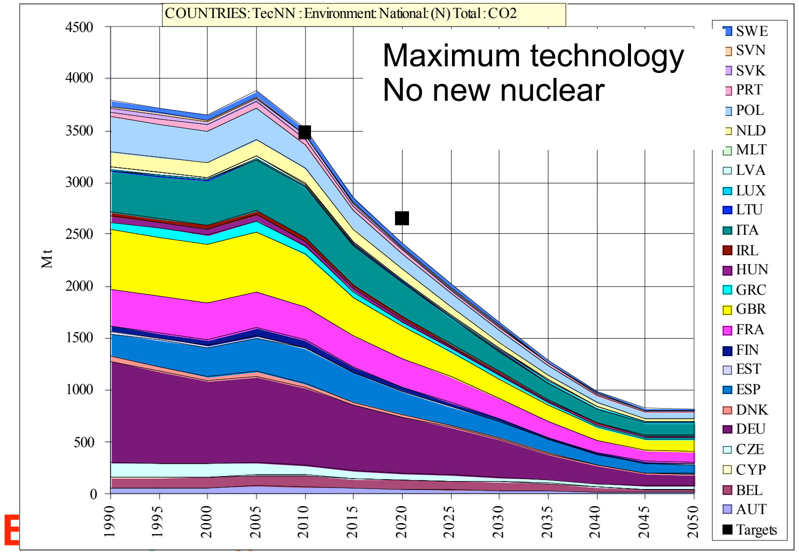
. The black squares show the targets for 2010 and a 30% reduction by 2020.

