

BIOsynergy



WP No 6

Name: Process chain design

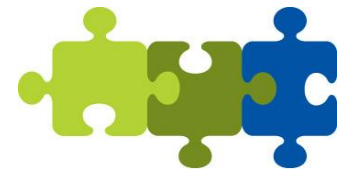
Description and progress

Researcher: Katie Chong

WP Coordinator: Tony Bridgwater

Biosynergy Workshop

November 2010, Reims



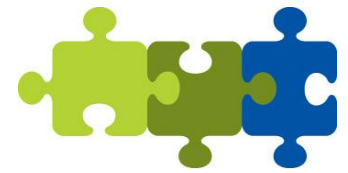
Objectives WP No.6

Identification of the most promising biorefinery chains for the European Union, and for some specific market sectors in terms of:

- Performance as yield and efficiency,
- Energy efficiency,
- Environmental performance as LCA,
- Cost as capital, operating and product costs
- Socioeconomics

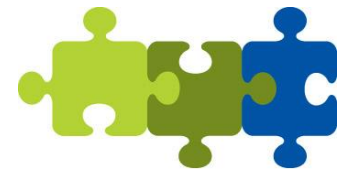
Participants: Aston, ECN, IFP, CRES, JR, JRC, Cepsa

Collaboration: ABNT

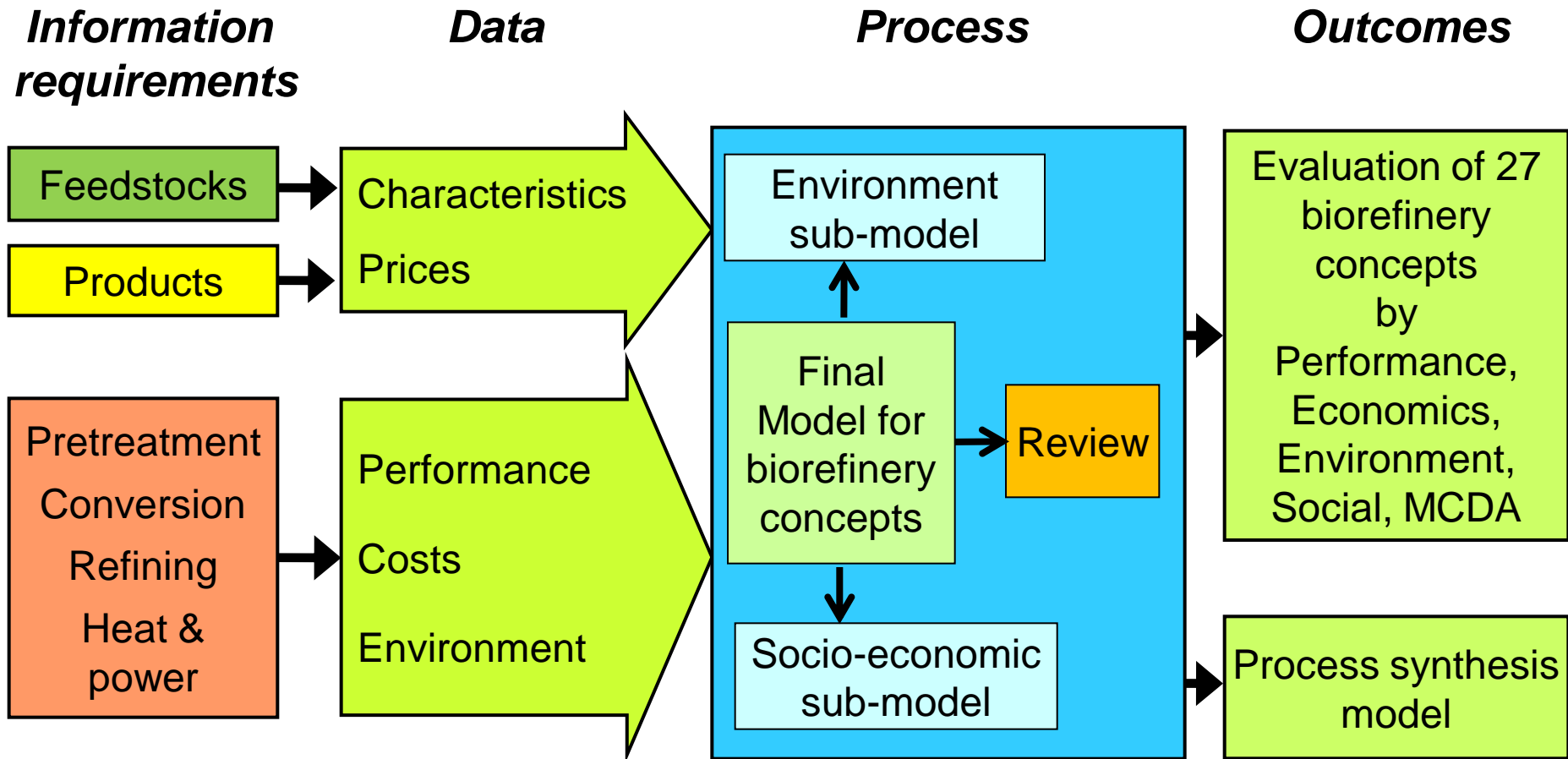


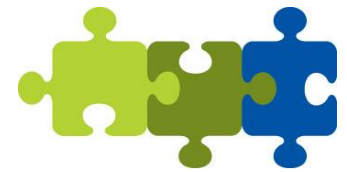
Methodology

- Construct a comprehensive and representative suite of biorefinery processes
- Evaluate these processes in terms of:
 - Performance in yield and energy balance – this requires mass and energy balances to be constructed, and at least minimal energy integration to be included
 - Cost – the capital and operating costs
 - Environmental performance as LCA and impact assessment
 - Socioeconomic assessment in terms of employment and investment



WP6 - Structure





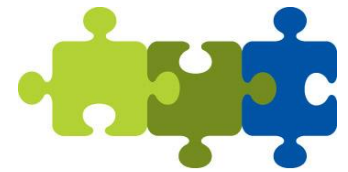
Feedstock, processes and products

Large number of feedstock, process and product options leads to an even larger number of possible combinations.

Example:

- 2 feedstocks, 4 pre-treatment options, 2 C6 conversion options, 5 C5 conversion options, 4 lignin utilisation options
- Possible combinations= $2 \times 4 \times 2 \times 5 \times 4$
= 320 !

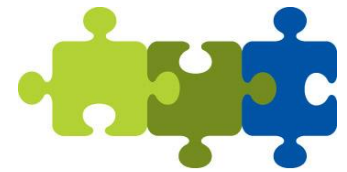
It is clear that there is a requirement for a logical and consistent methodological procedure for generating and comparing biorefinery process chains



