Integrated biorefinery model to produce transport fuels

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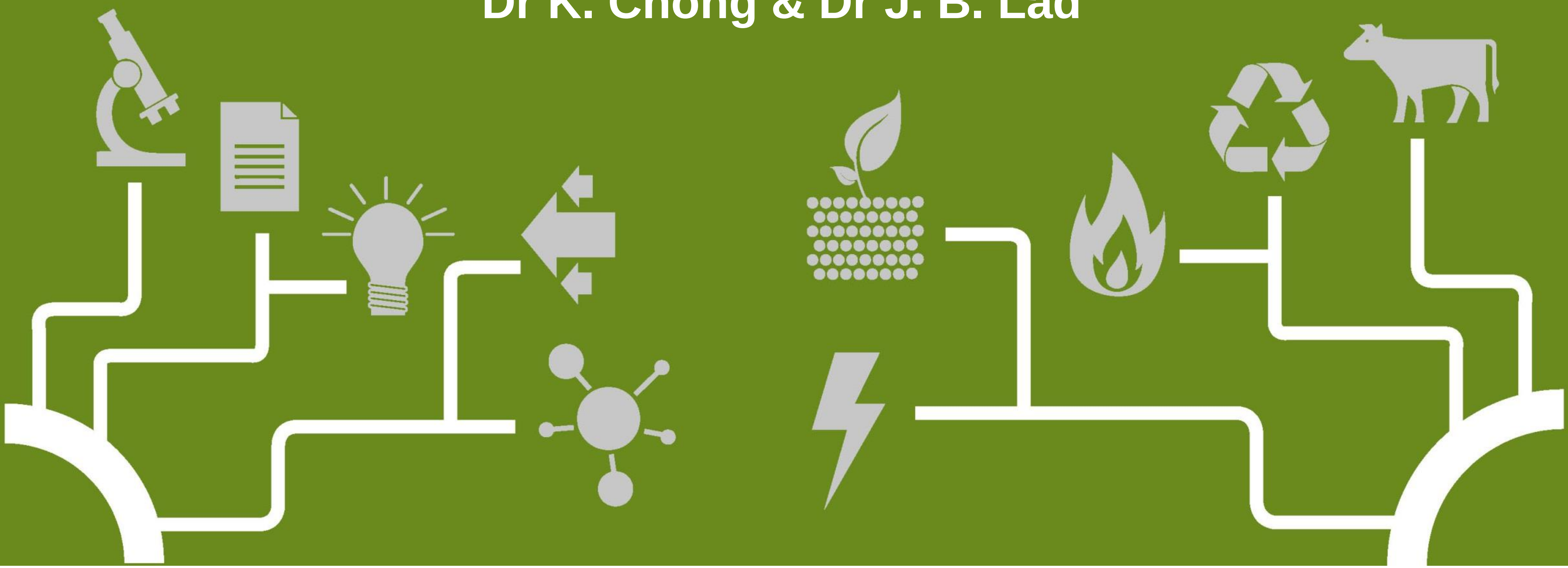
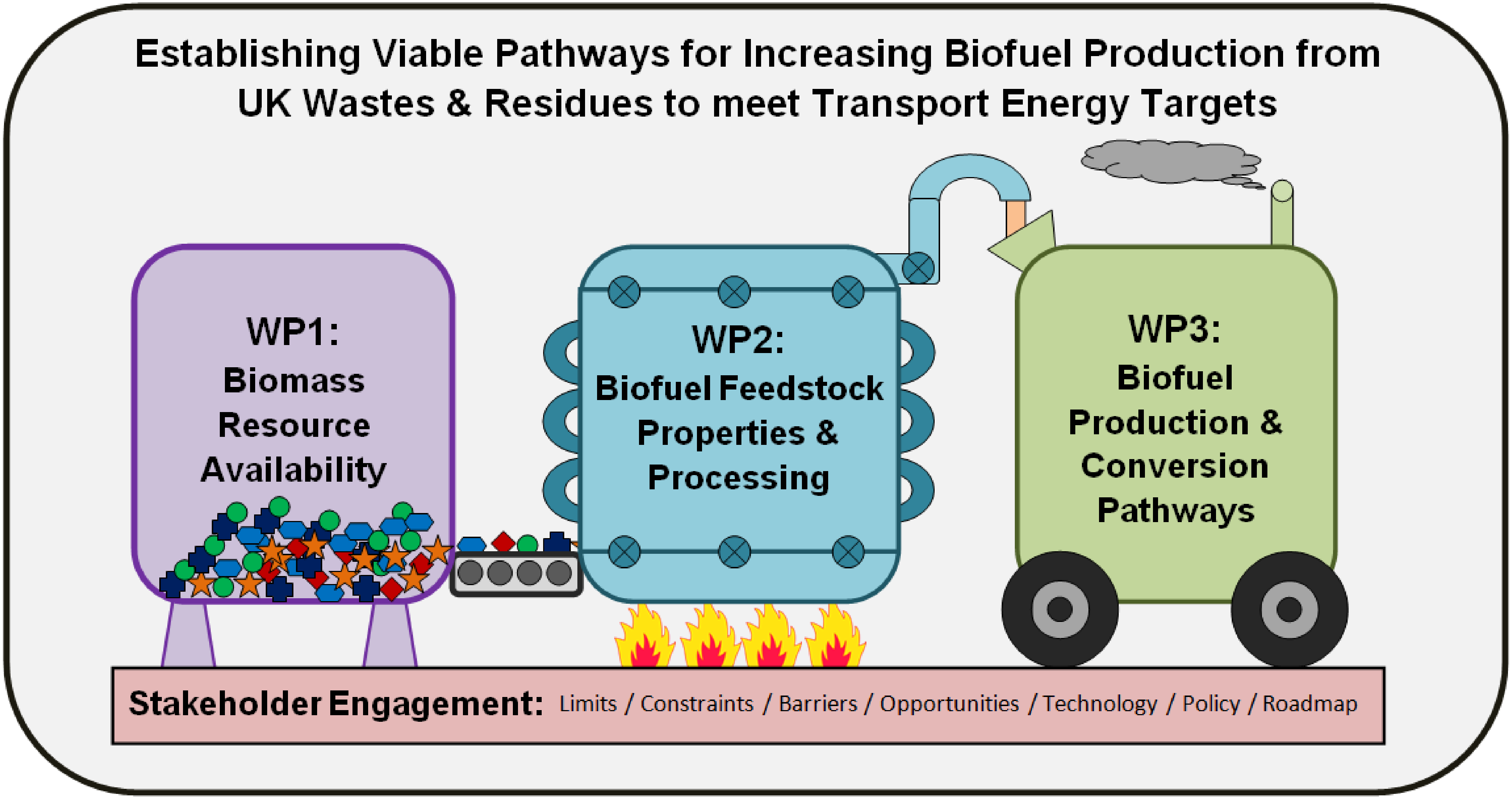


