



Modelling of woody biomass chains for heat production in the UK & formulation of scenarios for the residential sector using MARKAL

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Session 2-1 – Theme A

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- Review of bioenergy (and bio-heat) chains
- Changes to woody biomass heat chains in Markal
- Modelling of supply and demand runs
- Conclusion and next steps

Context and objectives

Context of the study

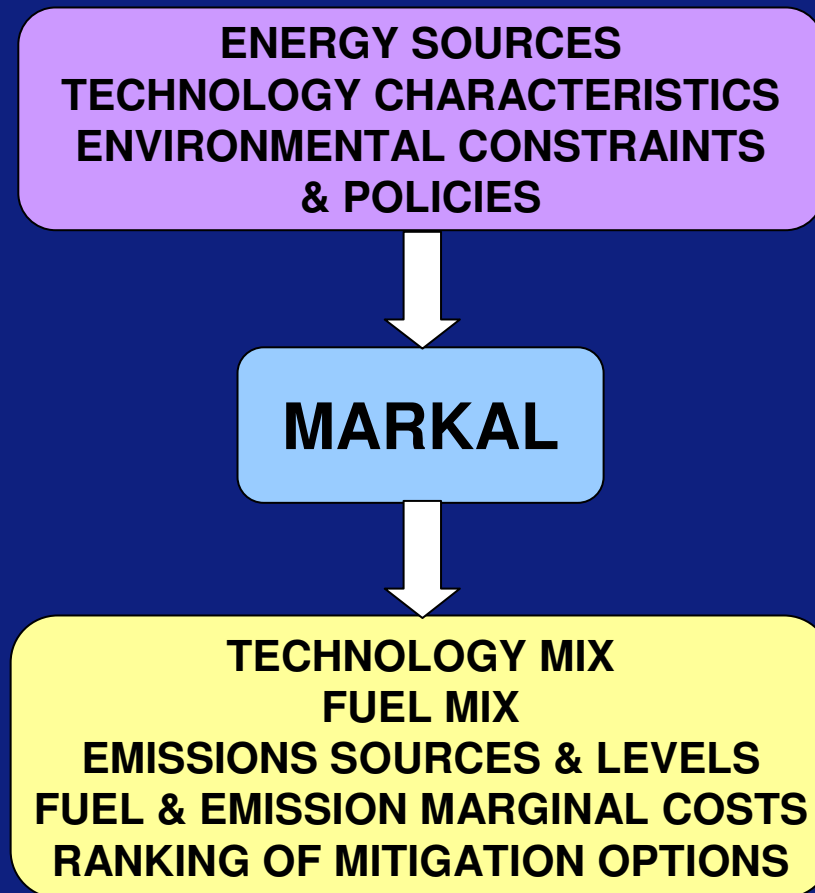
- 20% renewable energy by 2020 for all three consuming sectors: heat, electricity and transport fuel
- Biomass considered a “front runner” among sources of renewable heat, with wood the most common such fuel (pellets, chips, logs...)
- But exactly how much can biomass contribute to the long-term UK heat mix? Can policy help to increase bio-heat penetration? What are the implications of such increase?

Objectives of the study

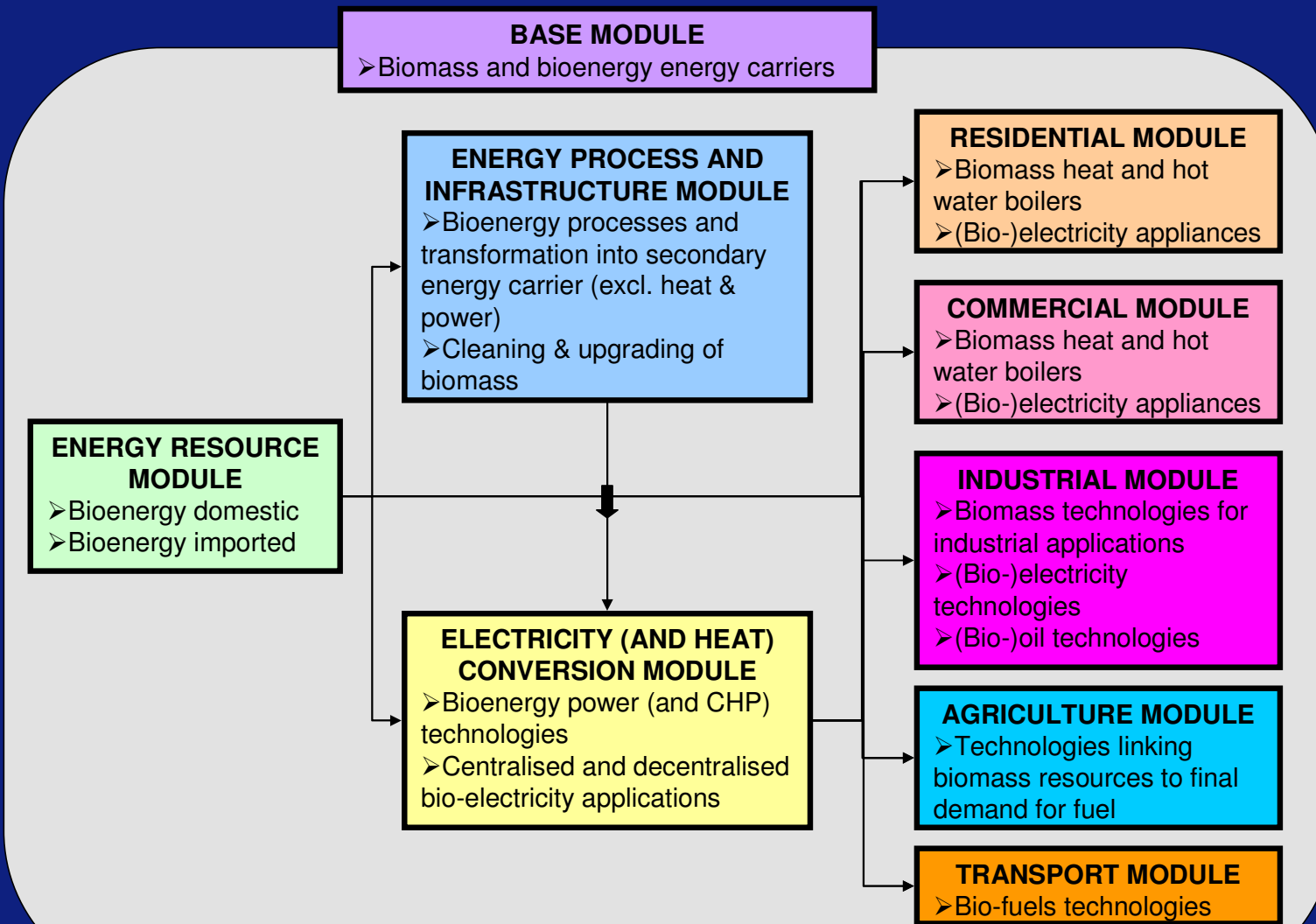
- Explore the possible contribution of woody biomass to the future heat demand in the UK residential sector
- Illustrate the implementation of an original method to formulate long-term bioenergy scenarios:
 - Case study of the residential heat sector of the UK
 - Combination of qualitative and quantitative insights

