



## **MARKAL Macro analysis of long run costs of mitigation targets**

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### **Presentation overview**

- UK MARKAL modelling
- Recent energy policy developments in the UK
- Carbon mitigation targets under the Climate Change Bill
- Summary results
- Conclusions
- Model limitations, and further development

## UK MARKAL modelling

- Pre-2004 support provided by ETSU (now AEA)
- Establishment of UKERC in 2004
- Key programme of work to develop energy modelling capability, including MARKAL
- Programme led by **PSI** (KCL next year) – main development team
- Developing range of MARKAL models, including Macro version
  
- **AEA** in partnership across different projects
- Both organisations involved in supporting recent Government policy activities

## Recent energy policy developments in the UK

- **2003 Energy White Paper**
- Intervening period – increasing political attention, public interest
- **2006 Energy Review: Our Energy Challenge - Securing clean, affordable energy for the long-term**
  - Programme of work setting out the challenges relating to energy security issues (e.g. reducing indigenous resources, old power plant stock) and need for clean energy
  - Set of proposals for addressing some of these challenges

## Recent energy policy developments in the UK

- **2007 Energy White Paper: Meeting the energy challenge**
  - Actual measures introduced – with additional detail
  - Examples of measures include
    - review of planning framework
    - changes to renewable obligation
    - energy efficiency commitment
    - carbon reduction commitment
  - Future of nuclear still under consultation and review – after legal challenge
  - Significant amount of supporting analysis, including MARKAL Macro analysis to explore longer term techno-economic impacts
  - Energy Bill in 2008 to implement legislative requirements of EWP

## UK Climate Change Bill

- **2007 Climate Change Bill** – introduced on 14<sup>th</sup> November 2007
- Legislative framework for setting carbon reduction targets in future years
- Reduction of 60% by 2050 – based on previous analysis (RCEP 2000)
- Independent **Committee on Climate Change** (setting 5 yearly carbon budgets) will keep targets under review
- MARKAL analysis to assess 70-80% reductions relative to 2000 levels
- Focus of results presented

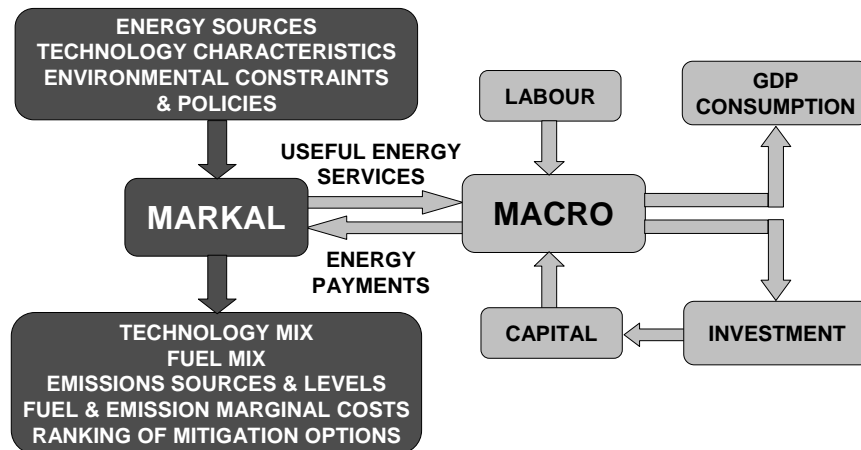
## UK model

- MARKAL / MARKAL-Macro versions
- Single region model
- 2000 base year
- 5 year time steps
  
- Updates since EWP 2003:
  - Resources supply curves
  - Enhanced process sector (refining)
  - Transport technologies
  - CCS
  - Plus full review of technology data

## UK model – why MARKAL-Macro?

- Part of PSI programme of work
- Government very interested in having detailed bottom up technology model that also gave some insights (albeit simple) on wider economic impacts
  
- Captures interplay between energy system and wider economy
- Maximises utility derived from consumption – but also minimising cost of energy system
- In doing this, considers trade-offs between payments for energy services with investment in capital and labour
- Useful outputs include levels of GDP, investment and consumption
  
- Also includes demand response feedback based on energy prices
- Single price elasticity of demand factor used – sub-sector level response depends on impact on growth, and alternative mitigation options