Project introduction



WP3 Objectives

Assessing conversion pathways applicable to UK wastes and residues

Tasks

- Identification of biofuels and conversion routes of interest
- Use data provided by WP1 and WP2 on feedstock availability and composition
- User friendly biorefinery model
- Techno-economic assessment of conversion pathways

Fuels of interest to DfT

Ethanol

Butanol

Diesel for HGV

Hydrogen

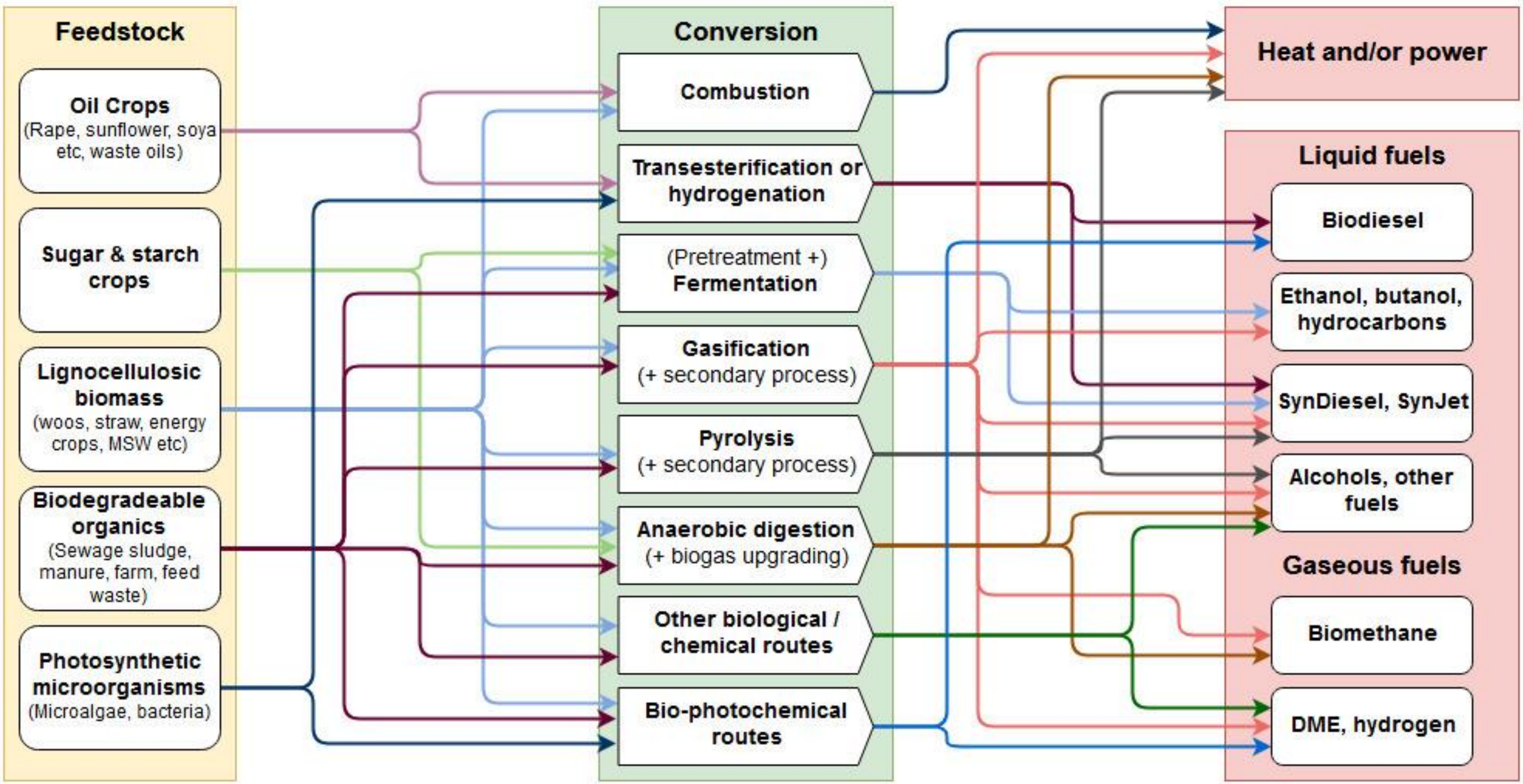
Jet fuels

Aston University

Supergen Bioenergy

EBRI
European Bioenergy Research Institute

Routes to biofuels



Adapted from IPPC, 2011

What we have done…

- Developed a flexible and robust **techno-economic model** to evaluate the potential of using various UK wastes & residues to the production of future bio-fuels
- Based on the composition of the feedstock the model determines the **mass flows**, **energy flows** and **costs** of process route/products
- The model will help recommend the most suitable processing route depending upon the feedstock composition
- Report to be released shortly….

What is techno-economic modelling and assessment?

Benefits of a TEA model

- Quick,
- Cost effective,
- Helps identify key areas for development,
- Can be used to identify/select a process route from a number of alternatives,
- Identifies whether a process is commercially viable.