Methodology

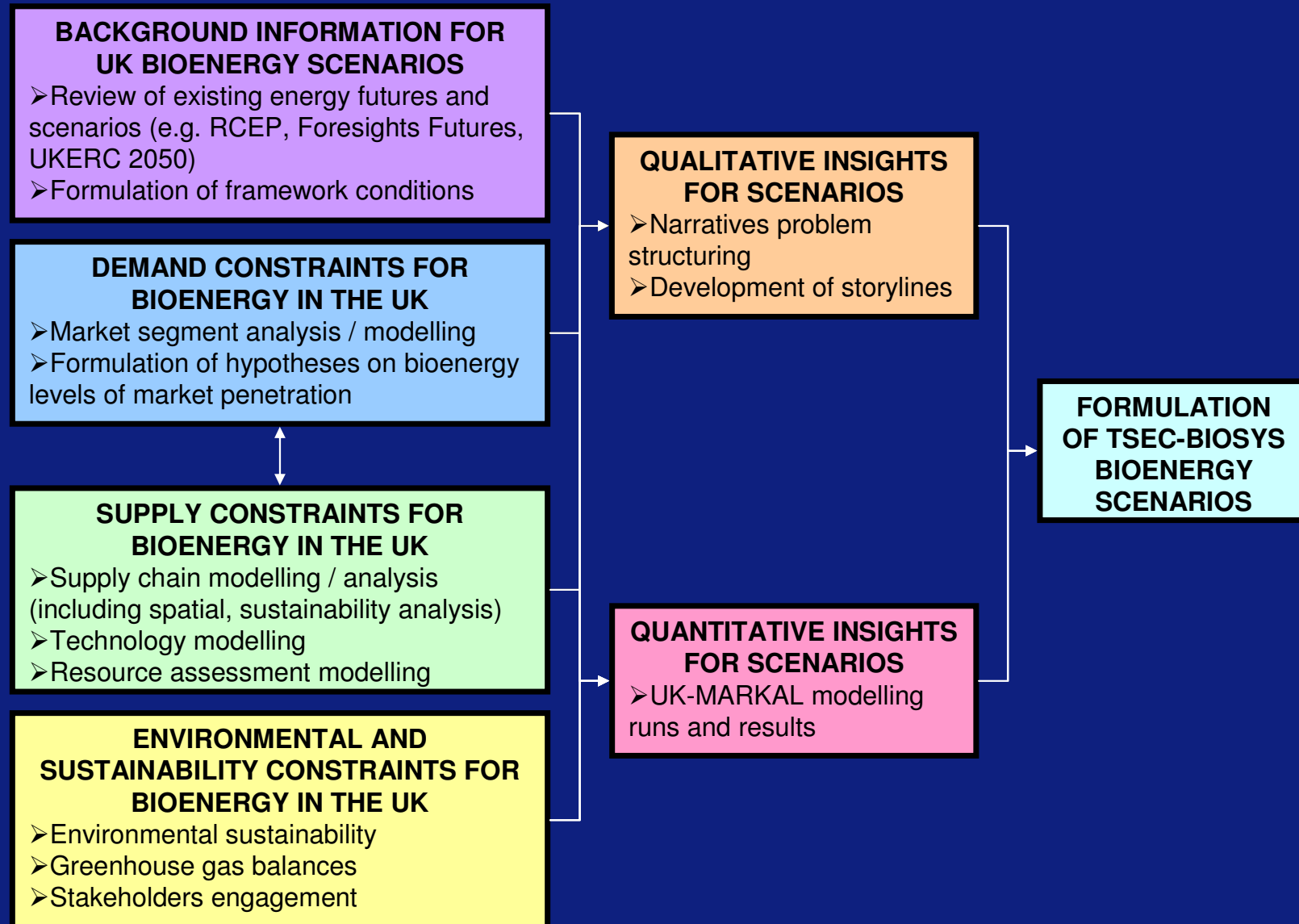
MARKAL modelling – an overview



Overview of bioenergy in UK-MARKAL



MARKAL contribution to the formulation of UK bioenergy scenarios



Review of bioenergy in UK-MARKAL

Changes to woody bio-heat chains

Review of bioenergy in UK-MARKAL

- October 2007 – July 2008
- Module by module, focus on bioenergy:
 - Review of the bioenergy chains considered
 - Review of the inputs and outputs for each technology
 - Review of the data characterising energy carriers, technologies, and resources
- Findings suggested that:
 - A lot of bioenergy options already covered but some important pathways missing (e.g. biogas to grid, district heating...)
 - Lack of systematic referencing in the datasets
 - Need for representation of up-to-date knowledge from bioenergy community

Summary of changes made to “direct” woody biomass to (residential) heat pathways

- Wood is still a versatile resource: can go to gasification, pyrolysis, enzymatic hydrolysis to ethanol
- Wood can be distributed directly to all final demand sectors (except transport) where dedicated boilers are now modelled
- New process: pelletisation / new conversion: district heating
- In the residential sector: three types of boilers possible (pellets, woodchips, or wood logs) with penetration constraints aligned with results of MSA

