Modelling Long-term Carbon Abatement Scenarios with UK MARKAL

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Outline

- Introduction
- Modelling and Results
- Comment and Interpretation
- Discussion

2006 UK MARKAL model

- MARKet ALLocation dynamic optimization model
- Dynamic optimization based on life-cycle costs of competing technologies and pathways
- Consistent and flexible what-if framework
  - Updated technology data
  - Resource supply curves (domestic and import)
  - Detailed infrastructure representation
  - Detailed technology pathways
    - nuclear cycles, biomass, hydrogen, refining,
  - Electricity sector
    - Grid representation, CO_2 storage, micro-gen
  - End-use detail
    - Industry, transport, residential, service sector
  - Full MACRO module
    - Demand response; GDP impacts

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Modelling principles

- Openness and transparency
  - Explicit assumptions and justifications
- Fully documented data sources
  - Validation sought from stakeholders
- Explicit sensitivity and uncertainty analysis
  - Thresholds & tipping points that favor one technology pathway or another
  - Important interactions and tradeoffs
  - Flexibility available in meeting goals
  - Robustness of results or outcomes
- Construction of consistent and policy relevant scenarios for evaluating the UK energy system

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Model and data validation

- Model reports and documentation made available at: www.ukerc.ac.uk/content/view/142/112
- Stakeholder workshops
  - Electricity generation: DTI, 10th April 2006
  - Road transportation: DfT, 16th March 2006
- Bilateral peer reviews
  - Hydrogen: David Joffe, Imperial College and UKSHEC
  - Nuclear: Paul Howarth, Dalton Institute, University of Manchester
  - Biomass: Ausillio Bauen, Imperial College and TSEC BIOSYS
  - Carbon capture: David Reiner, University of Cambridge and UKCCSC
- Data sensitivity analysis
  - Derek Smith, PSI Visiting Fellow
- Initial model peer review
  - Gerard Martinus, ECN Policy Studies, Netherlands

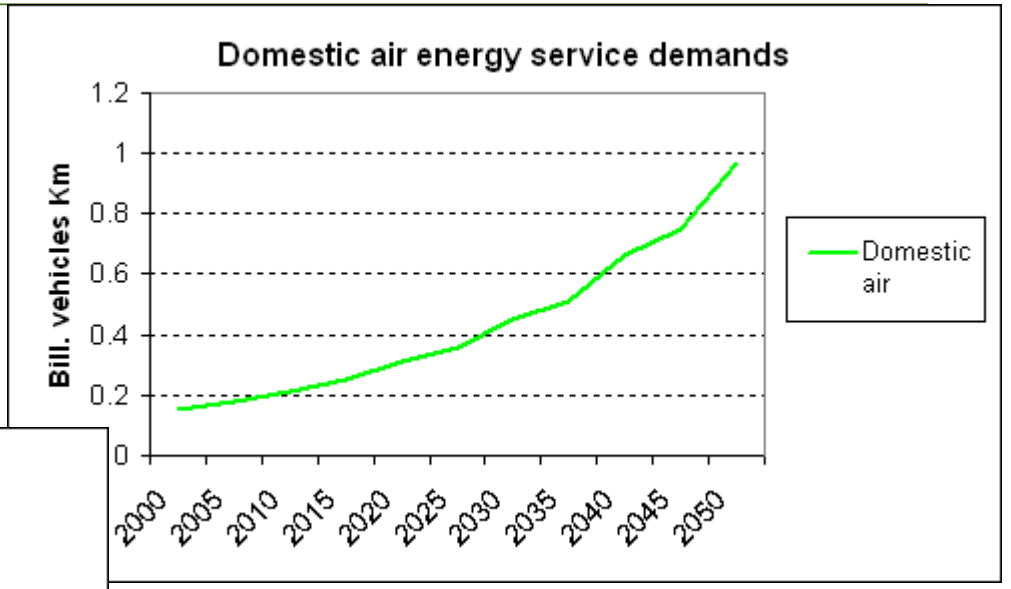
CAVEAT 1

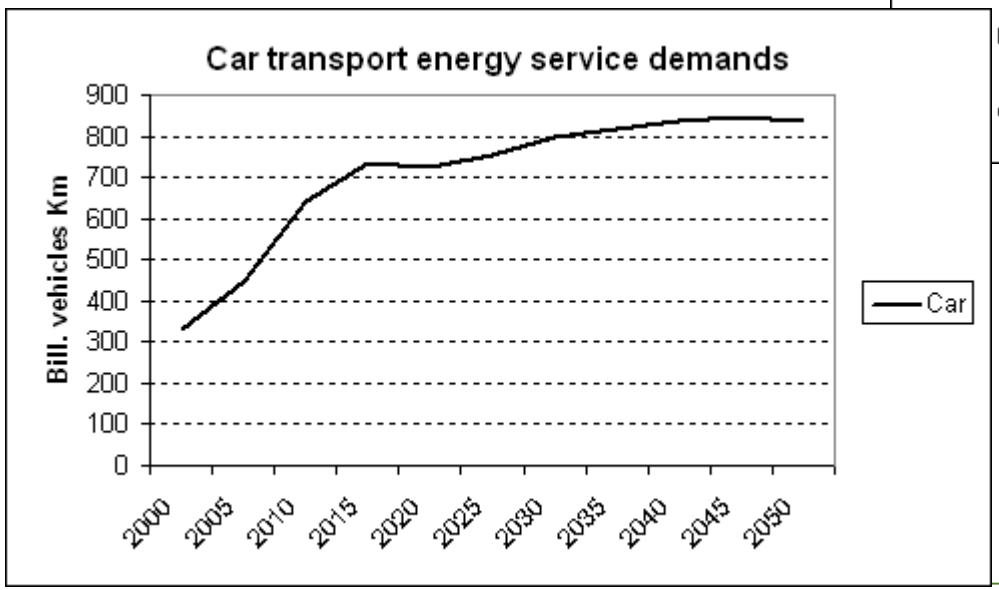
DRAFT RESULTS

Input Summary for MARKAL Base-case and 60% CO_2 Constrain Scenario

Parameter	Value / Source
Time frame	2000-2050, in 5 yearly intervals
Discount rate	Global 10%: Market investment rate End-use sectors 25%: Increased payback period requirements
Fuel prices	DTI (2006) Base import level; import and domestic stepped supply curves
Energy demands	DTI (2006): Includes CCP and CCPR through 2020; low growth projection through 2070
Calibration	DUKES (2005): Final energy, primary energy, CO_2 emissions, electricity generation, fuel resources, aggregate and sectoral disaggregation (within 2%)
Sectoral coverage	Industry (sub-sectors include chemicals, iron and steel, paper and pulp, non ferrous metals and other industry), services, residential, transport, agriculture, own energy industry use Non-energy fuel use not considered
Load profiles	Actual year 2000 electricity and heat load profiles (National Grid, 2006)
Taxation and policy measures	Included: CCL, hydrocarbon duty, transport fuel duty Not included EU ETS, LCP directive, and renewables targets (electricity and road)
Emissions	SO_2 & CO_2 additionally tracked by sector (electricity separately, or assigned to end-use sector)
Emissions trajectory	30% reduction from 2030; linear trend to 60% reduction from 2050
Technology treatment	Vintages for process, electricity, industrial transport, residential and commercial technologies Exogenous learning curves for early technologies in electricity, transport and hydrog All data corresponds to latest iteration