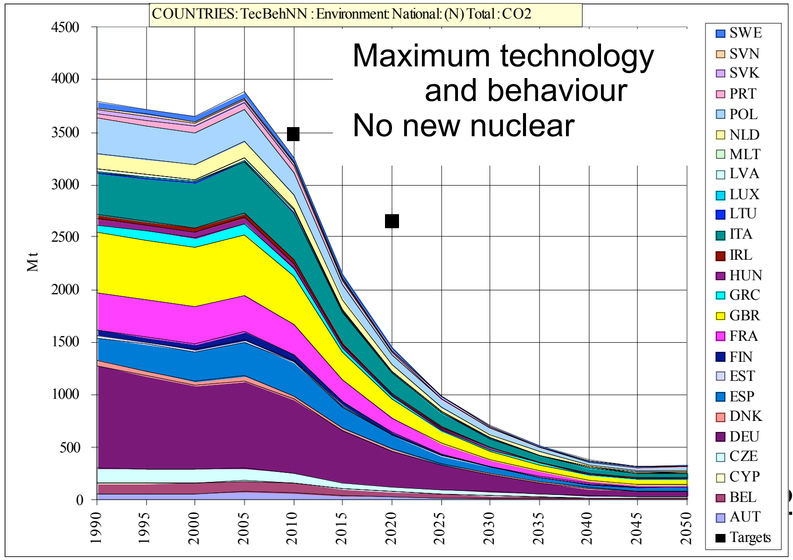


SEEScen sample: EU25 CO2 : variant scenarios



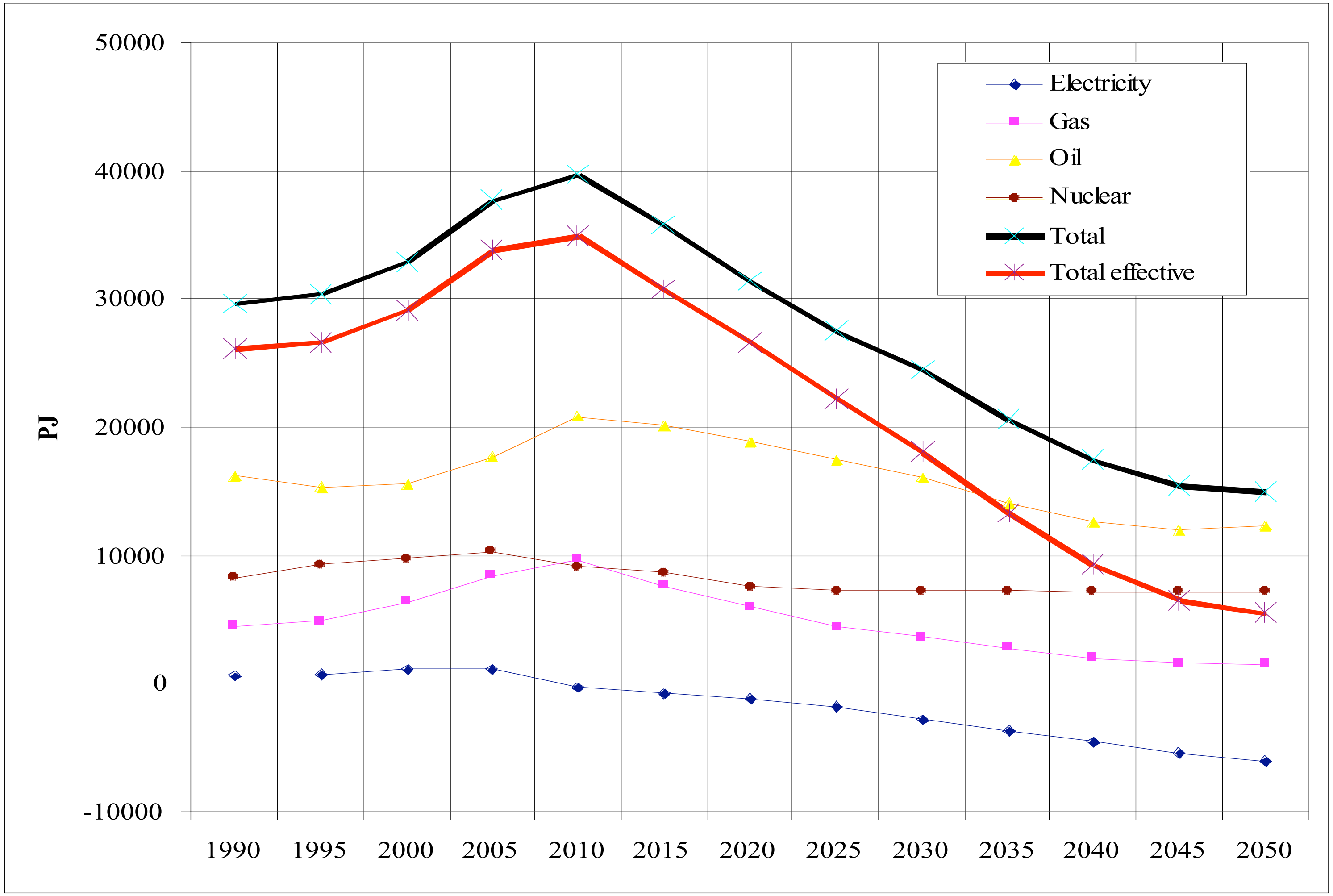






SEEScen sample: Energy security

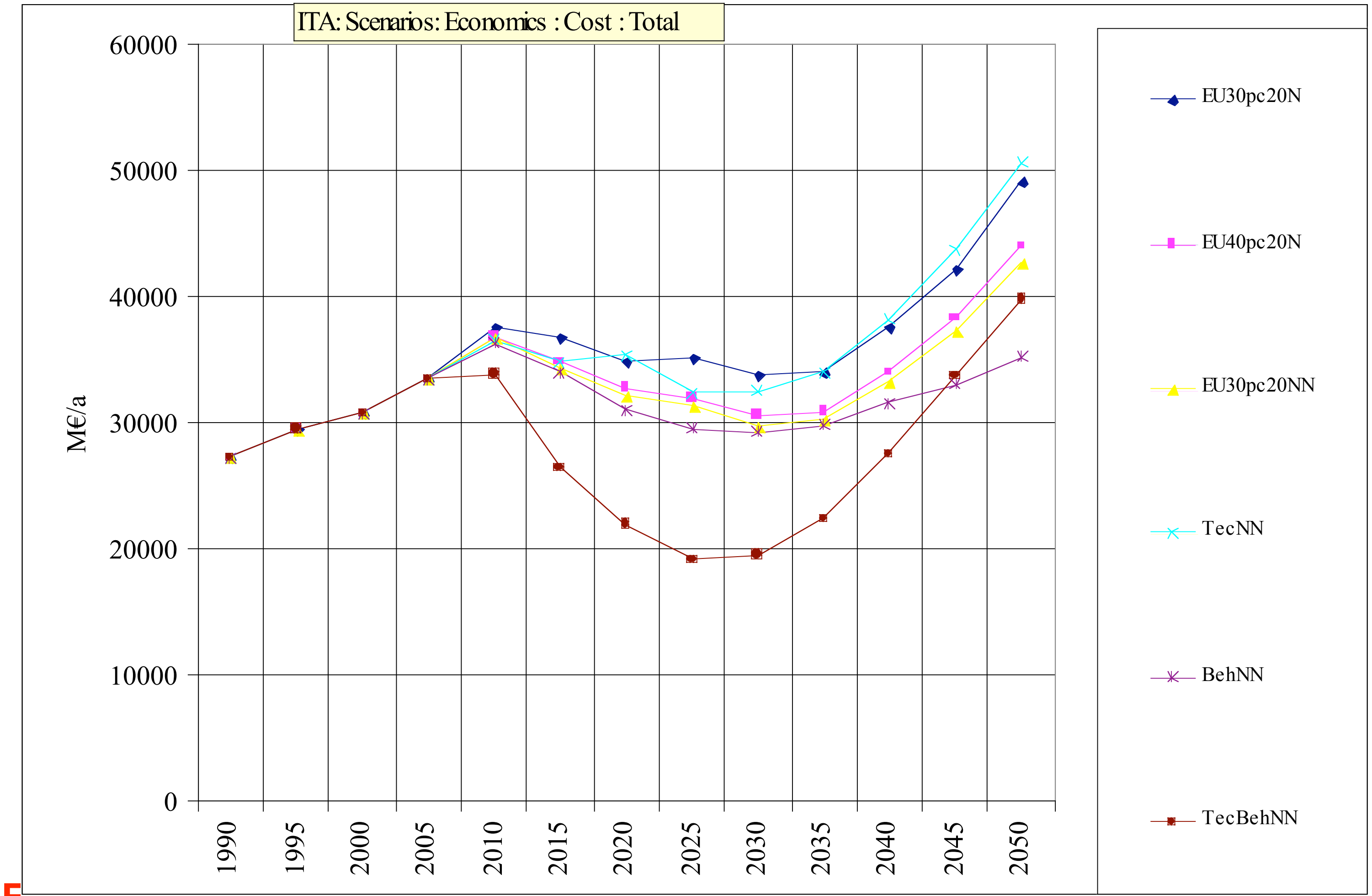
EU25 energy trade : including fuels for international transport: EU30pc20N scenario



SEEScen sample: Total cost by scenario: illustrative

It is possible that some low carbon scenarios will cost less than high carbon scenarios.

It is certain that reducing imports will enhance economic stability because of a lower trade imbalance, and less dependence on fluctuating fossil fuel prices.



Air pollution : emissions and reduction costs

The EU30N energy scenario results in lower emissions and control costs for all pollutants than in the EUV scenario.

