



Bioenergy MARKAL model and the formulation of UK Bioenergy Scenarios

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- Methodology
- Review and update of bioenergy chains in UK-MARKAL
- Definition of bioenergy scenarios
- Results of MARKAL BIOSYS “core runs”
- Conclusion and next steps

Introduction: context and objectives

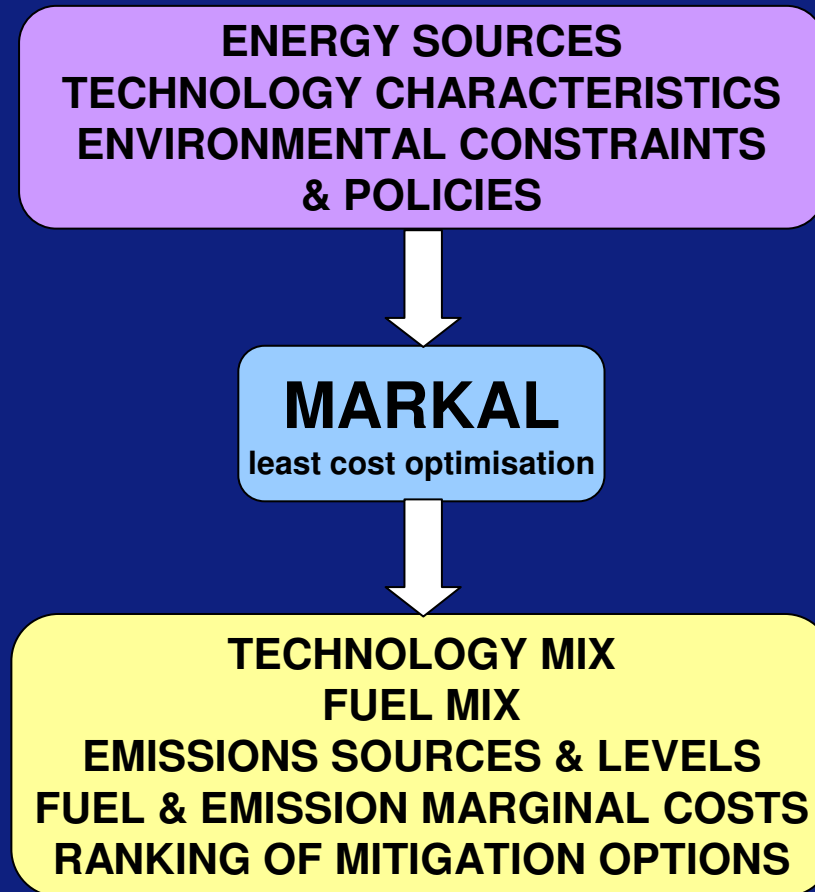
Context of the study

- Energy modelling holds an important role in policy making
- Markal contribution to this area has been developed over 20+ years
- UK-MARKAL model underpinned some of the policy recommendations included in the 2003 and 2007 Energy White Papers
- Also used for UKERC 2050 project and by the OCC etc.
- On-going review and improvement of the model is part of its strengths

Objectives of the TSEC-BIOSYS MARKAL modelling exercise and study

- Review the representation of bioenergy chains in the UK-MARKAL model version 3.12
- Propose key improvements for the representation of bioenergy
- Implement the improvements to bioenergy chains into an updated “MARKAL_BIOSYS” database
- Generate insights leading to the formulation of scenarios for the future of bioenergy in the UK by 2050

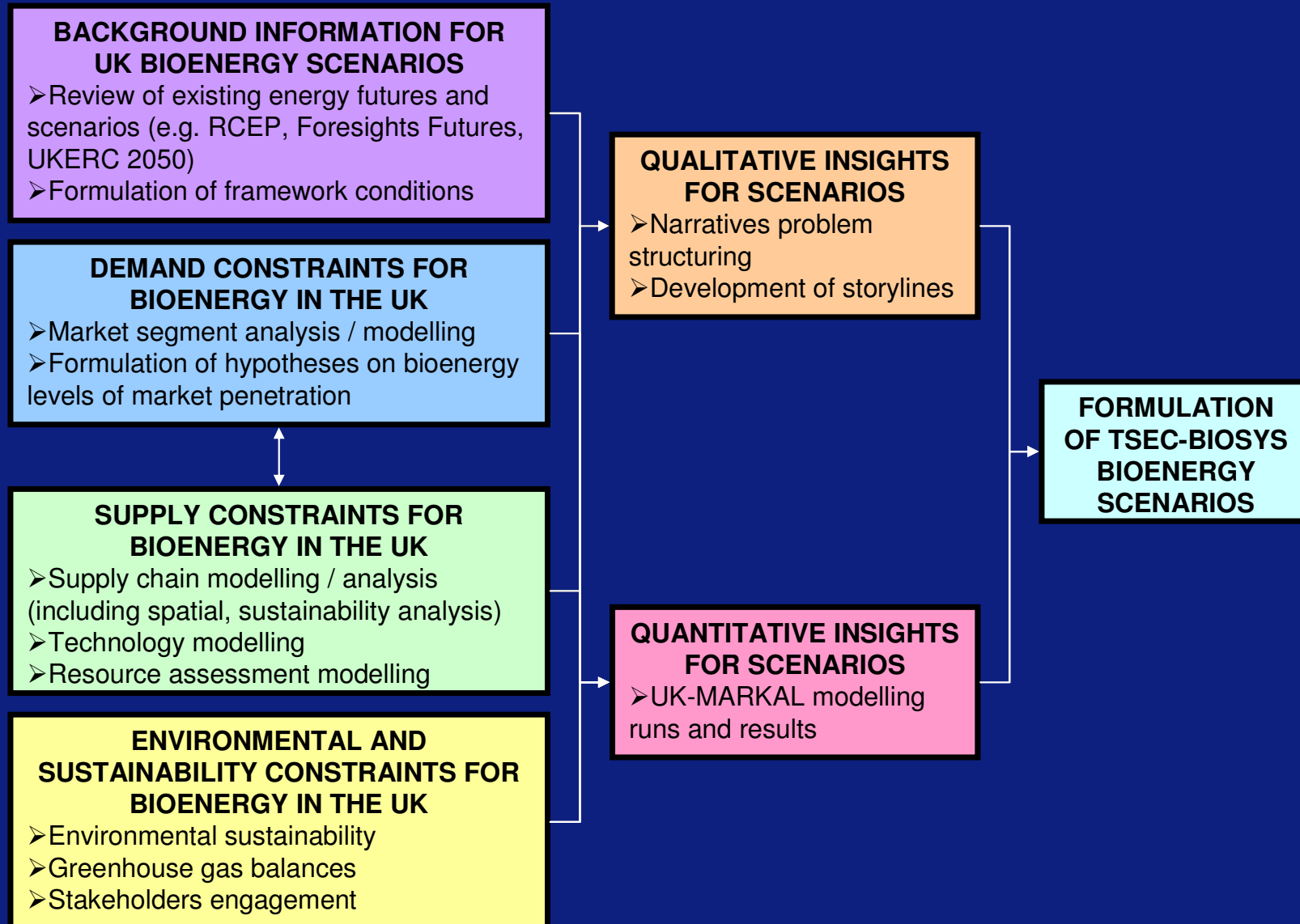
Reminder: MARKAL modelling



Reminder: running the UK-MARKAL model

- Model represents UK energy system
 - Starting from UK-MARKAL 2.1 & 3.12 => BIOSYS_MARKAL_V051108
- 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 analyses can be carried out in a systematic ‘what-if’ framework

Markal contribution to the formulation of UK bioenergy scenarios

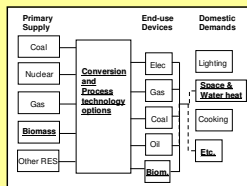


Methodology

Methodology used for MARKAL modelling focusing on bioenergy

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

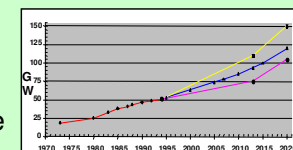
- Updated UK-MARKAL inputs with regards to bioenergy: domestic/imported resources, technologies' characteristics, etc.
- Use of standard UK-MARKAL other inputs: energy sources, technology characteristics, existing policies, etc.
- Definition of constraints (environmental, policies etc.) to be implemented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