Energy Service Demands





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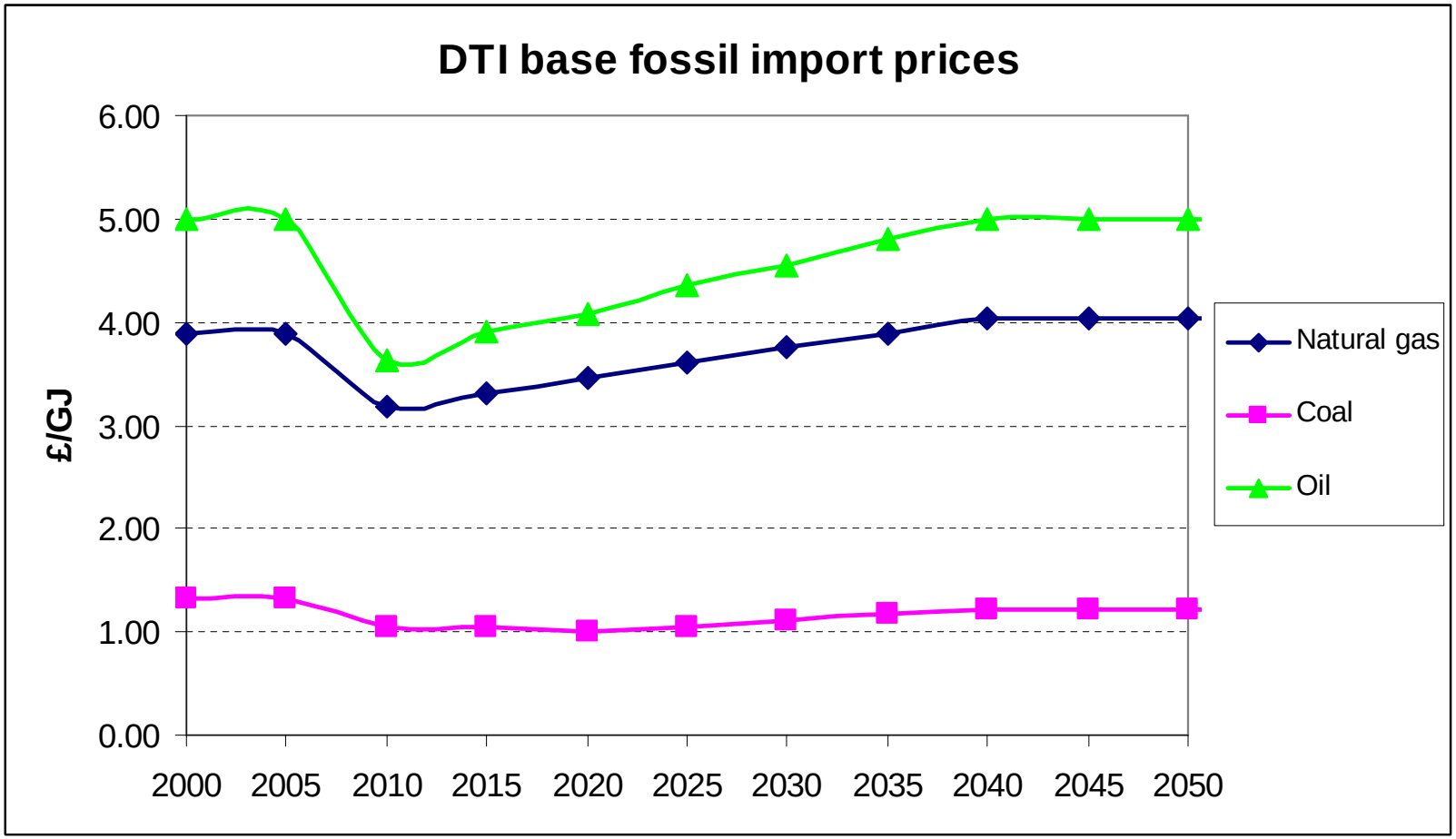
Base Fuel Prices



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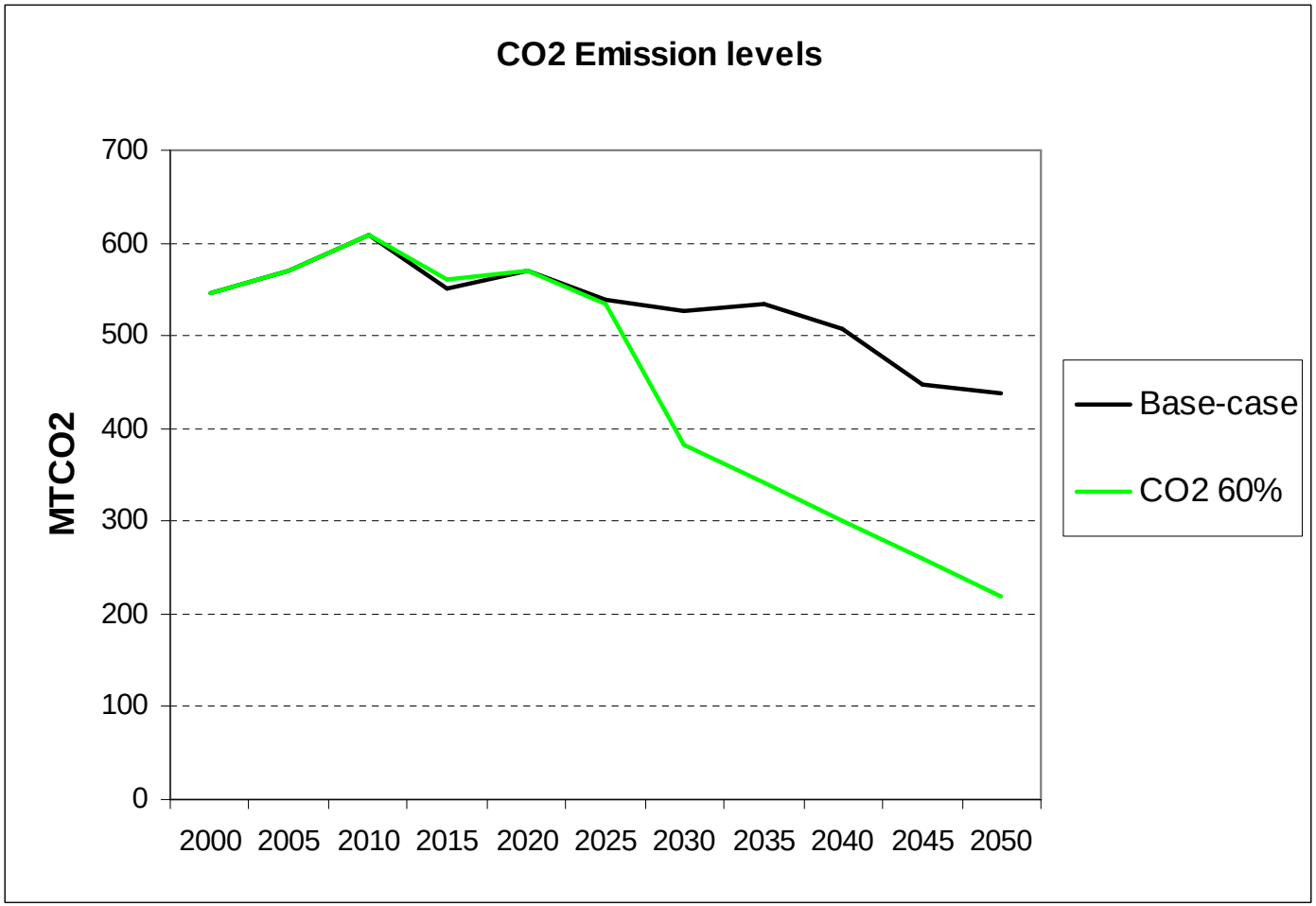
CO_2 emission levels



