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## ENERGY AND ELECTRICITY MODELS APPLIED TO THE UK

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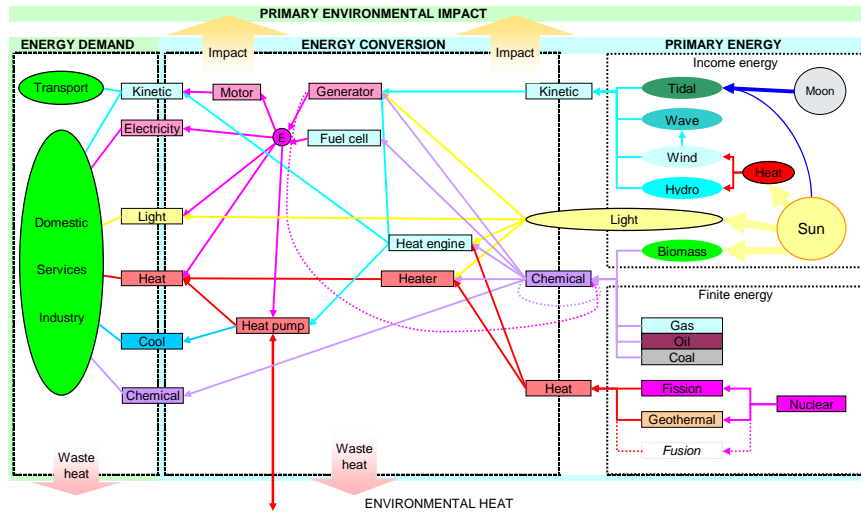
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### Modelling aims

- To identify energy and environment strategies that meet energy needs with safe, sustainable energy systems having limited environmental impact, and that are technically feasible and economically viable
- To investigate four classes of policy option:
  - **Lifestyle:** smaller cars, less air travel...
  - **Demand management:** insulation, ventilation control, recycling, appliances...
  - **Energy efficient conversion:** diesel engines, cogeneration...
  - **Fuel switching:** low/zero emission renewable and other sources
- To investigate temporal and spatial aspects of energy demand and supply, within the UK and at the international scale

## The energy system

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## Models presented

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Description and sample outputs are presented for the following models:

- **SEEScen:** Society, Energy and Environment Scenario model
- **EleServe:** Electricity system model
- **EST:** Energy Space Time model
- **InterEnergy:** Energy trade model

**Note:** some energy and socioeconomic data used are old

## SEEScen: Society, Energy, Environment Scenario model

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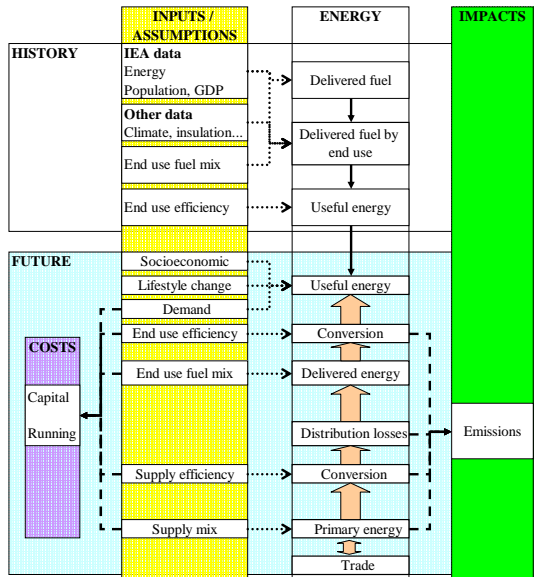
Applicable to any large country having IEA energy statistics

### Method

- Simulates system over years, or hours
- Optimisation under development

### Scenarios

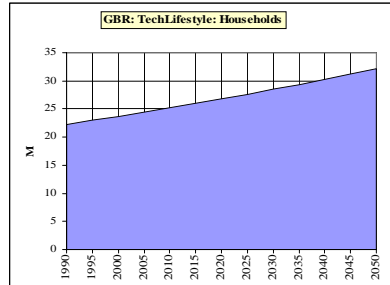
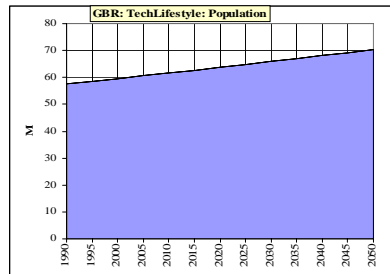
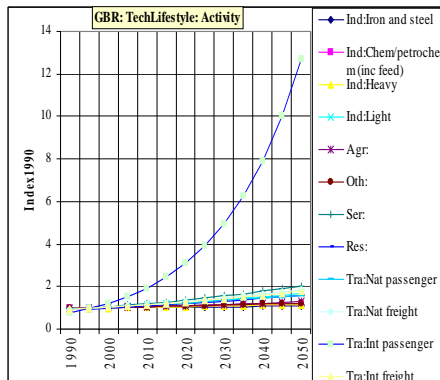
- Base/Kyoto
- Carbon15
- LifeStyle
- Tech High
- Tech Lifestyle