UK-MARKAL "BIOSYS-MARKAL" With updated bioenergy module

MARKAL MODELLING OUTPUTS

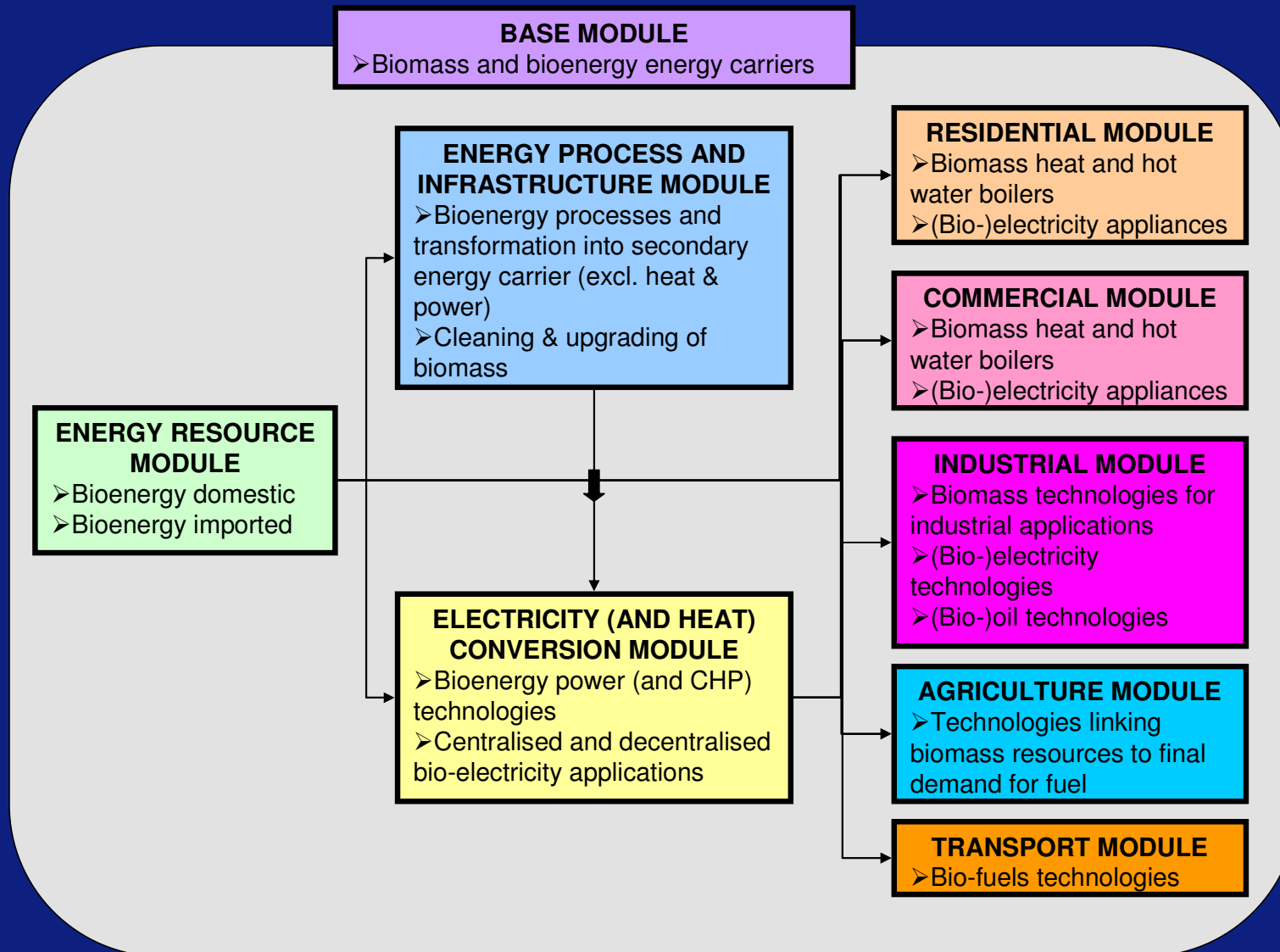
Key results of the modelling runs are examined in the light of the levels of bioenergy penetration in the three main final consumption sectors (heat, power and transport fuels), and what are the related implications for the energy system:

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



Review and update of bioenergy in UK-MARKAL

Reminder: overview of bioenergy in UK-MARKAL



Review of bioenergy in UK-MARKAL 3.12

- Exercise undertaken since October 2007
- Based on UK-MARKAL 3.12 database
 - Intermediate progress between energy white paper 2007 and UKERC 2050 project
- Module by module focus on bioenergy:
 - Review of the bioenergy chains considered
 - Review of the inputs and inputs for each technology
 - Review of the data characterising energy carriers, process & end use technologies, and resources
 - Review of road transport fuel taxation
- Findings cover all modules and are wide-ranging in terms of both structure and datasets
 - Working Paper 1 soon on TSEC BIOSYS website

Implementation of key changes into new BIOSYS_MARKAL database

- Includes some changes in structure of bioenergy module when compared to 3.12
 - Some added technologies / paths (e.g. pelletisation, aviation bio-kerosene)
 - Some neglected pathways (e.g. algal oil, dark fermentation, gas-powered vehicles)
 - Working Paper 2 soon on TSEC website
- Detailed data review for all bioenergy technologies
 - Datasets update to reflect (as much as possible...) expert-informed, up-to-date, UK-specific bioenergy knowledge and expectations
 - Working Paper 2Bis soon on TSEC-BIOSYS website

Defining bioenergy scenarios for MARKAL runs

Scenarios should be formulated to enable runs in MARKAL

“A scenario is a plausible description of how the future may develop based on a coherent and internally consistent set of assumptions (“scenario logic”) about key relationships and driving forces.”

Source: Nakicenovic *et al.* 2008

Four pillars of UK energy policy should also be the focus of TSEC-BIOSYS

- As defined in the UK Energy White Paper 2007:
 - Environment
 - Energy reliability***
 - Affordable energy for the poorest*
 - Competitive markets for businesses, industry and households**

- But when it comes down to MARKAL.....

* This is not directly modelled in MARKAL

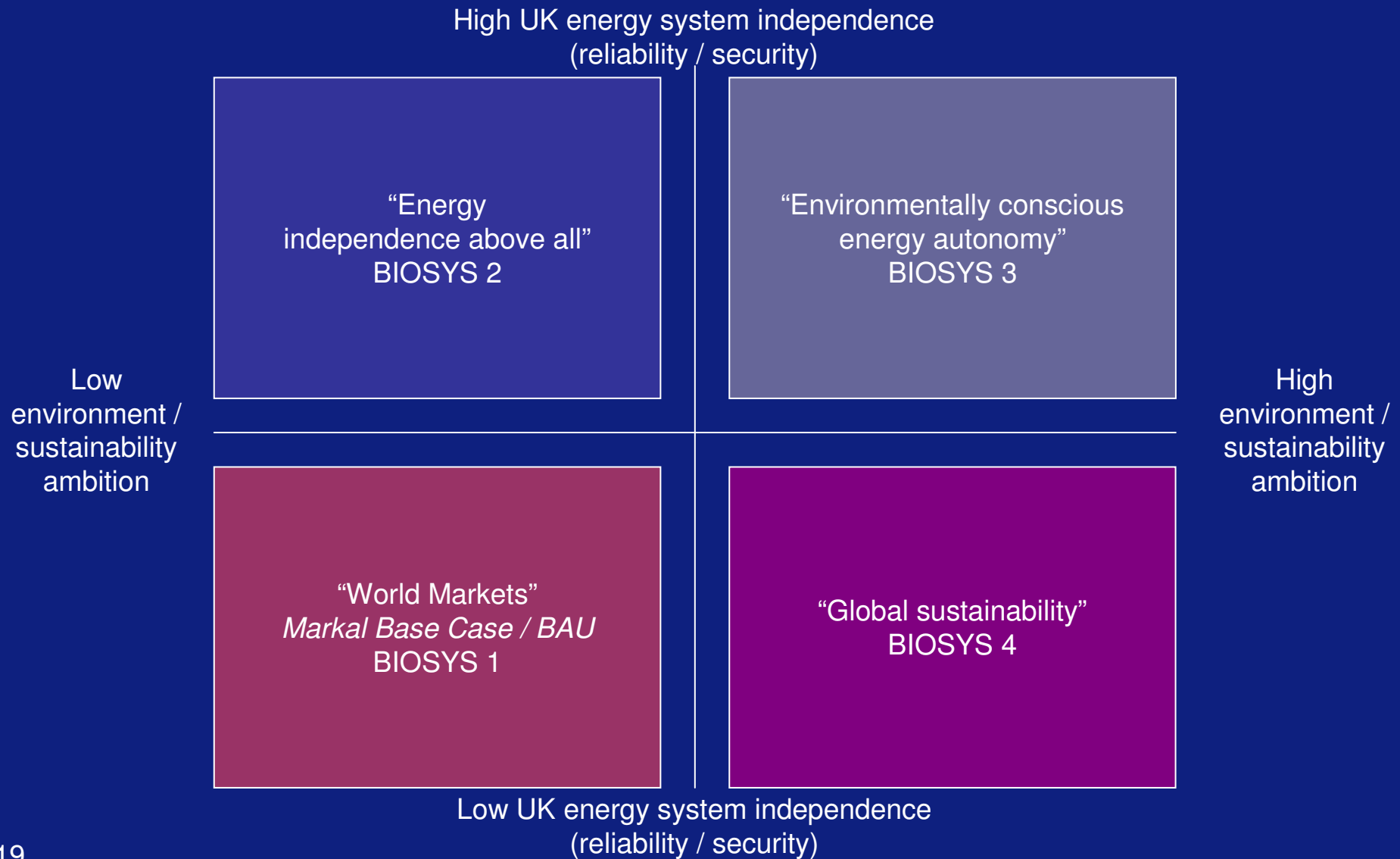
** By definition MARKAL provides the system configuration which offer the lowest overall discounted system cost over the time horizon chosen – so in a way it puts energy sources in competition