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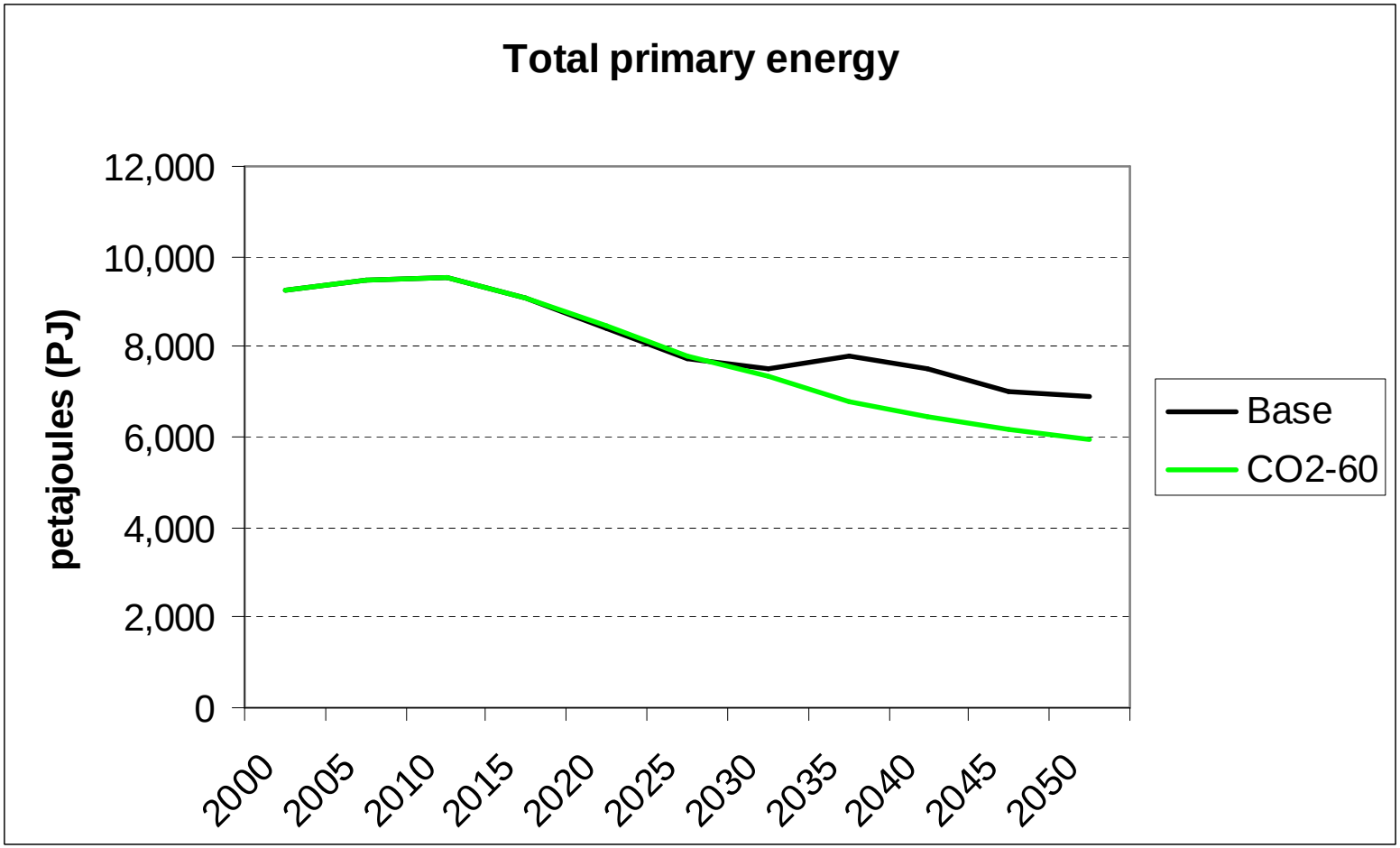
Total Primary Energy



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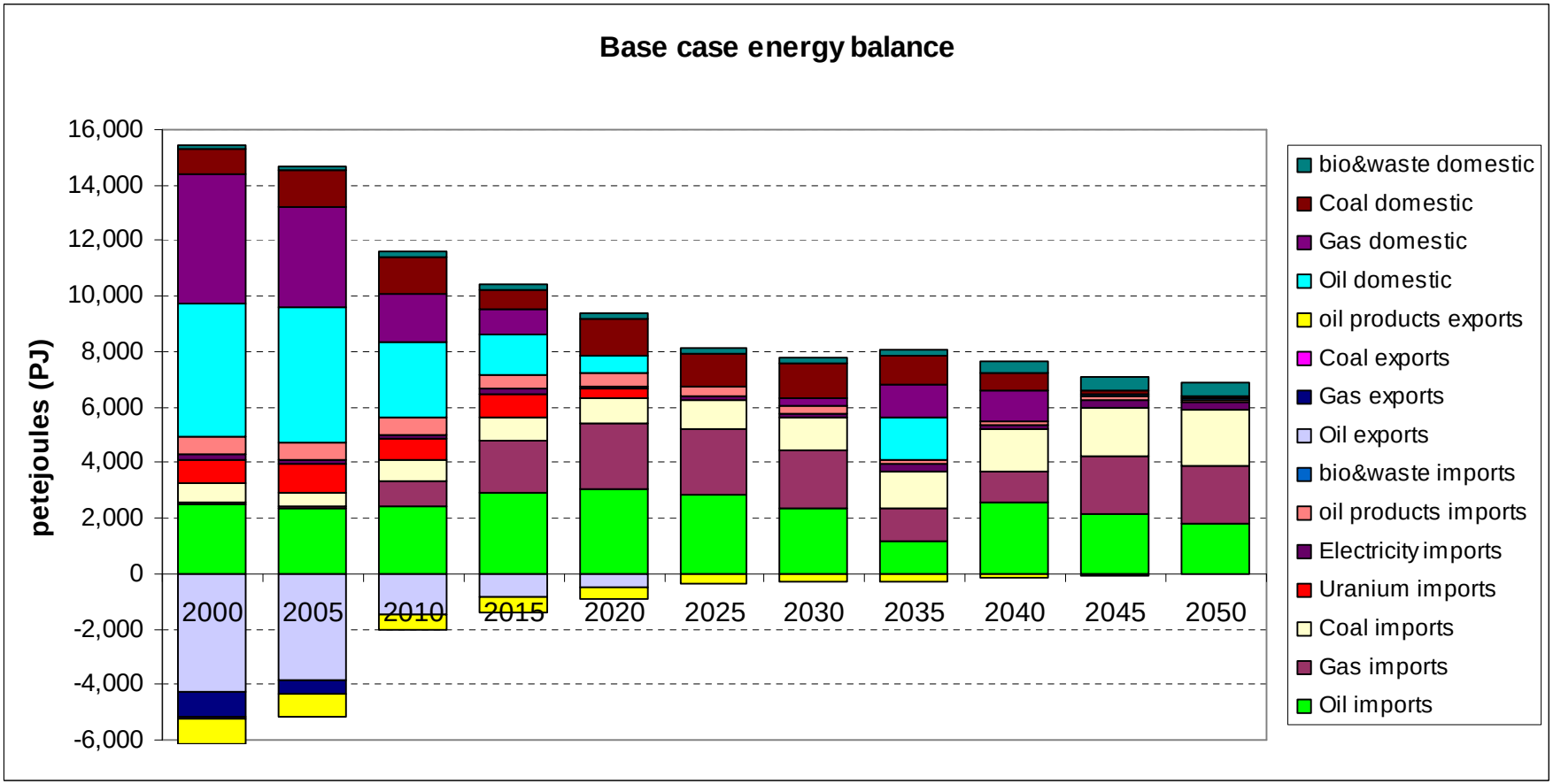
Base-case: production, imports, exports