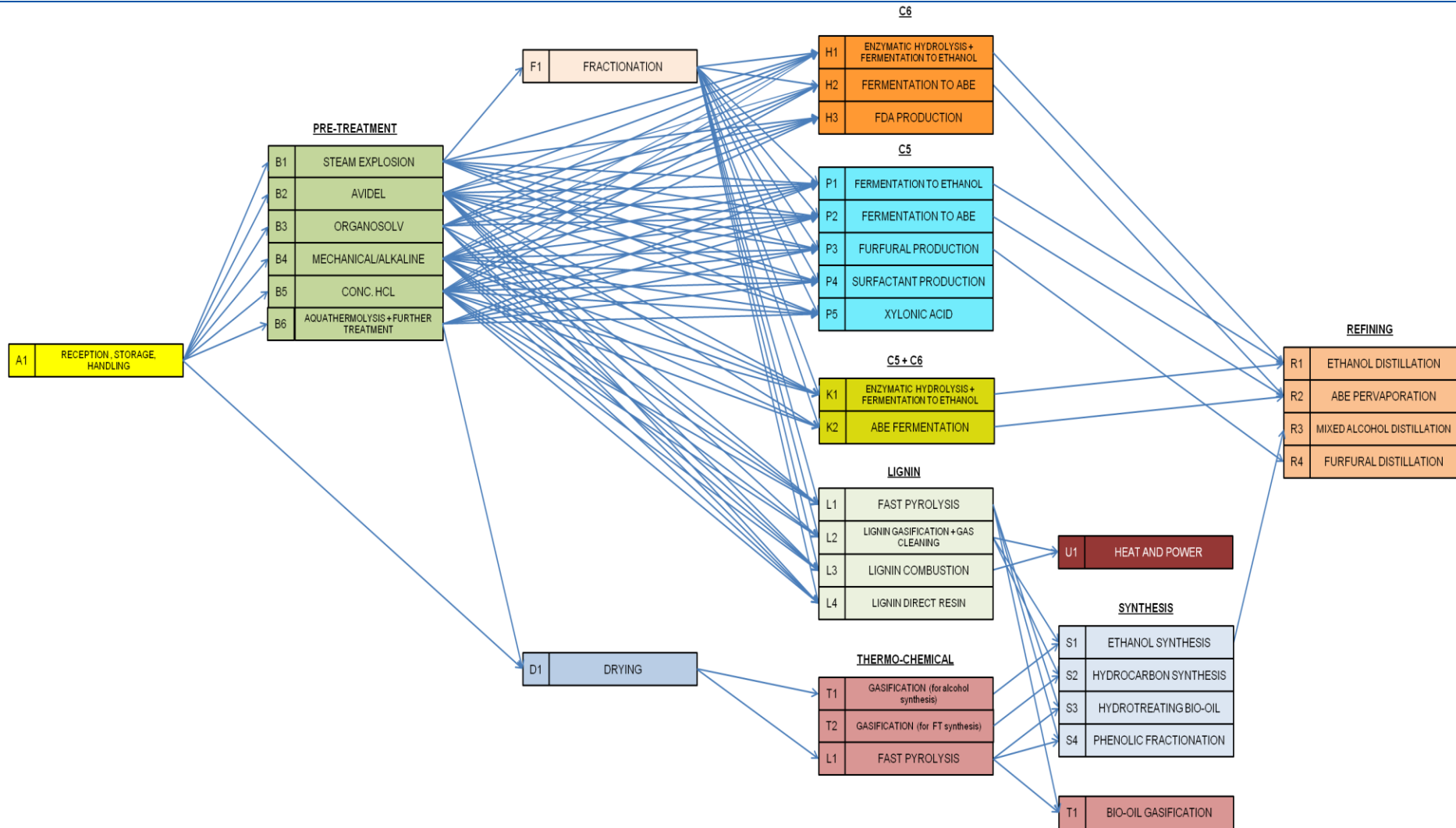
Methodology - overview

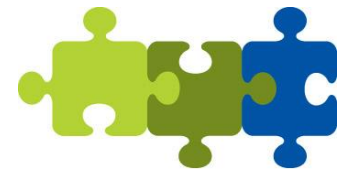
Consists of three steps

1. Chain generation (Process Synthesis)
2. Process modelling + data collection
 - i. Mass and energy balances
 - ii. Cost estimation
 - iii. Environmental LCA
 - iv. Socioeconomic
3. Chain evaluation and comparison (MCDA)