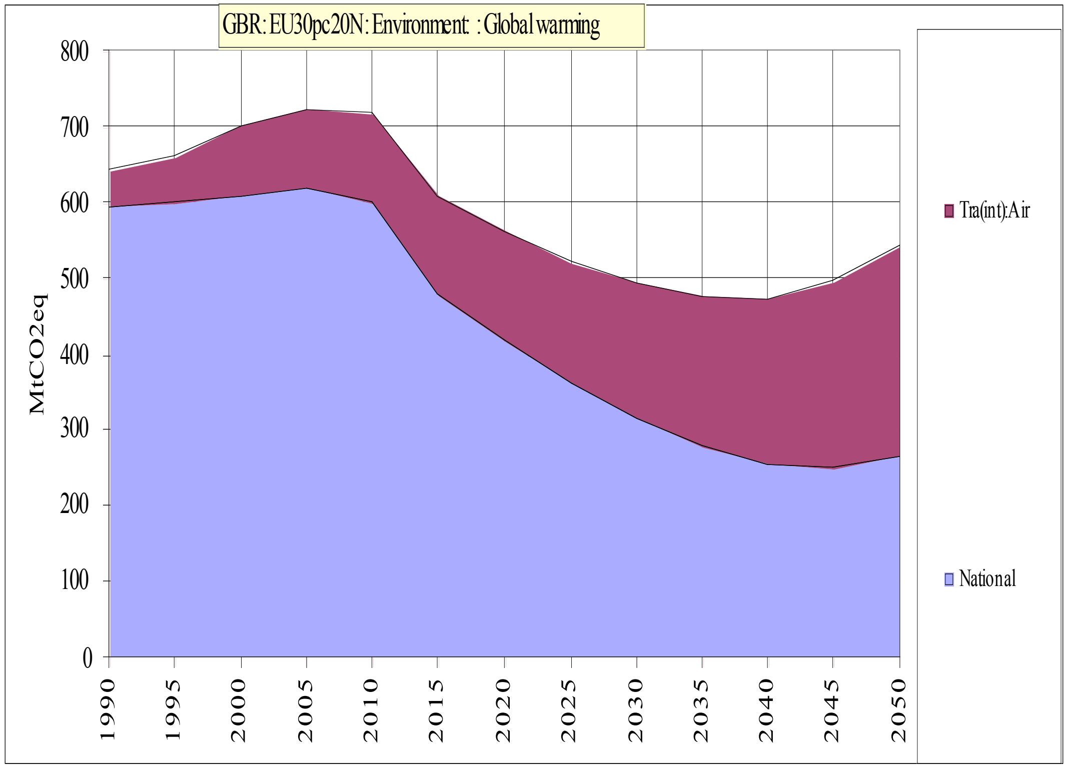
For 2020	EUV	EU30N	Reduction
Emission	**kt**		
NOx	6643	5321	20%
SO2	3831	3203	16%
VOC	5942	5725	4%
PM	3123	2917	7%
Control cost	**MEuro/year**		
NOx	43990	41345	6%
SO2	16298	12531	23%
VOC	3072	2954	4%
PM	9758	8135	17%
Total	**73118**	**64965**	**11%**

Further issues: aviation

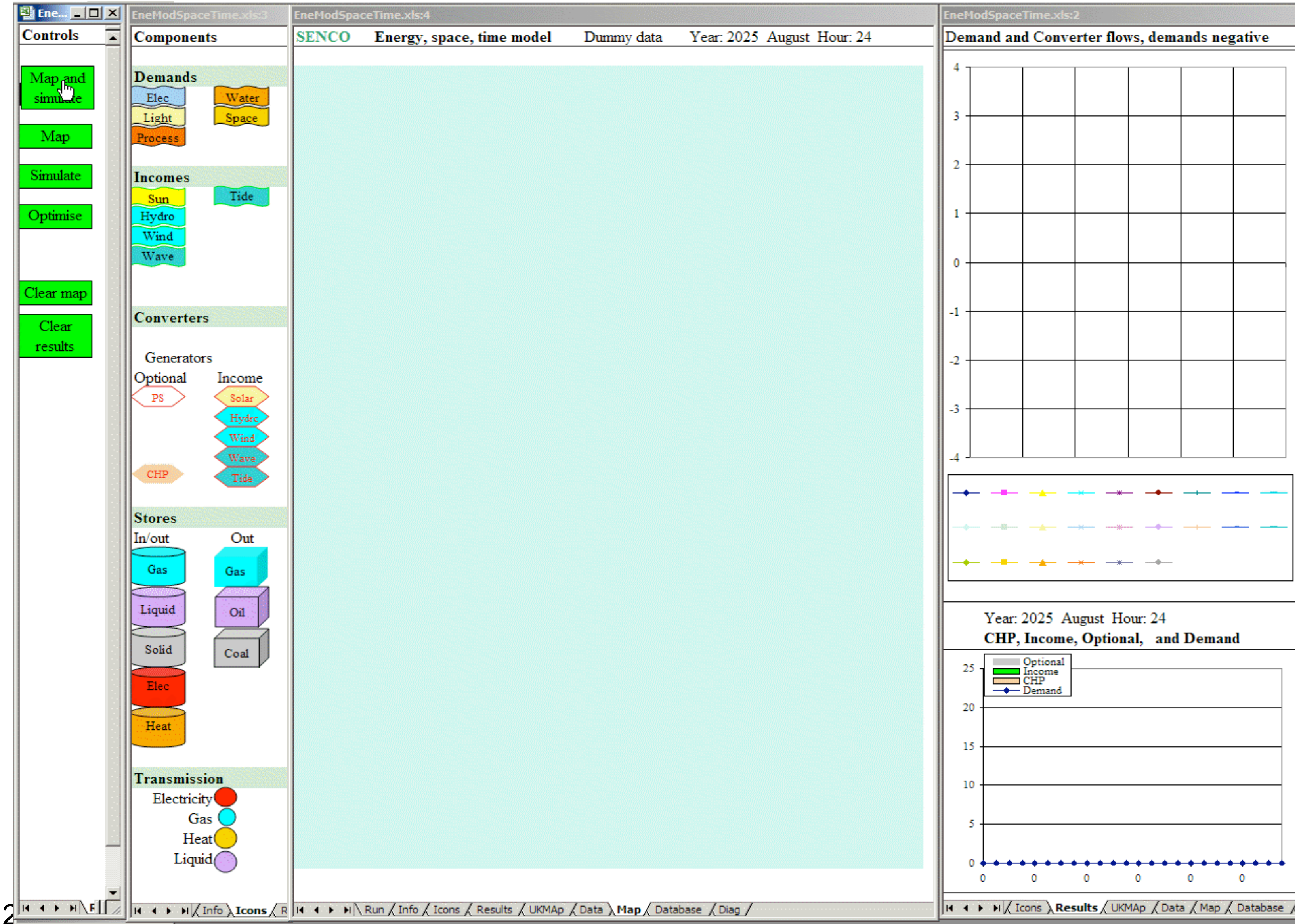
International aviation and shipping should be included in GHG inventories because their GHG emissions will become very large fractions of total.