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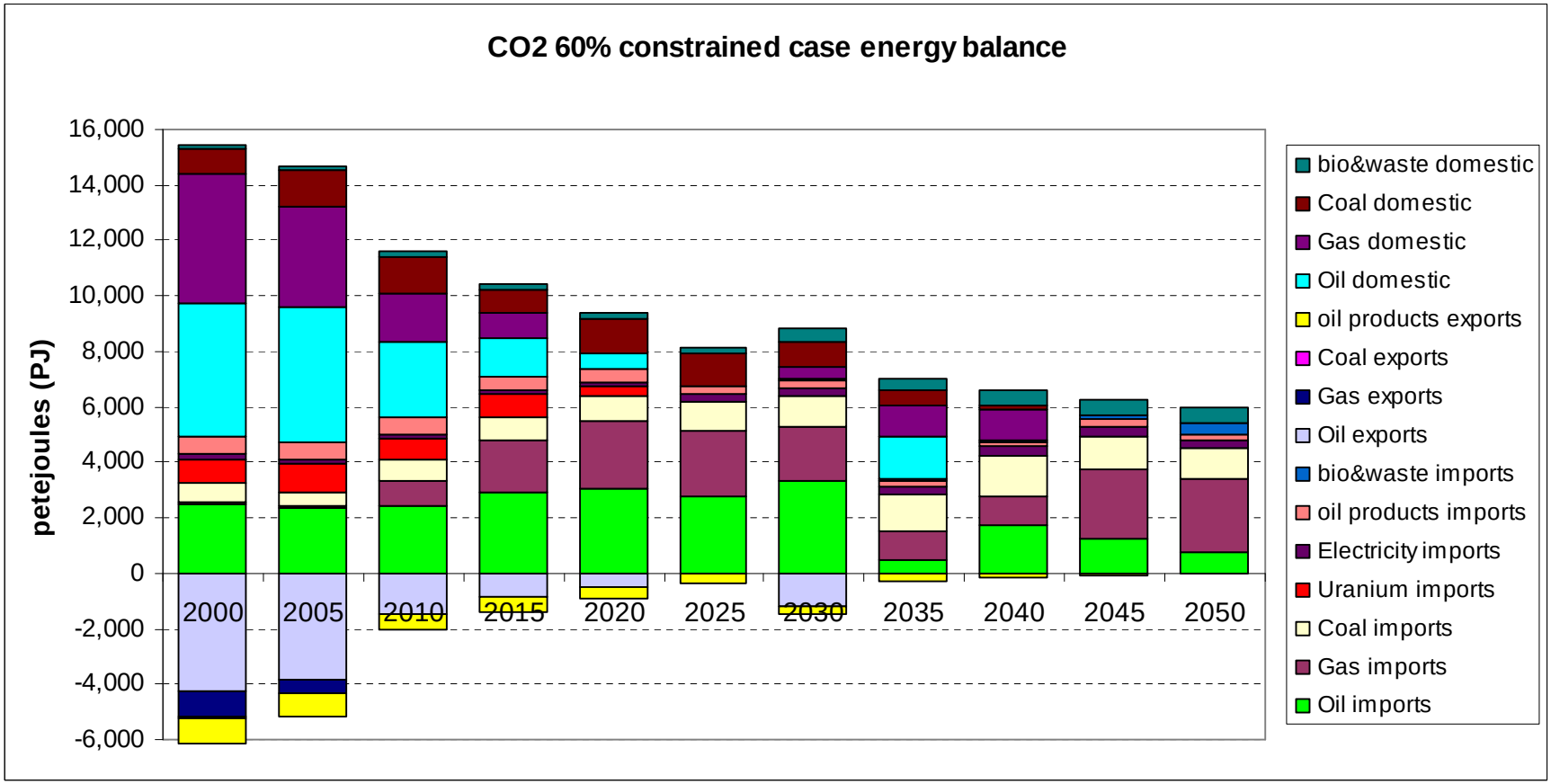
60% CO_2 case: production, imports, exports



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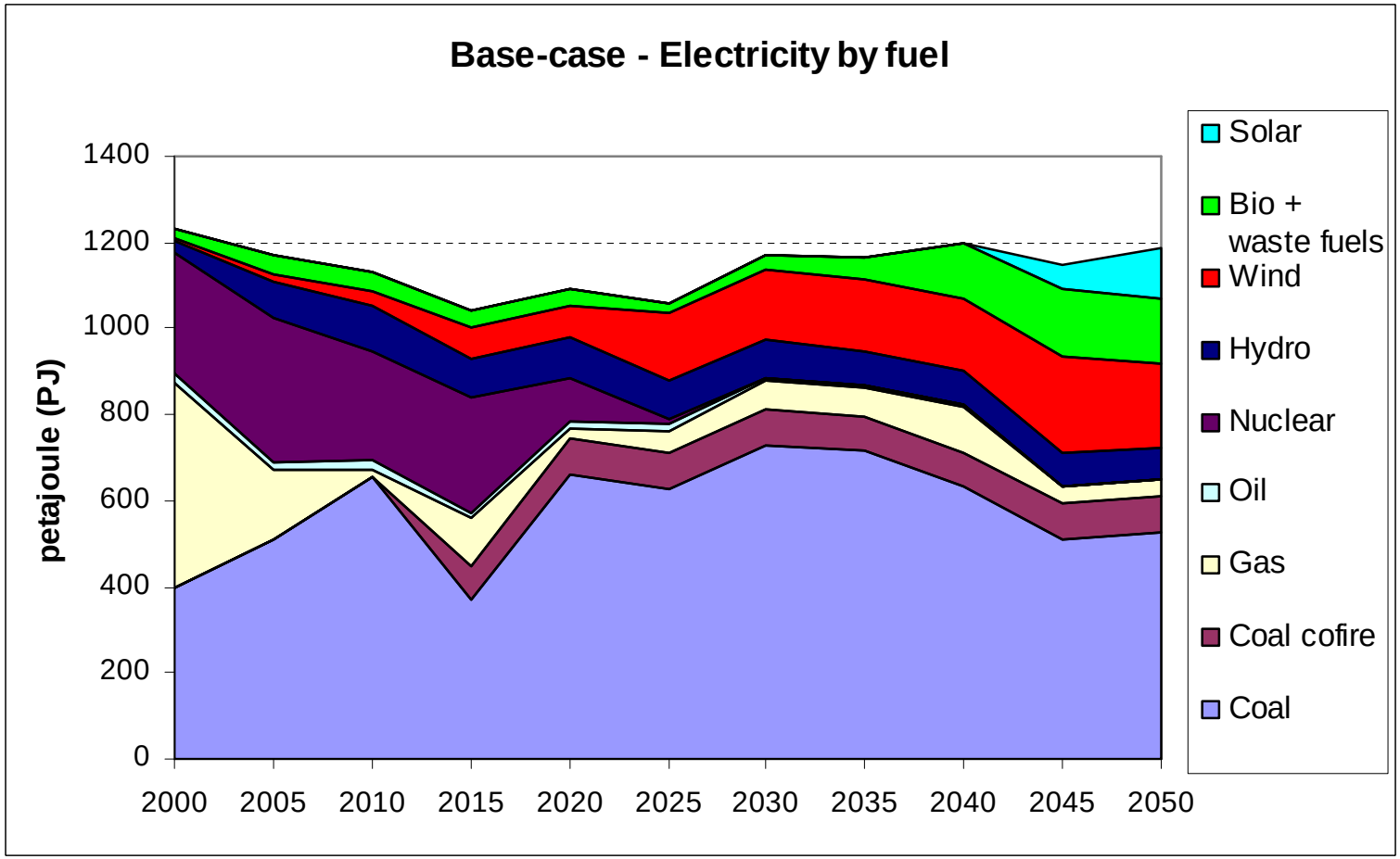
Base-case: electricity output



