IEA Bioenergy

Carbon balances of BECCS via gasification pathways

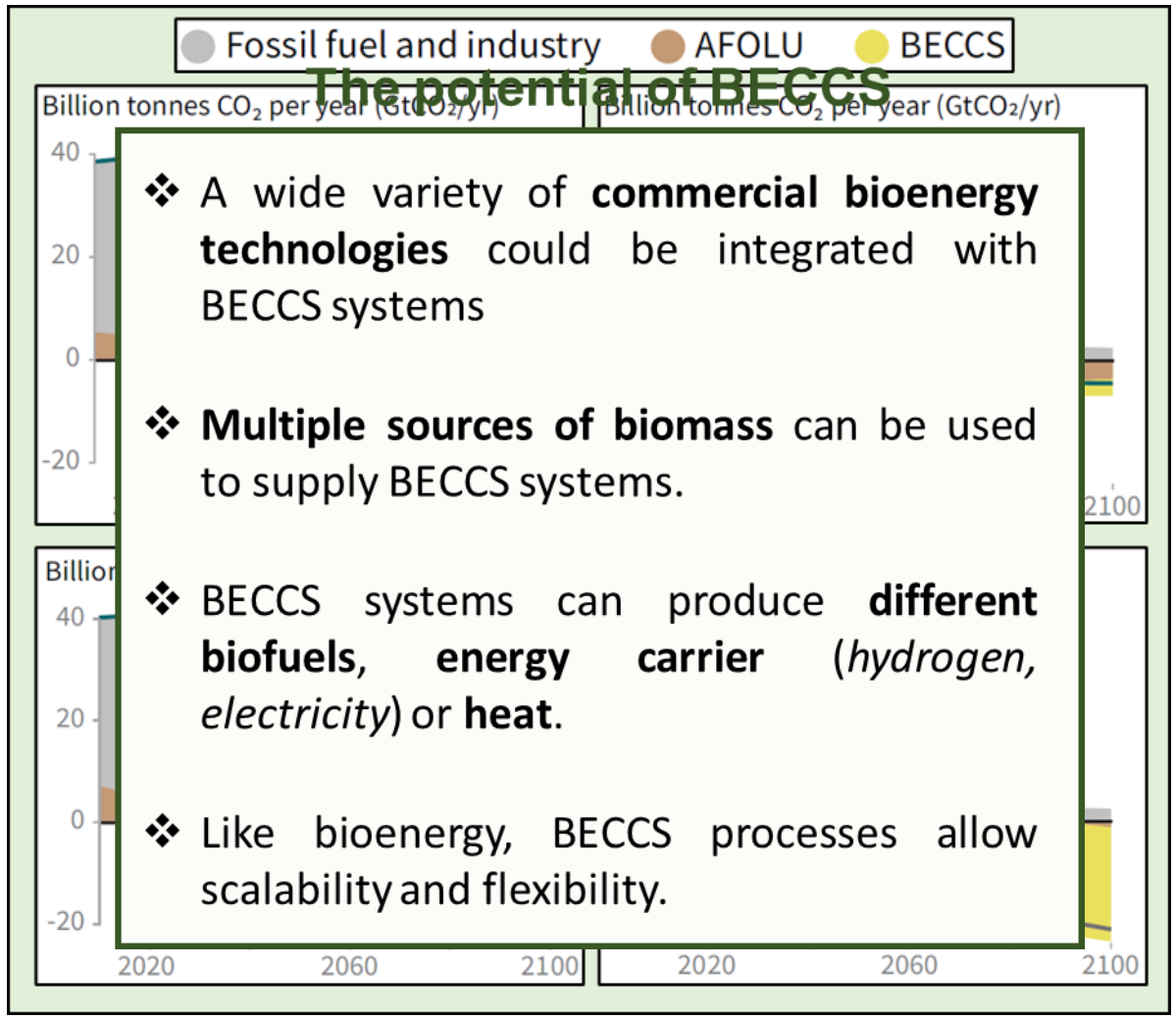
Alberto Almena-Ruiz, Patricia Thornley, Katie Chong, Mirjam Röder

