ENERGY SCENARIOS FOR EUROPE

strategies for the control of emissions of carbon dioxide and air pollutants

and to enhance energy security

for the Swedish Environmental Protection Agency

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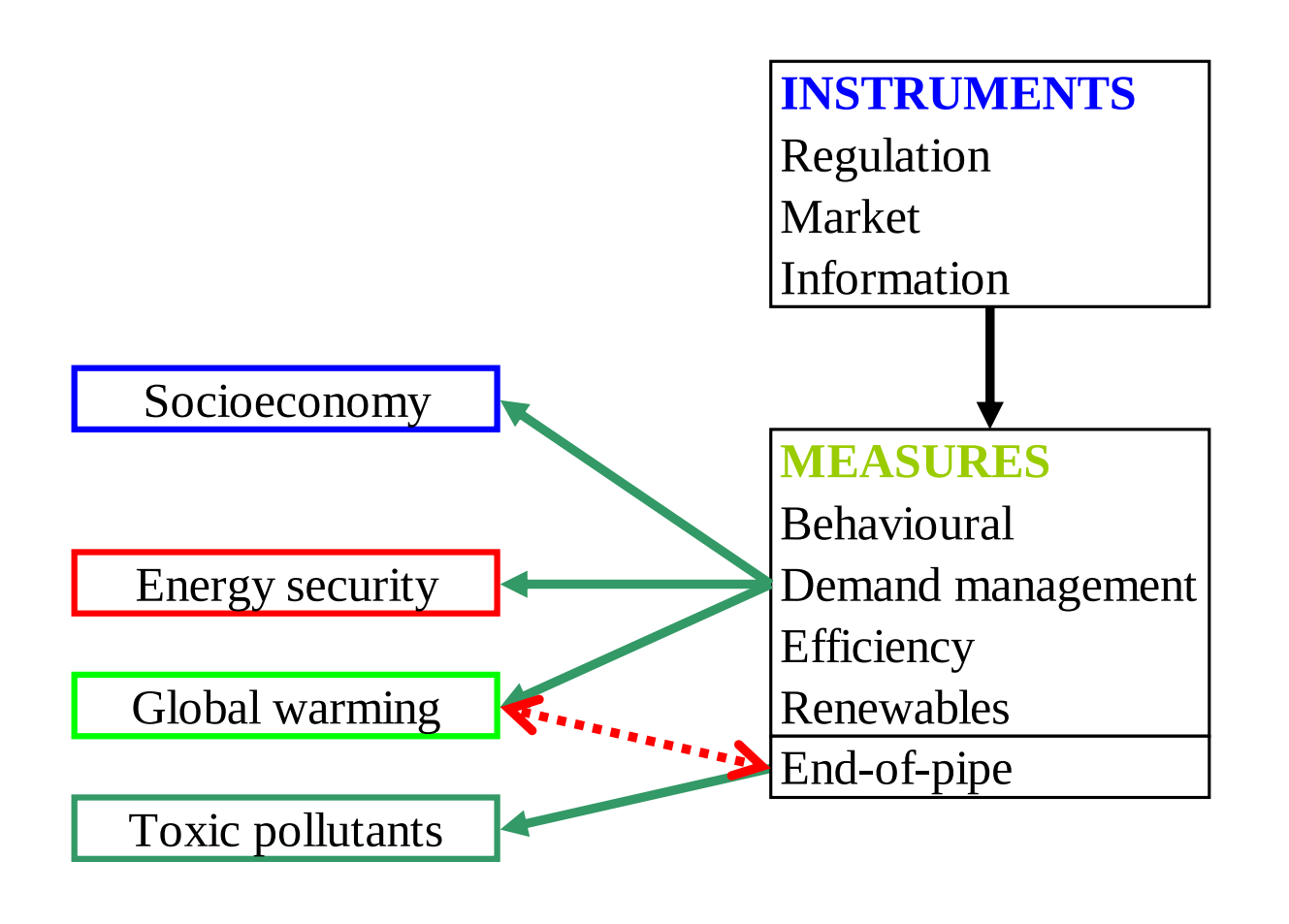
Contents

The data input, model and results need further checking and development. Comments welcomed.

Aims

Investigate energy strategies for the EU25 that achieve multiple environmental and energy goals at low or minimum overall cost.



Process

- Generate energy scenarios for each EU25 country
  - collect base data
  - develop assumptions about policy options
  - run scenarios
  - output results data
    - energy flows through different sectors and technologies
    - costs and emissions

- Translate energy flow data into RAINS format
- IIASA run RAINS

Some critical input assumptions

- CO2 targets
  - for 2010/12, 2020 and the longer term
  - include international transport - aviation, shipping?
  - include CO2 reductions through flexible mechanisms?

- Demand drivers
  - population and households
  - economic growth and sectoral activity

- Exogenous inputs
  - Transport projections as in PRIMES
  - future generation from existing and new nuclear stations as in PRIMES
  - international energy prices
  - energy trade balance constraints between EU25 and rest of world

Control options

Investigate deployment of 'Non-end-of-pipe' (NEOP) options that reduce finite fuel consumption and atmospheric emissions.

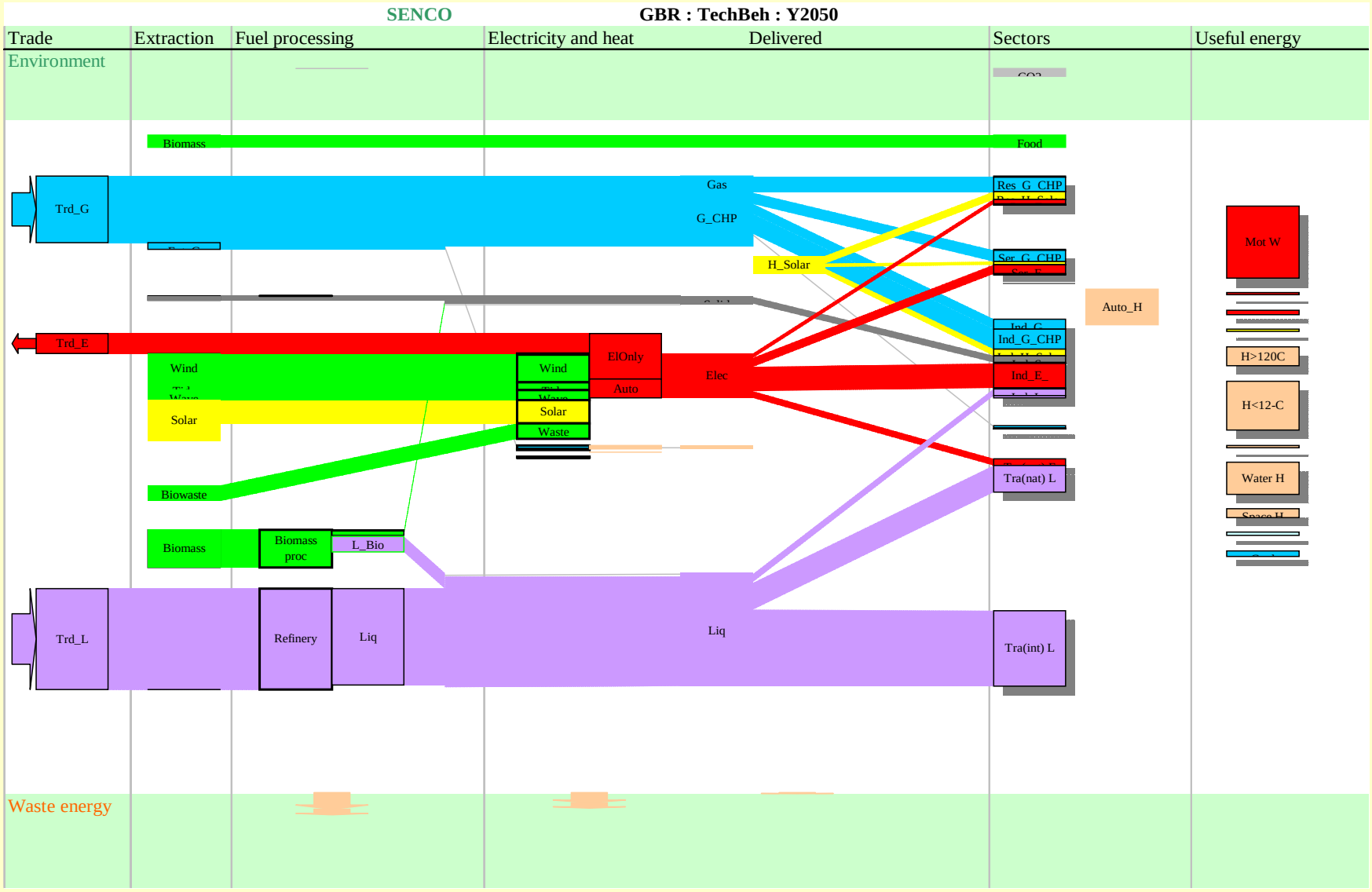
		Category	**Examples**
1	NEOP	Behavioural change	Smaller cars, lower speeds, lower thermostat
2	NEOP	Demand management	Building insulation, appliance efficiency
3	NEOP	Improved energy conversion	Boilers, heat pumps, CHP
4	NEOP	Fuel switching	From coal and oil to gas and renewables
5	EOP	End-of-pipe	Flue gas desulphurisation, catalytic converters, carbon sequestration

Scenarios

Six scenarios for each EU25 country were constructed to reach these objectives using different combinations of NEOP options:

Label	Target: % CO reduction	Target: Reduction date	Nuclear	EOPs
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

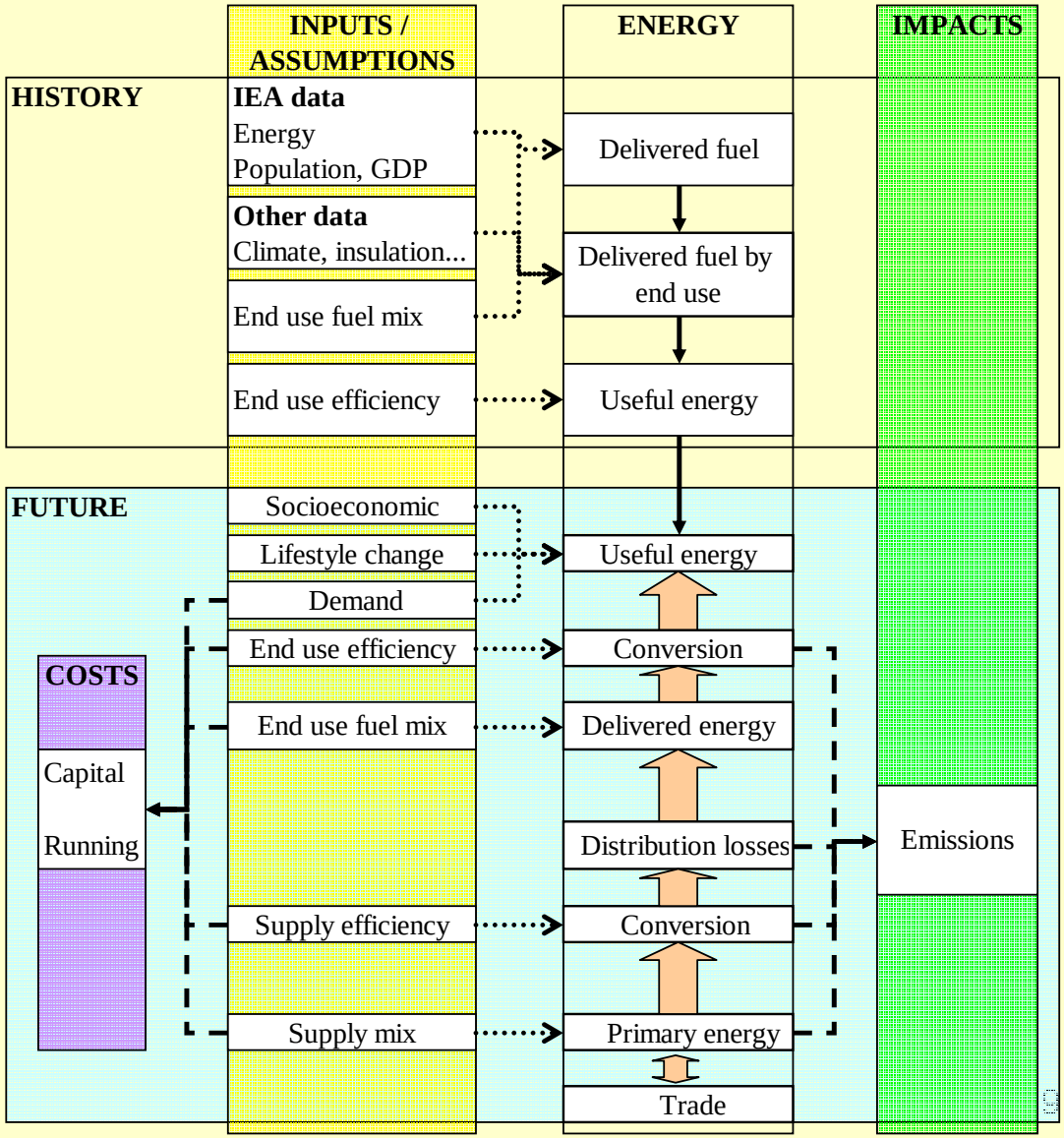
Sample output: UK scenario: energy flow chart for 2050