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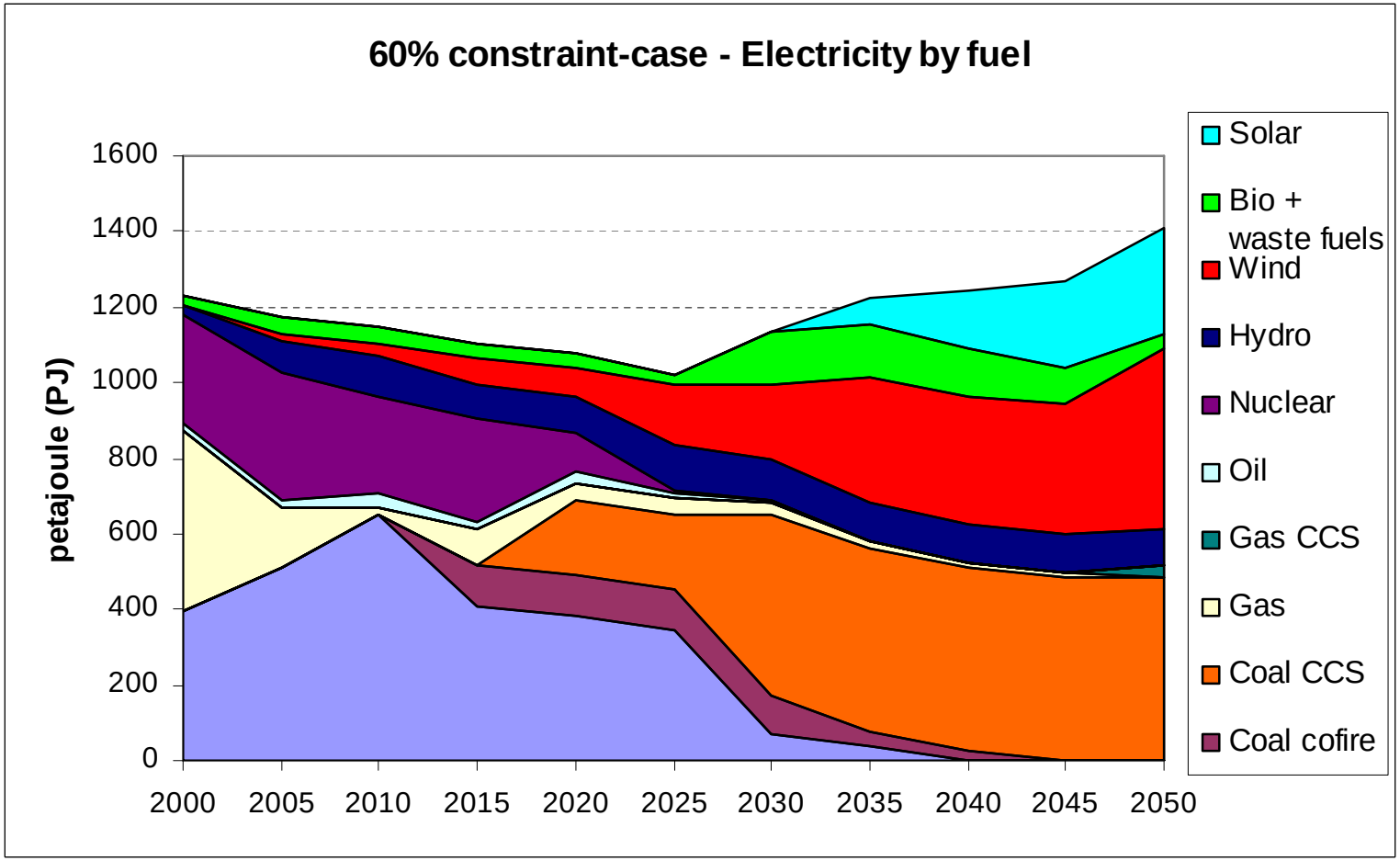
60% CO_2 case: electricity output



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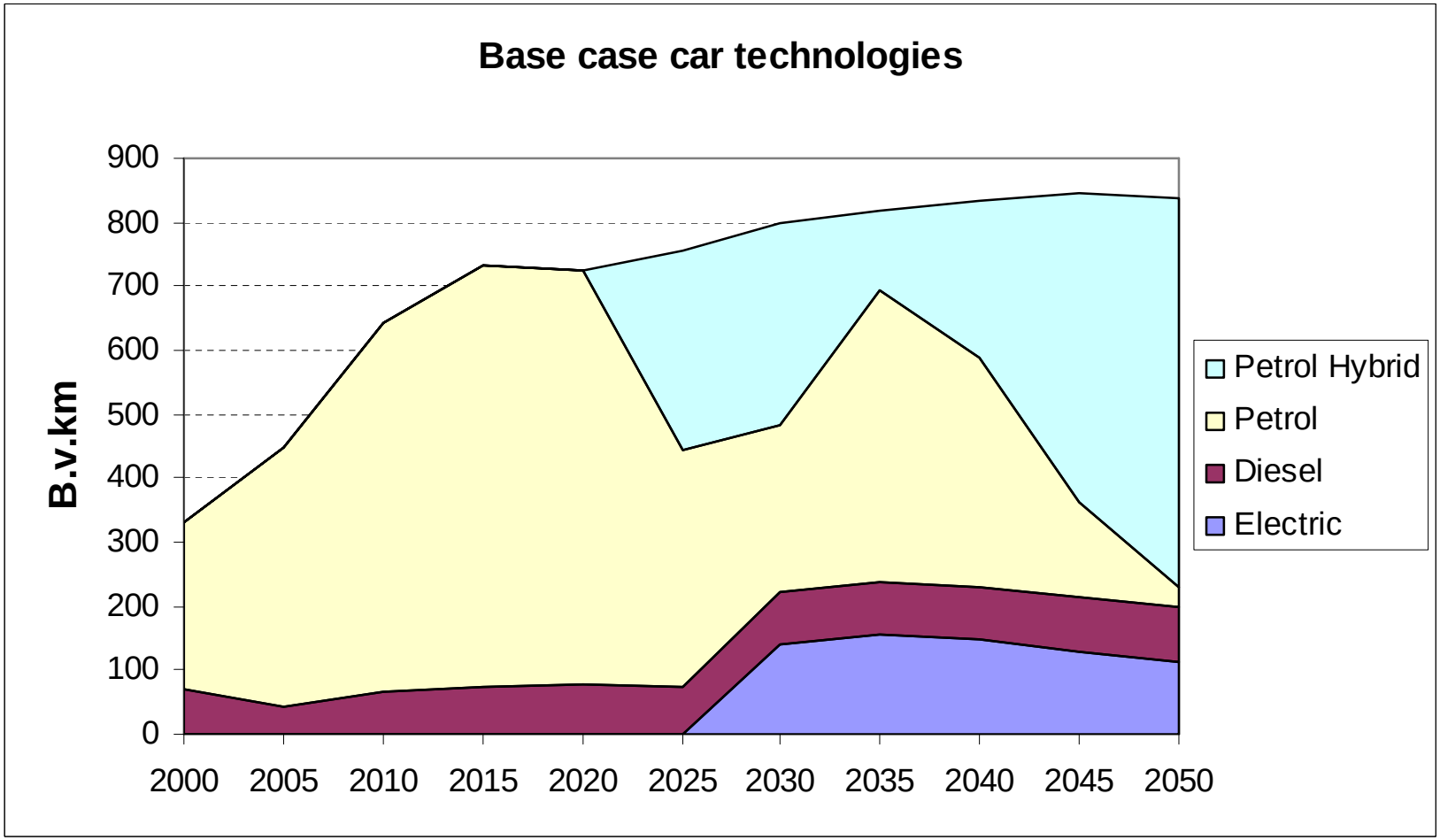
Base-case: private road transport technology diffusion