- **Low level.** Airports are emission hot spots because of aircraft taxiing, and landing and take-off, and because of road traffic.
- **Tropospheric emission.** Aircraft emit a substantial quantities of NOx whilst climbing to tropopause cruising altitude (about 12 km). This will contribute to surface pollution.
- **Tropopause/low stratosphere emission.** The high altitude emission of NOx and water vapour cause 2-3 times the global warming due to aviation CO2. Aviation may well become the dominant energy related greenhouse gas emitter for the UK over the coming decades.
- Of all the fossil fuels, kerosene is the most difficult to replace.

Further information on this is given in the references.

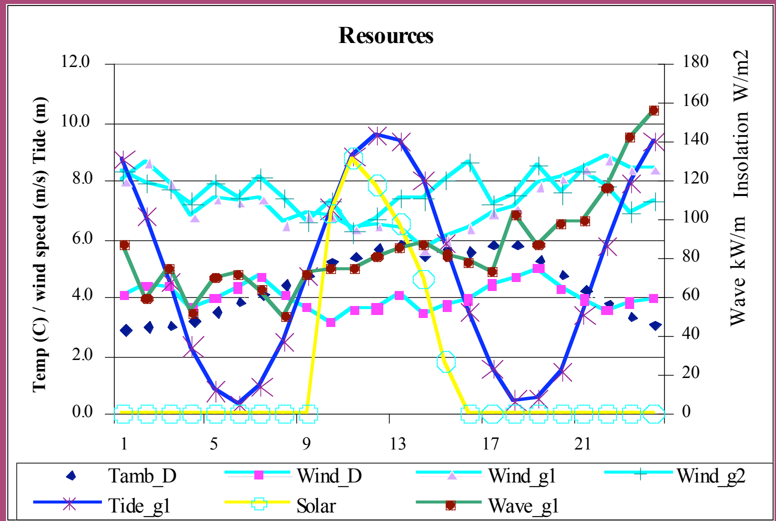


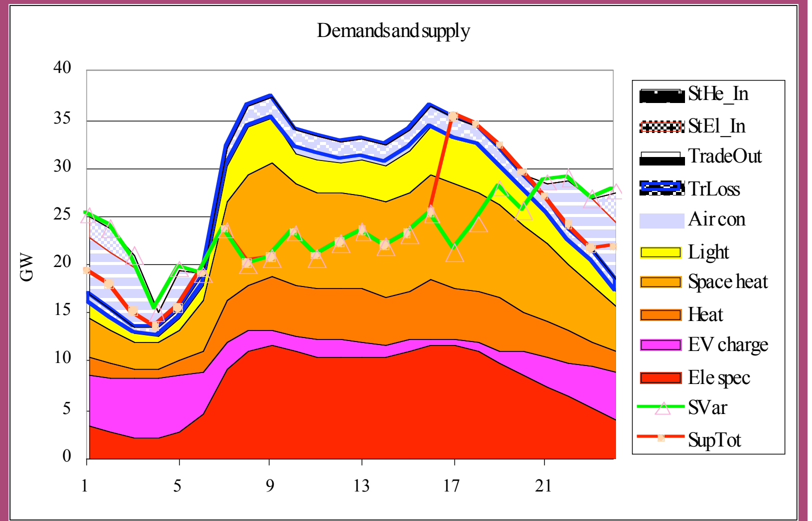
UK energy, space and time illustrated with EST : animated