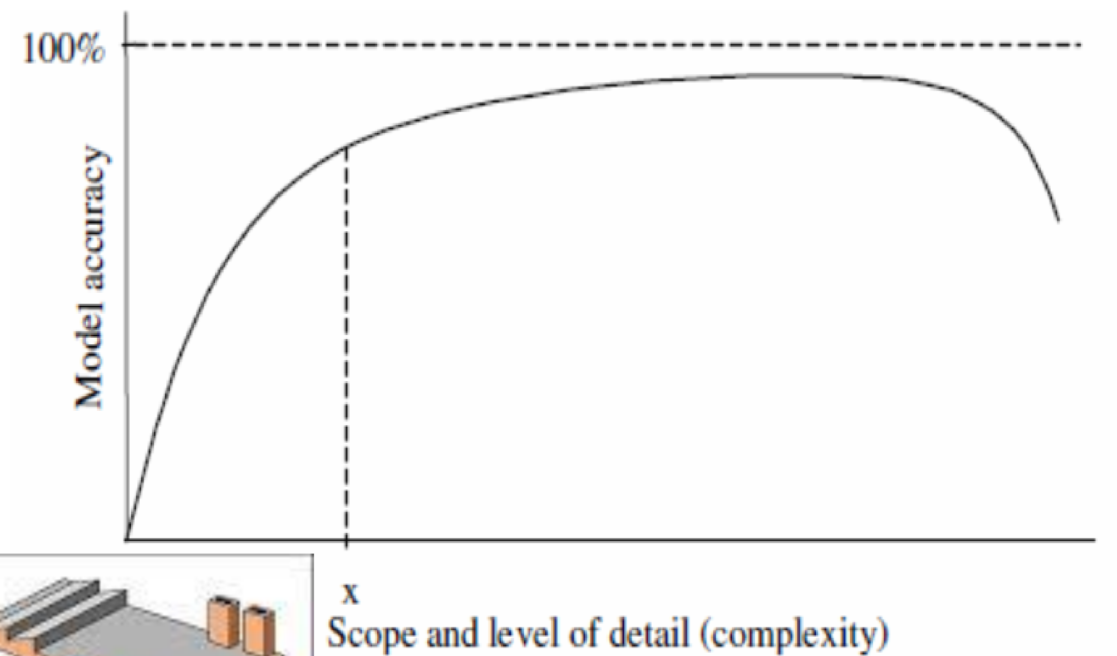
Modelling

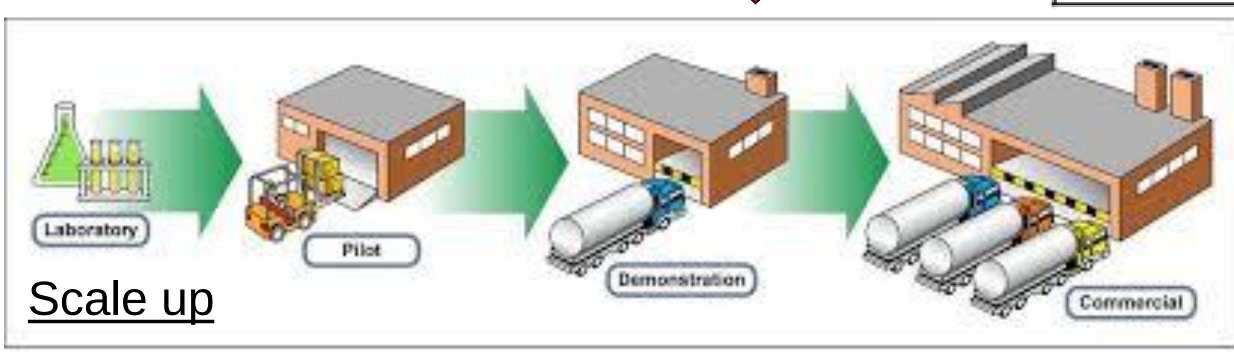
- Modelling is defined as (oxford dictionaries):

“The devising or use of abstract mathematic models”