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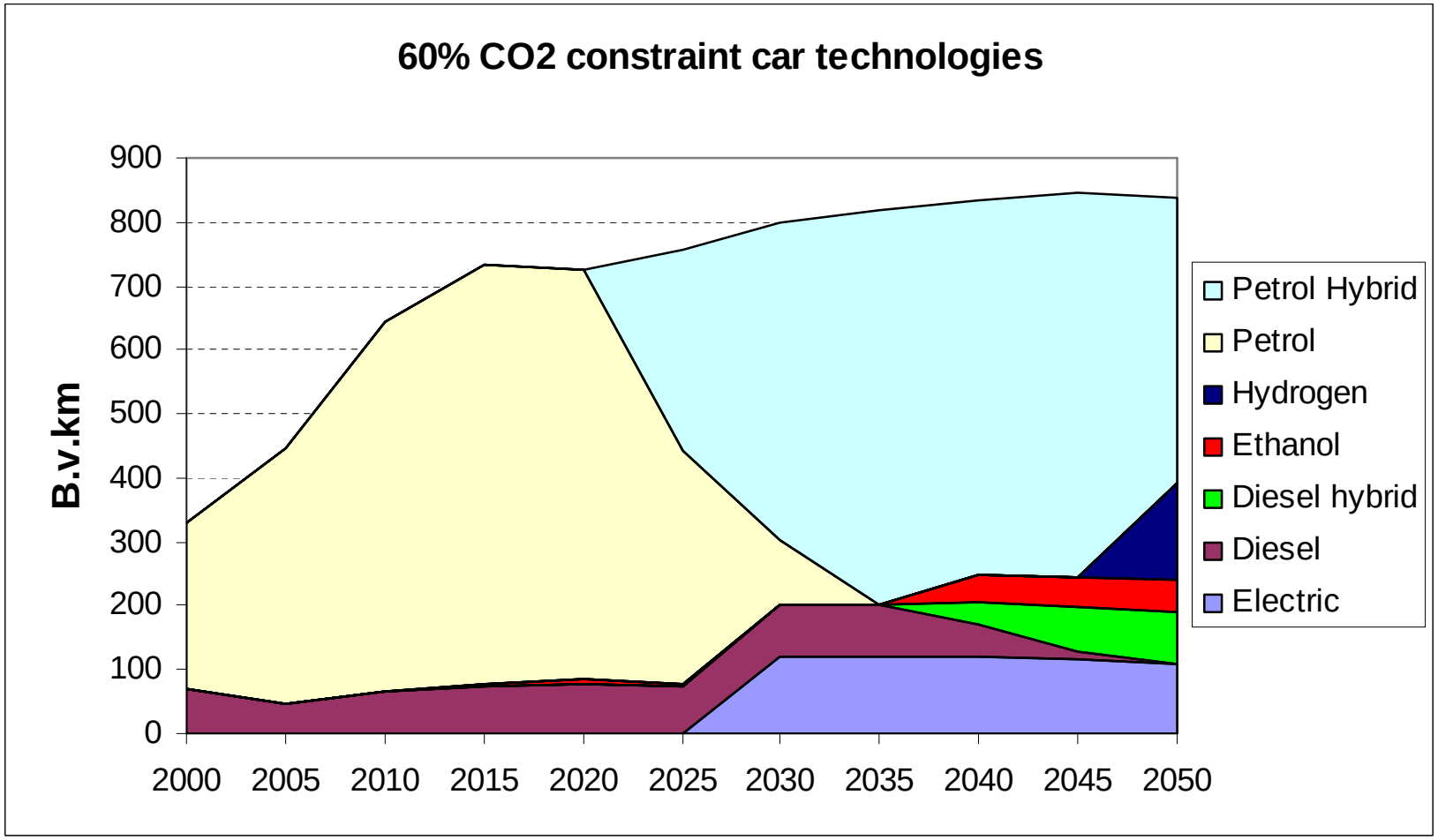
60% CO_2 case: private road transport technology diffusion



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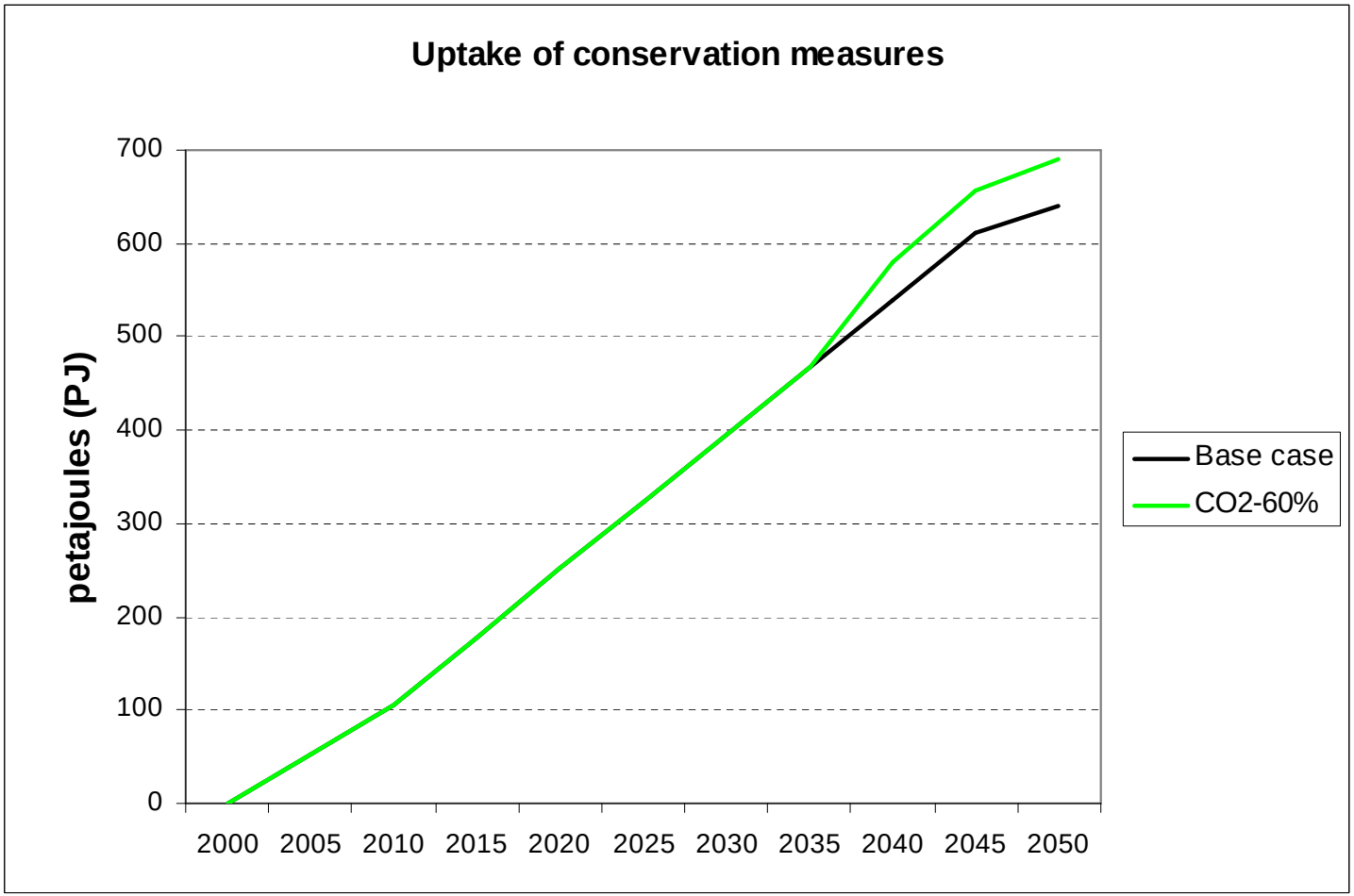
Residential and services: conservation measures