## Demand drivers

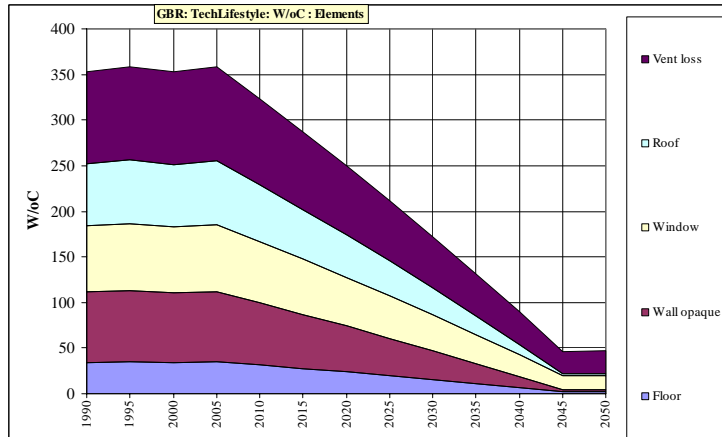
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- Human needs: food, comfort, hygiene, health, culture
- Population and households
- Wealth
- Consumption pattern: choices of expenditure on goods and services

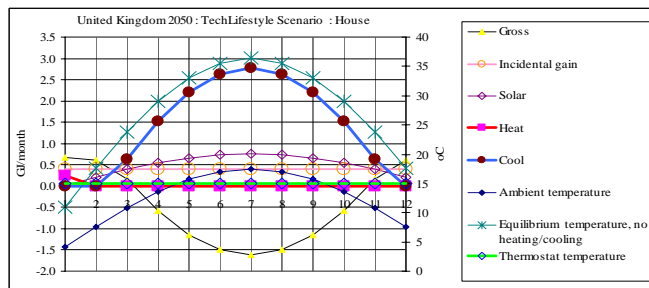
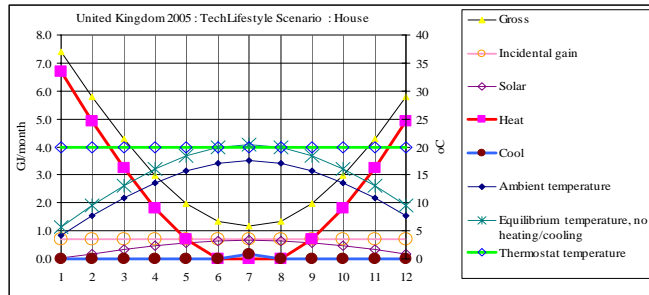


## Demand management - House: specific heat losses of elements

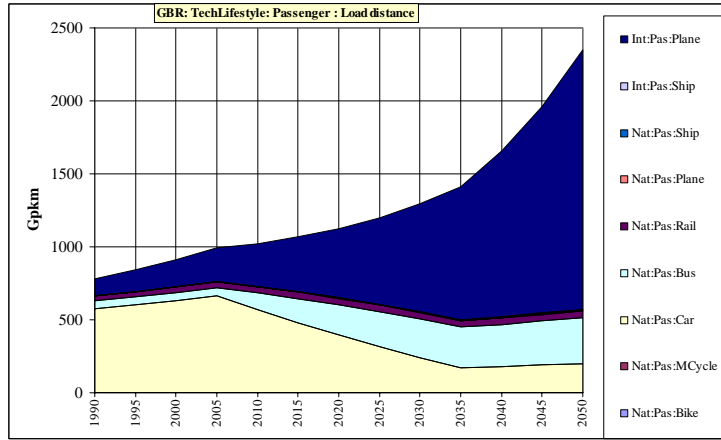
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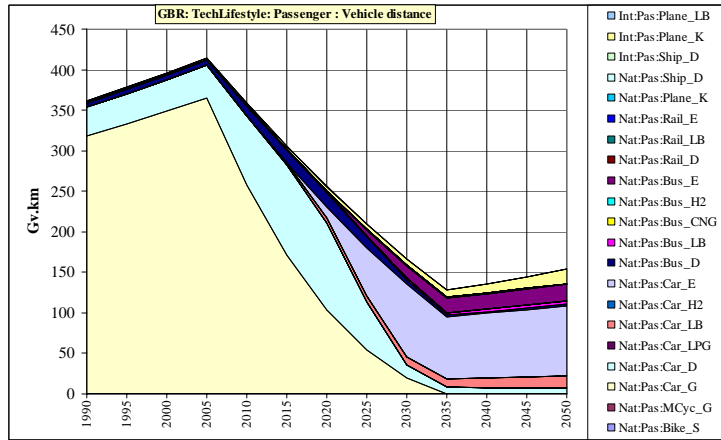
## House energy