*** BERR's work on energy reliability is summarised under the headings „security of energy supply“ (then divided into the topics „security of supply“ and „quality and continuity of UK supply“)

Resulting approach chosen for TSEC- BIOSYS MARKAL scenarios

- Policy focus: 4 “core” scenarios (incl. BAU) based on the UK policy objectives that can be modelled
- Quantitative insights
 - Each core scenario as a distinct possible future defined based on the core scenario : detailed specification for each run
 - Variants are constructed for each core scenario as additional relevant possible run to investigate (based on ‘wish list’, with supporting analysis of the core scenario runs)
- Qualitative insights
 - Operational information for the modelling are set up in a qualitative way (overall scenario matrix + 2x2 spaces of variation for each Markal technology)
 - Enriching the qualitative stories using the trilemma mapping exercise done in Theme 3

Modelled scenarios BIOSYS1-4: overview



BIOSYS 1: BAU/base case “World Markets”

- Cost effectiveness is the main driver of the energy system evolution, before concerns for energy security, energy efficiency or sustainable energy production and climate change
 - All base costs levels and bounds are set up as described in WP2Bis
 - Some were adjusted to reflect the representation of a BAU situation where energy security and sustainability are not high on the energy policy agenda

BIOSYS 2: “Energy independence above all”

- Energy security is the main driver of the UK energy policy
 - The import of energy sources (both fossil and bioenergy) is limited
 - The use of domestic bio-energy resources is stimulated
 - The domestic processing of resources is strongly encouraged by R&D programmes and subsidy schemes

BIOSYS 3: “Environmentally conscious energy autonomy”

- Energy security is moved forward on the agenda with priority given to low carbon and renewable sources
 - The import of energy sources (both fossil and bioenergy) is limited
 - The use of domestic bioenergy resources is encouraged under a strong sustainability framework
 - The domestic processing of resources is encouraged by R&D programmes and subsidy schemes, which focus on the less “controversial” technologies on the grounds on sustainability
 - The overall use of low carbon and renewable energy in the UK energy system is strongly supported by ambitious policies

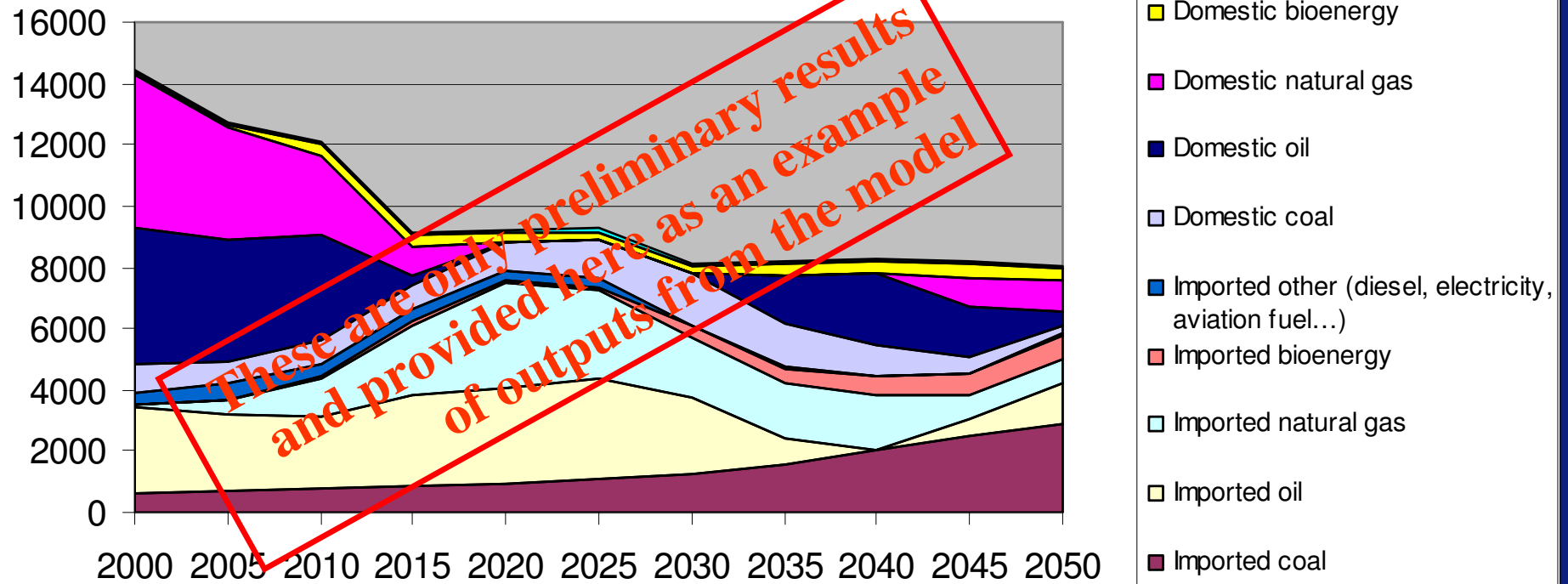
BIOSYS 4: “Global sustainability”

- Sustainability is promoted in energy production and supply in a globalised manner
 - Domestic and imported bioenergy resources are promoted under a strong sustainability framework
 - The overall use of low carbon and renewable energy in the UK energy system is strongly supported by ambitious policies

Results obtained so far:
insights into base case BIOSYS1
“World Markets”