Modelling supply and demand runs

Results

Modelled runs : overview

- Base run: with all changes implemented for TSEC-BIOSYS
- 7 additional run along 4 sensitivity axes // key issues & uncertainties from the supply and demand point of view:
 - Supply-focused runs: production cost of woody energy crops + share of agricultural land available for bioenergy crops
 - Demand-focused runs: CO2 reduction targets for 2050 + subsidies available for biomass boilers in the residential sector
- Reminder on focus: direct woody biomass to heat pathways (not biogas & pyrolysis bio-oil)

Modelled runs : overview - supply

High production costs
for woody energy crops

Run 3

Run 4

Low share of
agricultural land
available for
bioenergy crops

High share of
agricultural land
available for
bioenergy crops

Run 2

Base case
Run 1

Low production costs for
woody energy crops

Modelled runs : overview - demand

High CO2 constraint

Run 6

Run 7

Low subsidy for
boilers in
residential sector

High subsidy for
boilers in
residential
sector

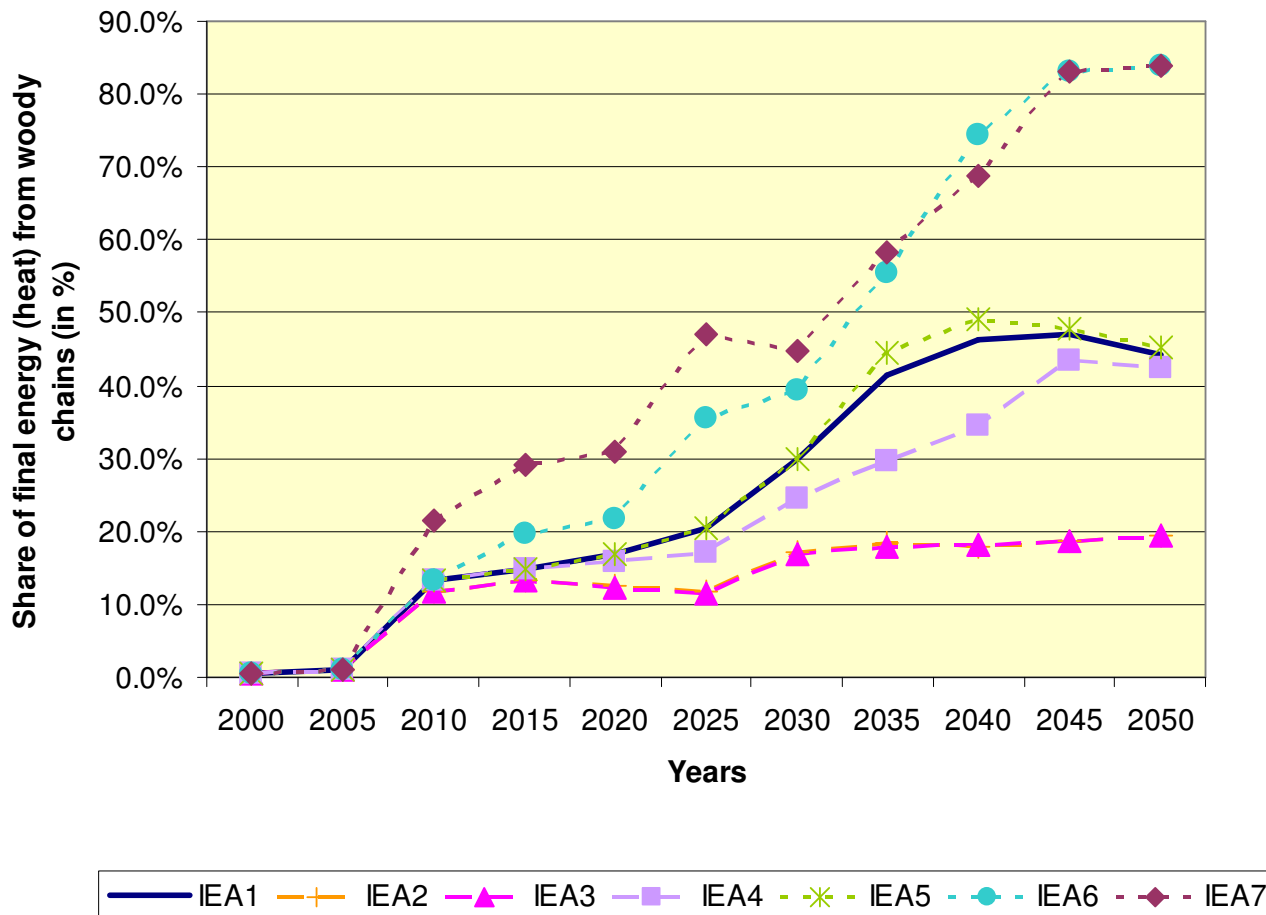
Base case
Run 1

Run 5

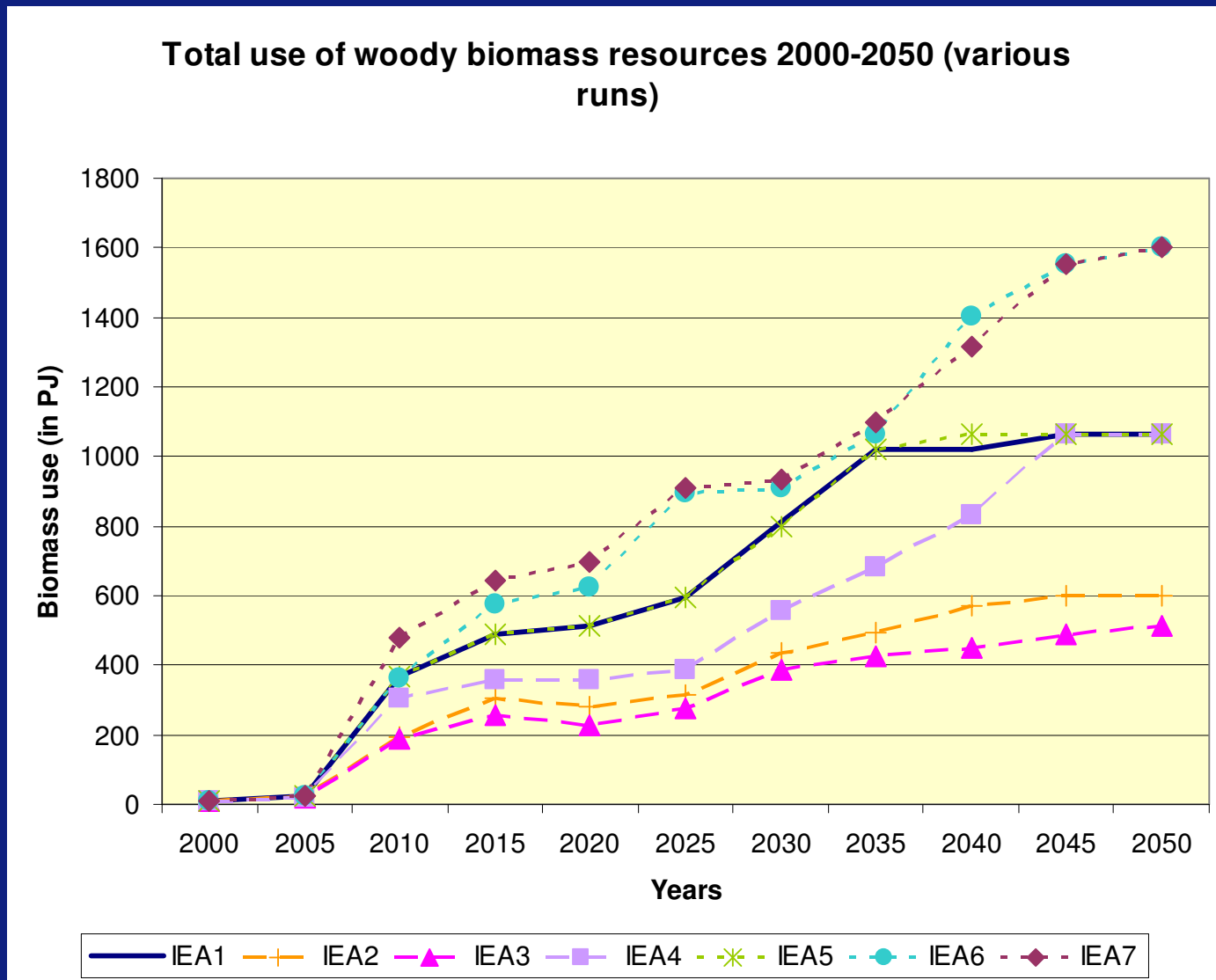
Low CO2 constraint

Results: Market penetration of woody biomass for residential heat

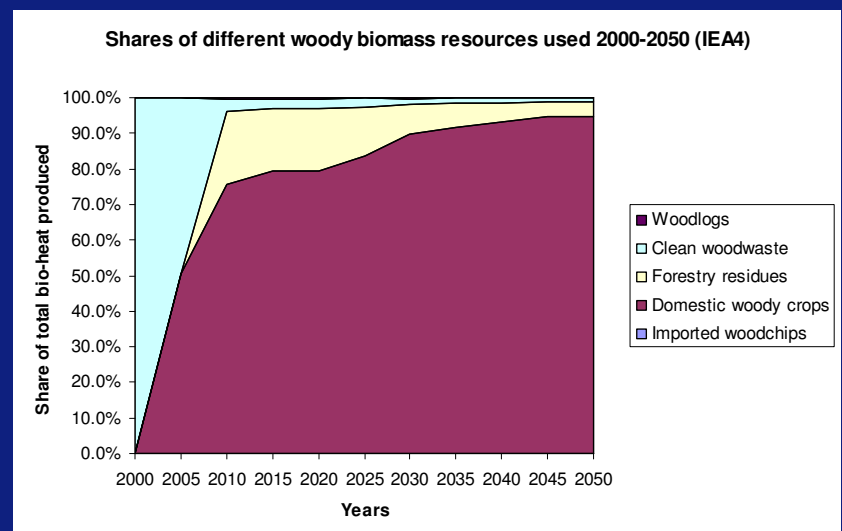
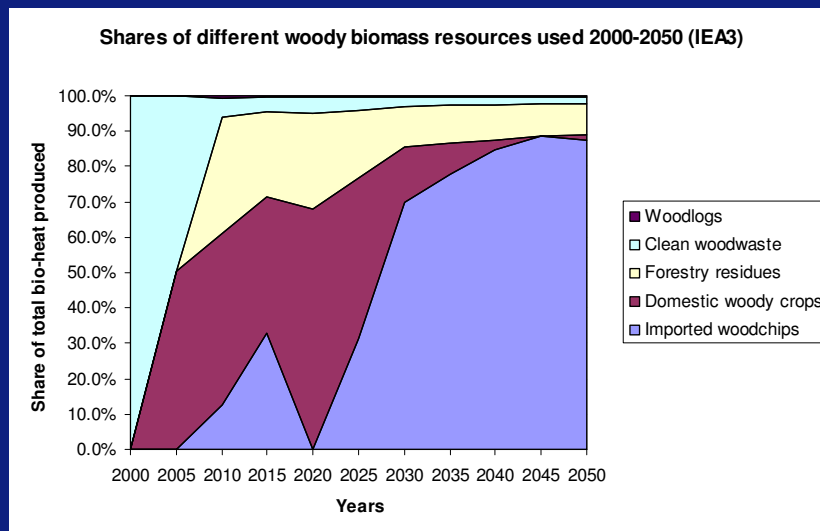
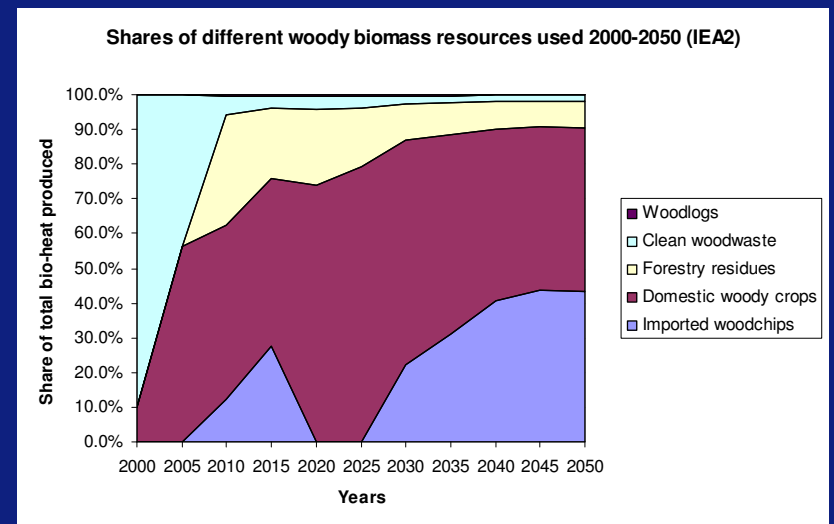
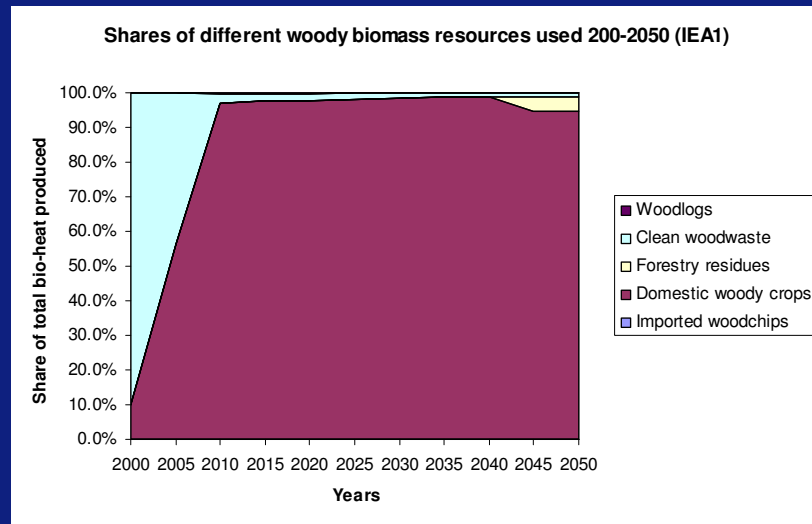
Penetration of the residential sector heat market with woody biomass chains 2000-2050 for various runs