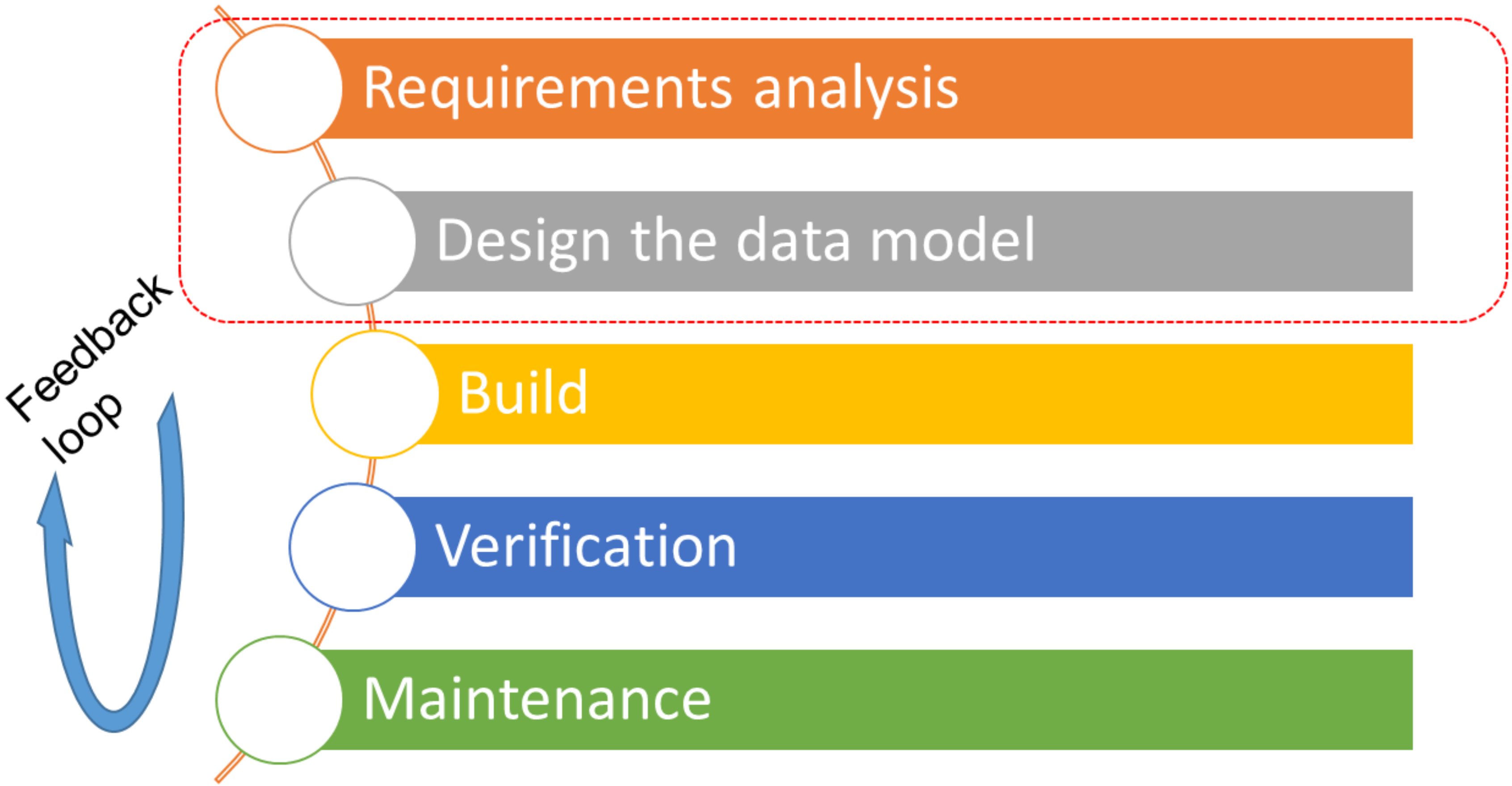
- **Simplification** of reality

- Built to serve a **purpose**





Modelling process



User(s)

Scope

Functionality

Data?