Transport: passenger load distance

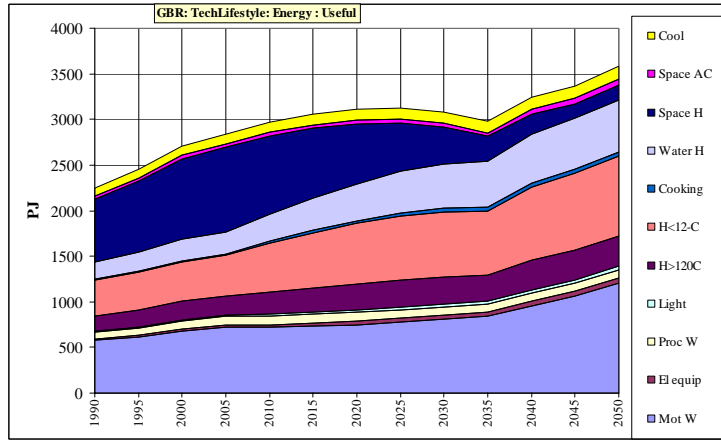


Transport: vehicle distance



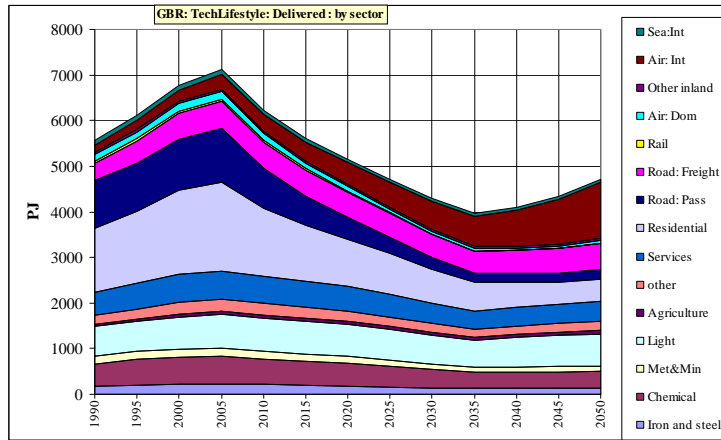
Useful energy

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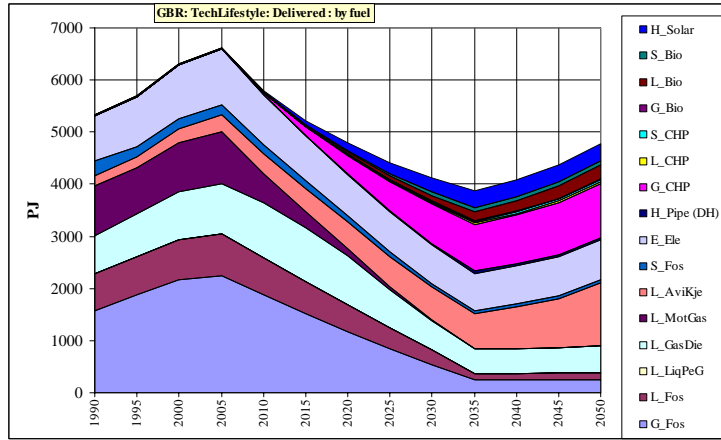


Energy: delivered by sector

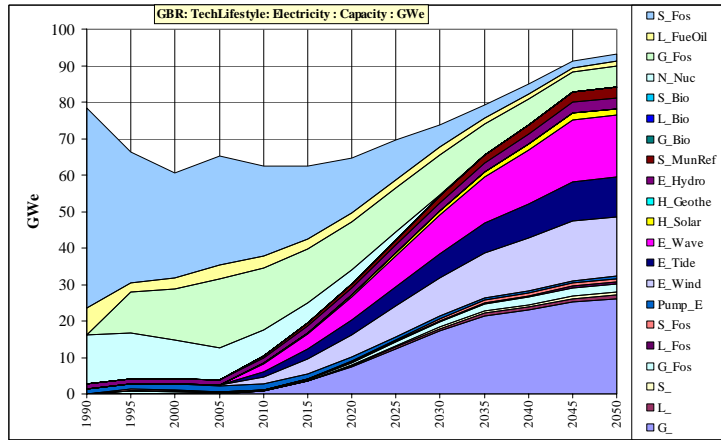
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Energy: delivered by fuel