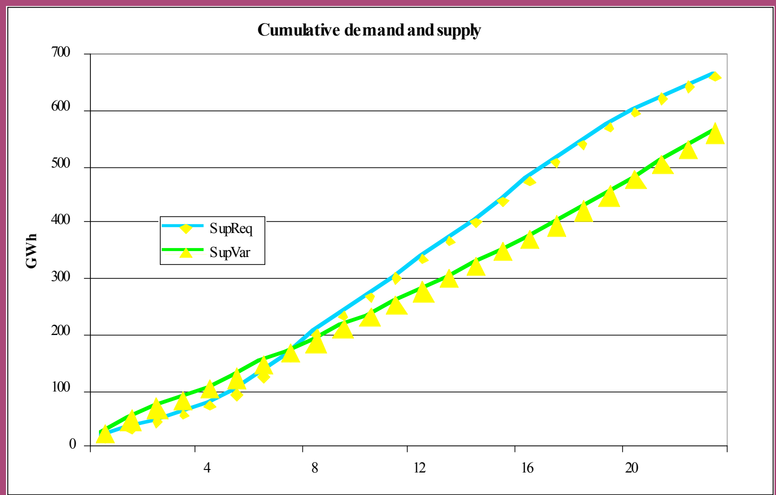


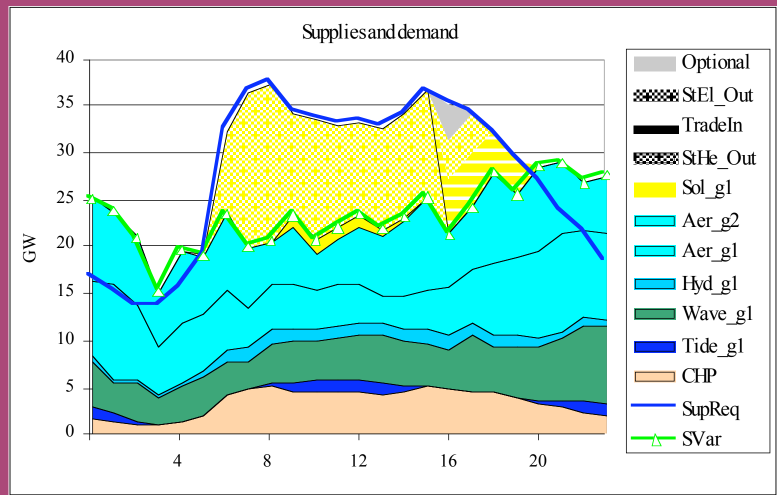
VarInt : Sample day : winter's day of variable supply deficit

SENCO **Energy, space, time** **model** **Demand and supply day sampling** Month 1 Dummy data **Days sampled** **1**