Results: Total use of woody biomass in the UK energy system

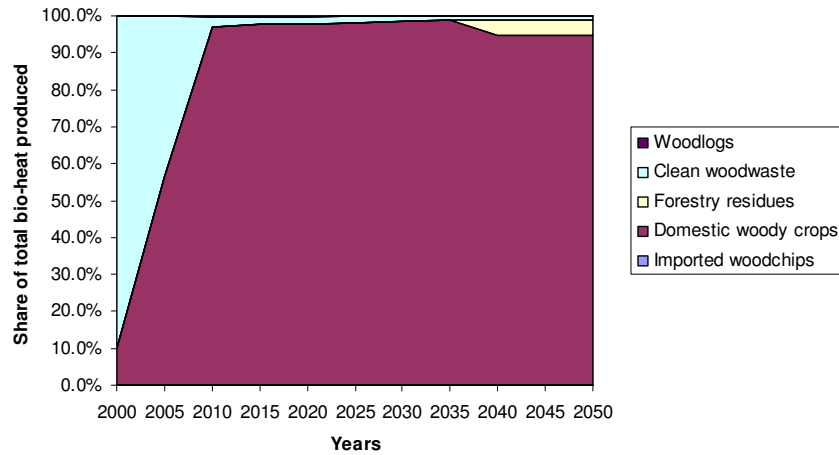


Shares of different woody resources used: Runs 1 -> 4

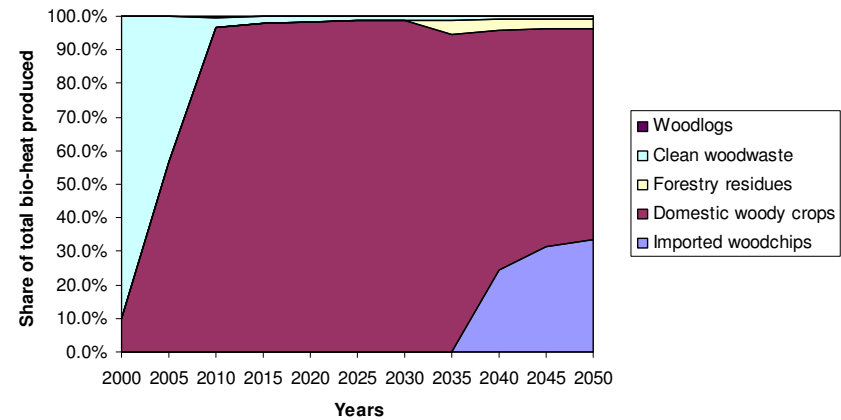


Shares of different woody resources used: Runs 1, 5 -> 7

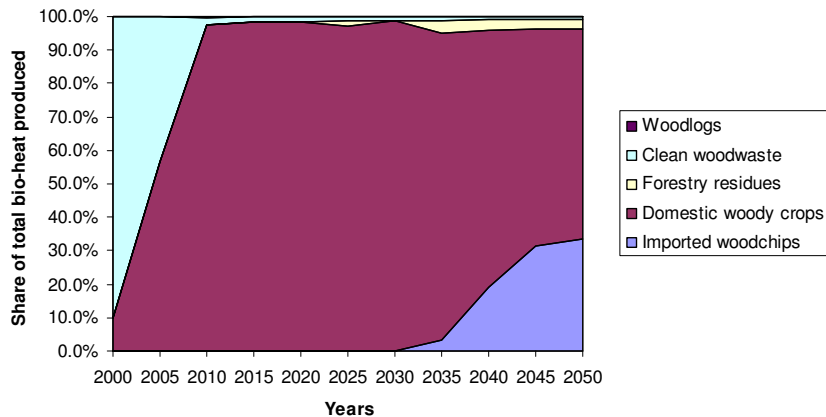
Shares of different woody biomass resources used 2000-2050 (IEA5)



Shares of different woody biomass resources used 2000-2050 (IEA6)