Mix and match process modules





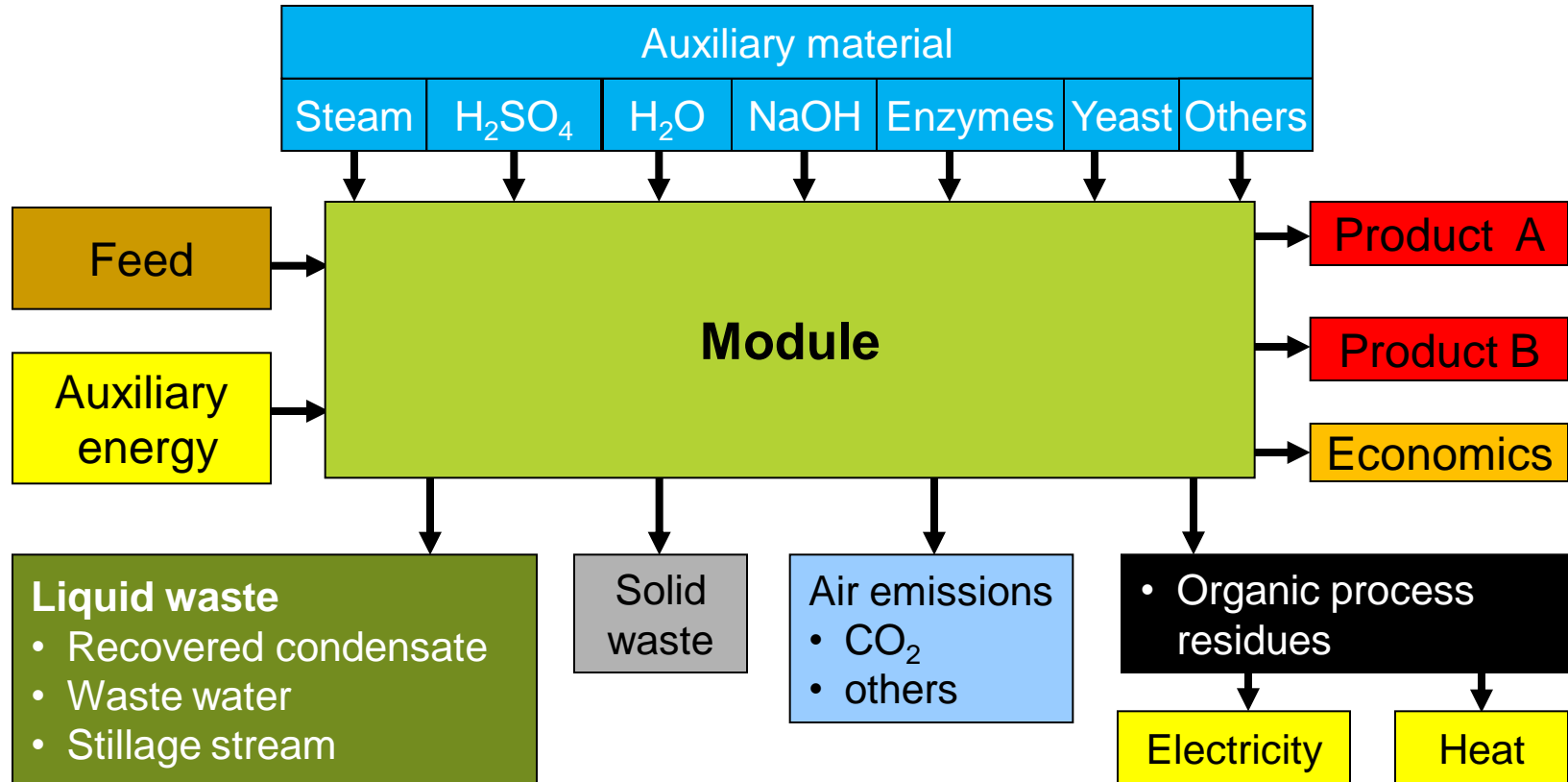
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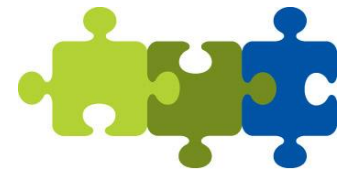
Module



Module inputs/outputs

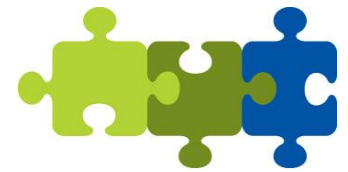
With in-built logic rules

Mass: t/a
Energy: MWh/a



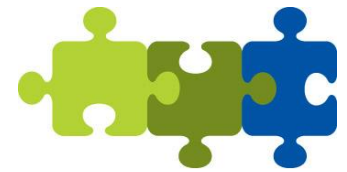
Biorefinery concepts

- 27 complete biorefinery concepts chosen by partners
- Biorefinery concepts using technologies and feedstocks from within the project with a number of other technologies for comparison
- Evaluated in terms of efficiency, cost, environmental and socio-economic performance
- Data provided by project partners or from the literature
- Validation carried out to ensure the accuracy of the models
- Possible with the methodology to investigate many more