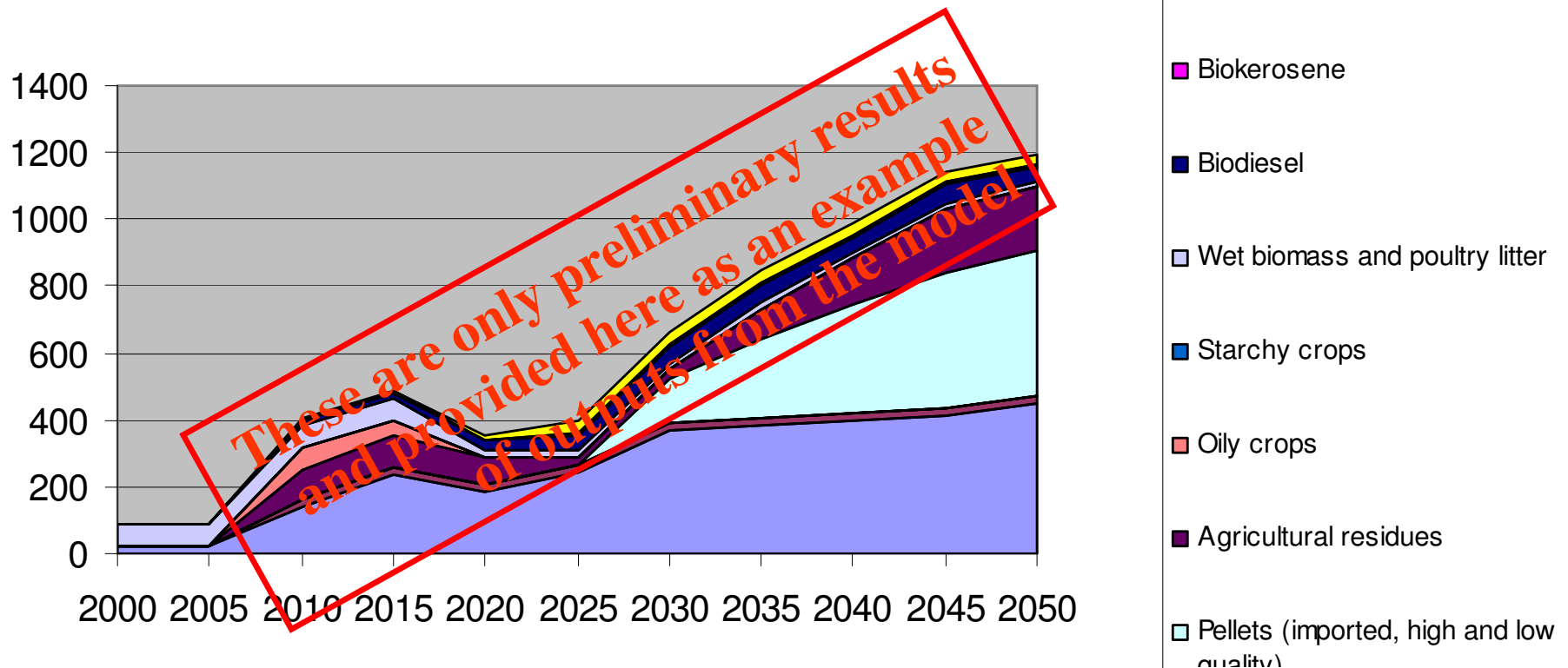
BIOSYS1: Energy resources results

BIOSYS 1: Energy resources by type



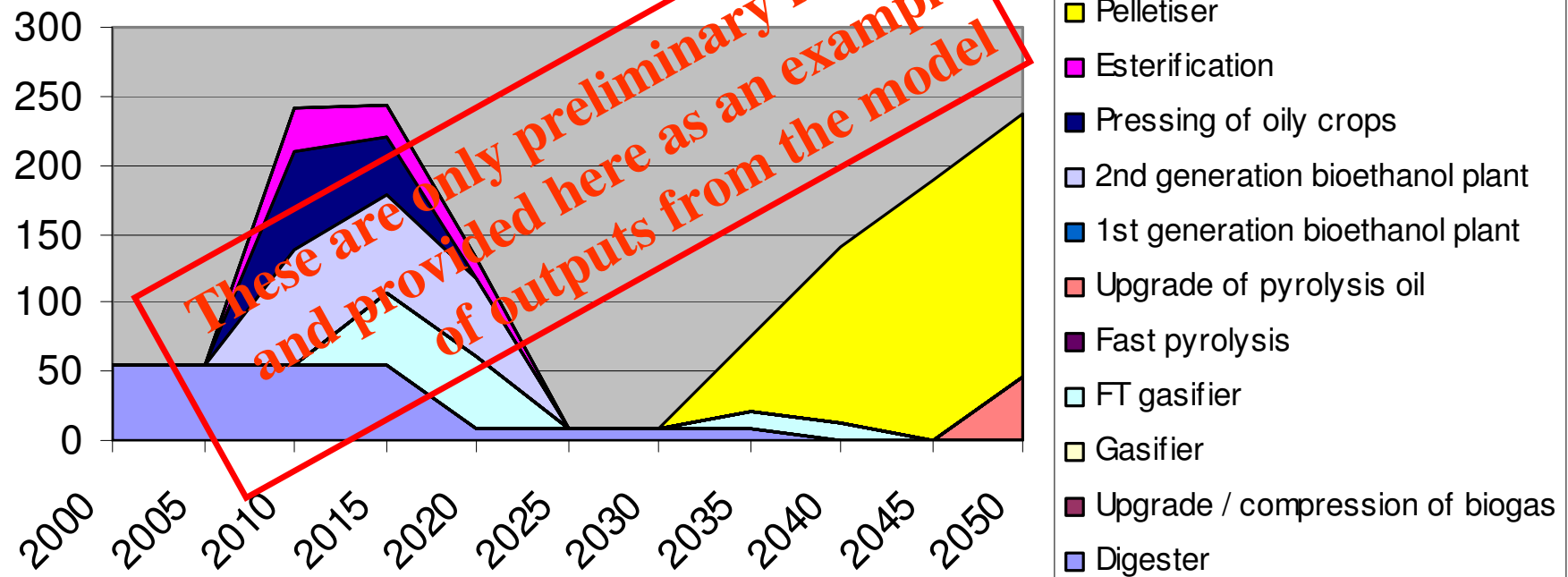
BIOSYS1: Bioenergy resources mix

BIOSYS1: bioenergy resource mix



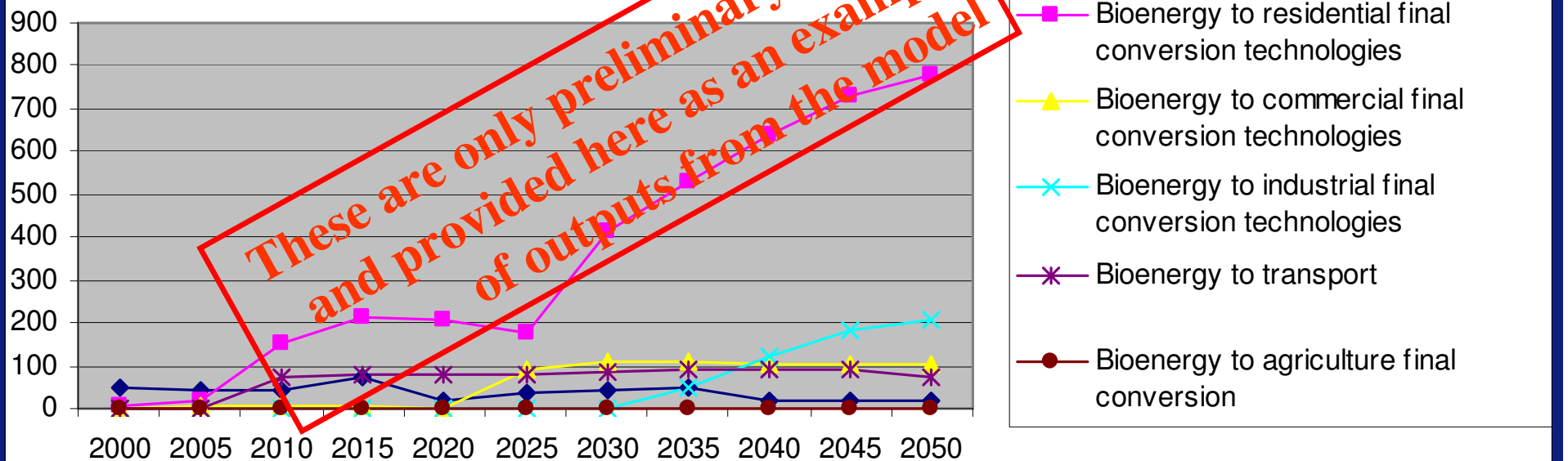
BIOSYS1: Processing of bioenergy

BIOSYS1: Processing of bioenergy resources (excluding direct distribution)