SEEScen: Society, Energy, Environment Scenario model

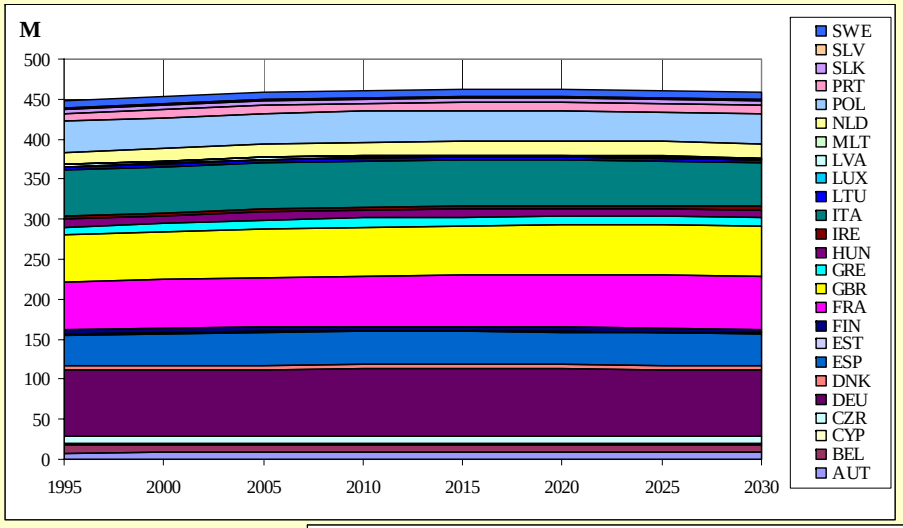
- SEEScen is applicable to any large country having IEA energy statistics
- SEEScen calculates energy flows in the demand and supply sectors, and the microeconomic costs of demand management and energy conversion technologies and fuels
- SEEScen is a national energy model that does not address detailed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

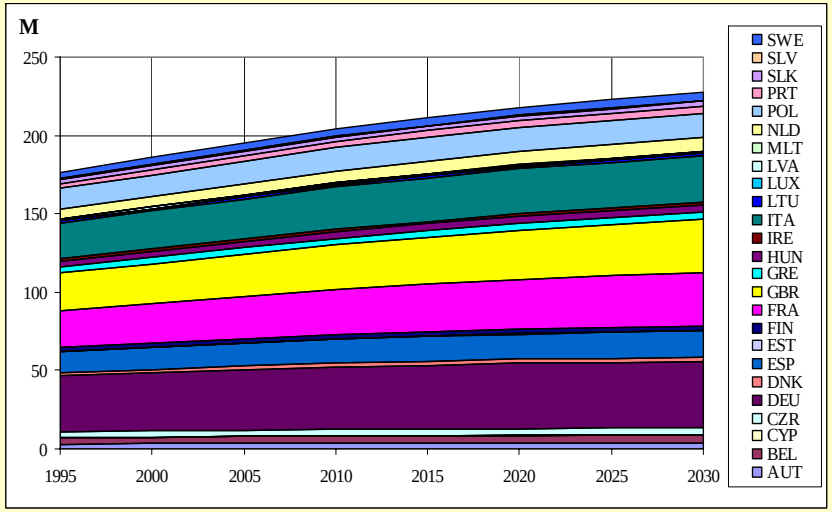


Exogenous assumptions (from PRIMES): basic drivers

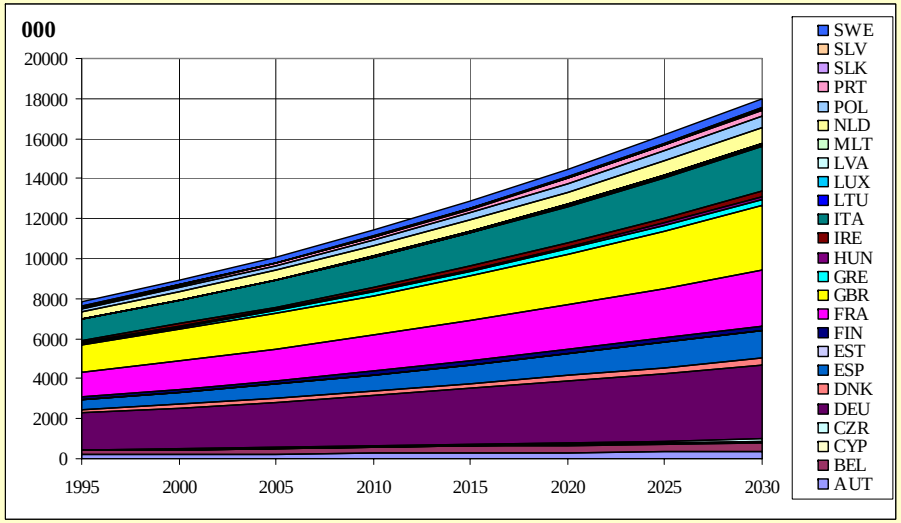
Population stablises



More households

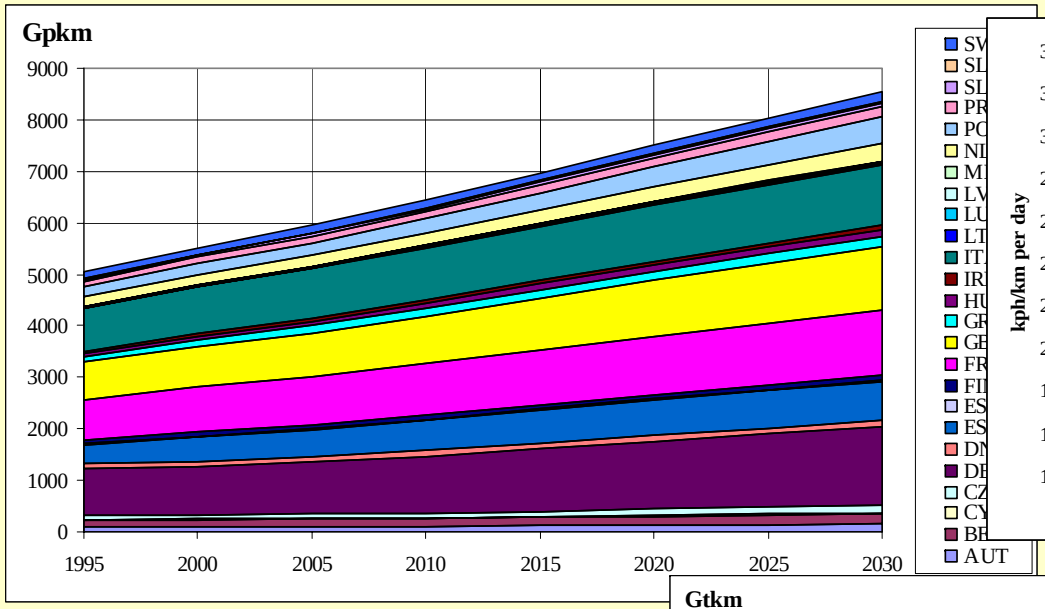


GDP growth

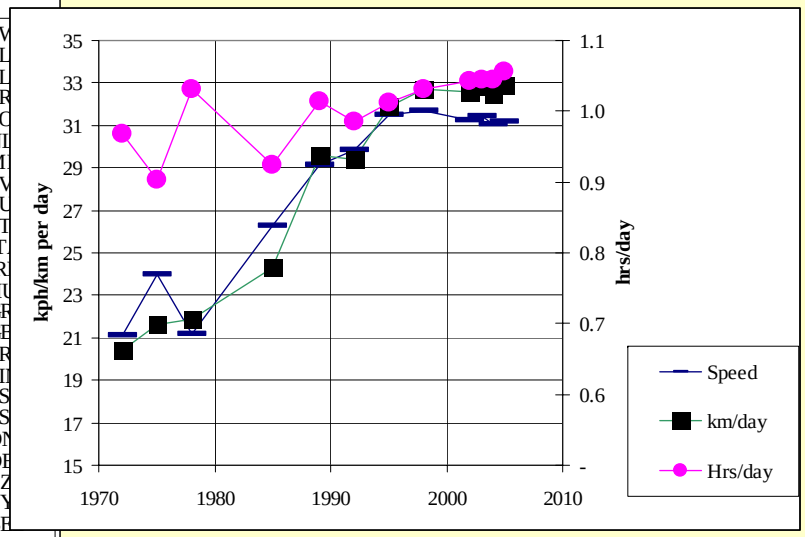


Exogenous assumptions (from PRIMES): transport demand

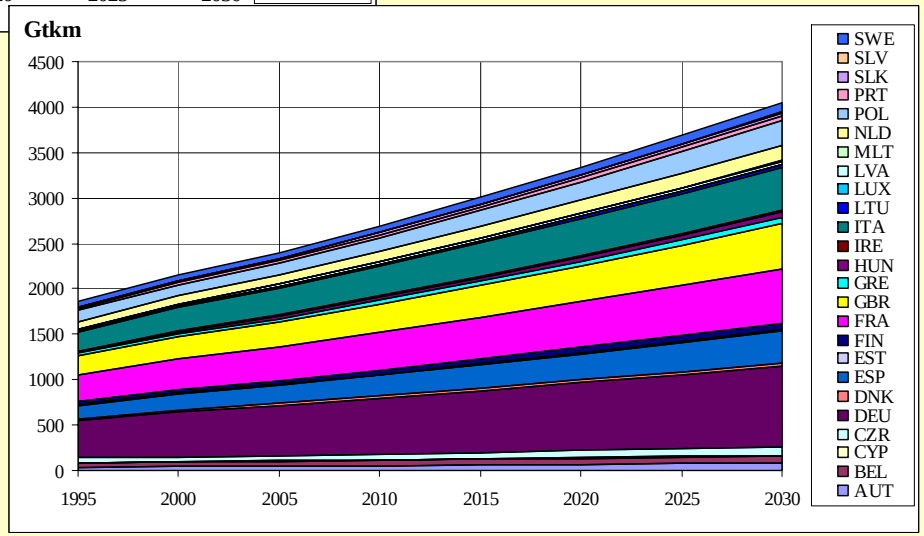
More passenger travel



But is saturation occurring?