Several approaches for developing models

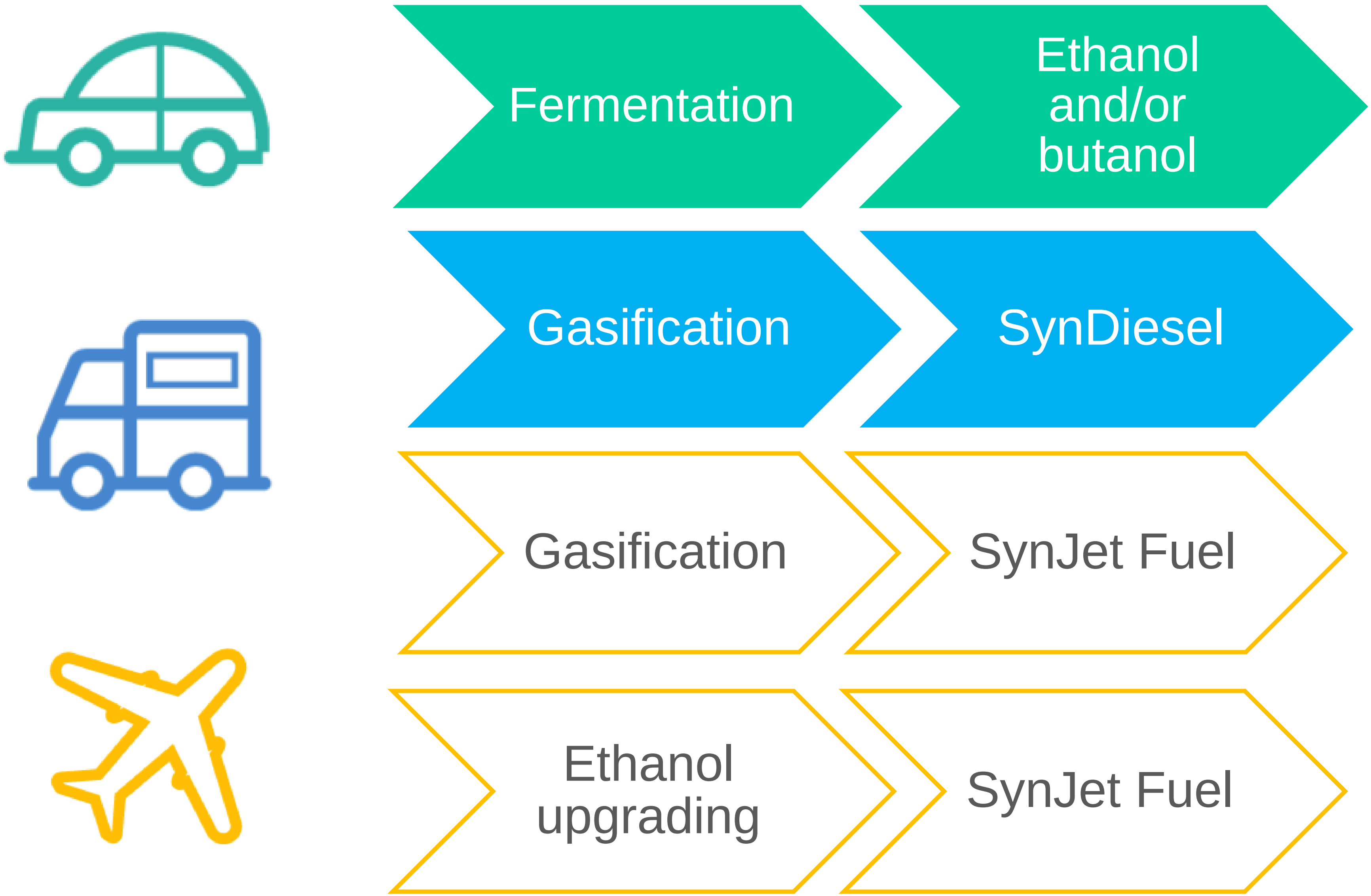
Modelling outputs

- **Mass** (kg h^{-1}) and **energy** (kW_{th}, kWe) balances
- **Capital** costs (CAPEX)
- **Operating** costs (OPEX)
- **Profitability** analysis (NPV, Payback time, IRR)
- **Sensitivity** analysis (Industrial partners validation)

TEA modelling considerations

- TEA model was built on experimental laboratory and pilot data, where possible
- Modular modelling structure
- Built in Excel
- Not a detailed process design
- User Interface for non-experts
- Costing estimated through a combination of vendor quotes and other plant costing data.