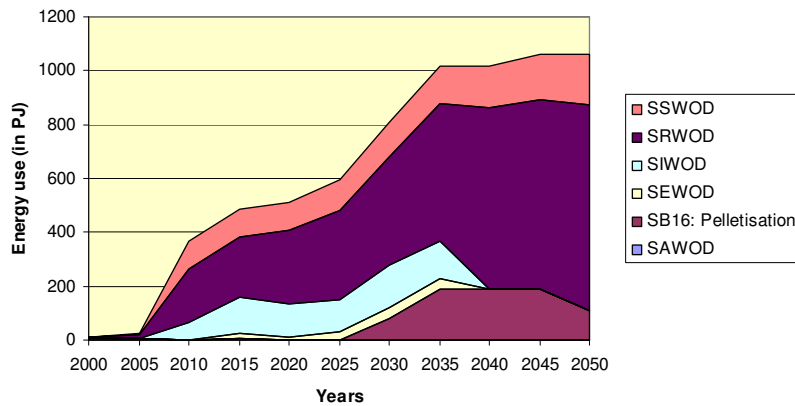


Shares of different woody biomass resources used 2000-2050 (IEA7)

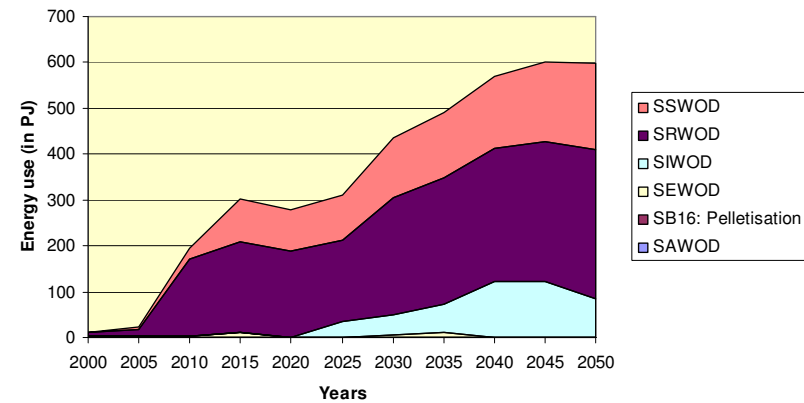


Use of woody biomass for different processes and / or final demand sectors (1)

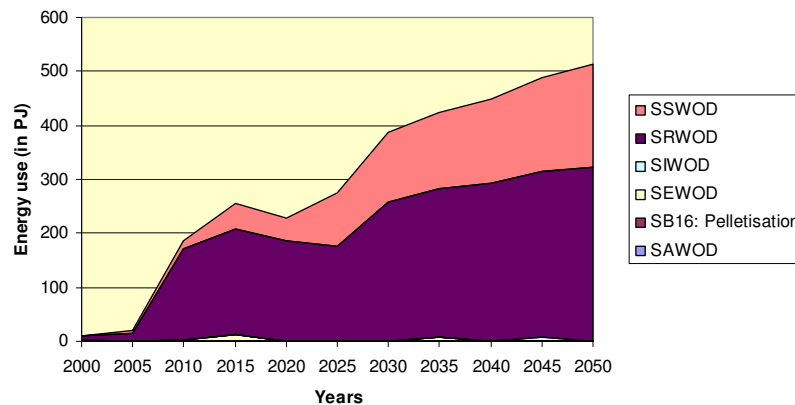
Use of wood for different processes and/or final demand sectors 2000-2050 (IEA1)



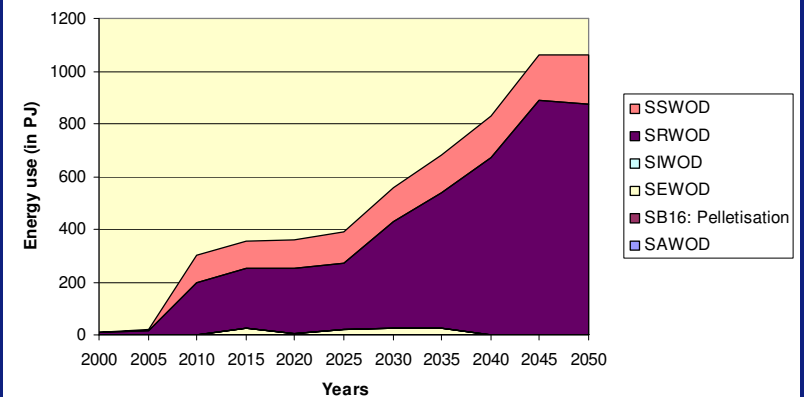
Use of wood for different processes and/or final demand sectors 2000-2050 (IEA2)



Use of wood for different processes and/or final demand sectors 2000-2050 (IEA3)

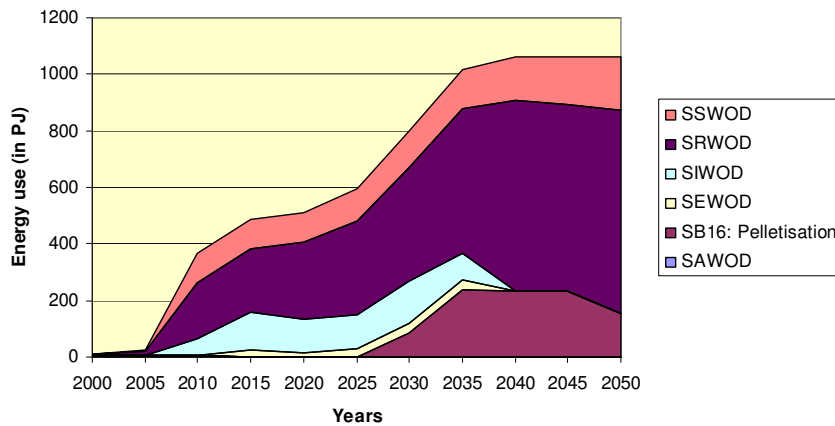


Use of wood for different processes and/or final demand sectors 2000-2050 (IEA4)