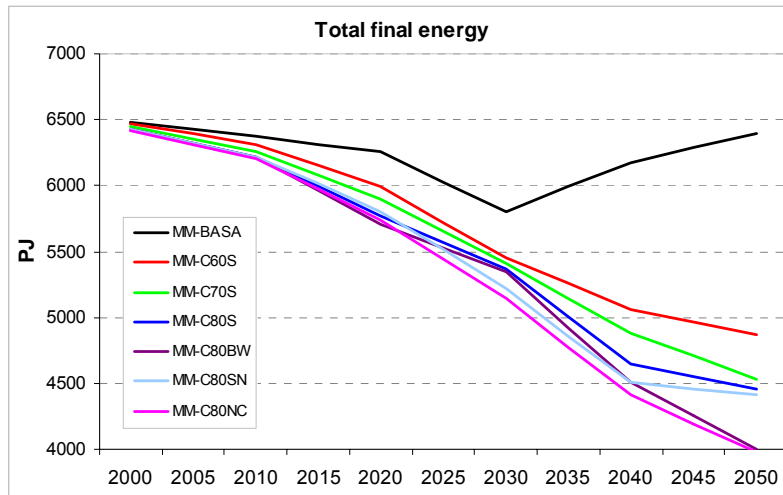
## UK MARKAL Macro (M-M) model



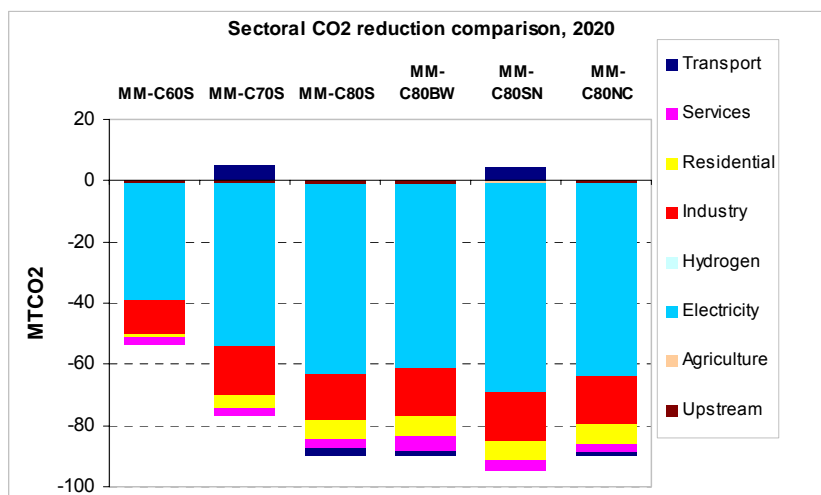
## Summary results

- 60%, 70% and 80% (in 2050) SLT
- 80% SLT - additional wind gen. / biomass import constraints
- 80% SLT - no nuclear
- 80% SLT - no nuclear plus additional wind / biomass constraints
  
- 80% SLT - restricted innovation
- 80% SLT - high fuel prices
- 80% SLT - no nuclear / CCS
- 60%, 70% and 80% (in 2050) ALT
  