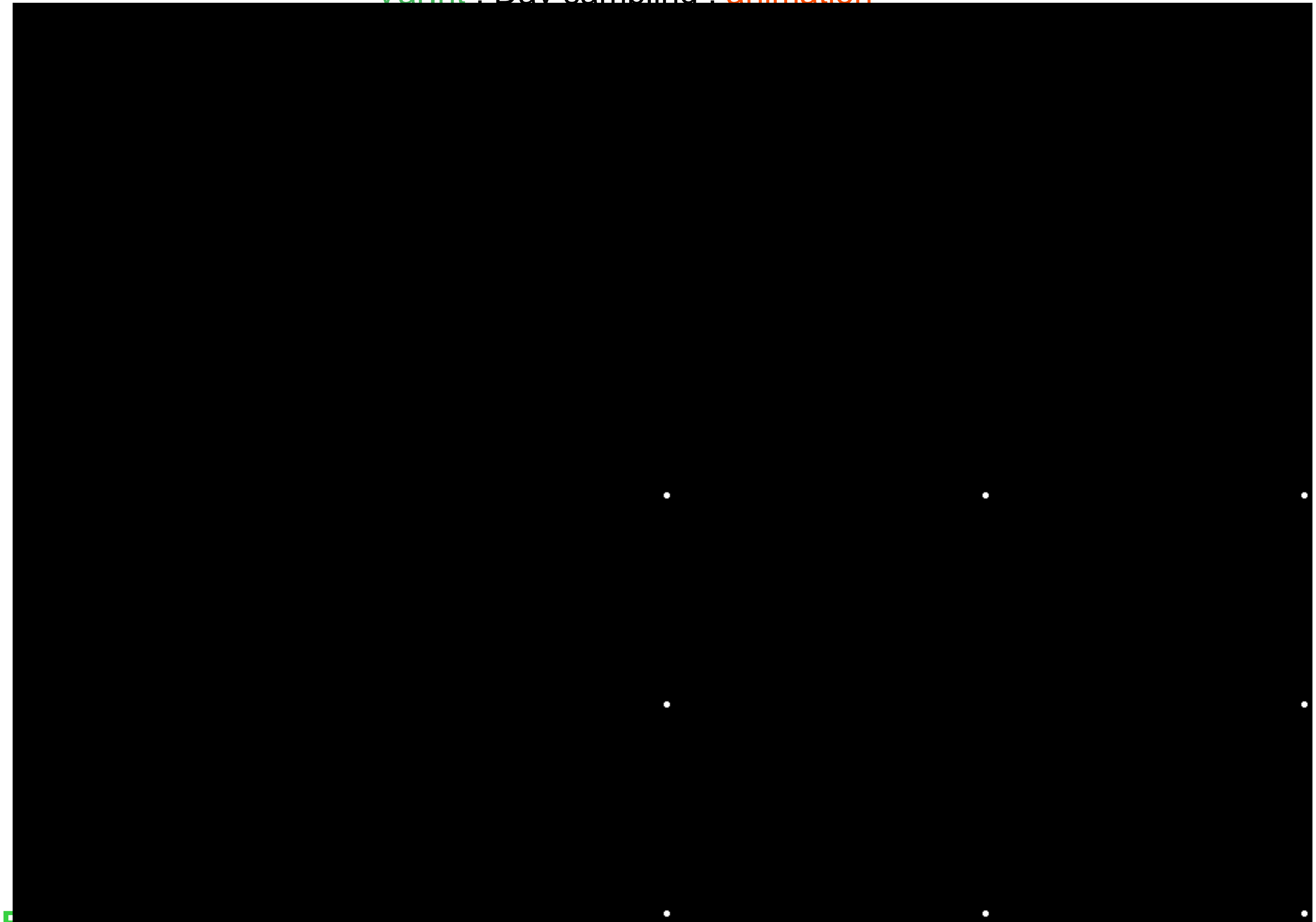








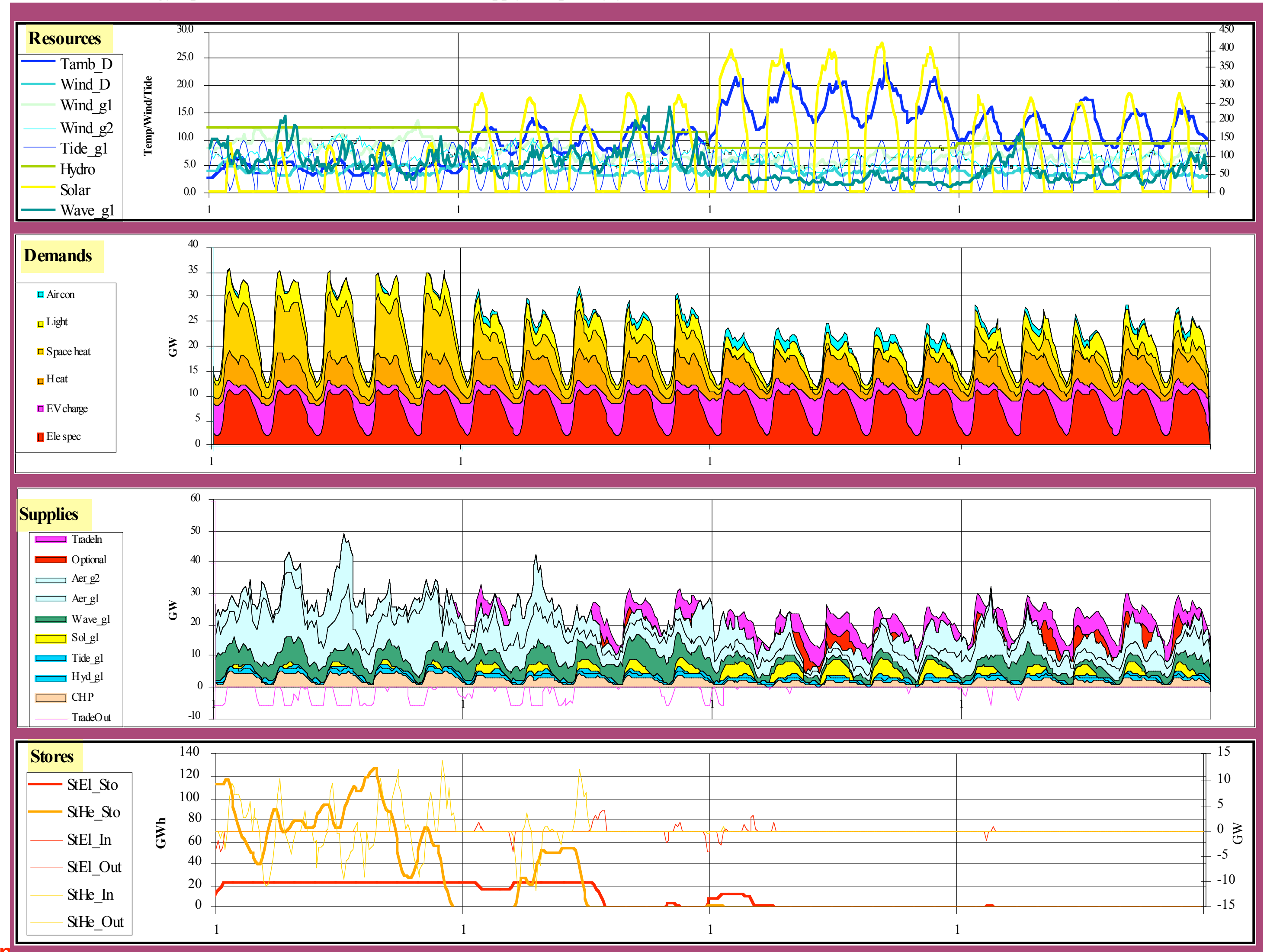
VarInt : Day sampling : animation



VarInt : Optimised system : sample year

These charts show the sampled year performance of the optimised system for one set of weather.

SENCO Energy, space, time model Demand and supply sample day year Months 1,4,7,10 5 Days/month



Large Point Sources of emissions

The map shows historical emissions (SO_2) from power stations and other large point sources in Europe and western Asia.

InterEnergy – trade optimisation animated

This shows InterEnergy seeking a least cost solution.

It illustrates how patterns of electricity flow might change.

An increase in renewable electricity will require a higher capacity grid with more sophisticated control

Renewable energy accounting

How to estimate the renewable energy fraction of total EU energy consumption?

These questions arise:

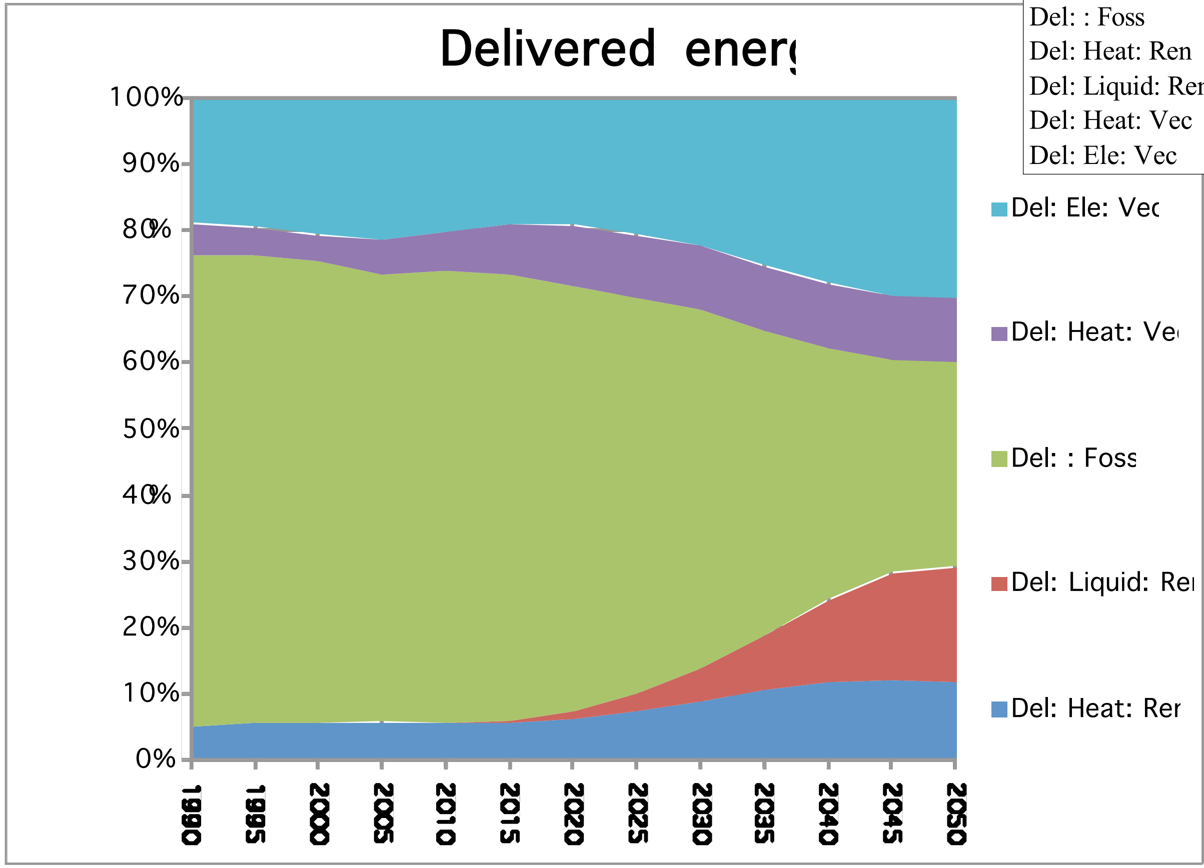
- Where in the energy flow system of a country is renewable energy measured?
- Which renewable energy sources are included?
- How are the renewable energy flows quantified and accounted?
- How is the fraction of renewable energy calculated?

The answers to these questions are largely arbitrary.

There is no obvious system for accounting for renewable energy that is applicable to all countries at all times.

EU25 renewable fractions, EU30pc20N scenario - delivered energy

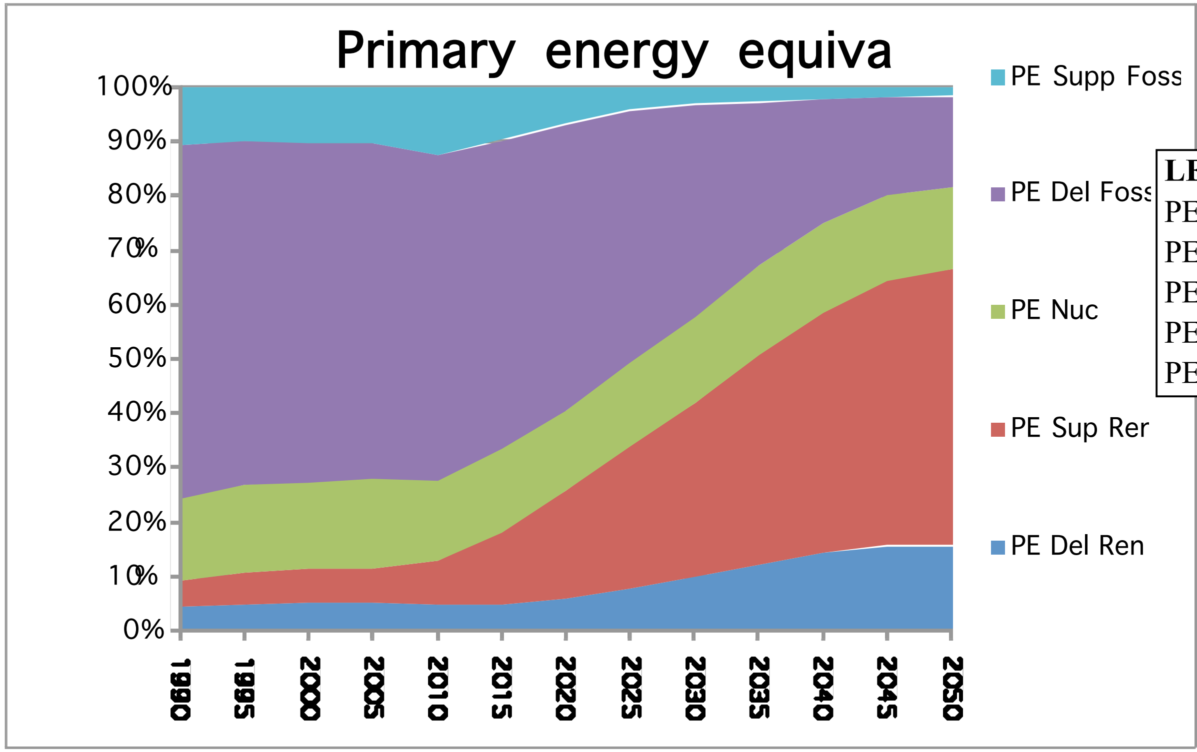
Renewable energy is 5% of delivered energy in 2020