Aston University
BIRMINGHAM UK

EBRI
Energy & Bioproducts Research Institute

The role of BECCS in climate change mitigation

➢ Illustrative model pathways to reach net zero emissions*

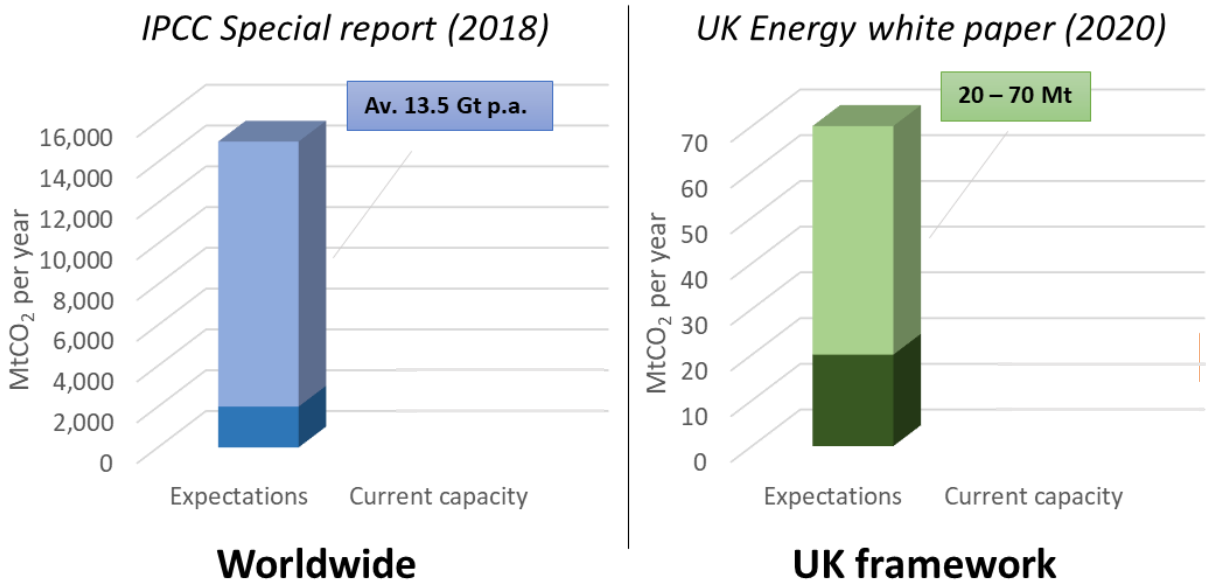


The potential of BECCS

- ❖ A wide variety of **commercial bioenergy technologies** could be integrated with BECCS systems
- ❖ **Multiple sources of biomass** can be used to supply BECCS systems.
- ❖ BECCS systems can produce **different biofuels**, **energy carrier** (*hydrogen, electricity*) or **heat**.
- ❖ Like bioenergy, BECCS processes allow scalability and flexibility.