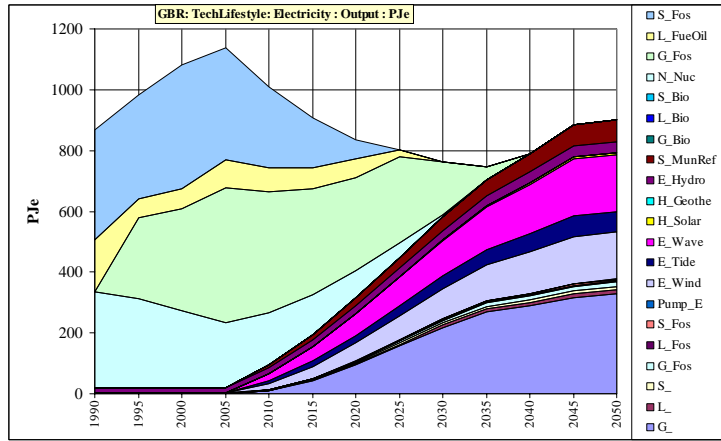


Electricity: generating capacity



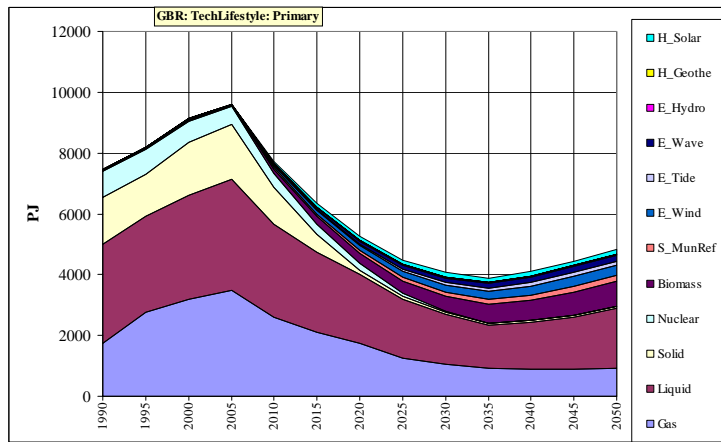
### Electricity: generation

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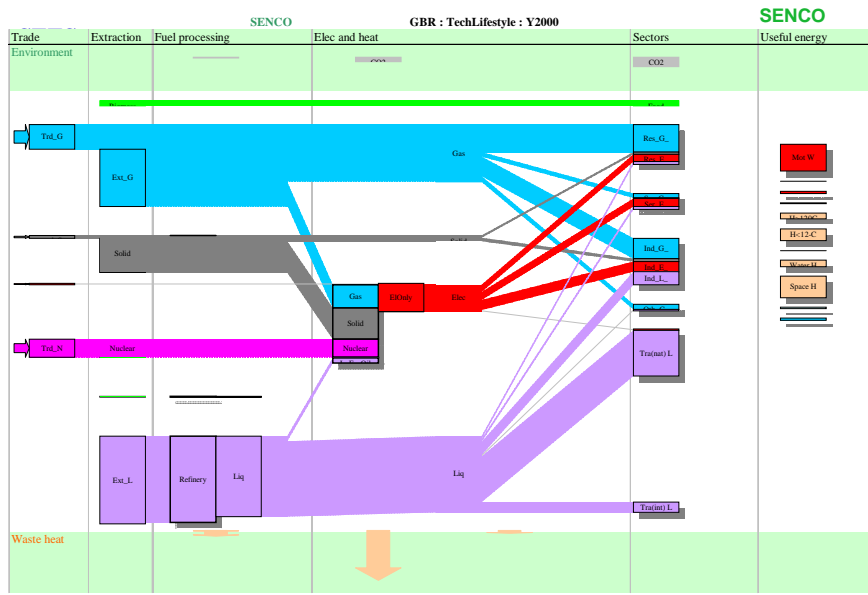
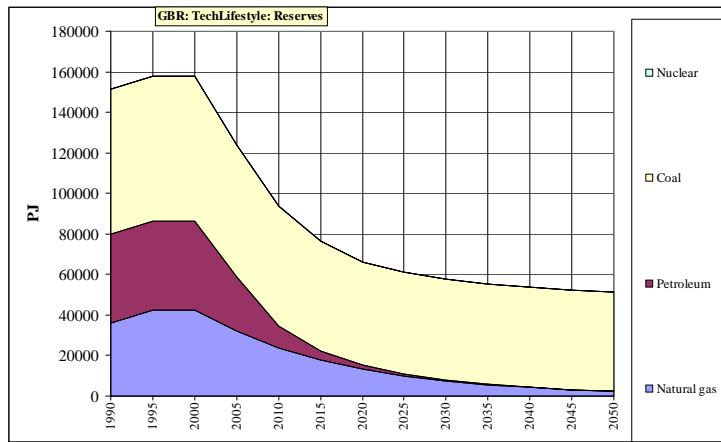
### Energy: primary