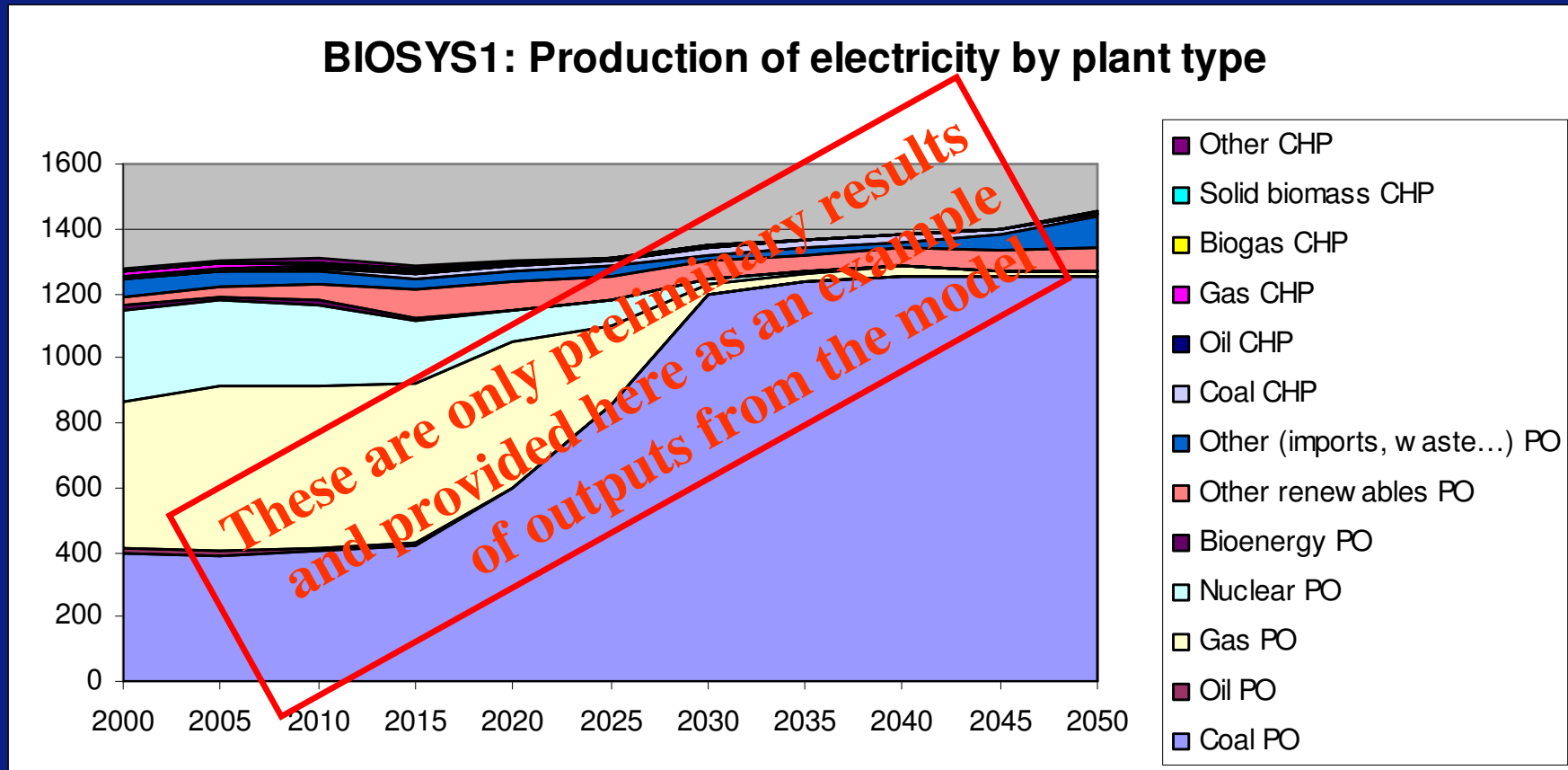


BIOSYS1: Distribution to various end-uses or final conversion

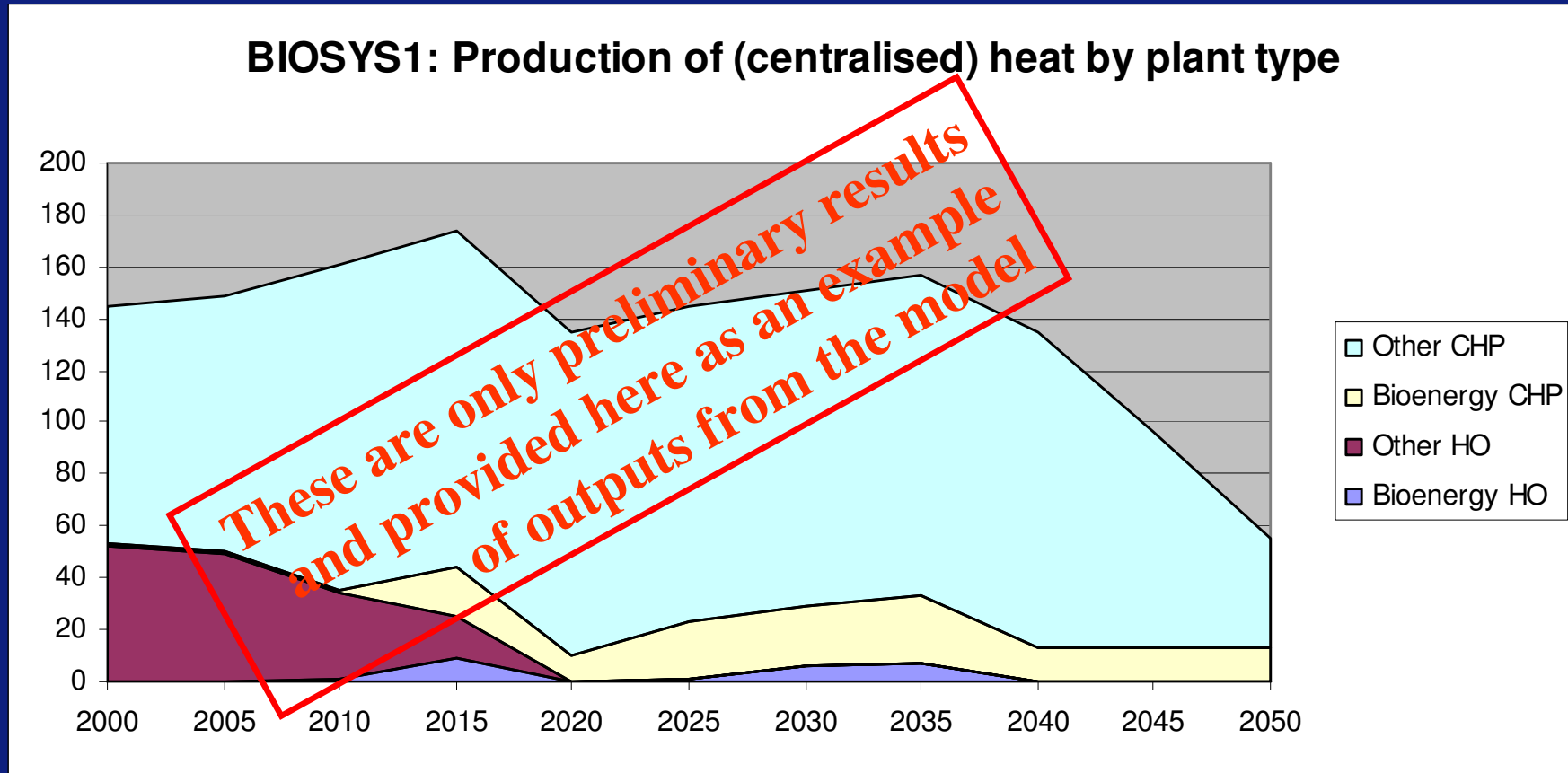
BIOSYS1: Bioenergy in distributed fuel to conversion and final end use sectors