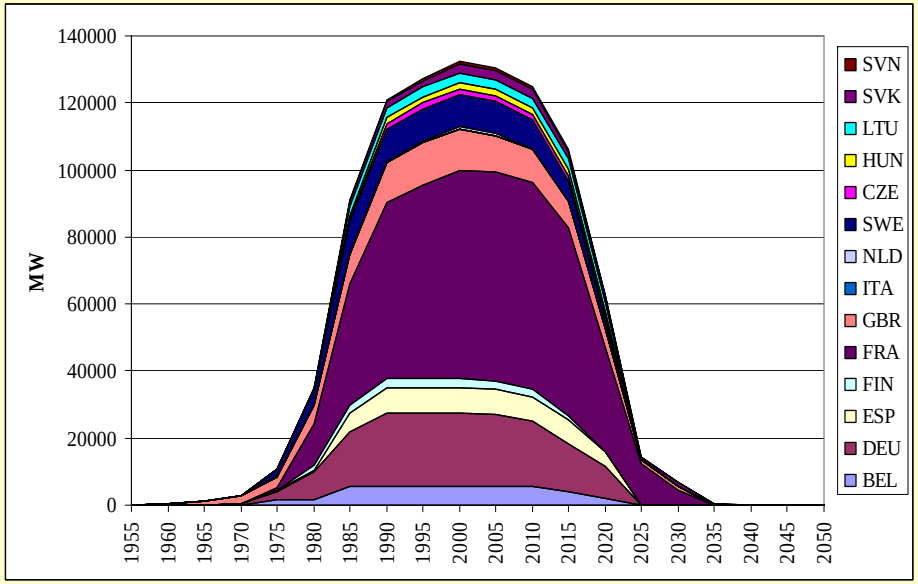


More freight transport

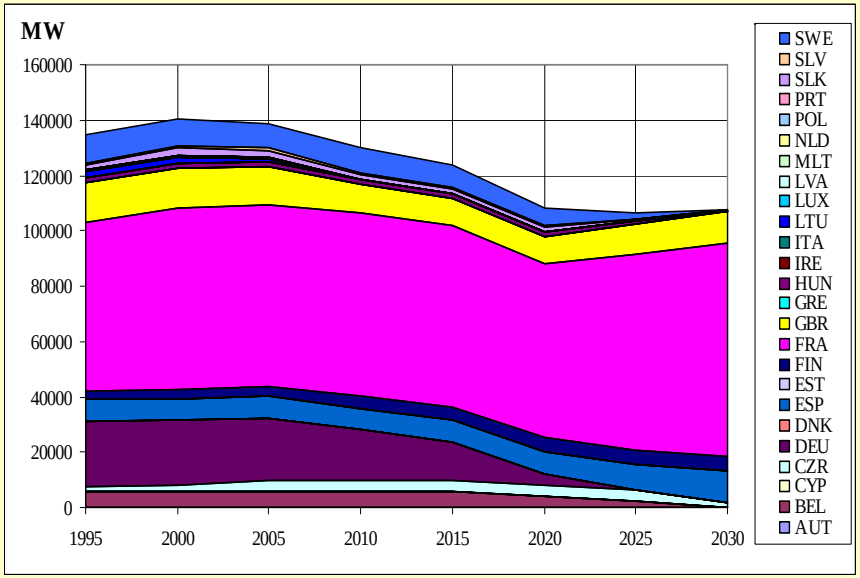


Exogenous assumptions: nuclear power

Profile with 35 years life

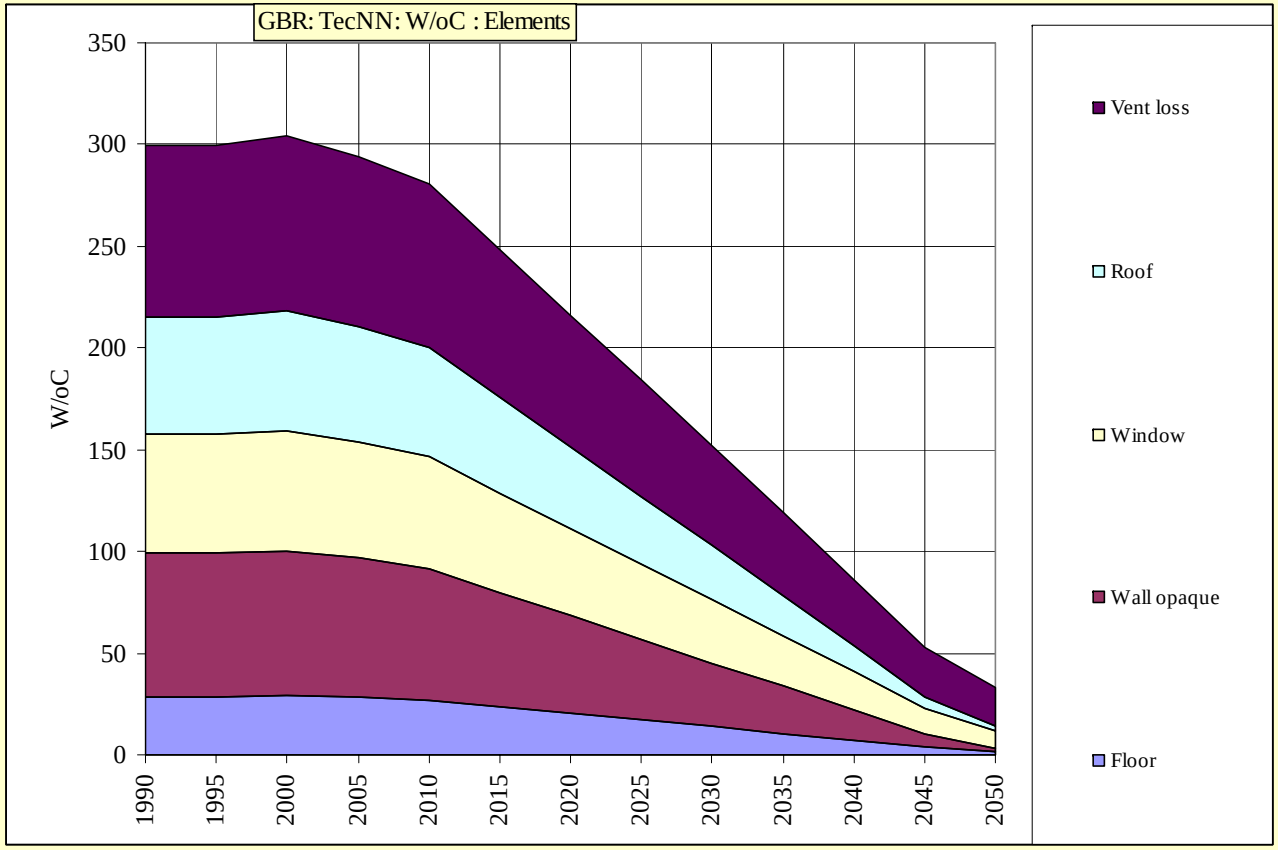


PRIMES profile with replacement



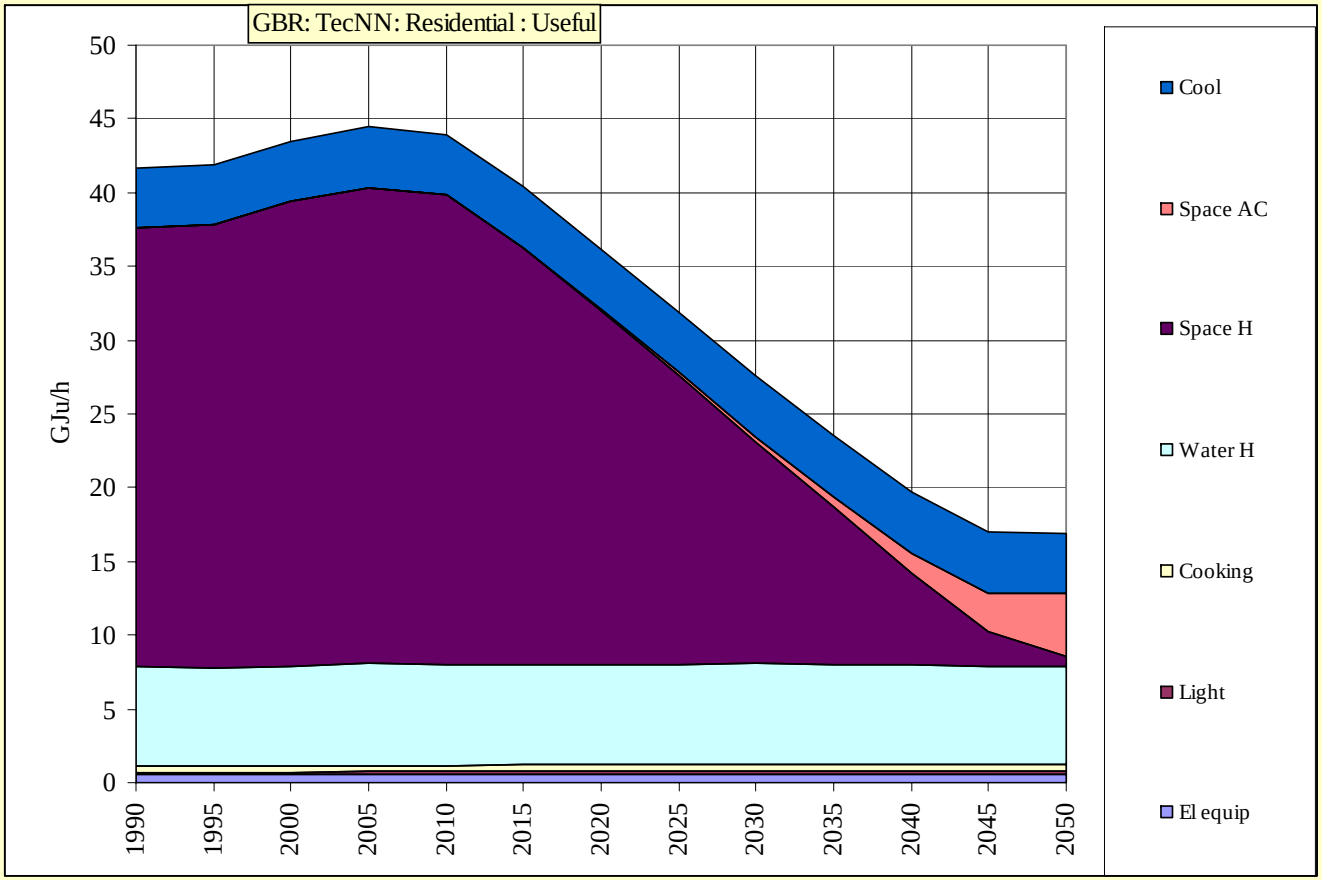
Domestic sector: house heat loss factors

- 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.



Domestic sector: useful energy services per household

- Space heating reduced, but not comfort
- Other demands eventually grow because of basic drivers
- Water heating becomes a large fraction of total, demand management requires further analysis



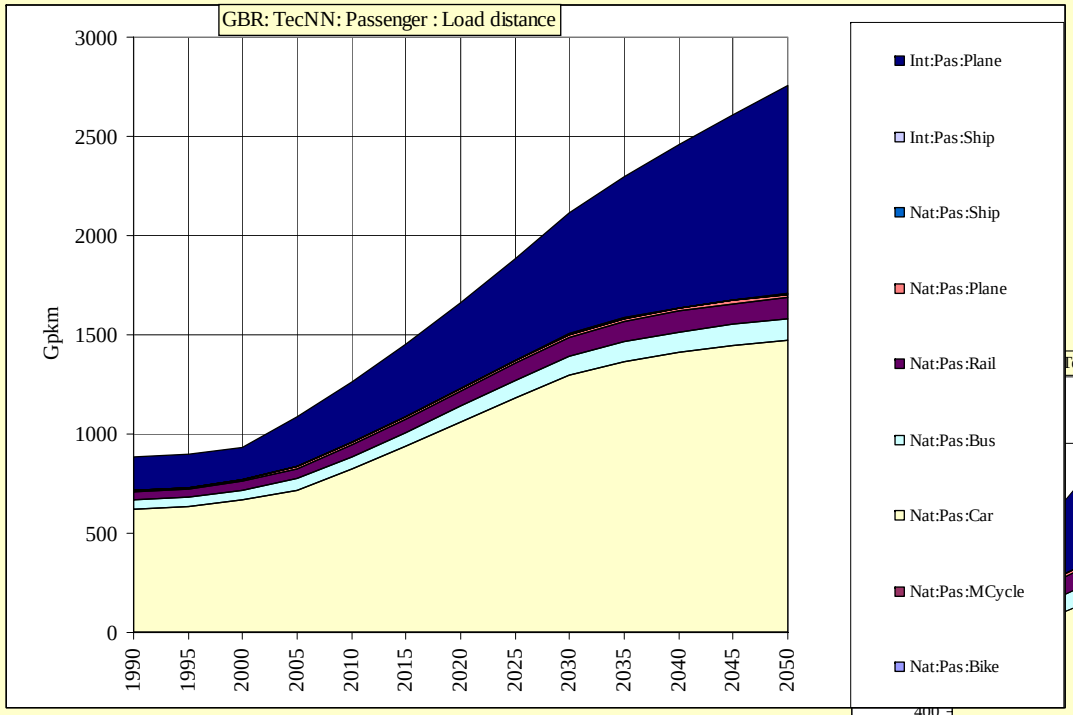
Transport

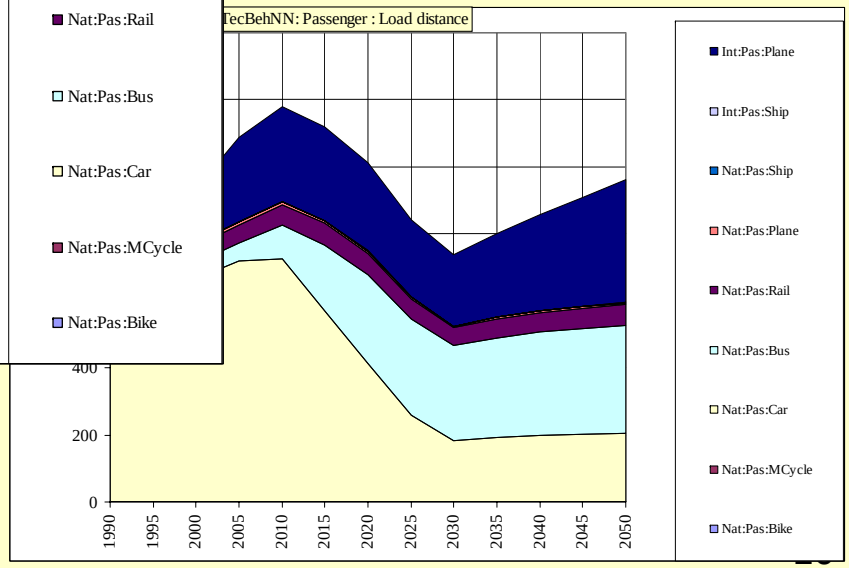
Options exercised:

- Demand management, especially in aviation sector
- Reduction in car power and top speed
- Increase in vehicle efficiency
  - light, low drag body
  - improved motor efficiency
- Implementation of speed limits
- 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 in the aviation sector
- Some penetration of vehicles using alternative fuels:
  - electricity for car and vans
  - biofuels principally for longer haul trucks and aircraft

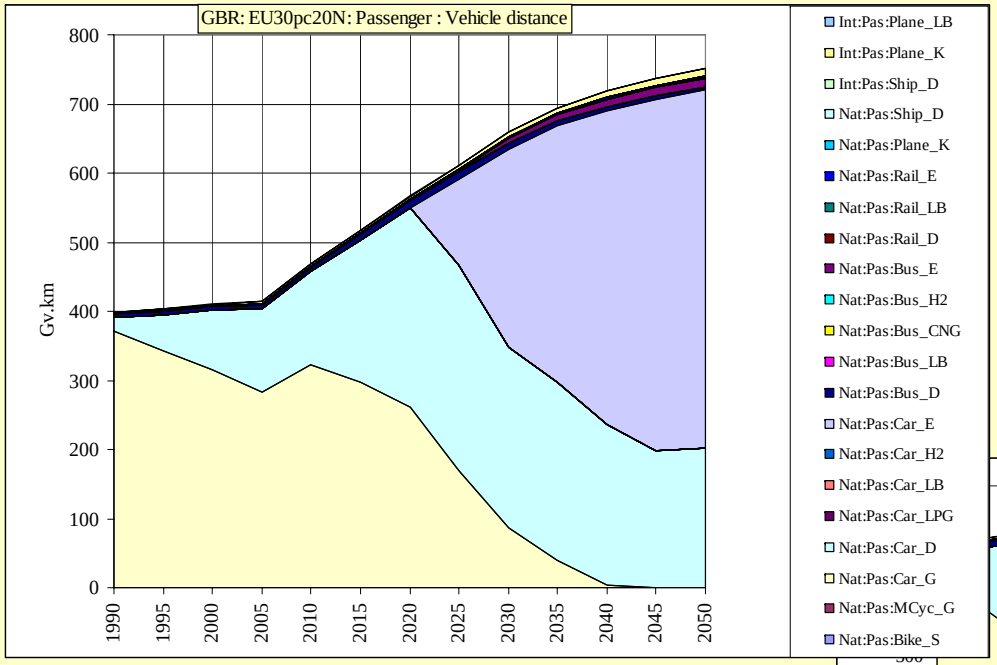
Transport: passenger demand by mode and vehicle type

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.

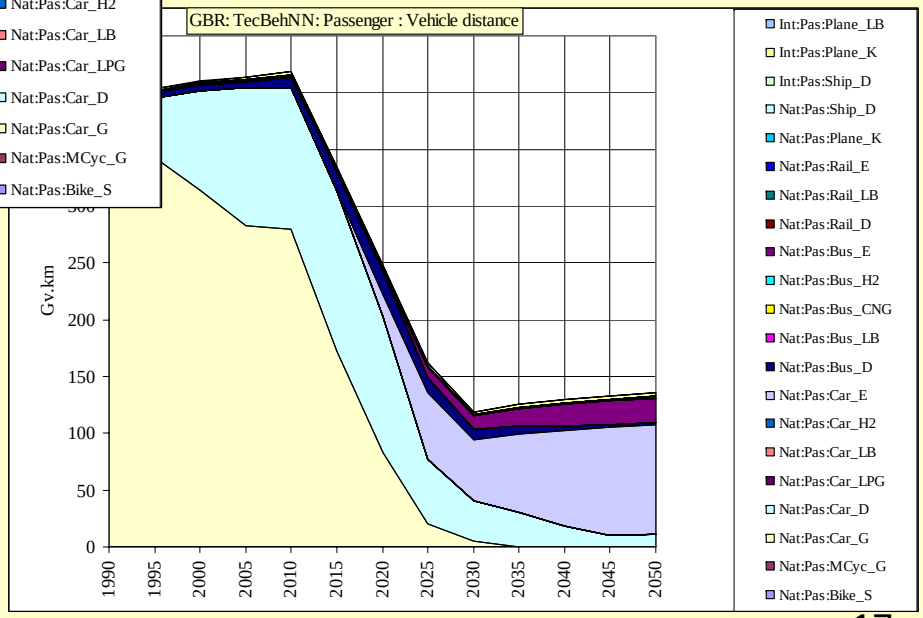




Transport: passenger vehicle distance



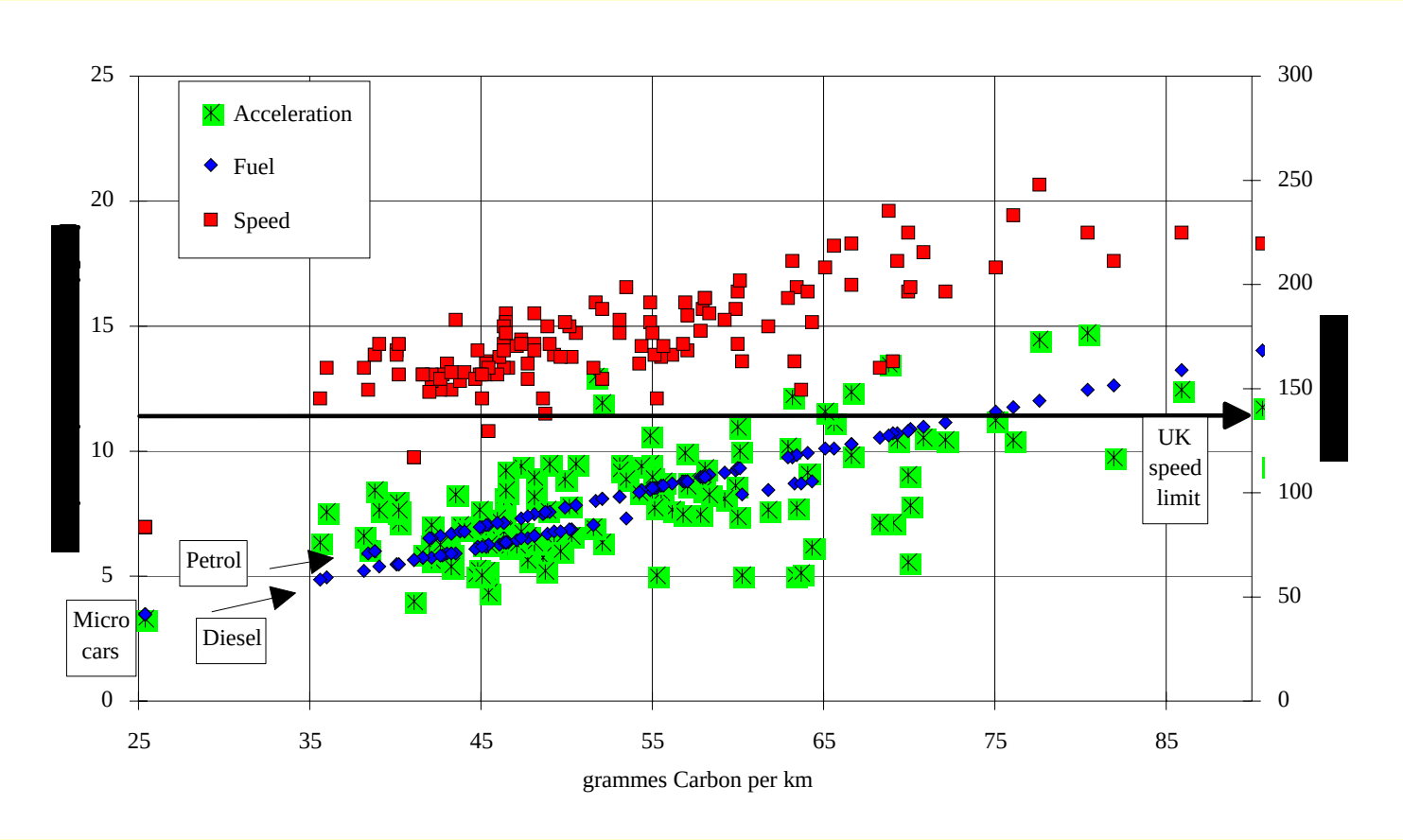
Demand management and modal shift can produce a large reduction in road traffic reduces congestion which gives benefits of less energy, pollution and travel time.



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

Passenger transport: carbon emission by car 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 about 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.