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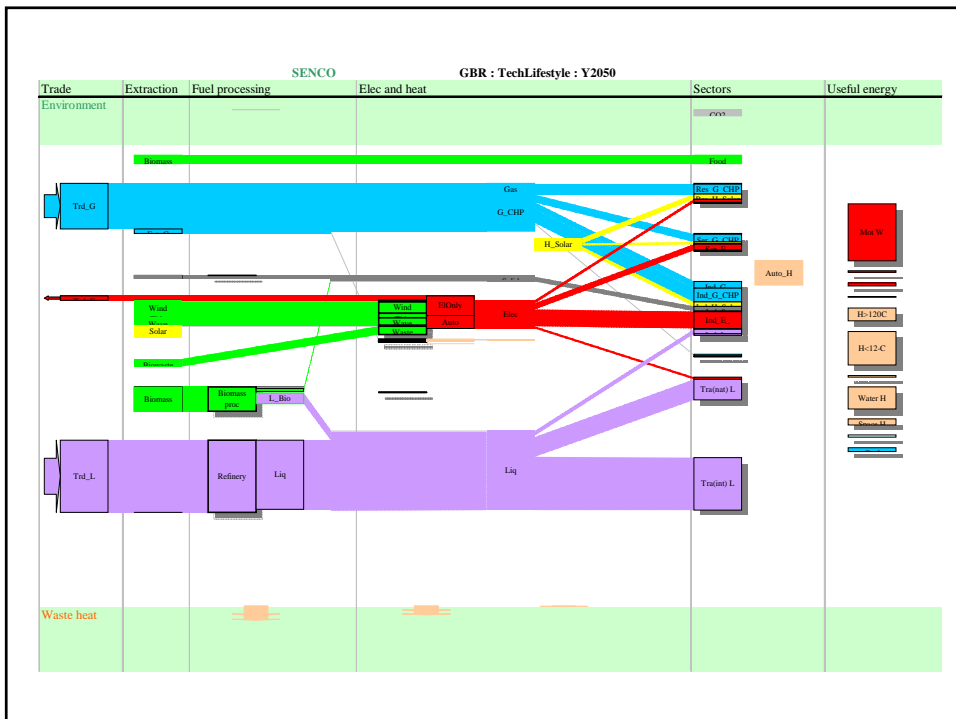
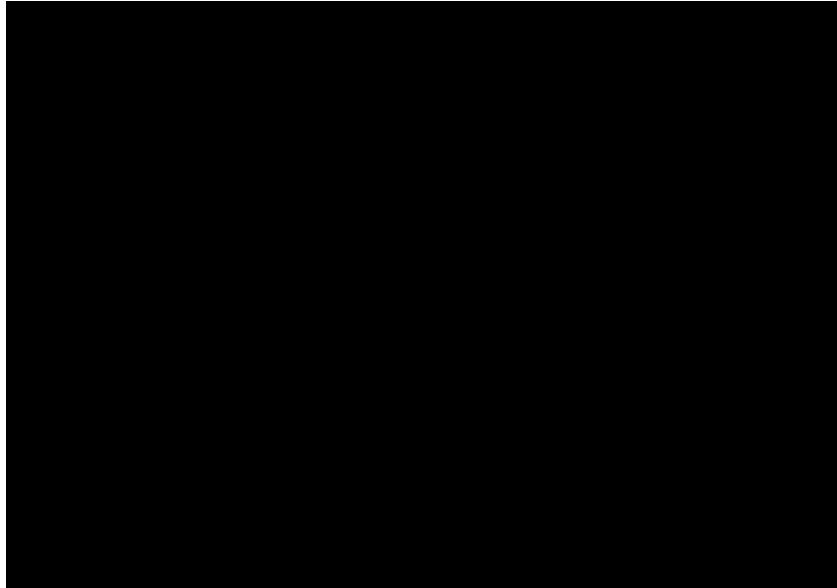


## Energy: fuel reserves

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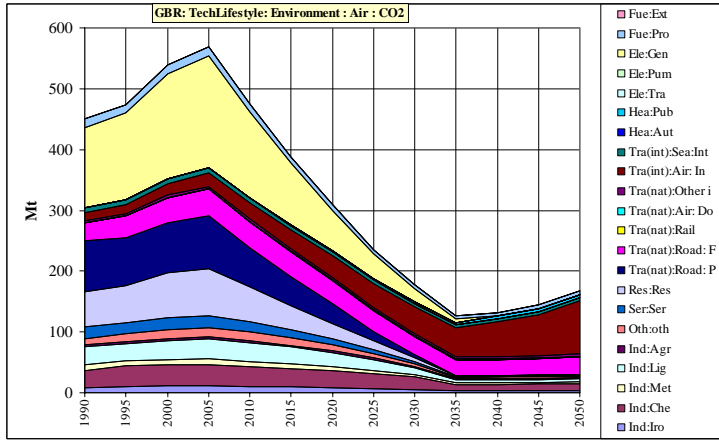


SEEScen : animated flow chart



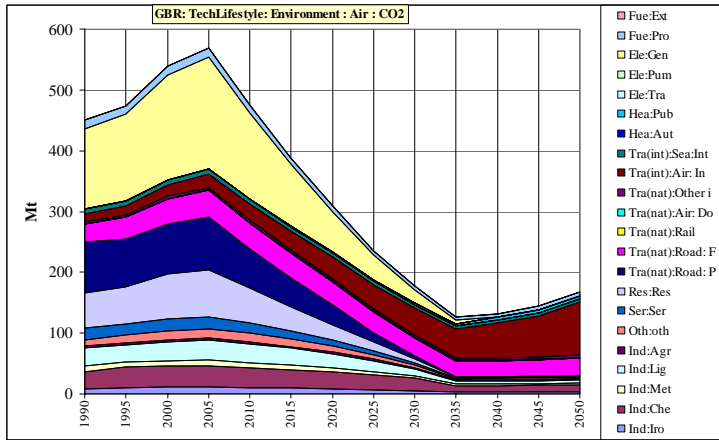
Environment: CO2 emission

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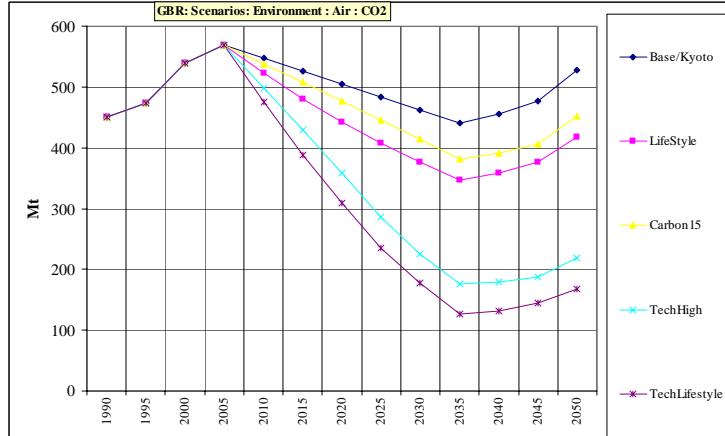