BIOSYS1: Electricity mix from centralised and decentralised plants

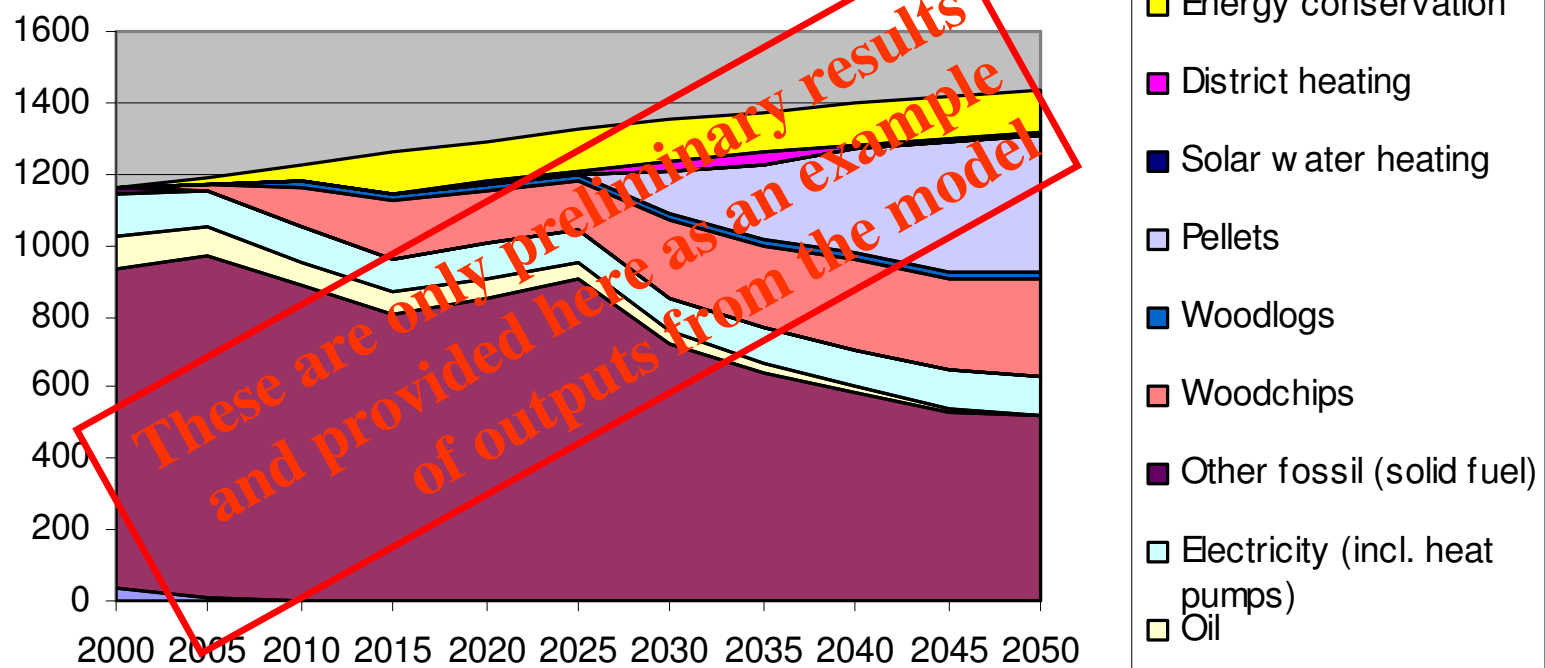


BIOSYS1: Heat-mix for “centralised” production plants

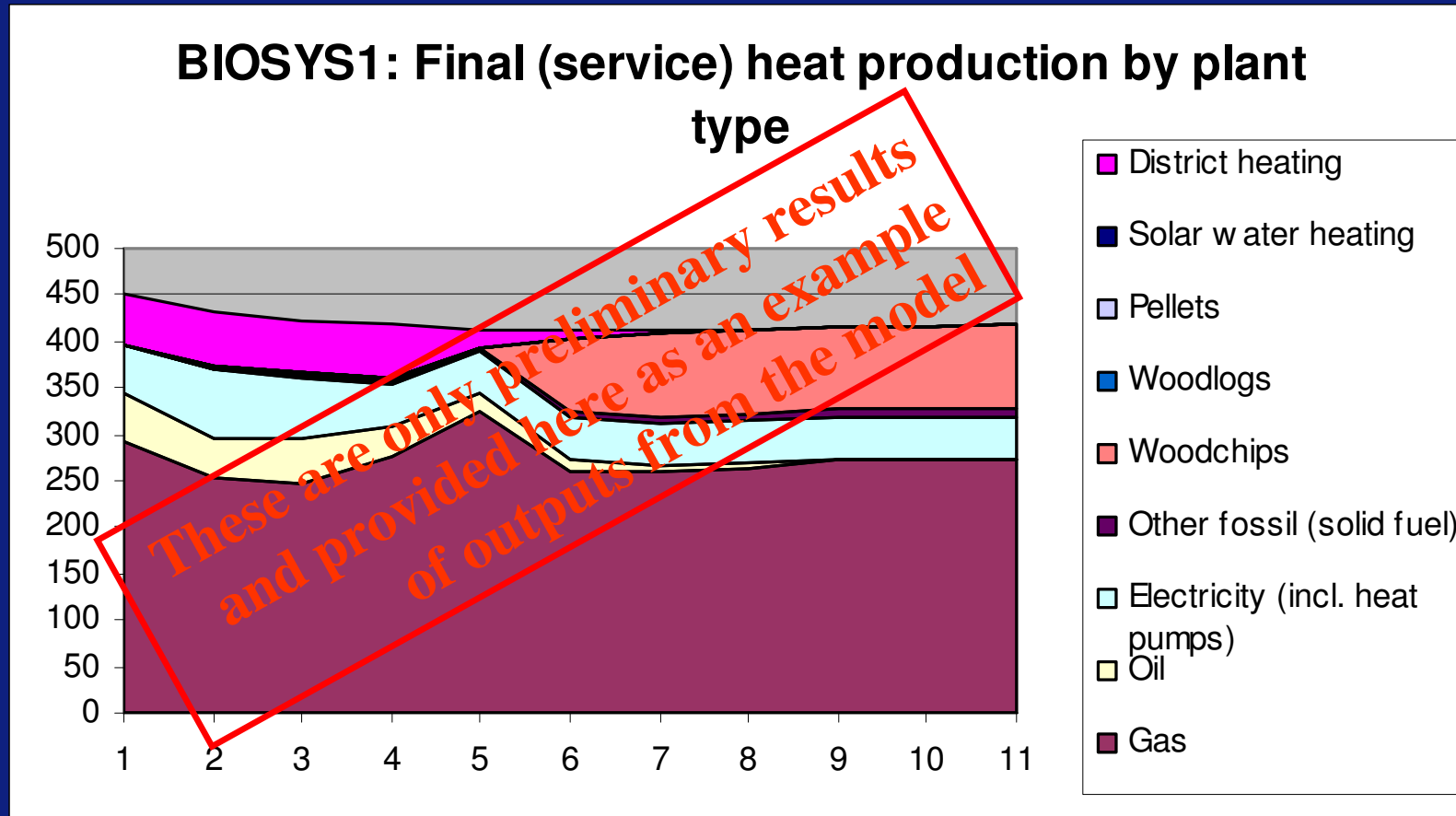


BIOSYS1: bioenergy in the residential sector

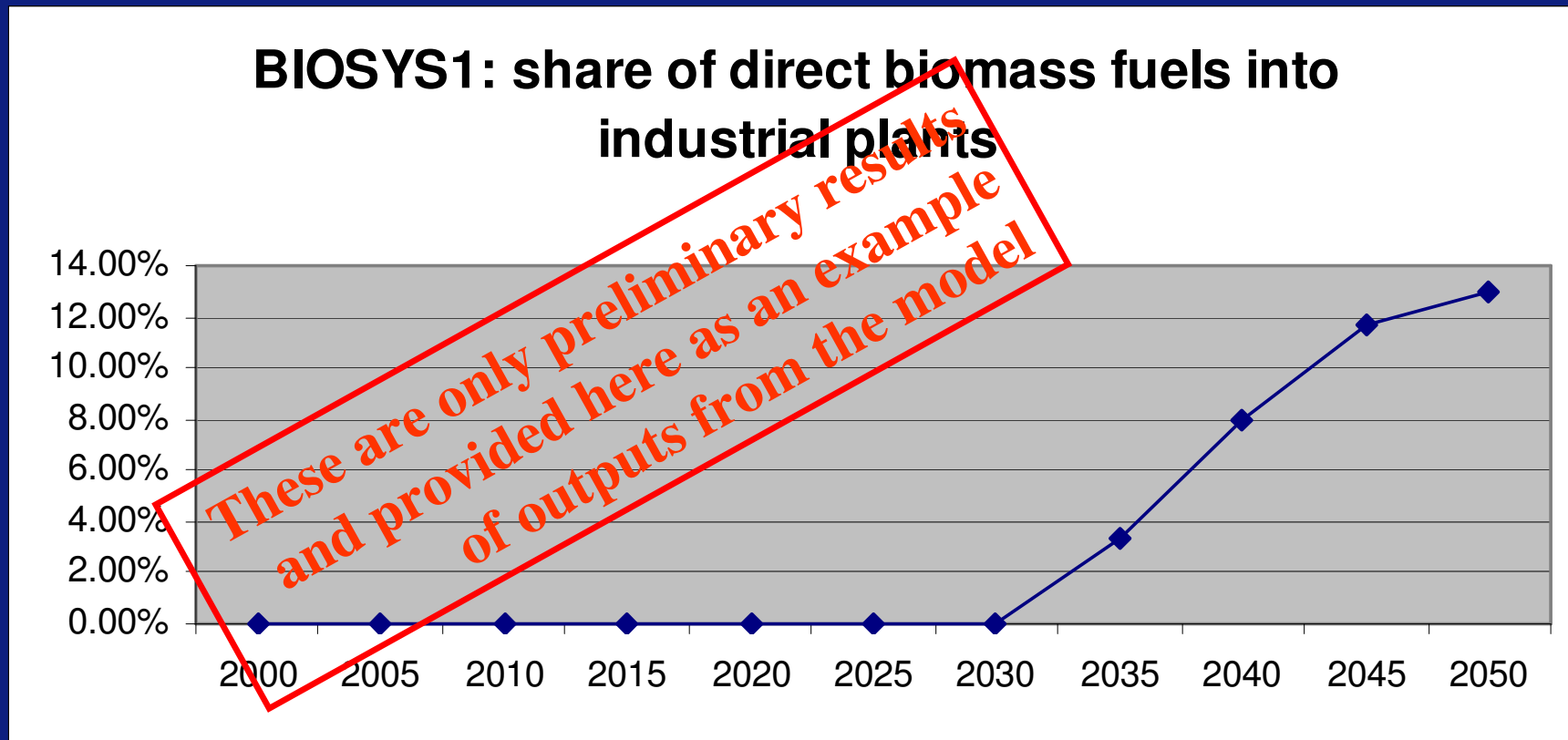
BIOSYS1: Final heat production by plant type