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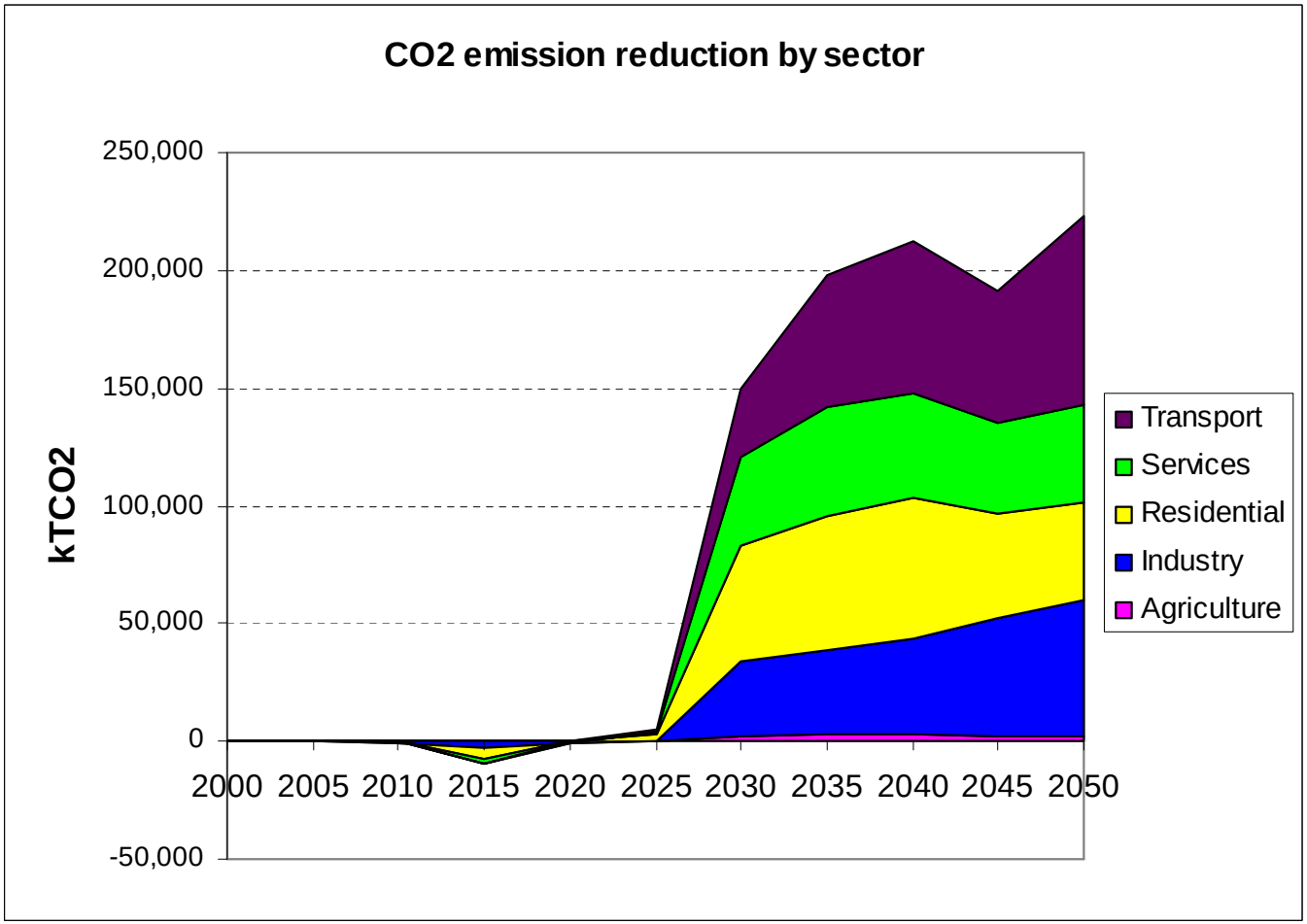
Sectoral CO_2 reduction:
(electricity and hydrogen assigned to end-uses)