Environment: CO2 emission

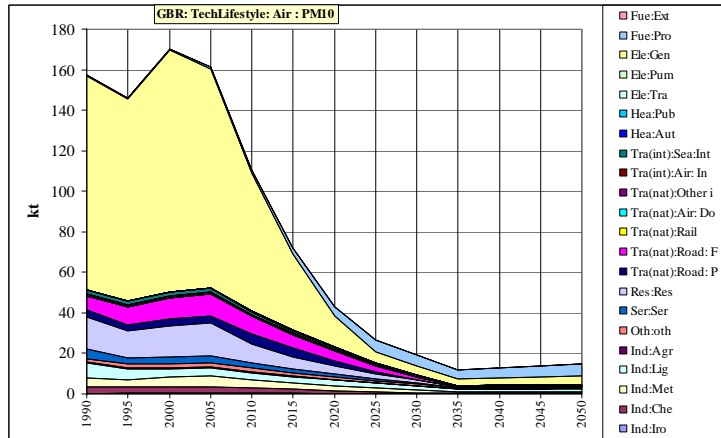
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Environment: CO2 emission by scenario

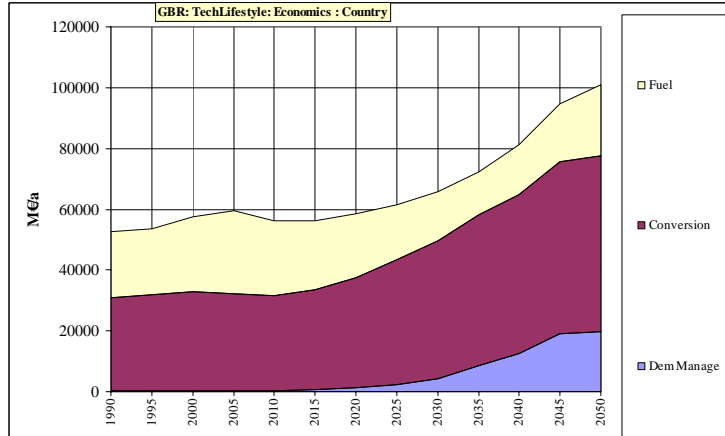


Environment: particulate emission



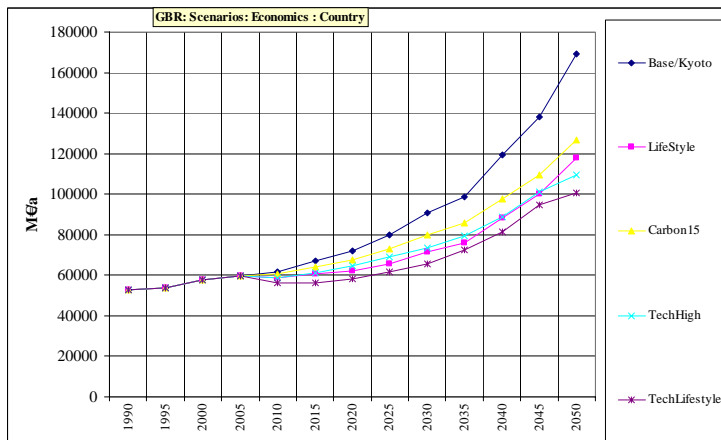
**Economics: annual costs of fuel, conversion and demand management**

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**Economics: total cost by scenario**

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### SEEScen results and model: some conclusions

- **Transport** the most difficult sector to control, because
  - growth, especially aviation
  - demand management and efficiency options limited
  - lack of alternatives to liquid fuels
- **Economics.** The total cost of energy services may be less in low emission scenarios because of the cost effectiveness of demand management and efficiency as compared to supply
- **Energy use and emissions increase** when presumed growth overtakes implementation of current technology options
- **Lifestyle** and consumption choices will be critical unless radical developments in renewable energy

SEEScen requires development:

- More recent data
- Fuel mix allocation
- Optimisation

### Systems aspects: space and time

SEEScen has a main focus on annual flows, although it can simulate seasonal and hourly flows.

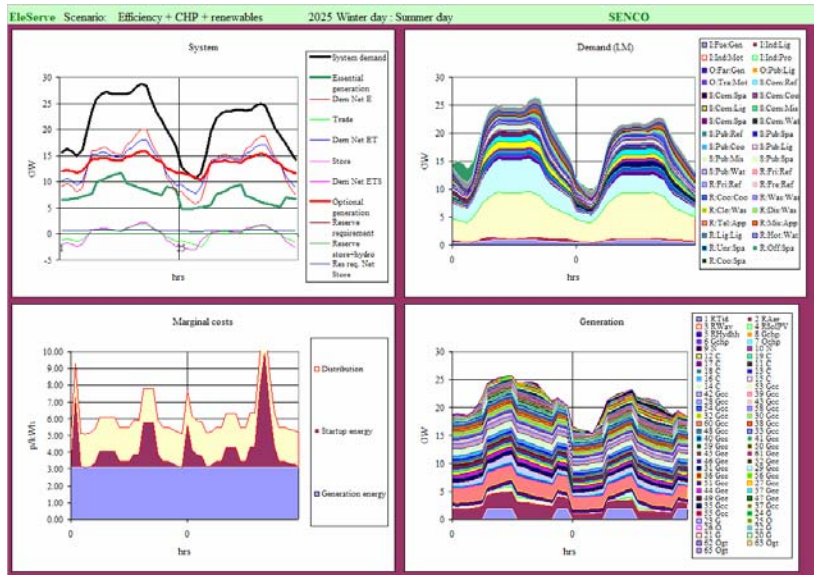
Other models are required to analyse issues arising with short term variations in demand and supply, and with the spatial location of demands and supplies.