Socio-economic assessment

- Employment
 - Direct
 - Induced
- Agriculture and land assessment
 - Consumption as % regional and national production
 - Land required (ha)
 - Land required as % of regional and national agricultural land
- Trade assessment
 - Revenue from traded feedstock and products
 - Revenue from traded feedstock and products as % of national GDP



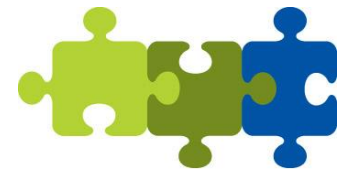
Life cycle impact assessment

quantitative

1. **Global Warming Potential** [t CO₂-eq.]
2. **Cumulated Primary Energy Demand** [GJ]
3. **Acidification Potential** [t SO₂-eq.]
4. **Eutrophication Potential** [t P-eq.]
5. **Photochemical Ozone Creation Potential** [t C₂H₄-eq.]

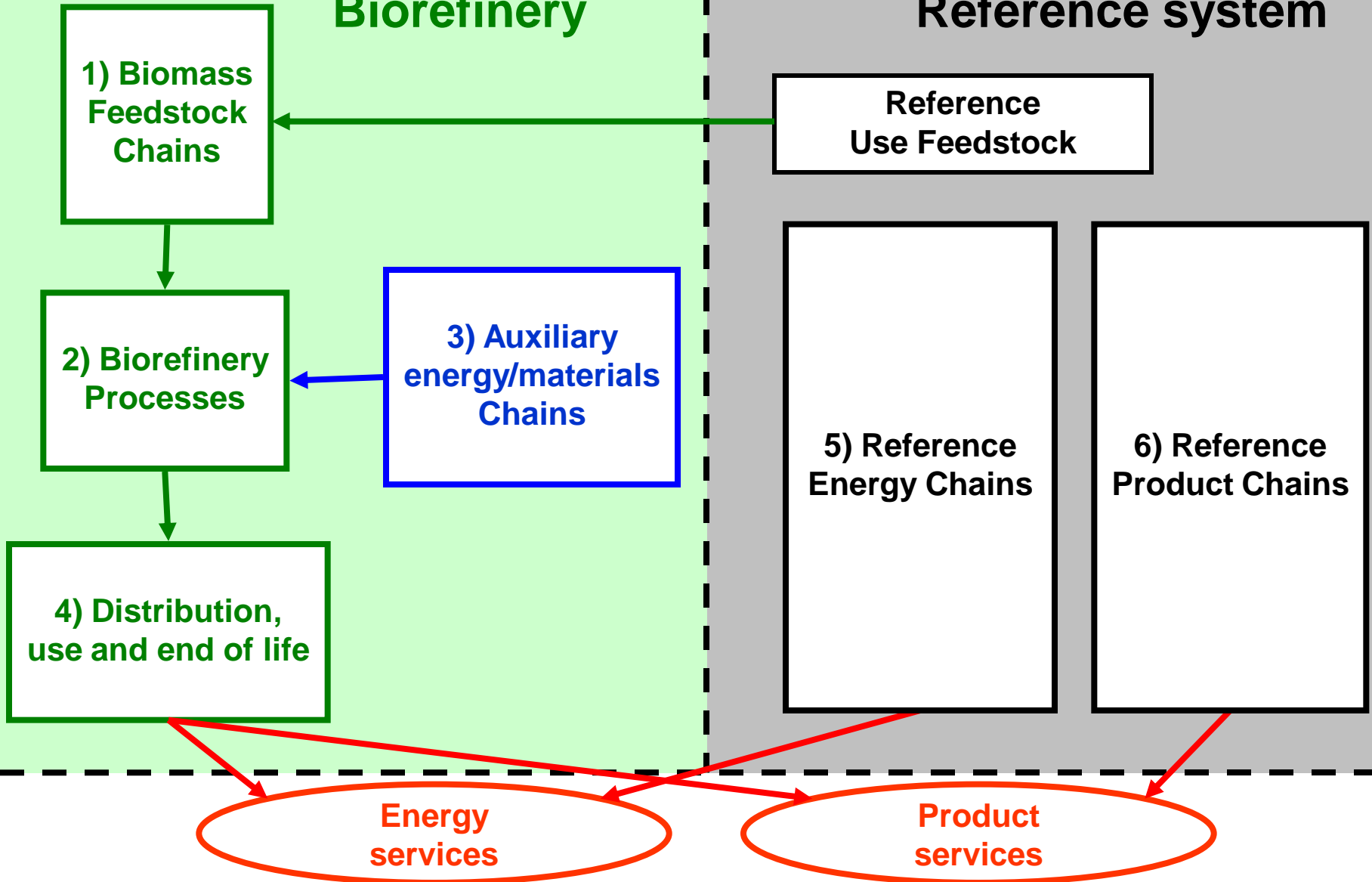
qualitative

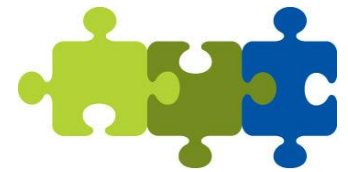
6. Abiotic Depletion
7. Freshwater Aquatic Ecotoxicity Potential
8. Marine Aquatic Ecotoxicity Potential
9. Terrestrial Ecotoxicity Potential
10. Human Toxicity Potential
11. Ozone Layer Depletion Potential



Biorefinery

Reference system

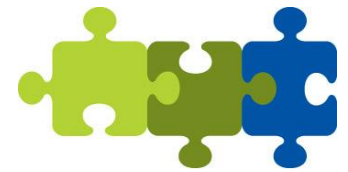




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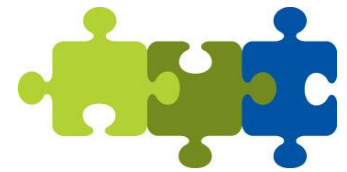
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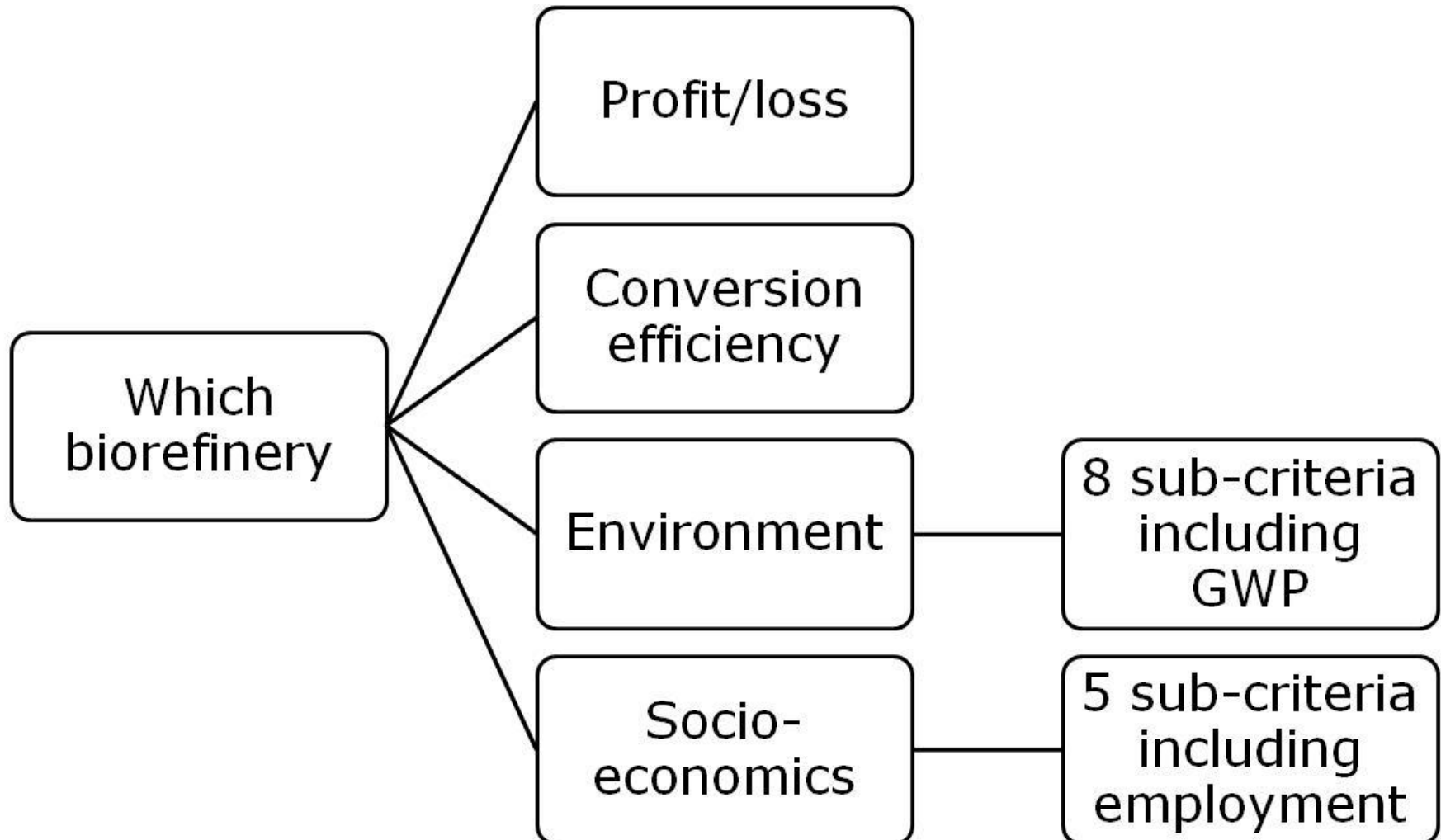