Selected processing routes



Aston University

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EBRI European Bioenergy Research Institute

Example of the TEA user interface

Processing scale, Hours of operation, Biomass type & Moisture content

Select the desired biofuel

Economic evaluation variables

CAPEX, OPEX, Profit, Net present value (NPV), Payback time & Internal rate of return (IRR).

UK WASTE & RESIDUES INTO ENERGY FOR THE DfT

Please enter the total biomass input:	12500.0	kg/h (wet)
Operating hours:	8064	h/y (assuming 4 weeks shutdown)
Total biomass for processing:	100800	wet tonnes/year
Select feedstock:	Residual MSW	
Moisture content:	70.0%	wt. % (wet basis)

Specify YES or NO, if process is required from each drop down list

Desired fuel:	Bio-ethanol	Select from dropdown list

Biomass composition:	wt. % (wet basis)	kg/h
Water	70.00%	8750.00
Cellulose	20.00%	2500.00
Hemicellulose	12.50%	1562.50
Lignin	12.50%	1562.50
Extractables	4.75%	593.75
Ash	0.20%	25.00
Other	0.05%	6.25
TOTAL	120.00%	15000.0

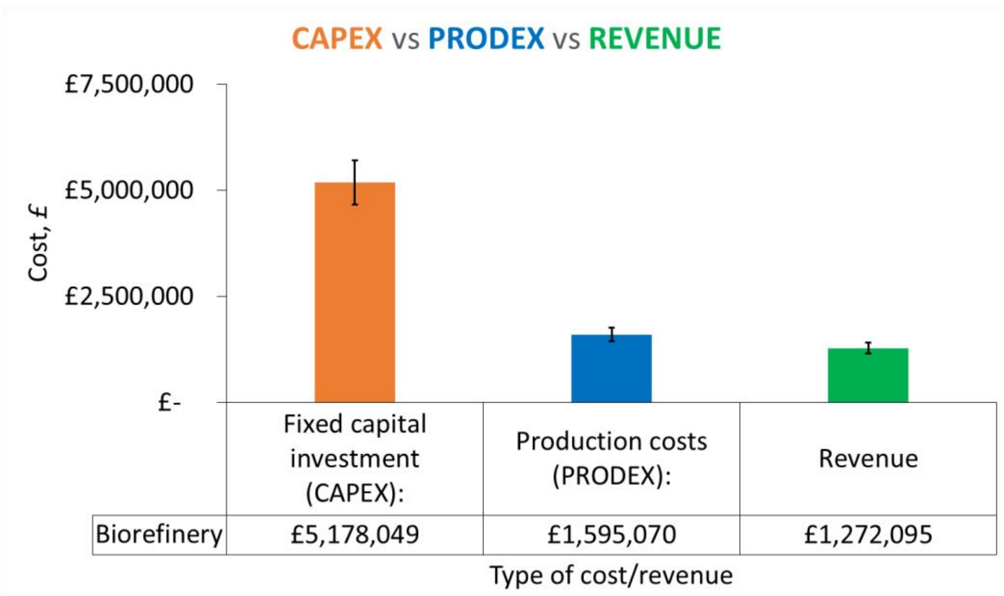
Economic variables:	Annual operating cost, (£/y)	
Biomass feedstock	£ 20.00	£/tonne (wet)
NaOH alkali	£ 275.00	£/tonne
H_2SO_4 acid	£ 60.00	£/tonne
Enzymes	£ 1,500.00	£/tonne
Intermediate pressure (IP) steam	£ 22.30	£/tonne
Electricity	£ 0.10	£/kWh
Demineralised water	£ 2.73	£/m^3
Landfill waste	£ 110.00	£/tonne
Waste water effluent disposal	£ 0.42	£/tonne
Product transportation	£ 600.00	£/ 25 m^3 Tanker