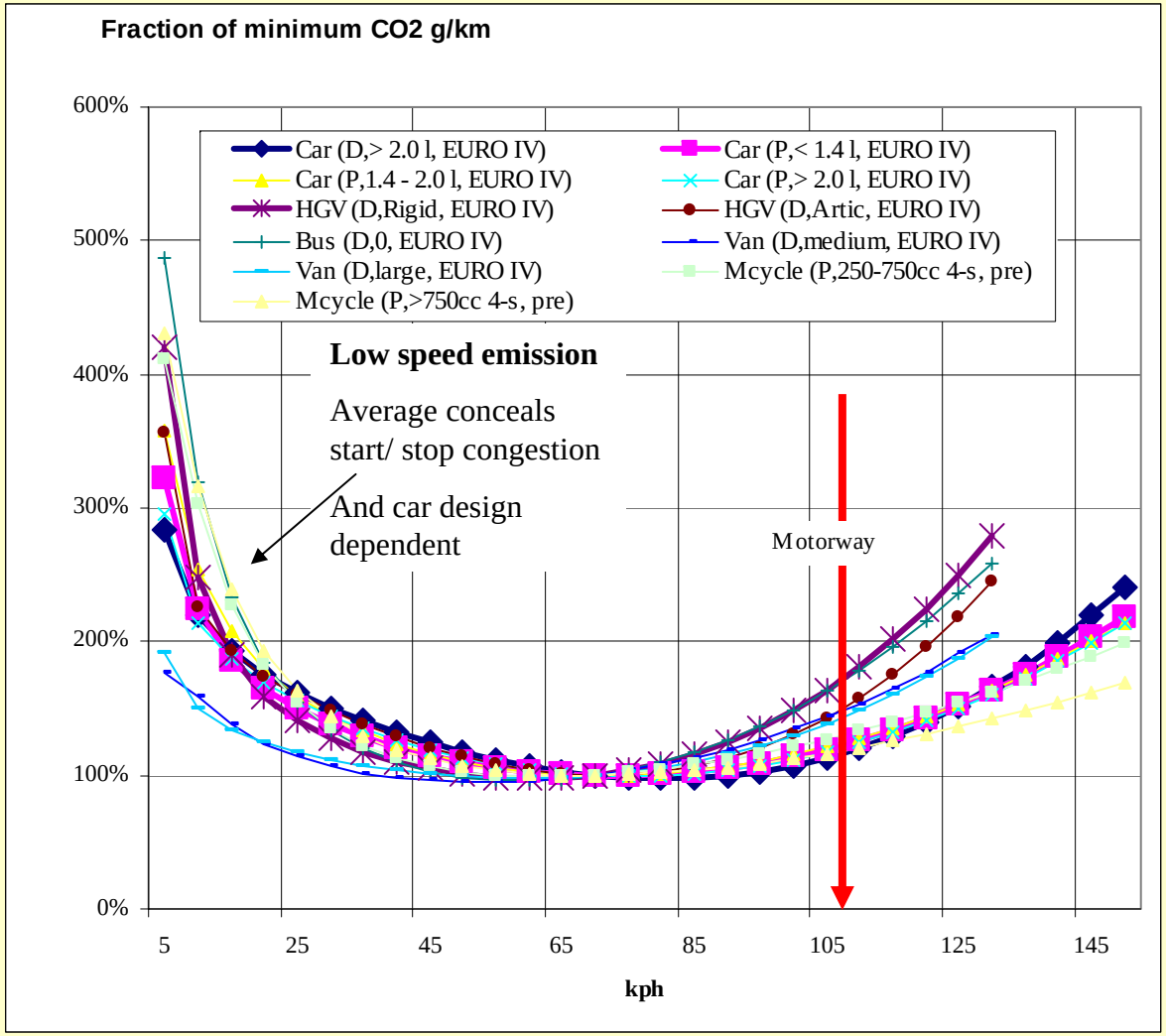


Transport: road speed and CO2 emission

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

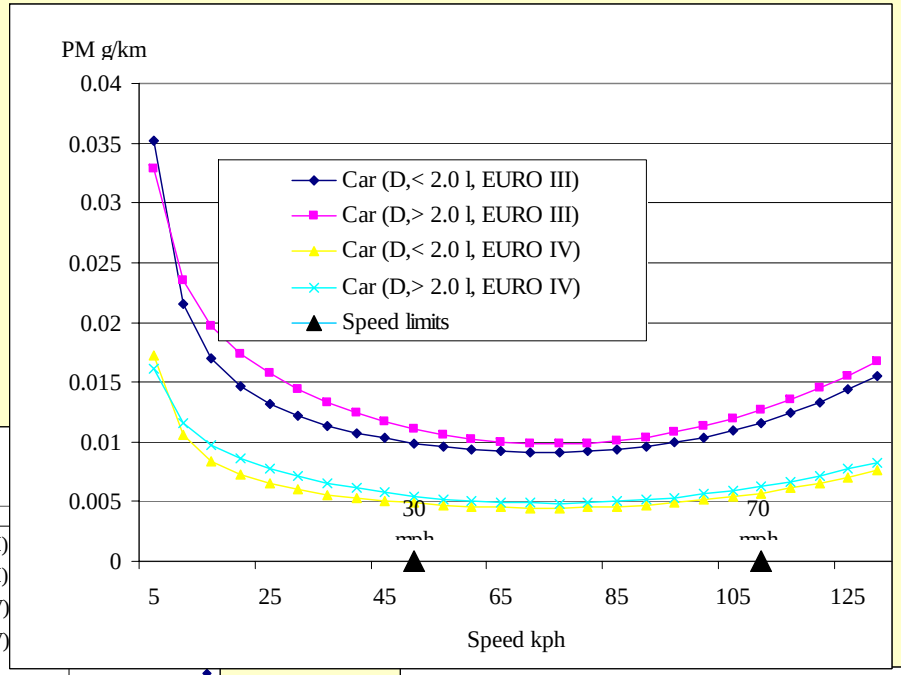
These curves are only applicable to current vehicles. The characteristics of future vehicles (e.g. urban internal combustion and electric powered) would be different. Minimum emission would probably be at a lower speed, and the fuel consumption and emissions at low speeds would not show the same increase.

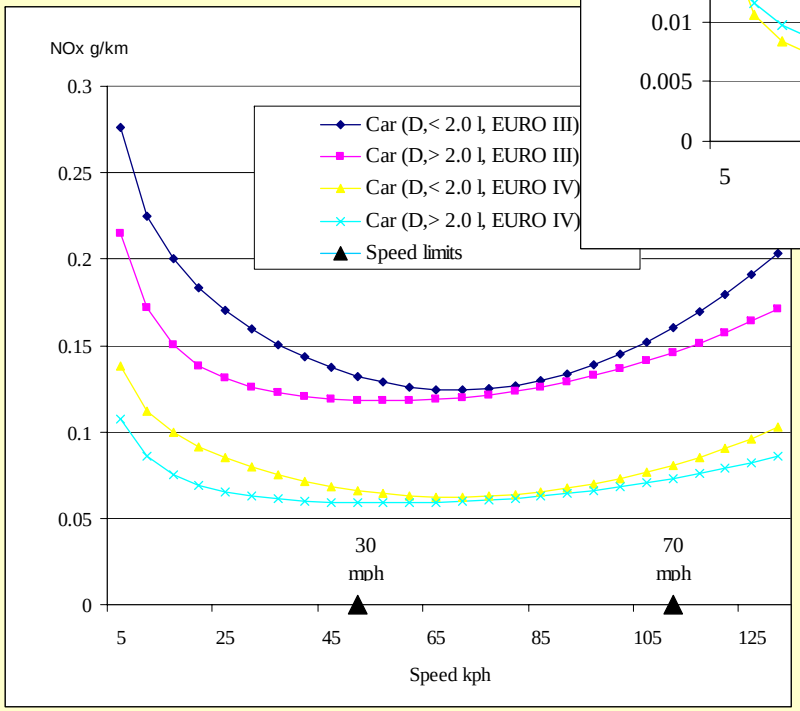
Potentially, the lowering of actual speeds on fast roads might reduce emissions on those roads by perhaps 10-20%.

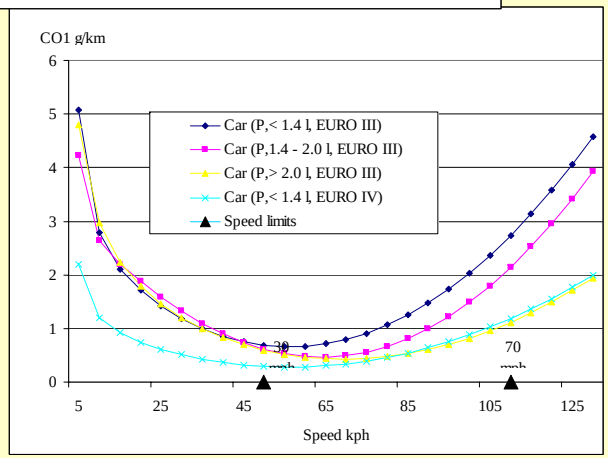


Transport: road speed and other emissions

The emissions of PM, NOx and carbon monoxide generally increase at higher speeds

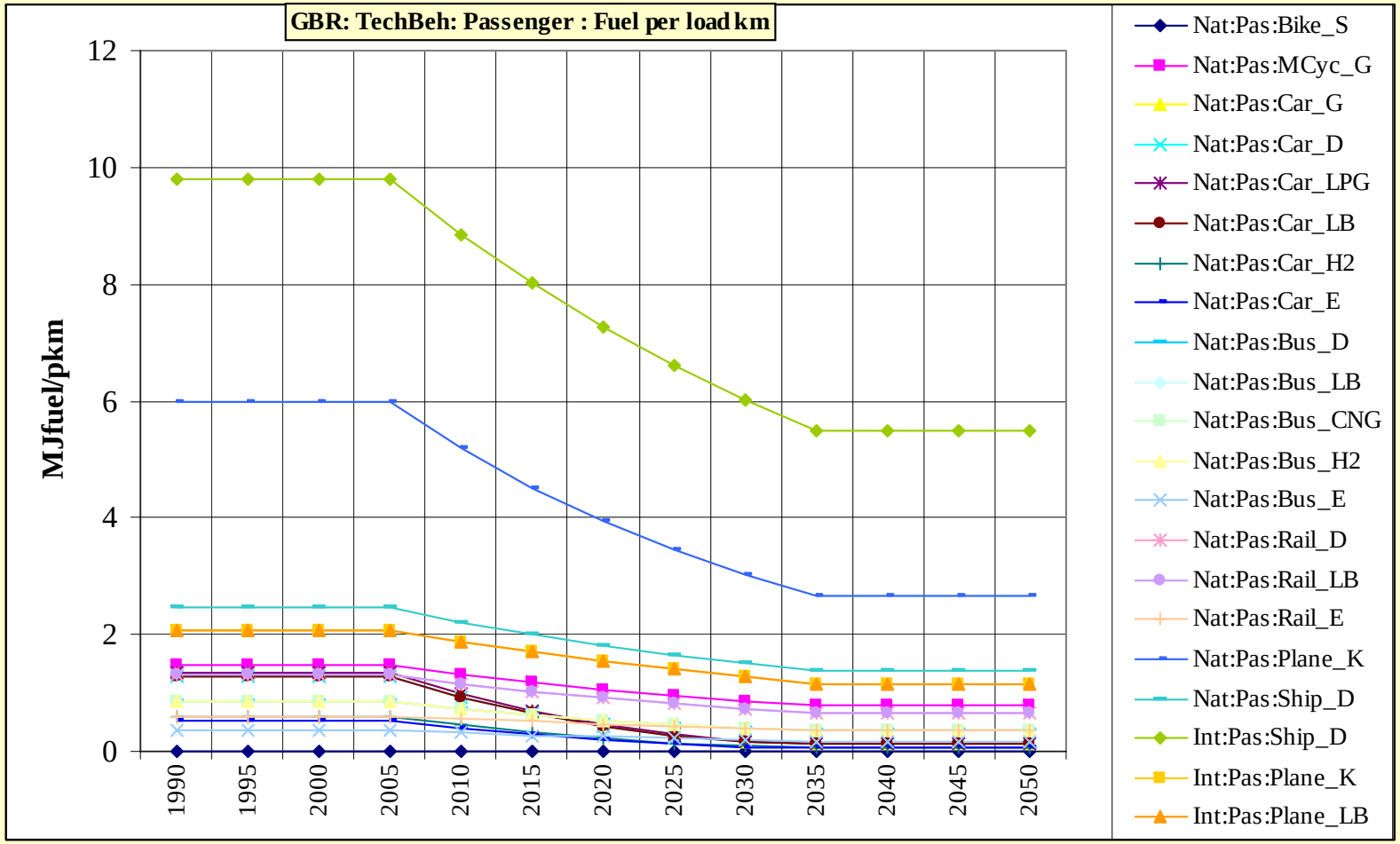






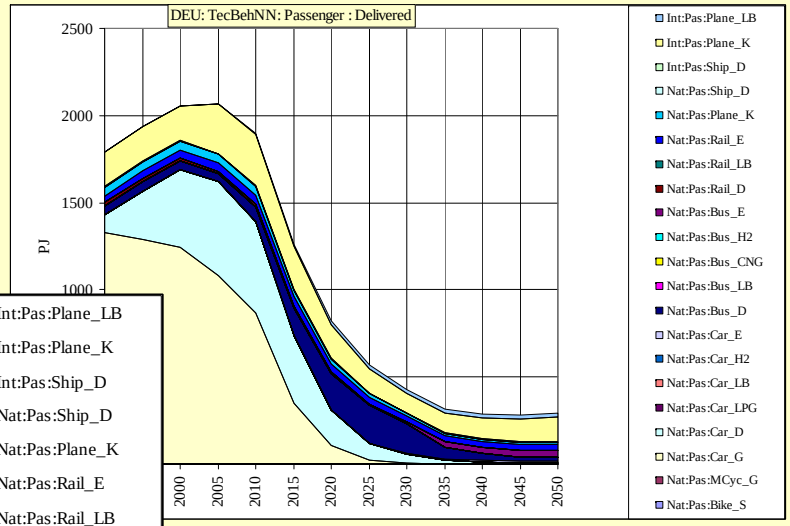
Transport: passenger: fuel per passenger km

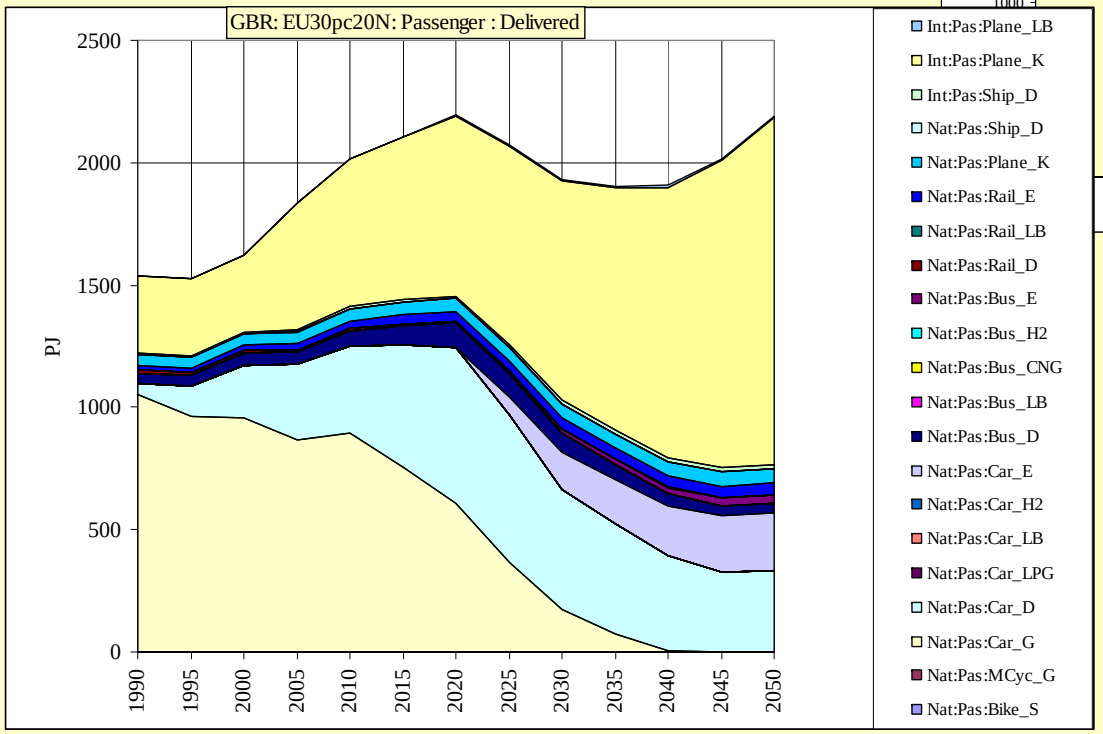
Reductions in fuel use because of technical improvement, better load factors, lower speeds, and less congestion.