- **EleServe** : Electricity system model for temporal analysis
- **EST** Energy Space Time model
- **InterEnergy** Energy trade model

**EleServe : Electricity Services model**

- **Electricity demand**
  - disaggregated into segments across sectors and end uses
  - each segment with
    - a temporal profile
    - load management characteristics
- **Electricity supply**
  - each renewable source with own temporal profile
  - heat related generation with its own temporal profile
  - optional thermal generators characterised by energy costs at full and part load, and for starting up
- **Operational control**
  - load management by moving demands if cost reduced
  - optional units brought on line to minimise diurnal costs

**EleServe : diurnal operation without load management**





### EleServe electricity model

- Demonstrates the importance of demand patterns and technologies in strategies for integrating variable electricity sources
- Indicates that high fractions of variable sources can be accommodated without substantial back-up capacity

Further work required:

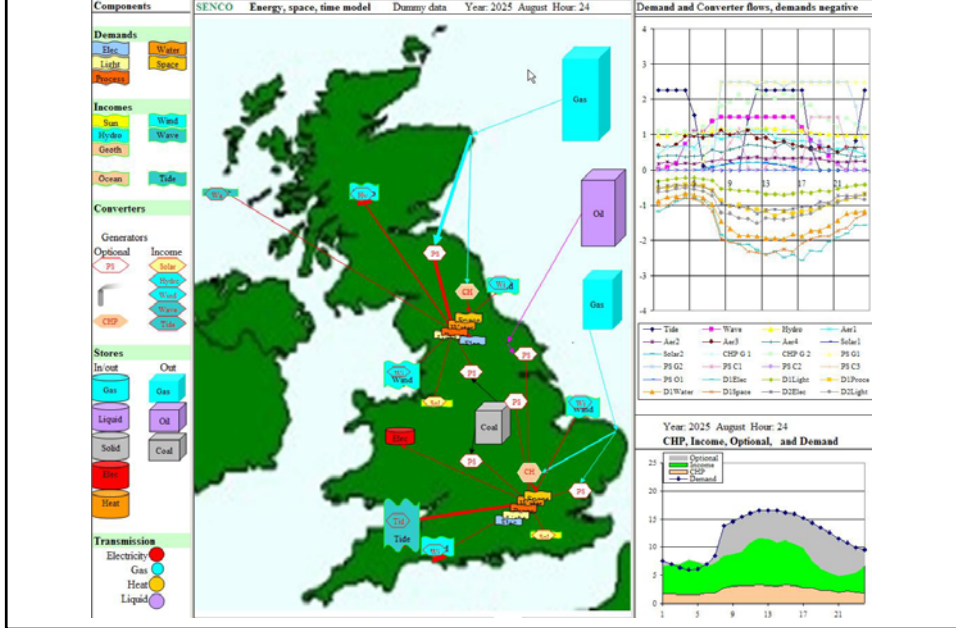
- data on current and future demand technologies
- feasibility of integrated control of demand and supply technologies
- more refined optimisation

### Energy, space, time: EST and InterTrade

- Models to assess potential effects of integrating spatially separate demands and sources, each with different temporal characteristics
- What is the least cost solution?
  - What is the best balance between local supply and long distance transmission for temporally variable demand and energy sources?
  - What is the best combination of demand management, variable supply, optional or back up generation and system or local storage?