BIOSYS1: bioenergy in the service sector

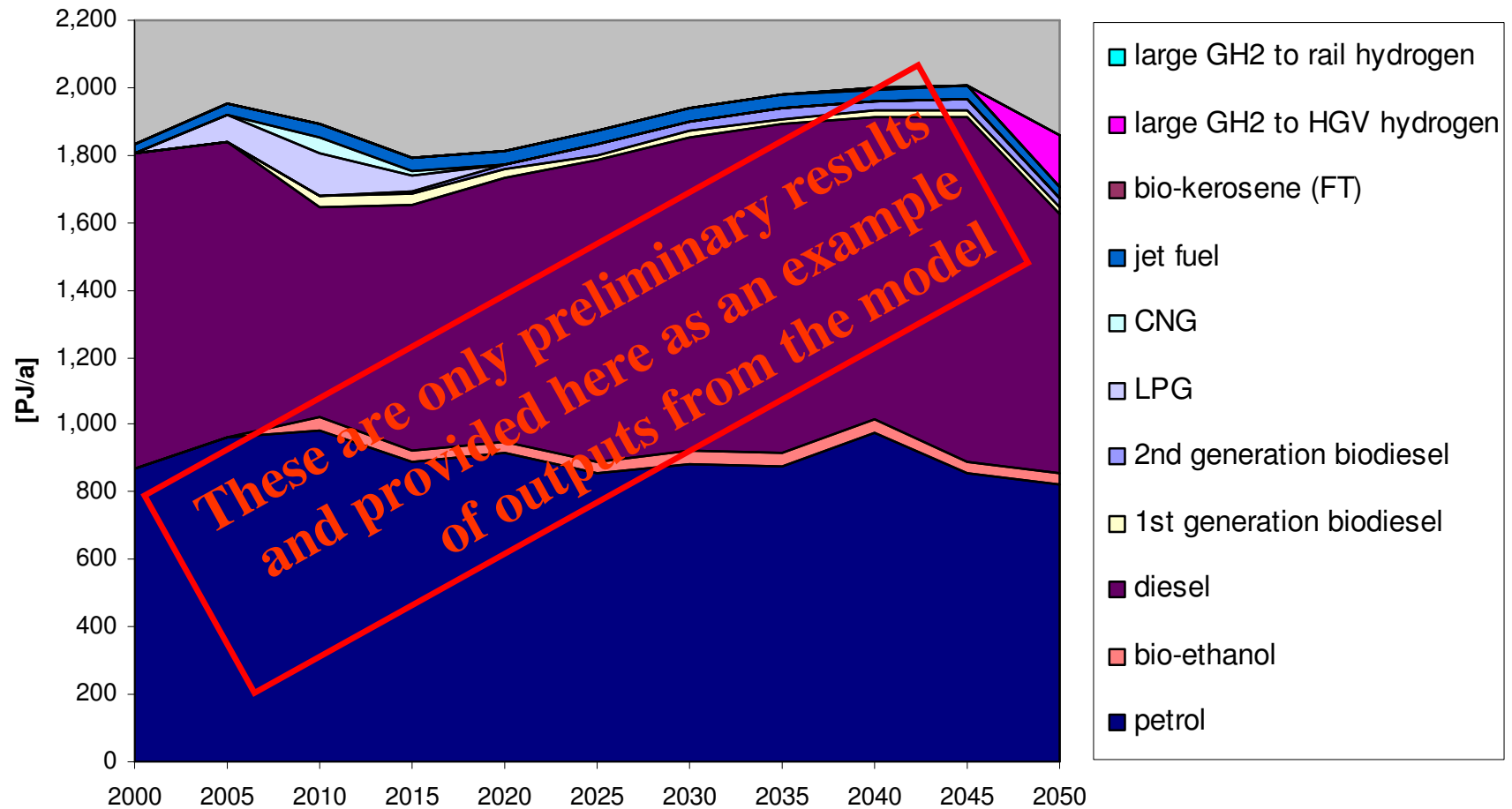


BIOSYS1: bioenergy in the industrial sector

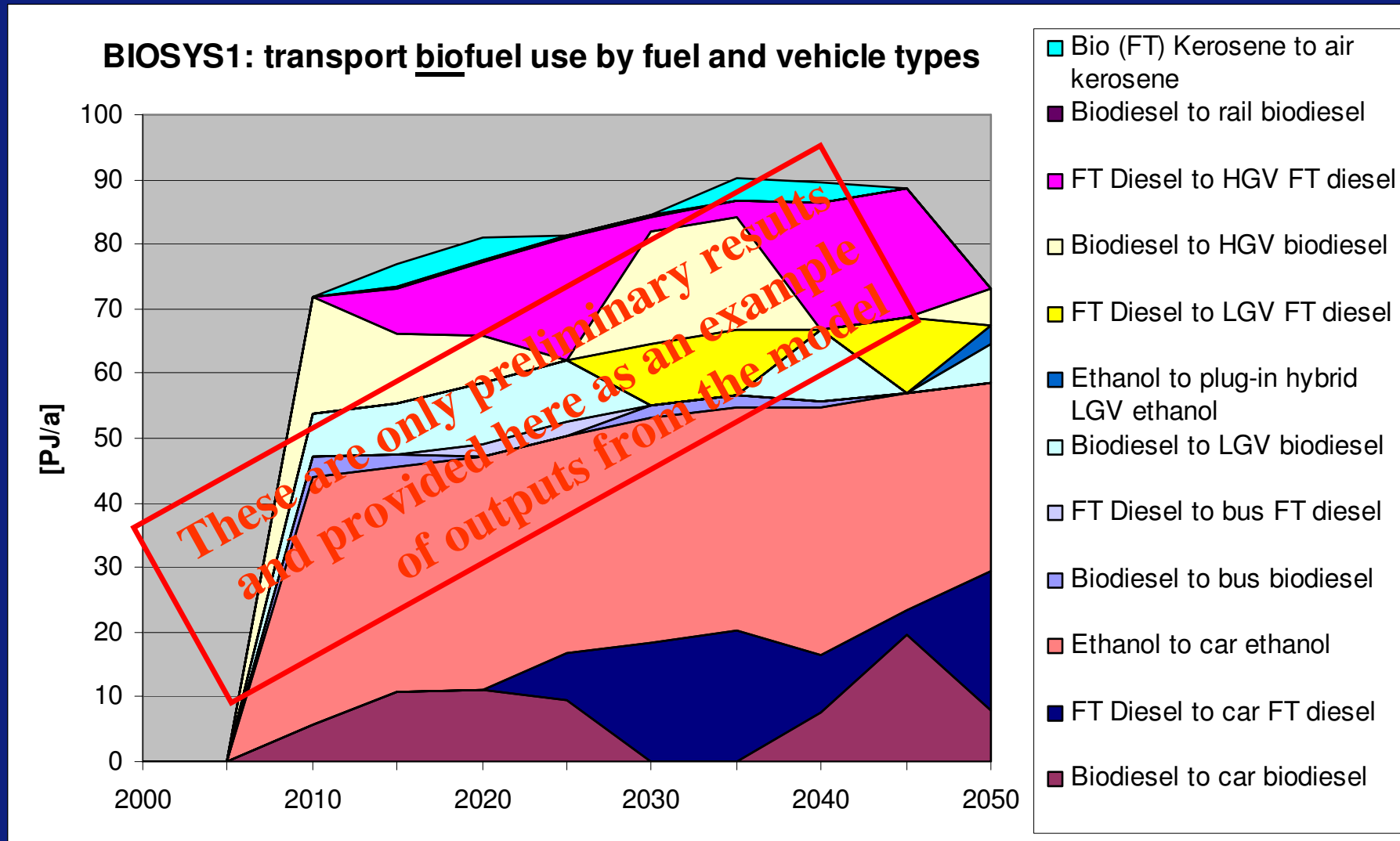


BIOSYS1: bioenergy in the transport sector

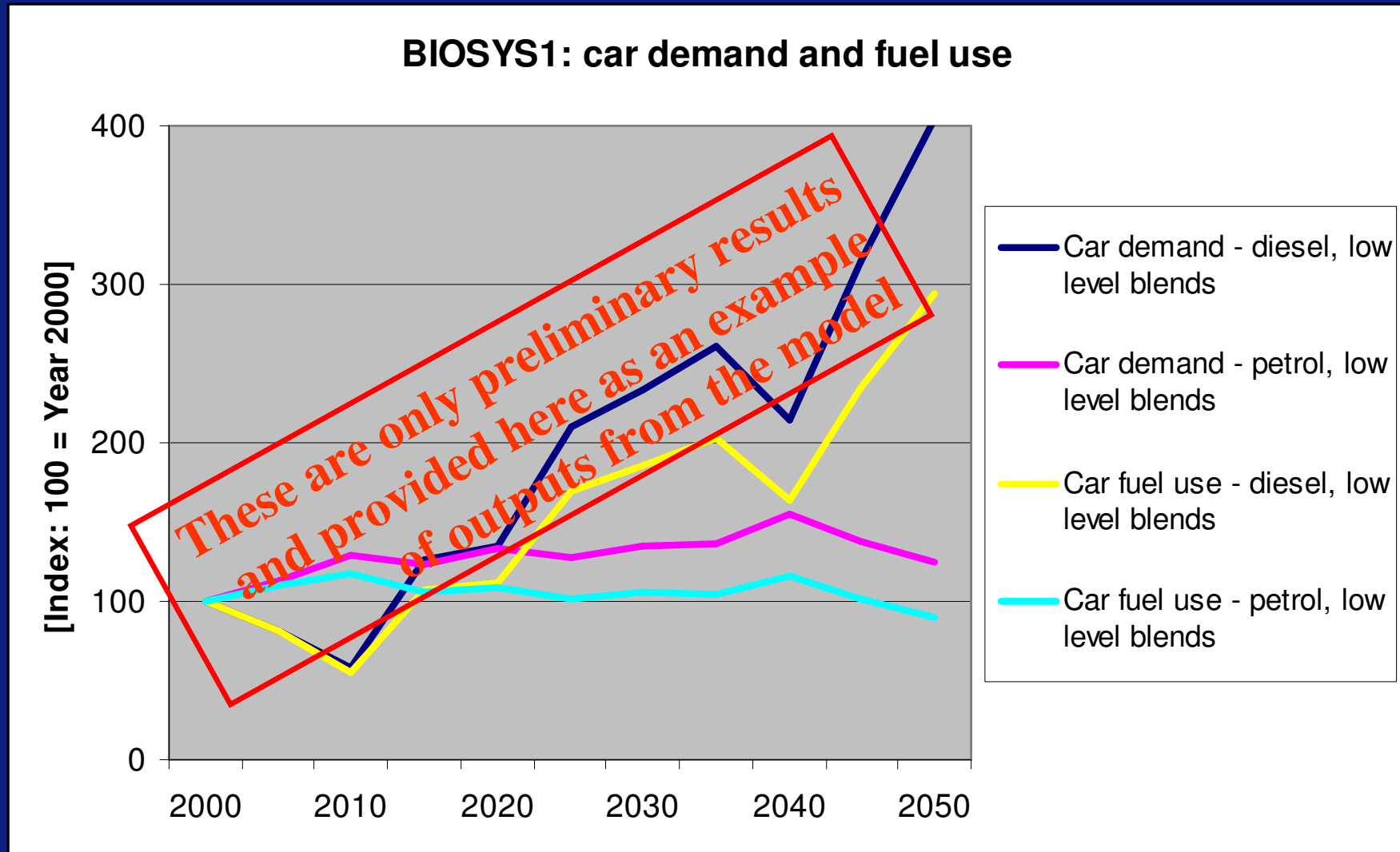
BIOSYS1: transport fuel use by fuel type