Transport: passenger: delivered energy

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

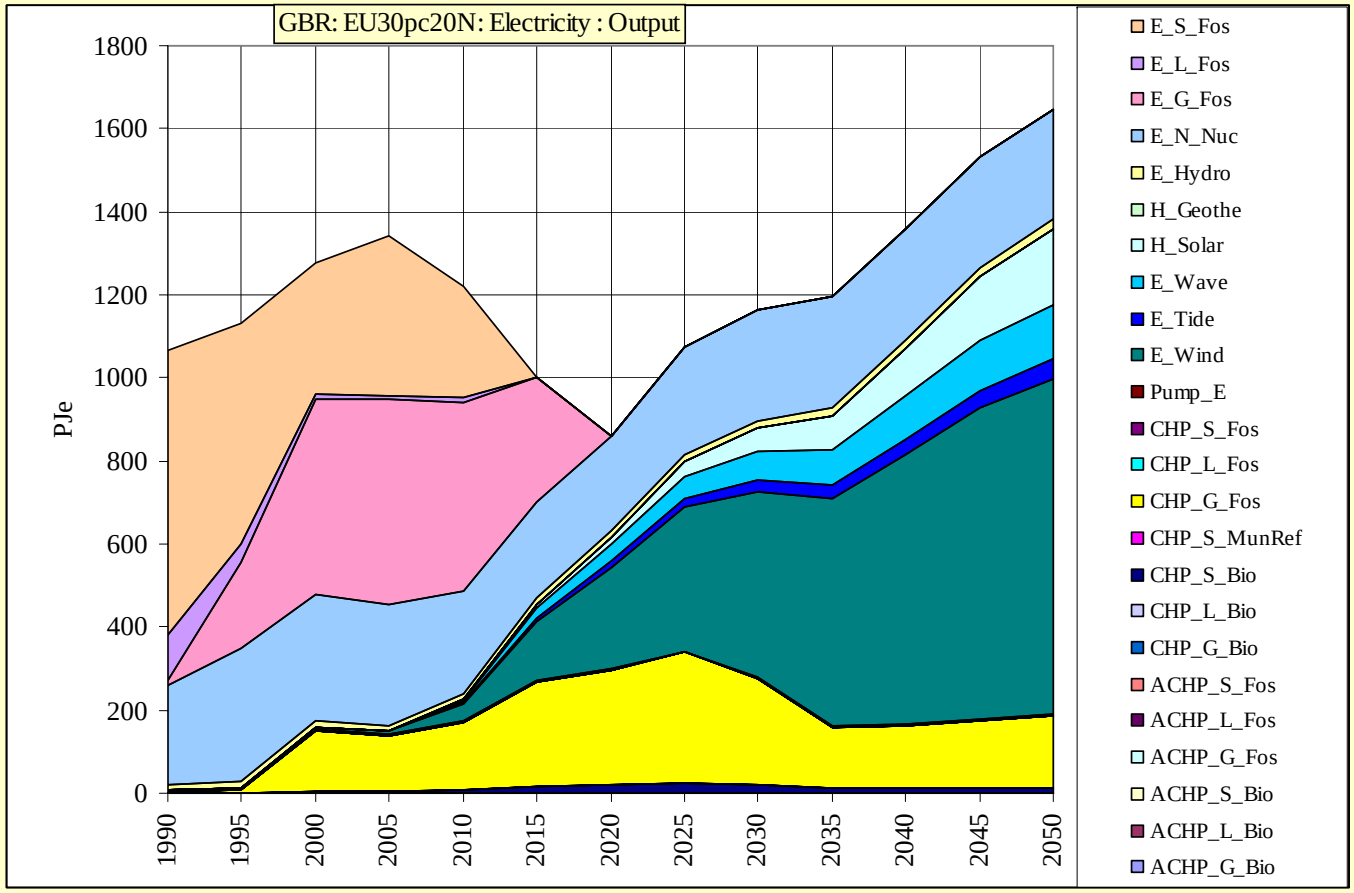




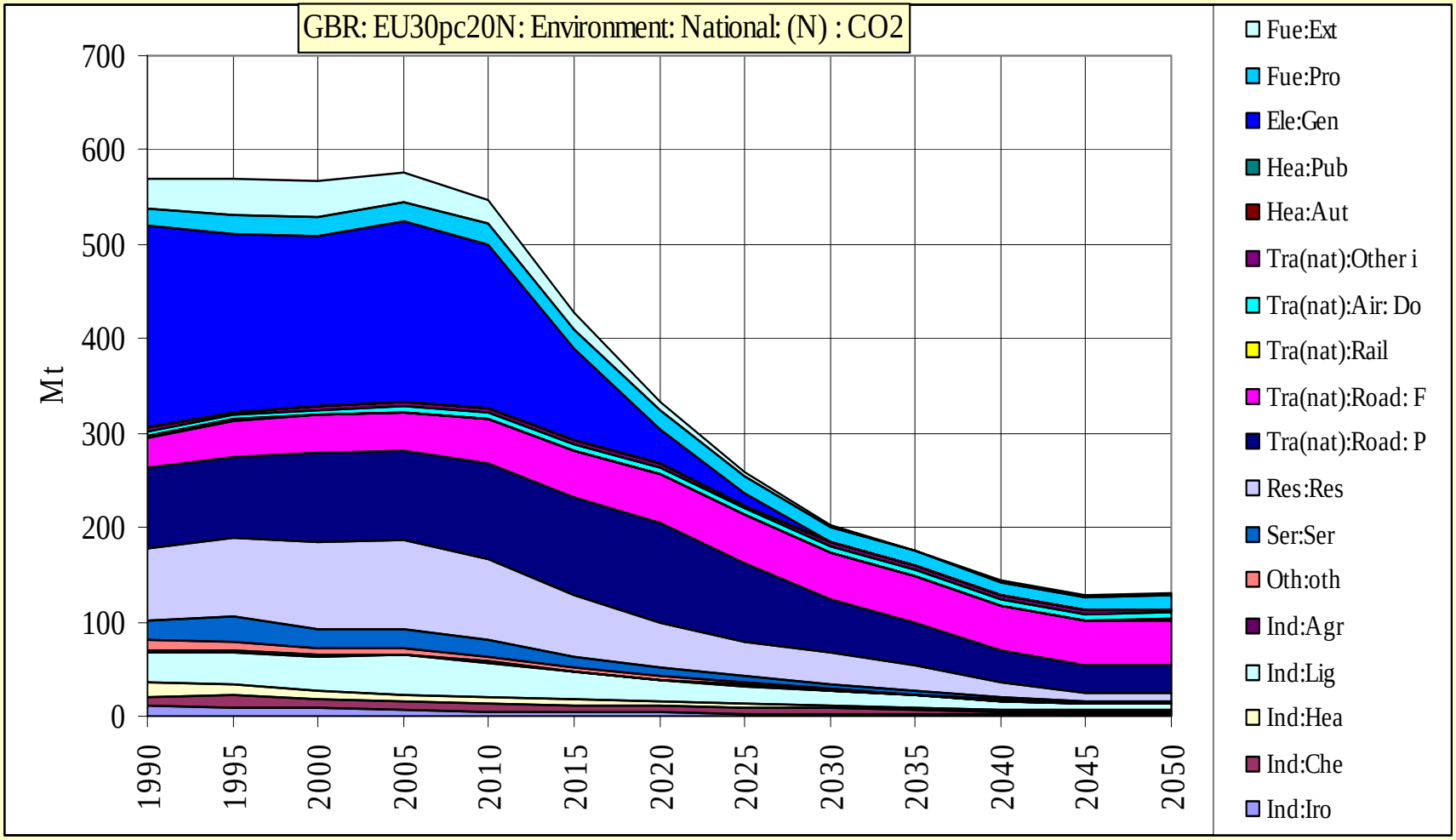
Sample output: UK scenario: electricity generation

Switch from electricity only fossil generation to:

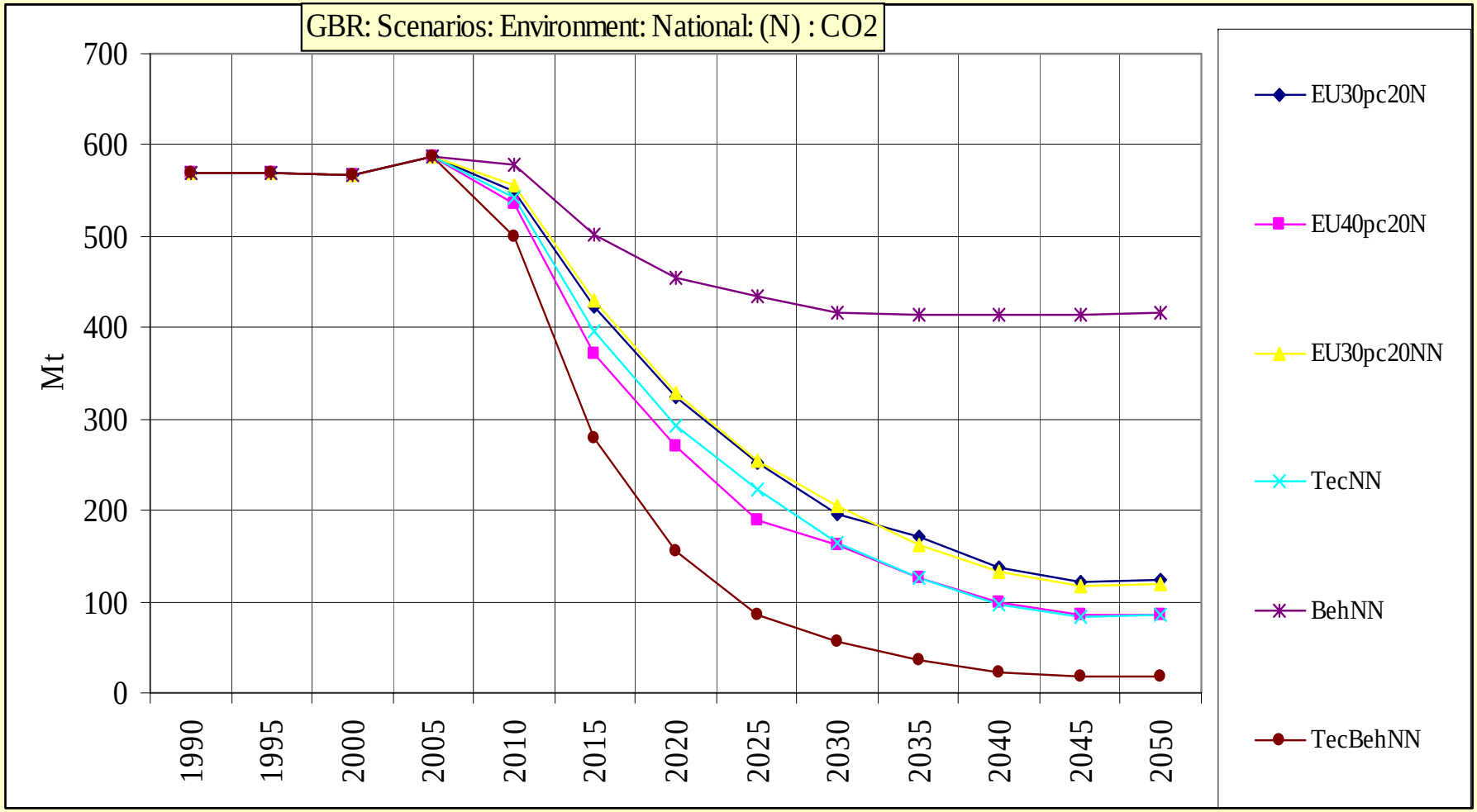
- Fossil CHP for medium term, and biomass CHP
- Renewable sources