LEGEND KEY	
Del: : Foss	Delivered fossil fuel
Del: Heat: Ren	End use biomass/solar heat
Del: Liquid: Ren	Delivered liquid
Del: Heat: Vec	Delivered heat (district heating)
Del: Ele: Vec	Delivered electricity

EU25 renewable fractions, EU30pc20N scenario - primary energy

Primary energy renewable fraction increases from 9% in 1990 to 26% in 2020.
(Official sources puts current fraction at 6-7%, so accounting convention here gives larger fraction)



LEGEND KEY

PE Del Ren	Delivered renewable
PE Sup Ren	Supply renewable
PE Nuc	Nuclear
PE Del Foss	Delivered fossil
PE Supp Fossil	Supply fossil

Conclusions: 1

Demand

- Large energy demand reduction feasible with technologies in all sectors, but smaller reductions in road freight transport, aviation and shipping.
- Behavioural change very important, especially in car choice and use, and air travel.

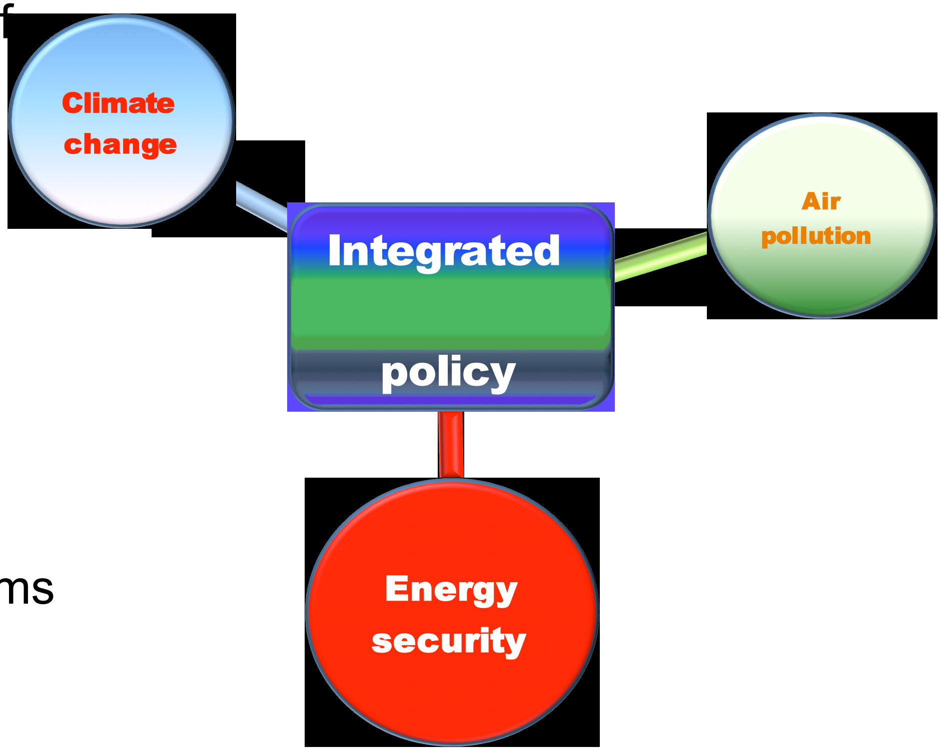
Supply

- A shift from fossil fuel heating to solar and electric heat pumps
- A shift from fossil electricity generation to a mix of renewables
- Large renewable electricity potential and Europe might become a net exporter of electricity
- but remain a large importer of oil
- Renewable energy fraction difficult to define.

- Main problem is replacing fossil liquid transport fuels, especially for aircraft and ships

Conclusions: 2

- Large CO_2 reductions possible
- Date and rate of introduction of measures critical.
- Low carbon scenarios have a lower total and air pollution control cost than high carbon scenarios
- Demand reduction and renewables address all problems simultaneously



Further material covering technical and behavioural aspects that may be of interest

UK Energy scenario: presentation
http://www.bartlett.ucl.ac.uk/markbarrett/Energy/UKEnergy/UKEneScenarioAnim140206.zip

Consumption: Report on consumption, energy and carbon dioxide including behavioural measures
http://www.bartlett.ucl.ac.uk/markbarrett/Consumption/EneCarbCons05.zip

Renewable electricity system: Feasibility of a high renewable electricity system
http://www.cbes.ucl.ac.uk/projects/energyreview/Bartlett%20Response%20to%20Energy%20Review%20-%20electricity.pdf
http://www.bartlett.ucl.ac.uk/markbarrett/Energy/UKEnergy/UKElectricityGreenLight_100506.ppt

Aviation: http://www.bartlett.ucl.ac.uk/markbarrett/Transport/Air/Aviation.htm
Technical scenarios http://www.bartlett.ucl.ac.uk/markbarrett/Transport/Air/Aviation94.zip
Effects of taxes: http://www.bartlett.ucl.ac.uk/markbarrett/Transport/Air/AvCharge.zip

Transport:
Summary presentation of some Auto-Oil work on transport and air quality, including some non-technical measures
http://www.bartlett.ucl.ac.uk/markbarrett/Transport/Land/AutoOil/JCAPWork.ppt

Large Point Sources: emissions and health effects
http://www.acidrain.org/pages/publications/reports.asp
http://www.bartlett.ucl.ac.uk/markbarrett/Environment/LPS/LPS.htm

General:
http://www.bartlett.ucl.ac.uk/markbarrett/Index.html

Thank you for your attention

More information available at:

Site : www.bartlett.ucl.ac.uk/markbarrett/Index.html

Email: Mark.Barrett@ucl.ac.uk

Tel Mobile: +44 07837 338297