- Plus many others

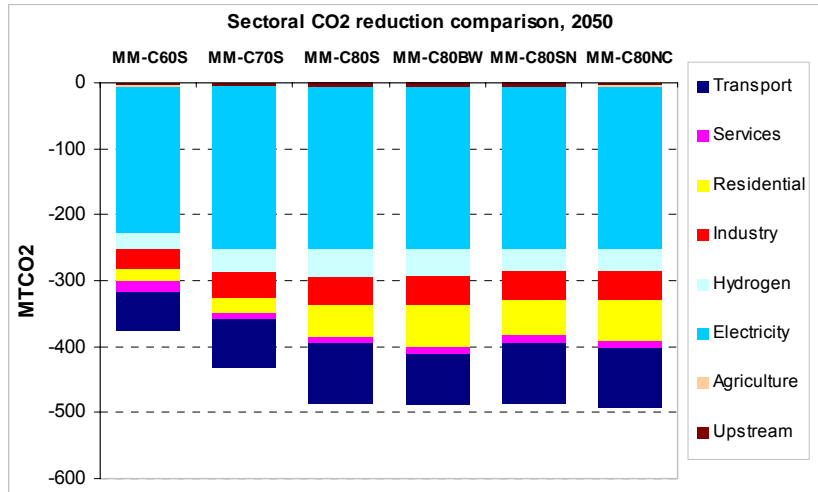
## Final energy demand



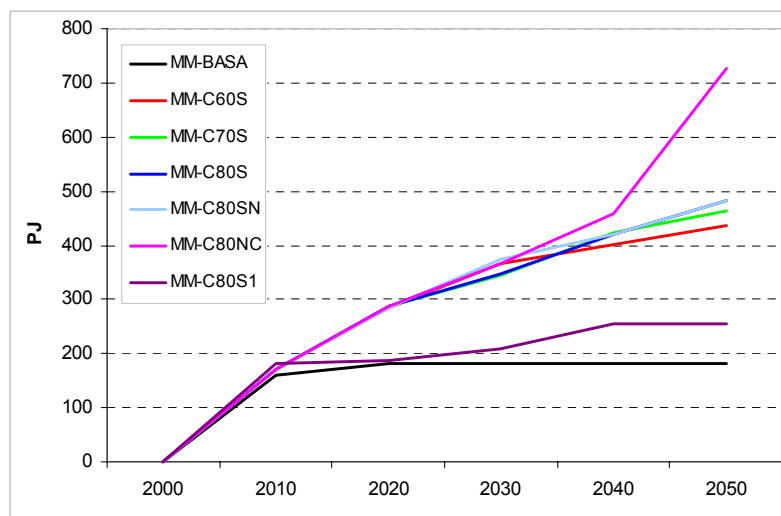
## Carbon emissions by sector



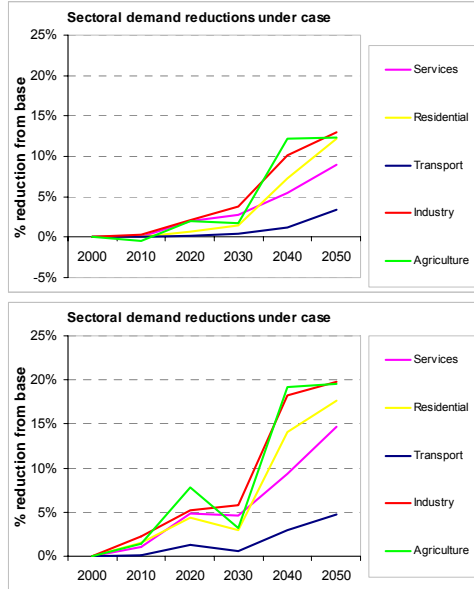
## Carbon emission reductions by sector



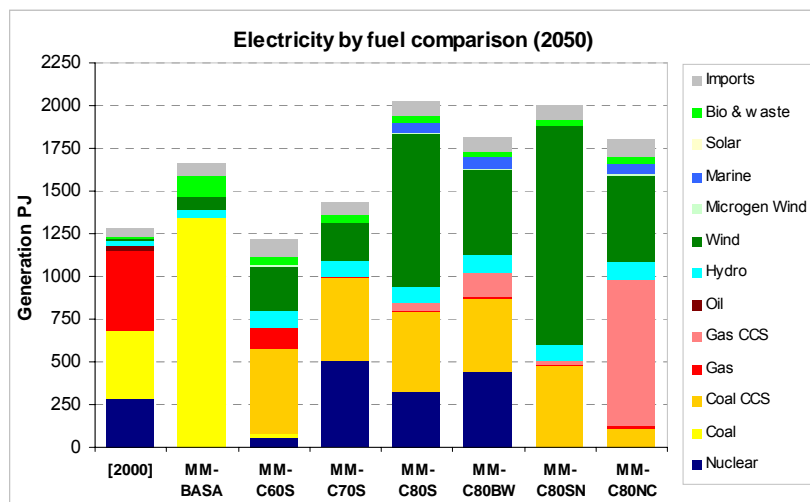
## Conservation



## Demand response (60% vs. 80%)

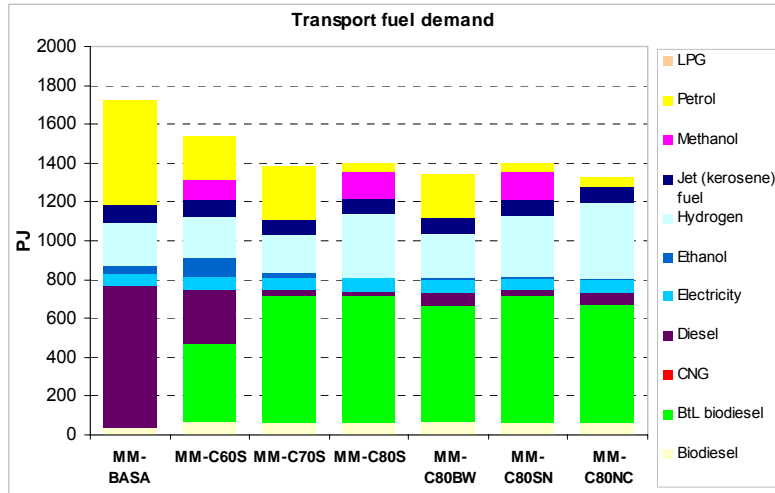


## Electricity generation

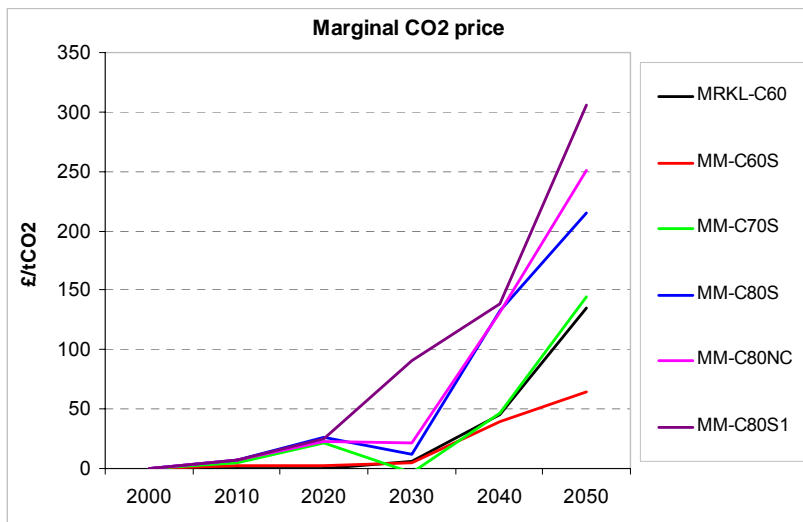




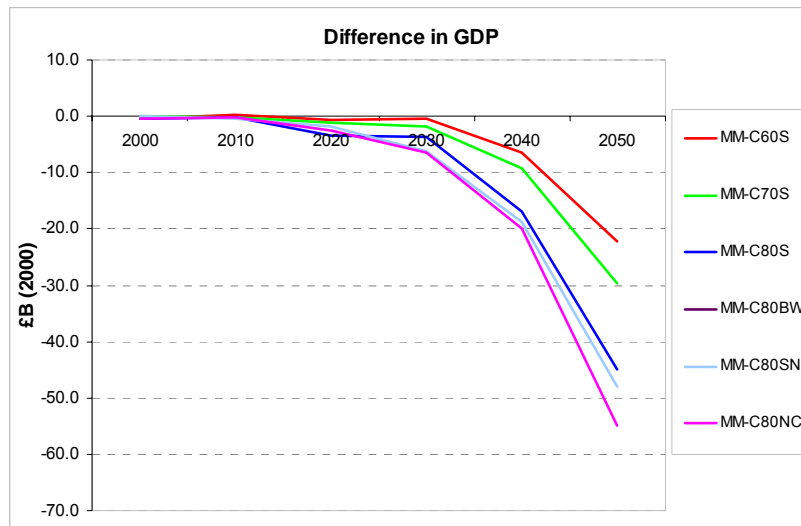
## Transport sector fuels



## Marginal costs of abatement



## Impacts on GDP



## Conclusions

- Based on assumptions, modelling provides useful insights
- Radical changes required in the energy system – across all sectors
- System (based on input assumptions) seems to be able to meet very stringent constraints
- Strong CO<sub>2</sub> price signal needed
- Economy wide impacts appear manageable – although at low end

## Model limitations and further development

- Resource potential – wind and biomass
- CCS constraints
- Nuclear costs
- Representation of heat sector
  
- Industry sector – better representation of technologies
- Transport – inclusion of PHEVs, international aviation / shipping

## Web links

- UKERC website – EWP 07 analysis and model documentation
- <http://www.ukerc.ac.uk/ResearchProgrammes/EnergySystemsandModelling/ESM.aspx>
  
- Additional analysis for Climate Change Bill
- <http://www.defra.gov.uk/environment/climatechange/research/index.htm#markal>