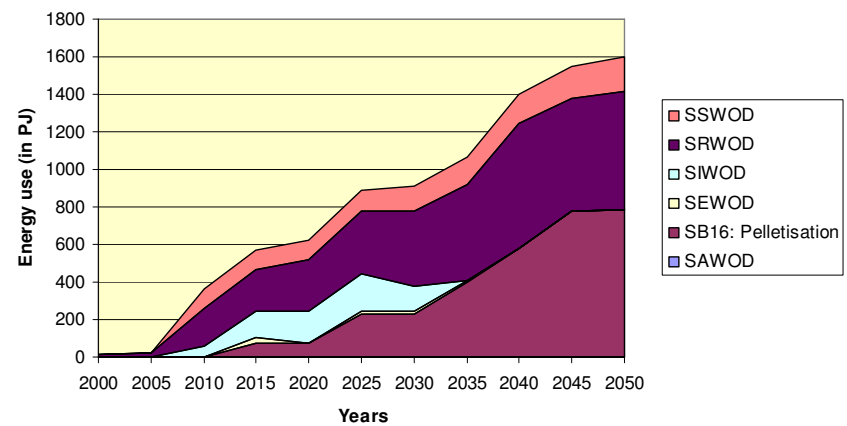


Use of woody biomass for different processes and / or final demand sectors (2)

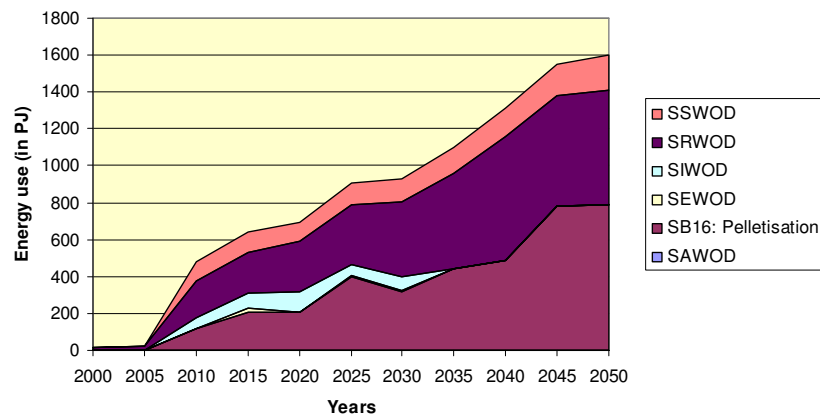
Use of wood for different processes and/or final demand sectors 2000-2050 (IEA5)



Use of wood for different processes and/or final demand sectors 2000-2050 (IEA6)



Use of wood for different processes and/or final demand sectors 2000-2050 (IEA7)



Preliminary conclusions
Advantages and limitations of the
approach
Next steps

Preliminary conclusions (1)

- Woody biomass can play a significant role in reaching the renewable energy targets under the form of heat in the residential sector
- There is a need for policy support in order to allow the domestic production of woody biomass, as well as to ensure the sustainability of needed imports
- Stimulating the demand for bio-heat is key to achieving significant penetration of the residential heat sector (here tested CO₂ targets, and subsidy scheme)

Preliminary conclusions (2)

- Because of the residential heat market structure, pelletised woody biomass is an important fuel to be promoted
- Subsidy programs are not enough (even when targeted) – even with seemingly “positive” woody supply chain context – only high CO₂ constraints on the energy system push penetration

Advantages of the approach

- Market Segment Analysis (MSA) results were a necessary input to the definition of constraints for bio-heat penetration and the obtaining of meaningful results
- Similarly, the results of the MARKAL modelling allow for a re-visiting of the levels of potentials for bio-heat in the residential sector (long-term)
- Linking MSA and MARKAL modelling with qualitative narratives allows for a systematic formulation of scenarios in line with present (bioenergy) expert knowledge, as well as strategic policy advice

Limitations of the approach (1)

- Difficulties in modelling some policy instruments (e.g. carbon trading)
- Base of Markal modelling is “lower cost optimisation”: how useful is that for the residential market (decentralised, “irrational”)?
- CO₂ emissions calculated based on emissions factors for domestic resources use: biomass is carbon-neutral... Life Cycle Assessment may be a good complement?

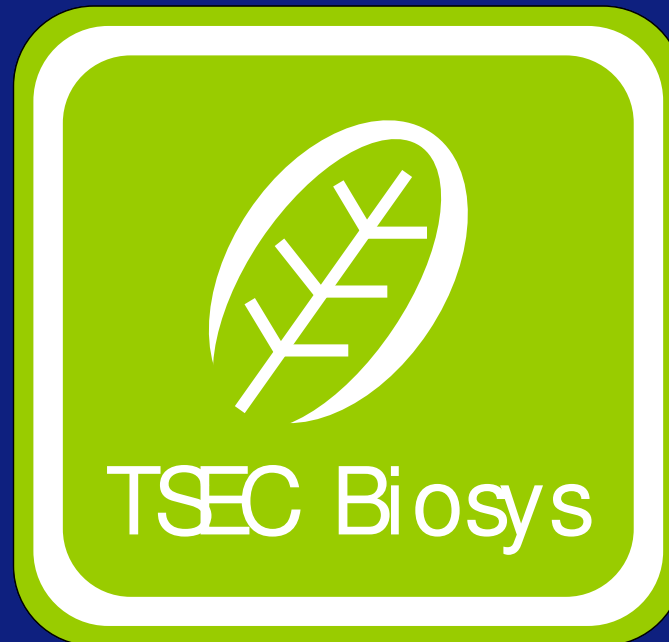
Limitations of the approach (2)

- Competition on woody biomass resources goes beyond the energy uses as modelled:
 - chemicals sector, wood industry, food and drink...
 - Impact on the uptake of bio-heat as well
- The cost of energy resources are endogenous inputs to the modelling... yet in reality
 - Correlation between energy fuels prices
 - Dynamic feedback between energy demand and supply
 - Fossil fuels are “inputs” to the production of woody biomass (trucks fuel, fertilisers...)

Next steps

- Testing of a combination of the runs proposed
- Analysing the potential contribution of “indirect” biomass fuels (e.g. pyrolysis bio-oil, biogas)
- Prepare additional runs for more policy instruments: zero-carbon homes, renewable heat obligation, higher CO₂ reduction targets

Thank you for your attention!