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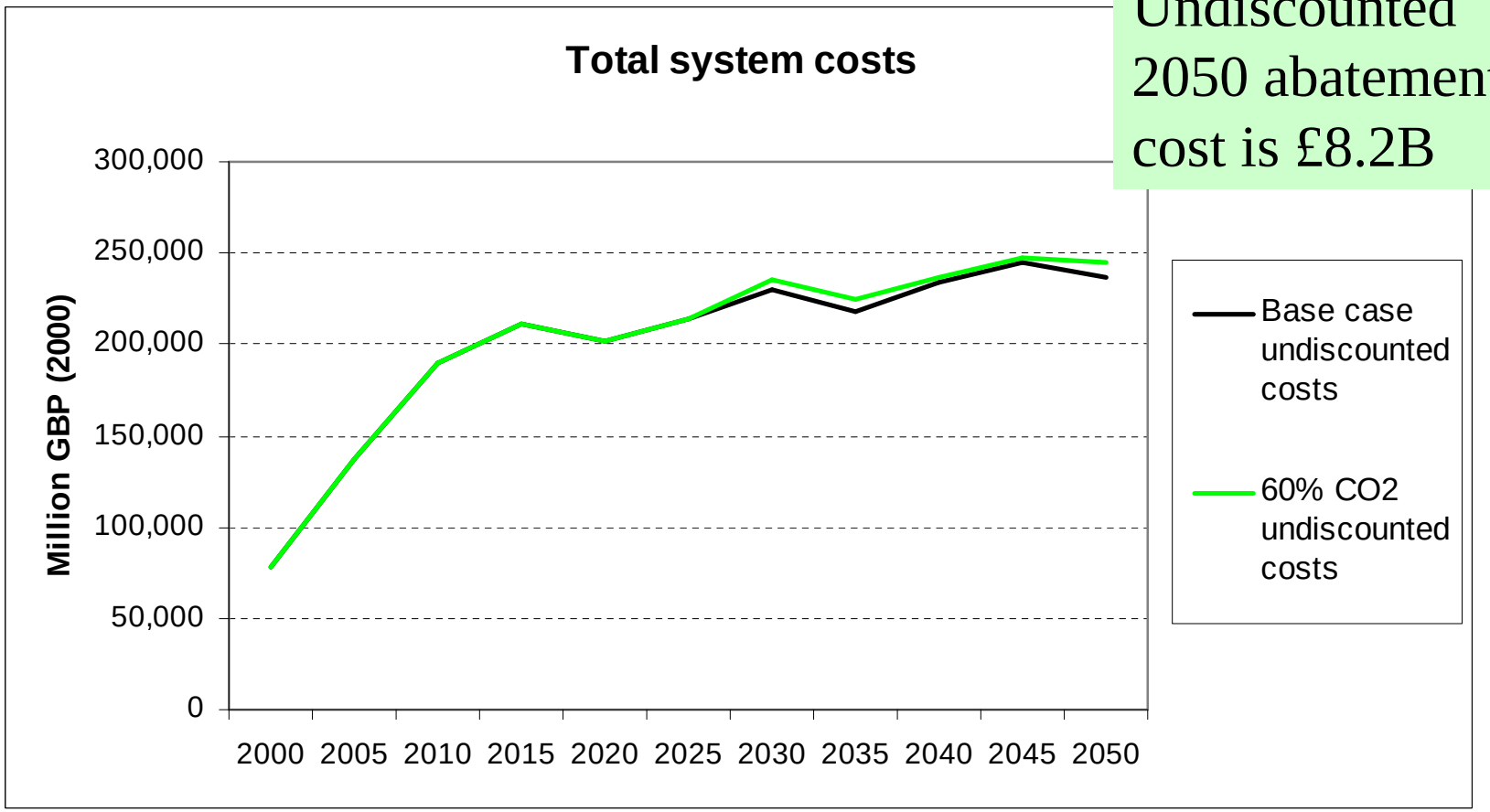
Total energy system costs



Undiscounted 2050 abatement cost is £8.2B

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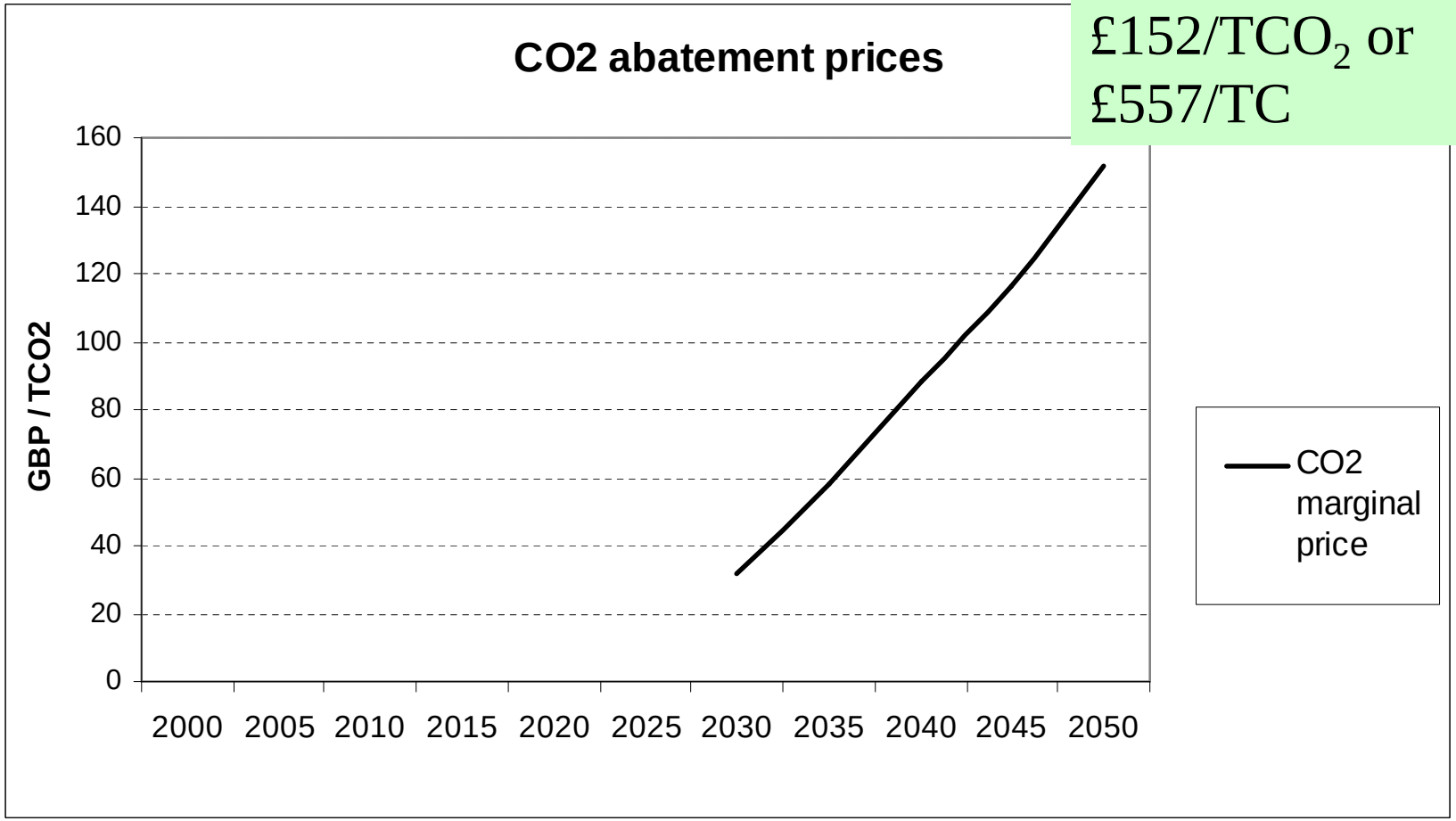
Marginal CO_2 prices

2050 CO_2 price at £152/TCO_2 or £557/TC



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CAVEAT 2

SENSITIVITY ANALYSIS!!

Parametric & probabilistic

Initial list of modelling insights

- Baselines are crucial (low growth in this case)
- Energy imports are substantial and growing
- All sectors contribute to abatement
- Coal and CCS are key electricity base-load techs
- Renewables are key peaking and shoulder techs
- Comparatively less take-up of conservation
- CO_2 emission price signals are significant

Implications for policy and decision making

- Models are not truth machines. They are intended to stimulate thought and deliver insights into complex realities
- Difference between
  - Forecasts – derived from past trends, theory
  - Scenario projections – derived from input assumptions
- Importance of uncertainty/sensitivity analysis, ranges (rather than point estimates) of data
- Good models are GIGO (Garbage In, Garbage Out): crucial importance of transparent assumptions and sourced data (with ranges)
- Models should not be used to justify prior preferences or decisions (but can all too easily be used in this way)
- Importance of model evaluation: UKERC ESMT aspires to provide this over the medium term

Thank you

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