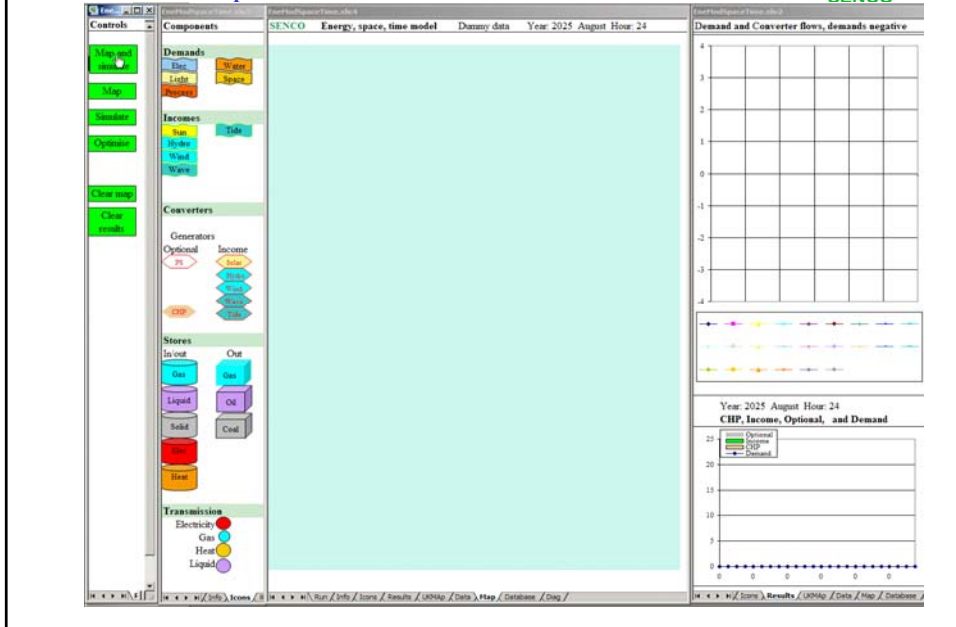
### EST: Energy, time and space

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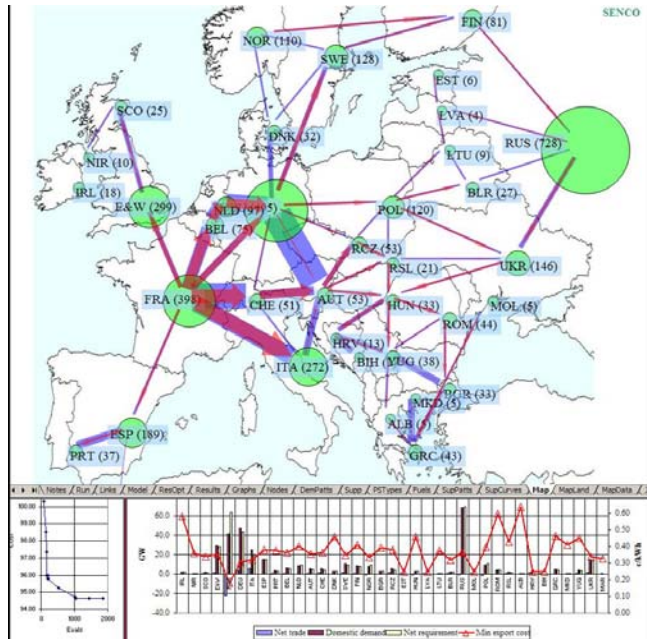
### UK – time and space

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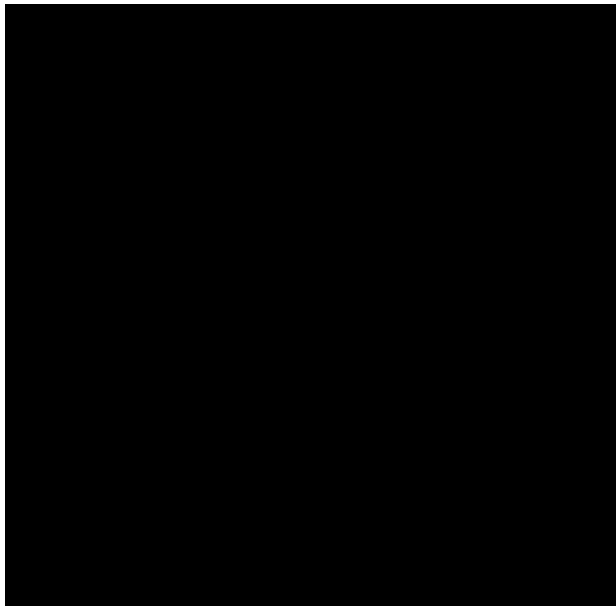
## InterEnergy – trade

- Trade of energy over links of finite capacity
- Time varying demands and supply
- Minimise avoidable marginal cost
- Marginal cost curves for supply generated by model such as EleServe



## InterEnergy – trade

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### Europe and western Asia – large point sources

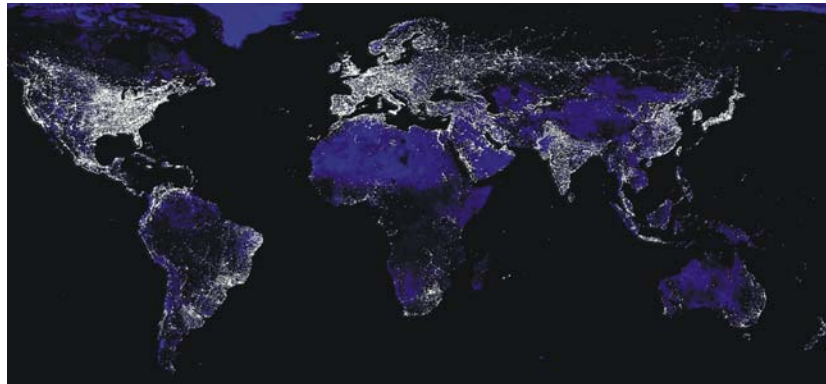
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What is the best regional strategy for reducing emissions from these sources?

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- Regular diurnal and seasonal variations in demands
- Regular diurnal and seasonal incomes of solar energy
- Predictable tidal energy income

World

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- What is optimum balance between supply, transmission and storage?
- Which investments are most cost efficient in reducing GHG emission? Should the UK invest in photovoltaic systems in Africa, rather than the UK? This could be done through the Clean Development Mechanism