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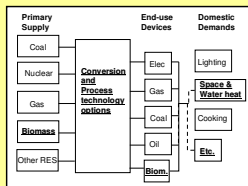
Running the UK-MARKAL model

- Database representing UK energy system
- MARKAL optimises (minimizes) discounted total energy system cost
- Initial set-up to mimic UK energy system in year 2000
- Model then optimizes in 5-year time steps through to 2050
- A full range of scenarios and sensitivity analysis is carried out in a systematic 'what-if' framework
- Used for the 2003 & 2007 Energy White Paper, and for the UKERC 2050 exercise

Methodology used for MARKAL modelling focusing on bioenergy in TSEC-BIOSYS

UPDATE OF THE BIOENERGY MODULE IN UK-MARKAL

- Review of the Reference Energy System (RES) for bioenergy in UK-MARKAL
- Drafting of updated bioenergy-RES for UK-MARKAL
- Populating of the updated bioenergy-RES with relevant data for the time horizon
- Testing of the updated bioenergy-RES
- Linking of the updated bioenergy-RES with the existing UK-MARKAL



MARKAL MODELLING INPUTS

- Updated UK-MARKAL inputs with regards to bioenergy: domestic/imported resources, technologies' characteristics, etc.
- Use of standard UK-MARKAL other inputs: energy sources, technology characteristics, existing policies, etc.
- Definition of constraints (environmental, policies etc.) to be implemented for the running of scenarios

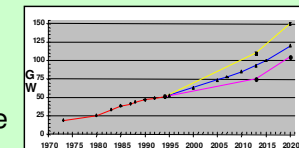
UK-MARKAL "BIOSYS-MARKAL"

With updated bioenergy module

MARKAL MODELLING OUTPUTS

Key results of the modelling runs are examined in the light of the levels of bioenergy penetration in the three main final consumption sectors (heat, power and transport fuels), and what are the related implications for the energy system:

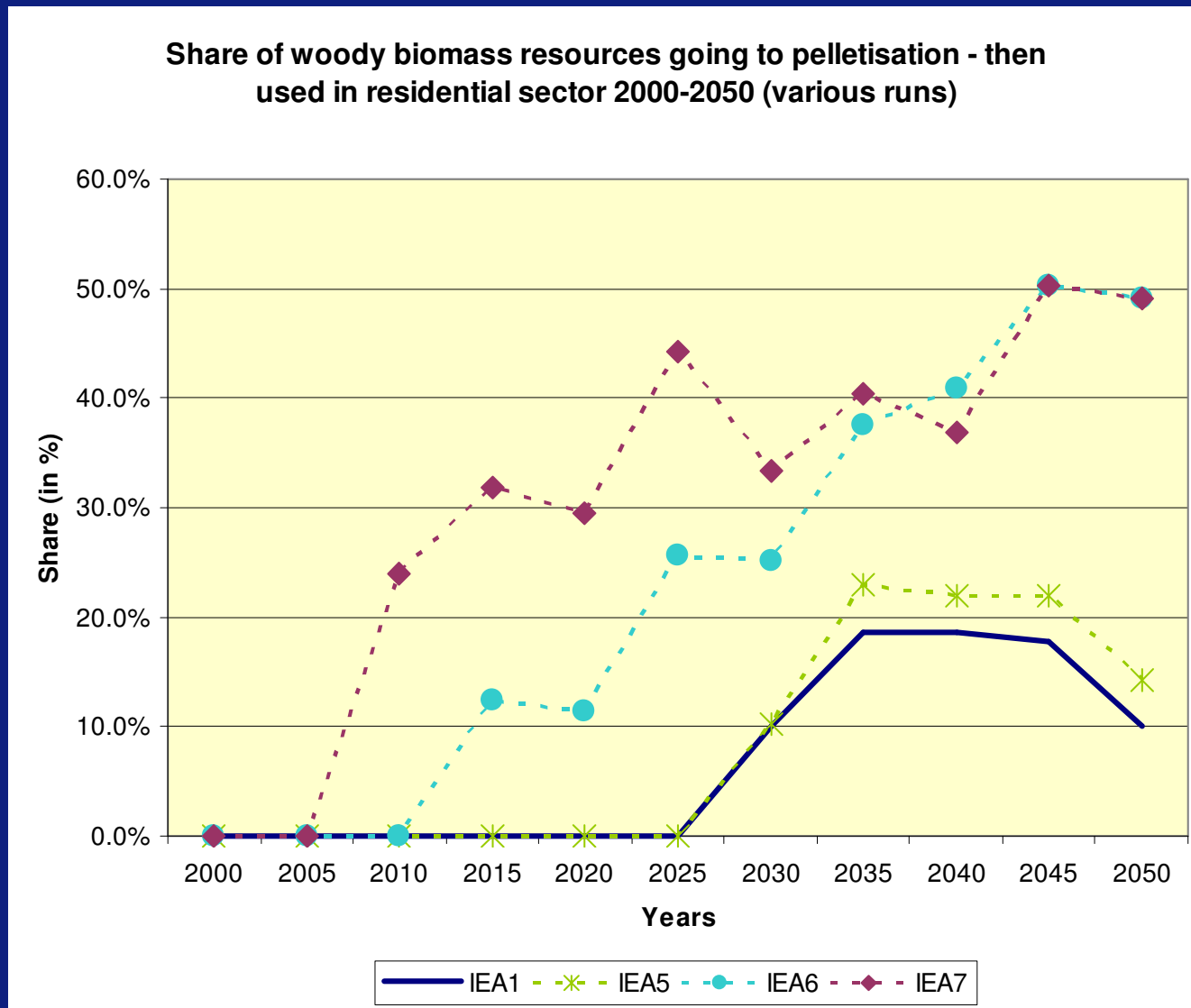
- Technology and fuel mix
- Sustainability issues (land-use change & availability, carbon emissions etc.)



Application to the residential heat sector

- Application of Market Segment Analysis (MSA)
– and trilemma problem structuring => qualitative storylines
- Focus on modelling runs for woody biomass chains with UK-MARKAL => quantitative insights
- Combination of information => exploration of long-term residential bio-heat scenarios

Share of woody biomass resources going to pelletisation (then to residential sector)



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