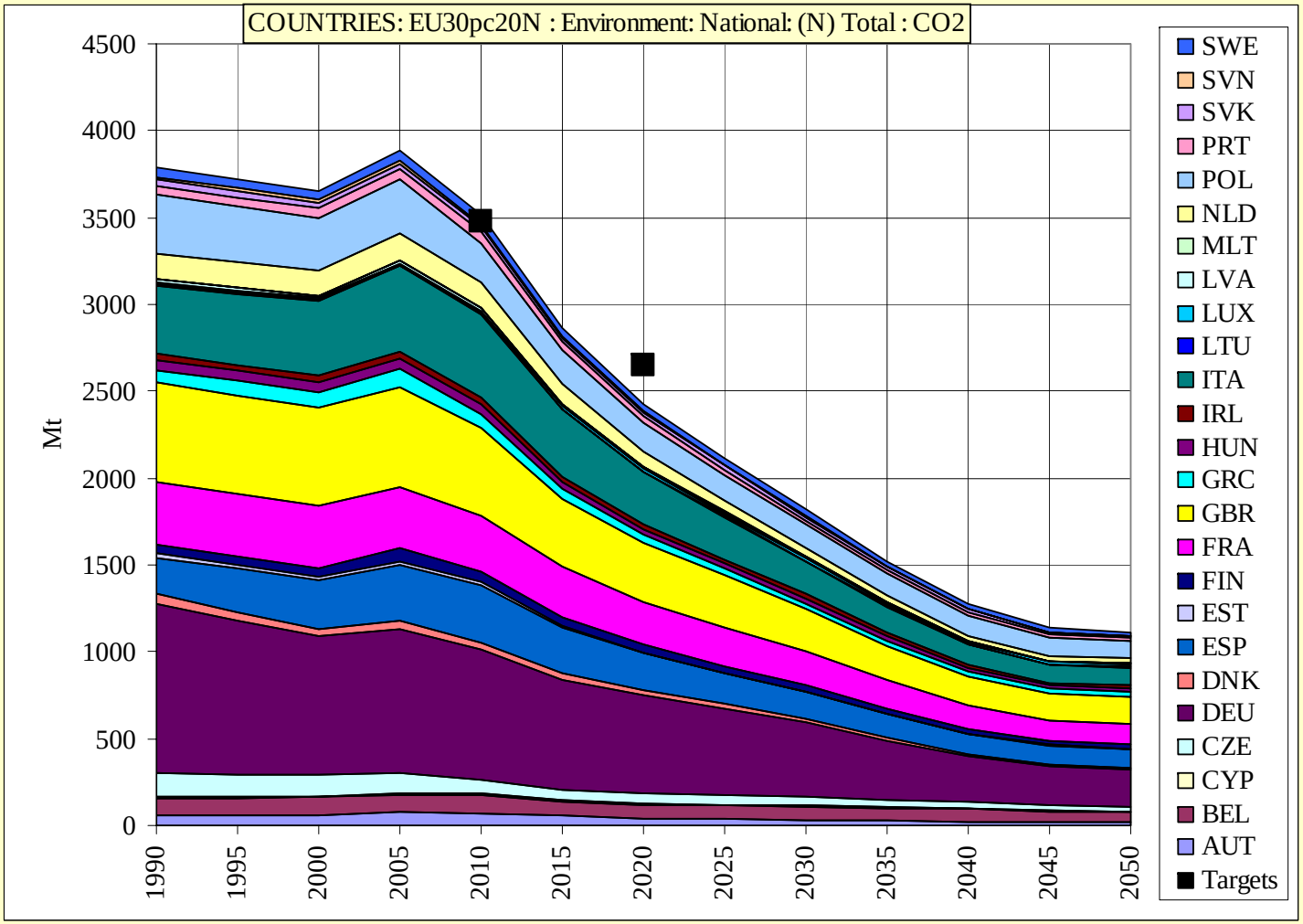
Sample output: UK scenario: CO2 excluding international transport