BIOSYS1: bioenergy in the transport sector



BIOSYS1: 'business as usual' for cars



BIOSYS1: summary and main messages

- Biomass seems a competitive option to supply energy
 - It reaches significant shares of penetration in the heat sector (20-50%)
 - Power and transport fuel use from biomass remain rather low (resp. <1% and up to 5%)
- Domestic resources are used first and domestic processing is used to produce transport biofuels and biogas before 2020
- Domestic resources are then completed by cheap imported feedstock and domestic processing is progressively abandoned except for pelletising

BIOSYS1: summary and main messages

- Other findings
 - Biogas is not compressed to be injected in the gas grid or for transport applications
 - Fast pyrolysis technologies are not taken up over the model's time horizon

(Preliminary) conclusions
Next steps

(Preliminary) conclusions

- Preliminary results encouraging
 - “Updated” bioenergy chains are used by the model with interesting levels of penetration in all sectors
 - The results exhibit some interesting dynamics occurring between sectors and fuels, which better reflect bioenergy versatility
- However... the results also show some limitations of the model
 - “On/off” shifts from one resource to another are not always representative of real system/infrastructure inertia

(Preliminary) conclusions (2)

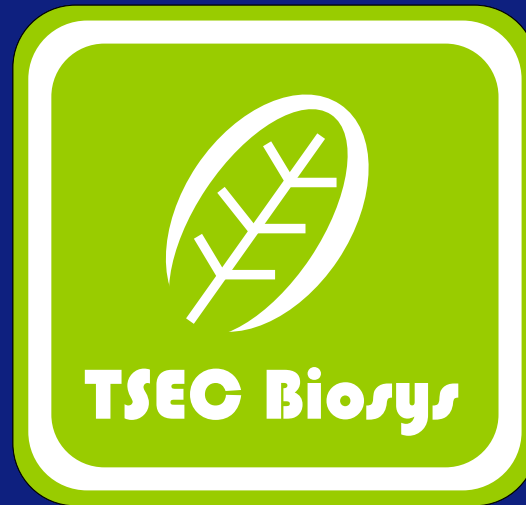
- Also...some “bugs” or modelling errors were identified
 - Model assumptions need refinement (e.g. short term transport fuel mix, bio-methanol in transport)
- Finally... time is “the enemy”
 - Many possible runs and variants to look at
 - Whilst the modelling of runs is “fairly” easy, their analysis can be tricky and time consuming

Next steps

- Detailed analysis of core scenarios results BIOSYS 2,3,4 to be completed (next week)
- Refining of the core scenarios based on bugs and findings to be undertaken, and validated (end Nov 08)
- Qualitative storyline to be formulated in more details by linking with trilemma maps – both Markal inputs and outputs (Dec 08)
- Key variants to be listed and prioritised for each core scenario (Dec 08-Jan 09)
- Variants results to enrich quantitative and quantitative analysis / outputs (Jan 09)

Thank you for your attention!

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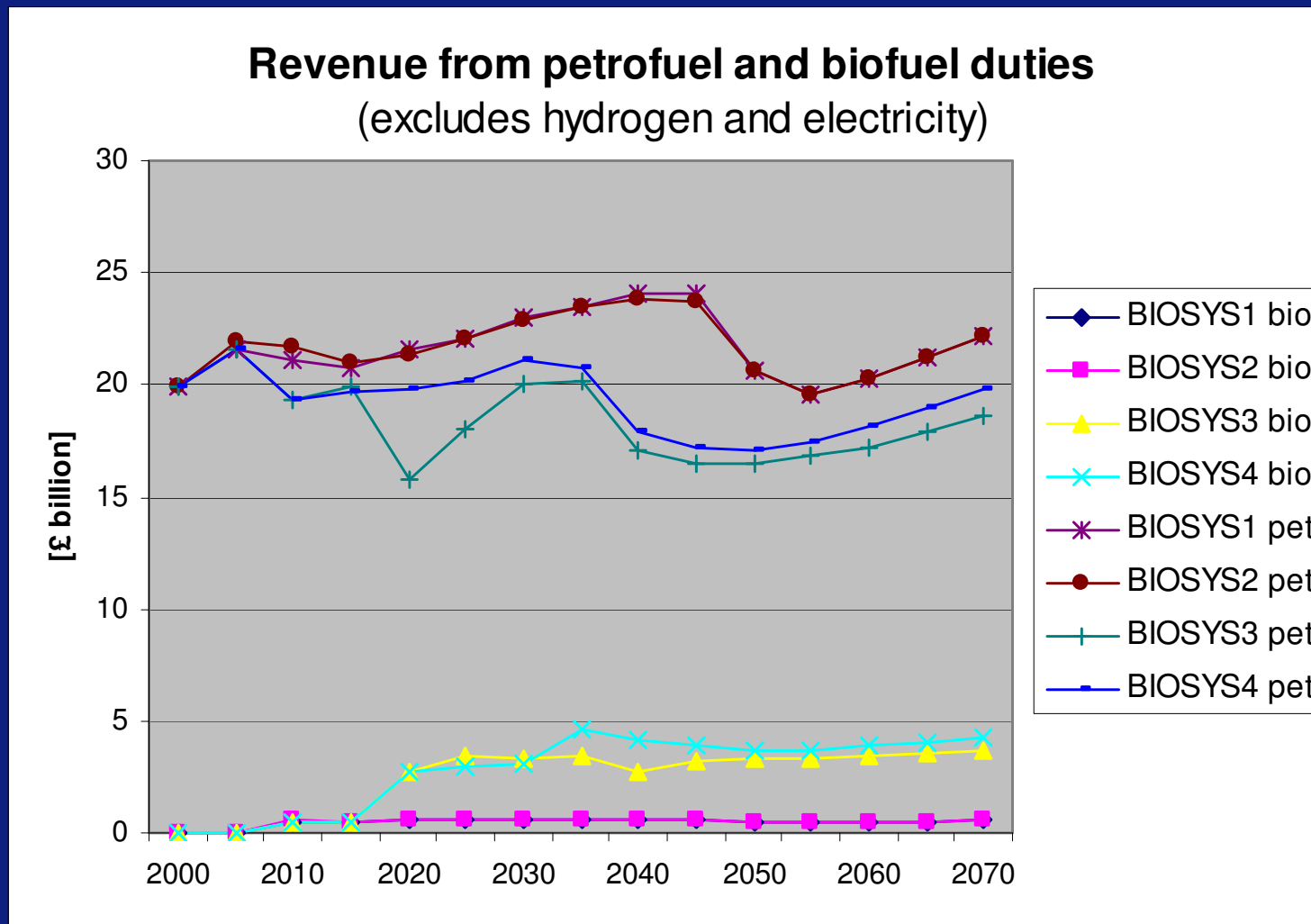


Additional slides if needed
Outlook on other core scenarios

Overview of results for other core scenarios

- Transport sector:
 - CO₂ emissions reduced by approx. -30% by 2050 in a -60% constrained world (BIOSYS3 and 4)
 - Significantly higher biodiesel take-up in BIOSYS3 and 4
 - High level bioethanol (E85) take-up only in BIOSYS4: ~100PJ for vans from 2050
 - Bio-methanol take-up in BIOSYS3 and 4: ~150-300PJ for ICE vans from 2020 – dodgy!

Insights of results for other core scenarios - road fuel taxation effects



BIOSYS: transport sector CO₂ emissions

Note: BIOSYS3 and 4 have -60% target