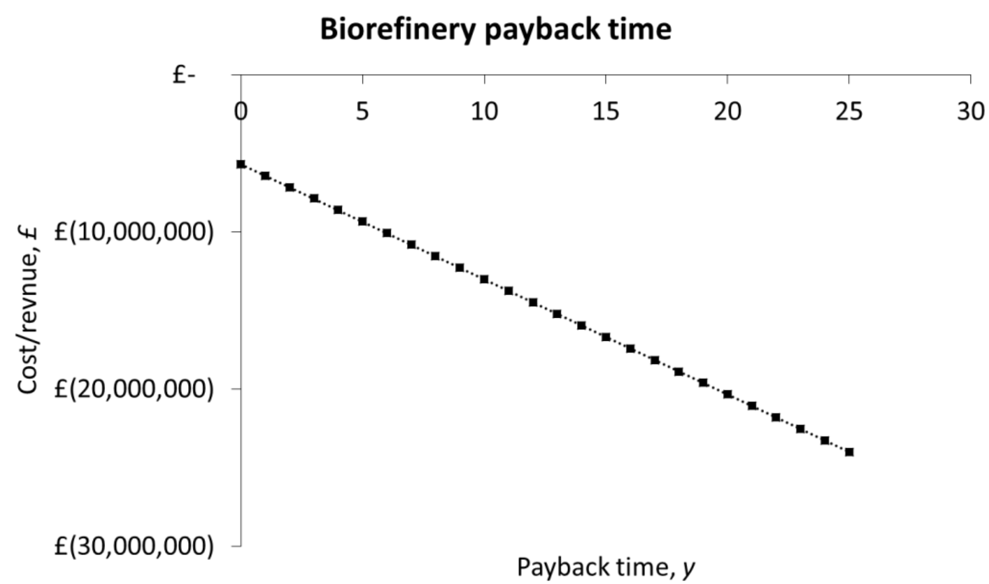
Product value		
Biodiesel	£ 100.0	£/m^3
Biobutanol	£ 650.0	£/m^3
Bioethanol	£ 550.0	£/m^3
Biojet fuel	£ 550.0	£/m^3
SynDiesel	£ 600.0	£/m^3

PROCESSING STAGE	CAPEX, £	OPEX, £/y	PRODUCT REVENUE, £/y
Bioethanol [Fermentation]	£ 2,487,040	£ 248,704	£ 1,539,067
Biodeisel [Transesterfication]			
Biojet fuel [Gasification+FT]			
Syndiesel [Pyrolysis+Upgrading]			
TOTAL	£ 2,487,040	£ 248,704	£ 1,539,067

PROCESSING STAGE	NET PRESENT VALUE (NPV), £	NPV of PRODUCT, £	PAYBACK TIME, Y
Bioethanol [Enzymatic Fermentation]	£ 6,354,104	£ 13,984,382	3
Biodeisel [Transesterfication]			
Biojet fuel [Gasification+FT]			
Syndiesel [Pyrolysis+Upgrading]			
TOTAL	£ 6,354,104	£ 13,984,382	

Example of the results format





Internal rate of return

#NUM!

Payback time

~~>25~~

Example of the results format

Total inputs	kg/h
Spent grains feed	865.67
Ionic liquid	4640.00
Water	10440.00
TOTAL	**15945.67**
Total outputs	**kg/h**
Dry isolate product &/or to next stage	458.80
Pulp liquid stream	486.87
Lignin precipitation	66.66
Water recycle and ionic liquid recycle	14897.71
Membrane filtration losses	35.63
TOTAL	**15945.67**
MB Check	**0.00**

Total inputs	kg/h
BSG feedstock	458.80
Water & solvents	337.27
TOTAL	**796.07**
Total outputs	**kg/h**
Hemicellulose liquid product	121.90
Cellulose & lignin product stream to IL	674.17
TOTAL	**796.07**
MB Check	**0.00**

Conclusions

- A flexible and robust TEA model was developed for a biomass and waste biorefinery for **the production of liquid biofuels**
- The model is capable of evaluating approximately 220 different biorefinery configurations
- The model can be used as a basis for larger scale process design
- In the next stage the design requires: waste, energy and water re-integration/re-uses.

Acknowledgements

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Thanks! Any questions?

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