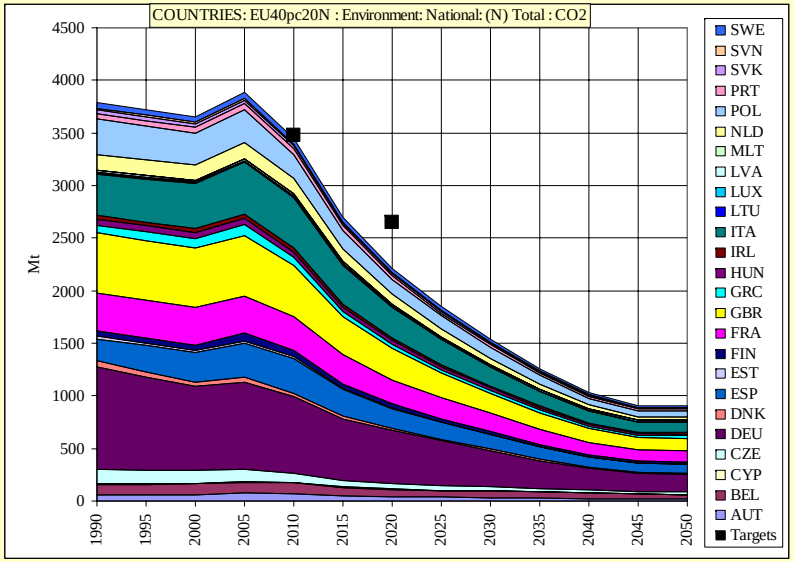
Sample output: UK CO2 by scenario

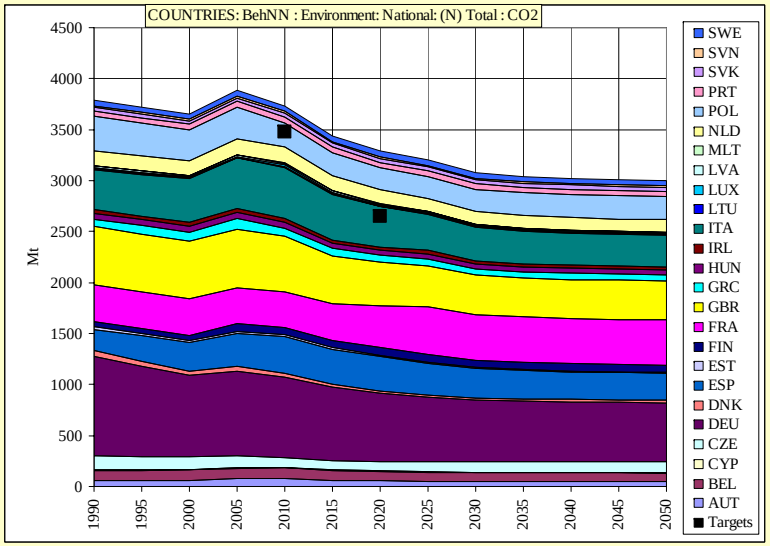


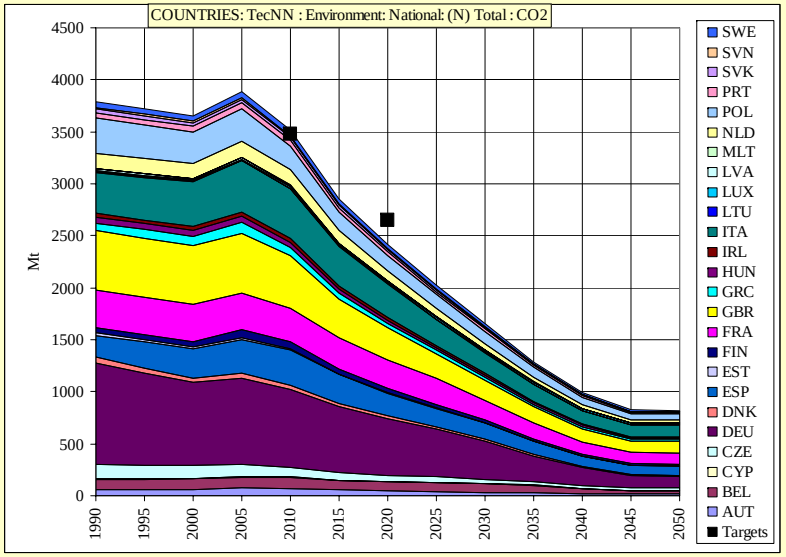
EU25 CO2 : EU30pc20N scenario

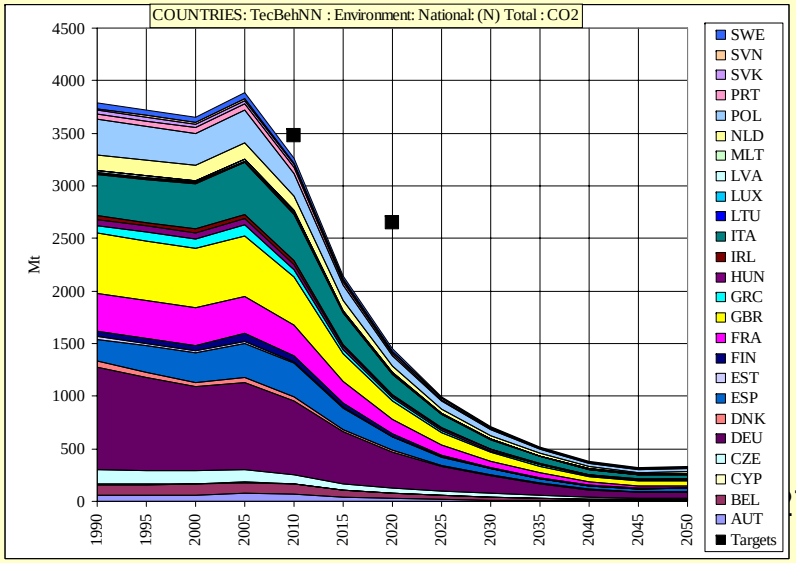


EU25 CO2 : variant scenarios

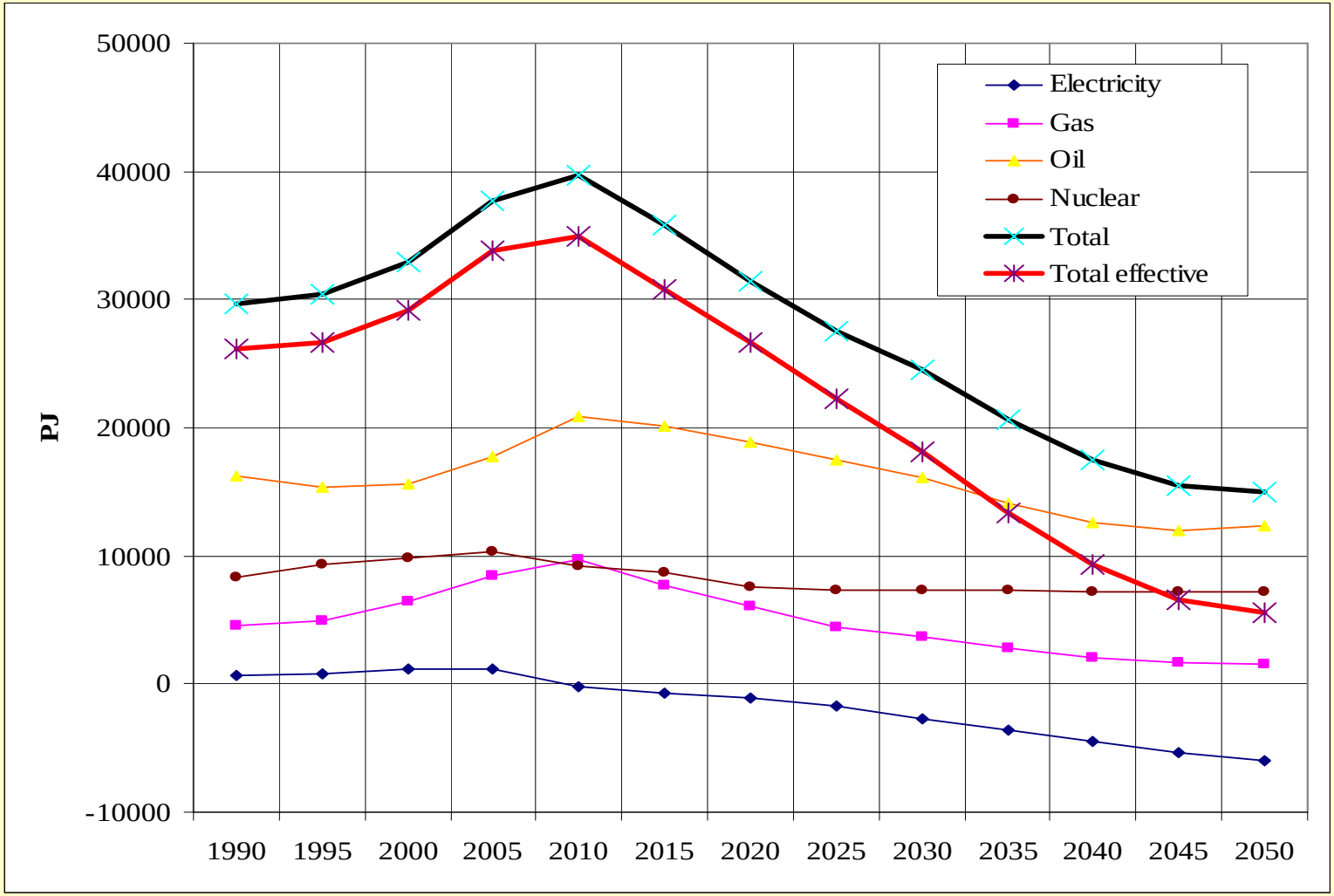






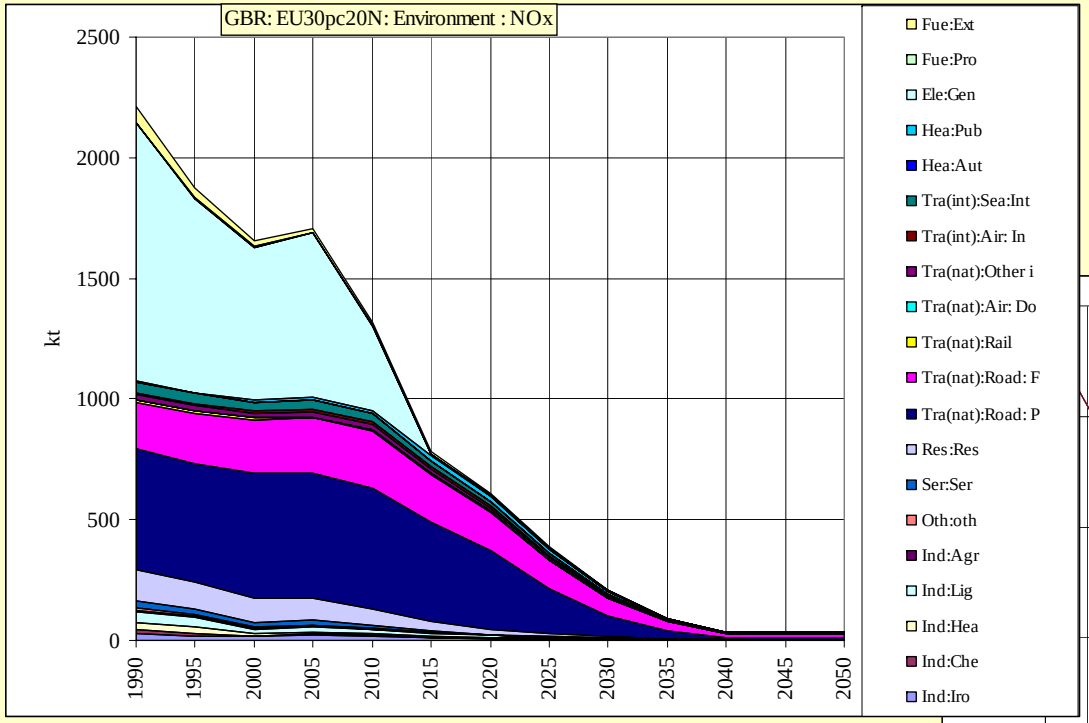


EU25 energy trade : including fuels for international transport
EU30pc20N scenario

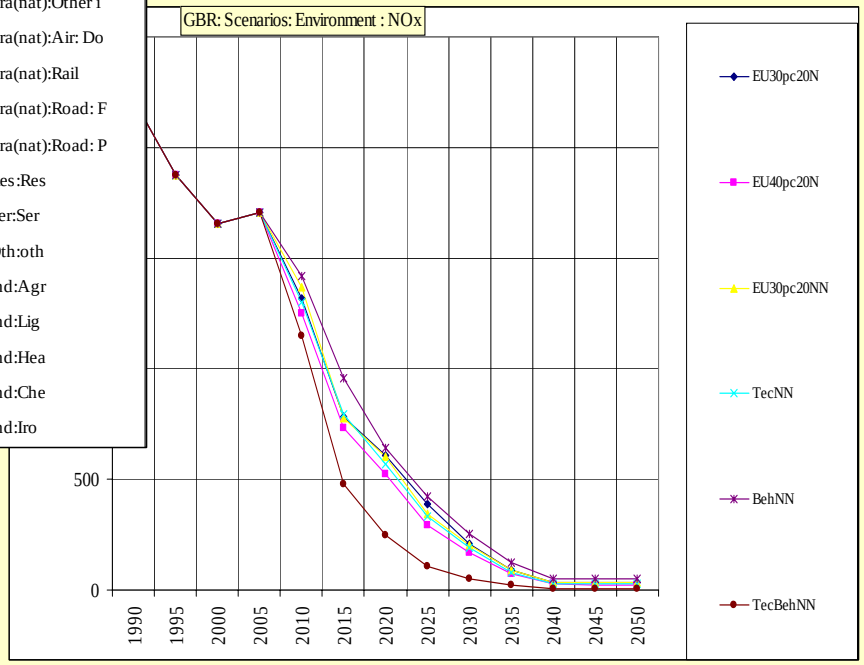


Sample output: UK NOx illustration only

SEEScen calculates SO2, NOx, CO but factors not validated yet



Less fossil fuel consumption,
less toxic air pollutant emission



Costs of scenario measures: illustrative

How will low carbon measures affect total costs?

- More spent on demand management and renewable capital costs
- Less spent on fuel because lower fuel consumption **and** lower fuel prices

SEEScen calculates:

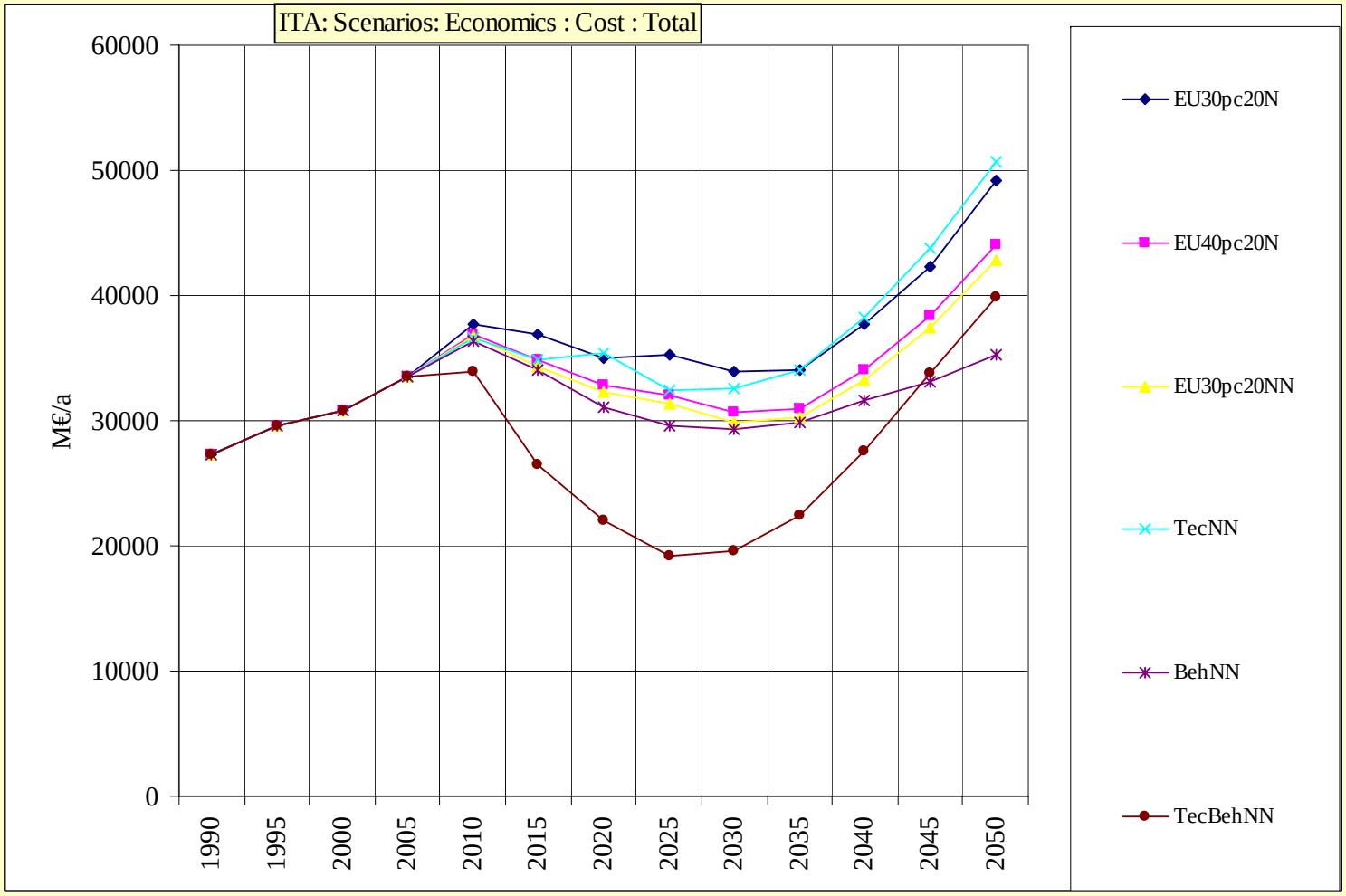
For all technologies (demand and supply)

- the annuitised capital costs
- Operation and maintenance costs

- Fuel costs

Total cost by scenario: illustrative

Possible that some low carbon scenarios will cost less than high carbon scenarios; and more economic stability because less dependence on fluctuating fossil fuel prices.



The main findings

- Large CO_2 reductions possible
- Date and rate of introduction of NEOP measures critical

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

- 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

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

Policy

- Energy security is a large driver of energy policy.
- Rate of introduction of measures is important.

- How to implement NEOP options in each sector, especially behavioural?
  - Fuel efficient design and use of cars
  - Freight transport demand
  - Air transport demand
- Retrofit of demand management and energy efficiency to buildings

Issues arising

Scope and framework

- International aviation and shipping should be included in inventories because their emissions will become very large fraction of total

- Better detailing of technology needs and priorities (e.g. solar PV)
- Further exploration of how to replace fossil liquid fuels with synthetic fuels or electricity

Data where were we in 2004?

A critical need is for accessible, comprehensive and consistent data across the EU25 so that energy demand, demand management and renewable supply can be analysed and modelled. If the starting point is unknown, even more so the future.

For example;

- Behavioural information – temperatures in buildings, driving speeds.
- Details of building stocks and energy efficiency levels
- Details of the demand structure of passenger and freight transport
- Breakdown of industrial demand by end use
- Current efficiency of end-use appliances, boilers, etc
- Information about the potential supply and costs from all renewables

SEEScen contains a comprehensive **energy technology database** of

– the energy performance, emissions and costs of technologies for demand management, conversion and supply

This might be improved with projections of technological development

Modelling and data issues

Modelling

- Development of energy supply allocation algorithms
- Integration with Large Point Sources data and modelling
- System dynamics
- International trade and integrated strategy

Economic aspects

- Better estimation of net additional cost of low carbon scenarios
- Modelling of interaction between fossil fuel consumption, imports and fuel prices

Europe and western Asia – large point sources

The environmental impact of energy is a global issue: what is the best strategy for reducing emissions within a larger region?

InterEnergy – trade optimisation animated

This shows InterEnergy seeking a least cost solution.

It illustrates how patterns of electricity flow might change.

Unlike VarInt this model accounts for transmission constraints.

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