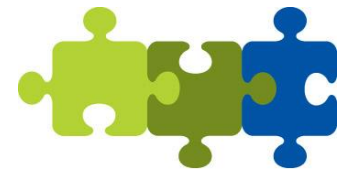
MCDA

- MCDA – Multi Criteria Decision Analysis – was used to compare concepts
- Provides a technique to measure the extent that each biorefinery achieves desired objectives such as lowest capital cost, highest efficiency, best LCA etc
- The method considers all criteria
- The “scores” for each concept come from the modelling processes
- Each criterion is weighted according to their perceived importance
- The result is a set of scored concepts ranked according to objective set by weighting



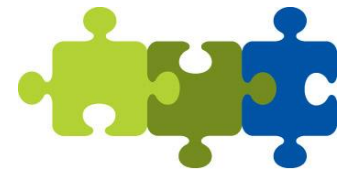
Chain comparison - criteria





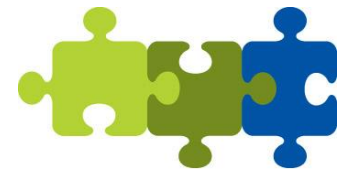
Weighting

- Different weightings applied to criteria according to particular objective
- Examples for this project:
 - Equal weighting
 - Techno-economic weighting
 - Enviro-socio weighting



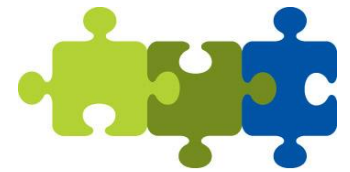
Conclusions

- Most promising biorefineries:
 - Produce specialty chemicals in addition to ethanol
 - Simple processing routes
 - Those that utilise all fractions of the biomass producing only value added products
- Least promising biorefineries:
 - Poor conversion efficiency combined with -€ loss
 - Those with a high heat and power demand, heat/power provision becomes expensive and biomass requirement too high
 - To produce only heat and power from biomass not cost effective



Overall project results

- Flexible, modular, process synthesis methodology
- Will enable the generation, analysis and comparison of biorefinery process chains
- Result will be the identification of the most promising biorefinery process chains
- Most promising could mean:
 - Most cost effective
 - Most environmentally friendly
 - Highest efficiency
- Provides some clear directions for R&D in short, medium and long term
- The system may be expanded to include many more process options in the future



Thanks for listening!
Questions?