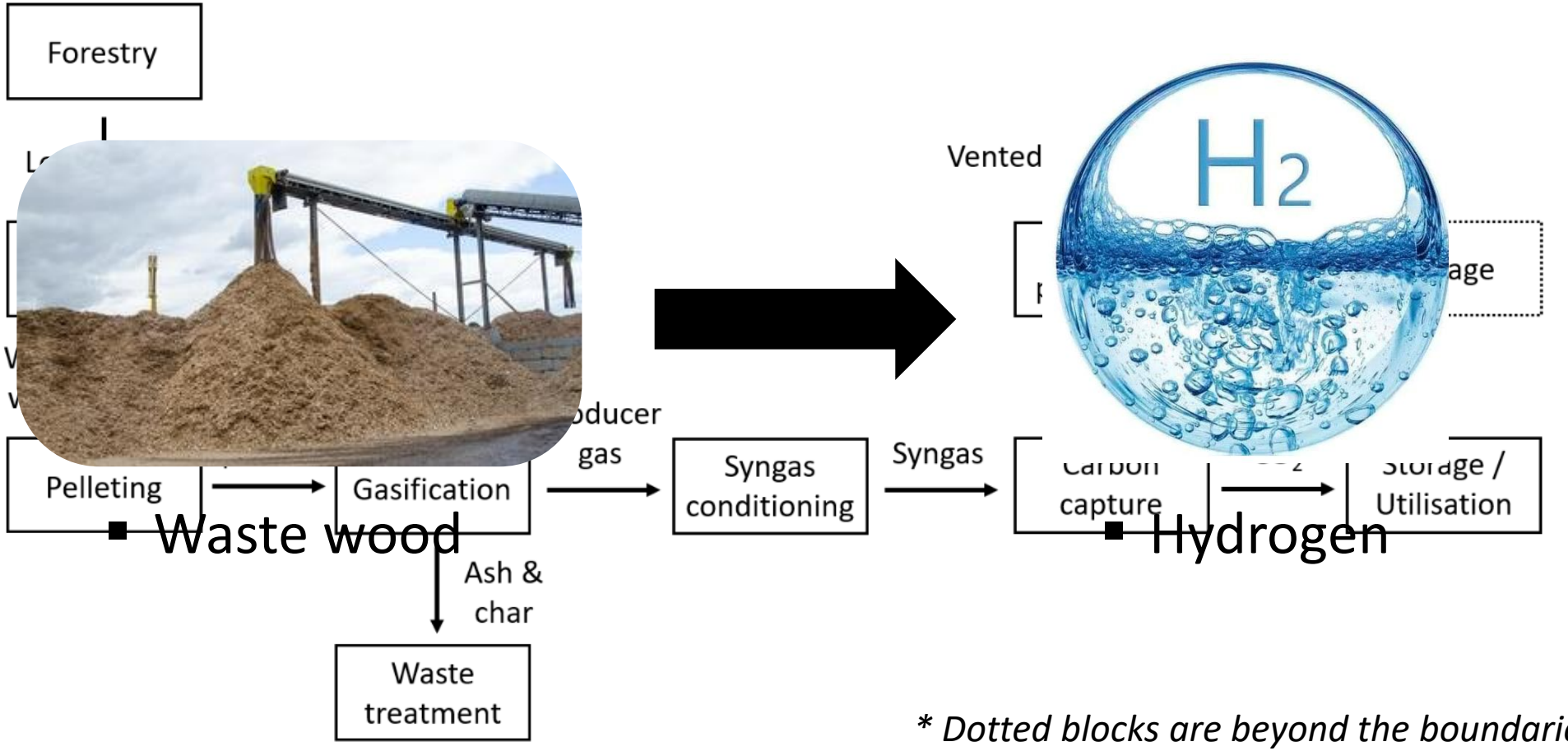
- **Most of the scenarios** modelled by the **IPCC** limiting global warming to 1.5°C **consider BECCS**.
- UK Energy White Paper: BECCS is expected to contribute to reach net-zero by 2050

Ambitions **VS** **Current situation**



Description of the process

Case study: **hydrogen** production via **gasification** with **pre-combustion CO_2 capture** using waste wood, e.g. white wood pellets from sawmill residues.



** Dotted blocks are beyond the boundaries for the LCA.*

Description of the case study

Decentralised BECCS deployment

- Low initial investment per facility
- Use of sustainable regional resources
- Local energy supply
- CO_2 utilisation market

EBRI gasification pilot plant

Technology	Biomass catalytic gasification
	Fluidised bed gasifier
	Tar removal
	Pre combustion CC (methanol absorption)
	Membrane for H_2 purification
Scale	1 MW (300 kg/h biomass)
Energy vector	Hydrogen: fuel cell purity
Captured CO_2 fate	Storage

Almena et al., 2022. Biomass and Bioenergy (Under review)

Methodology

Objective. Quantify:

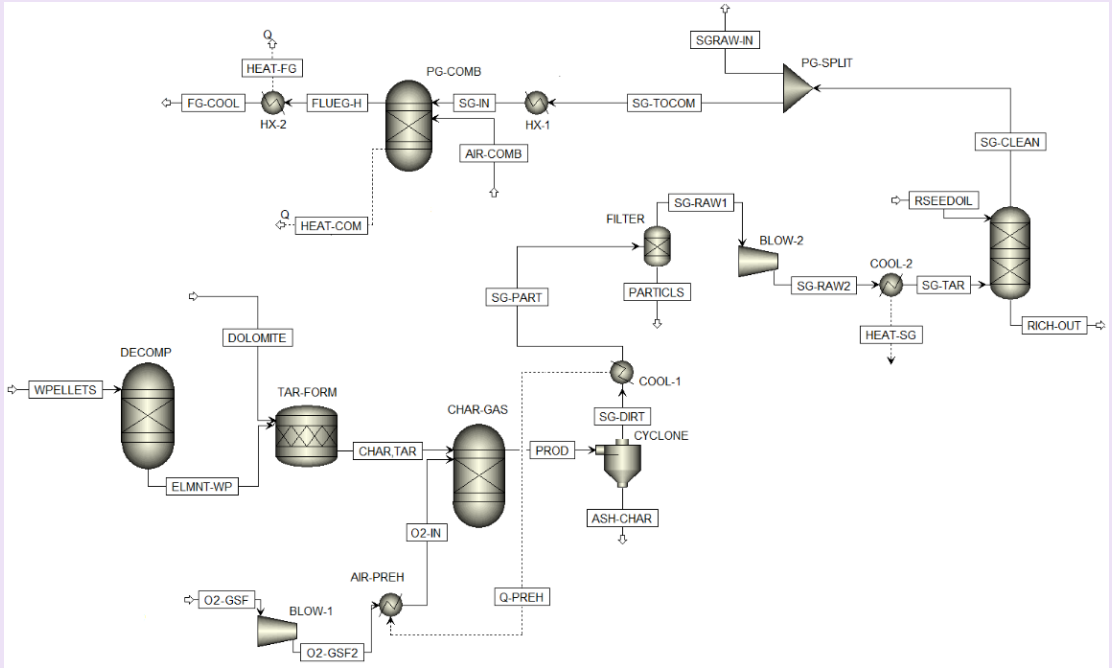
Net-emissions. ***Is there CDR potential?***

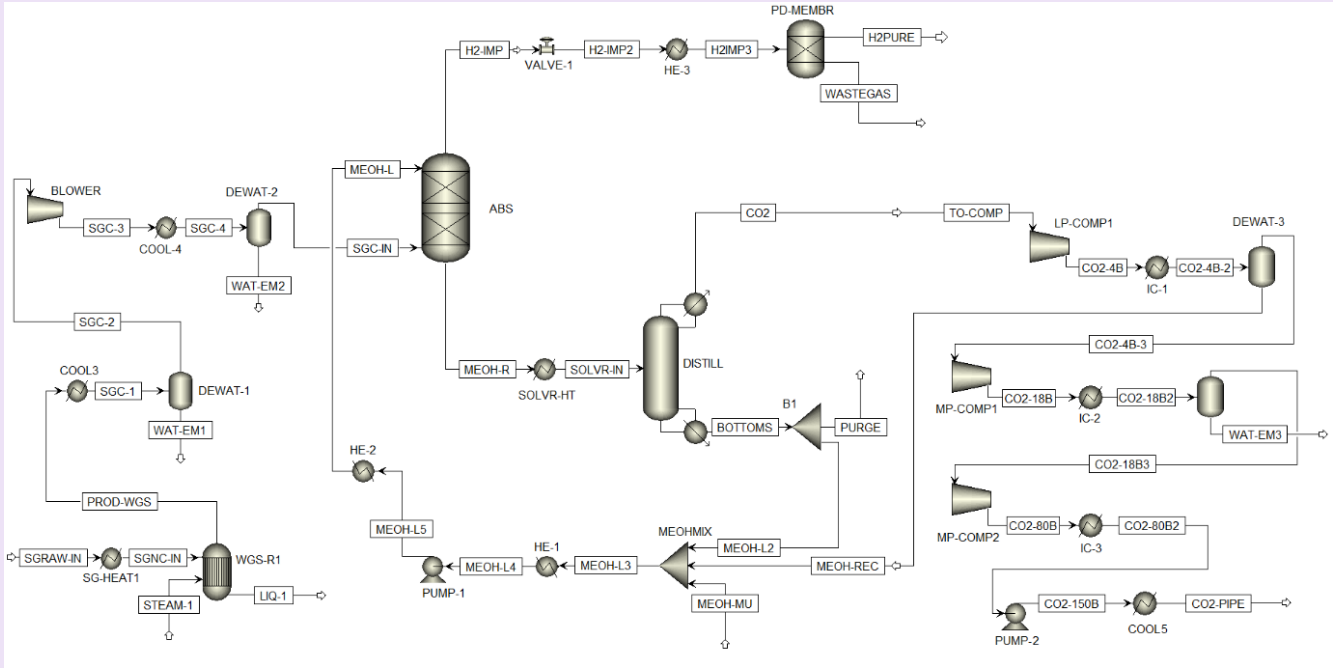
Biomass-to-hydrogen yield of the process. ***Is it feasible?***

Biomass requirements. ***Is there enough?***

A- Process modelling and simulation

B- Life cycle assessment of the supply chain

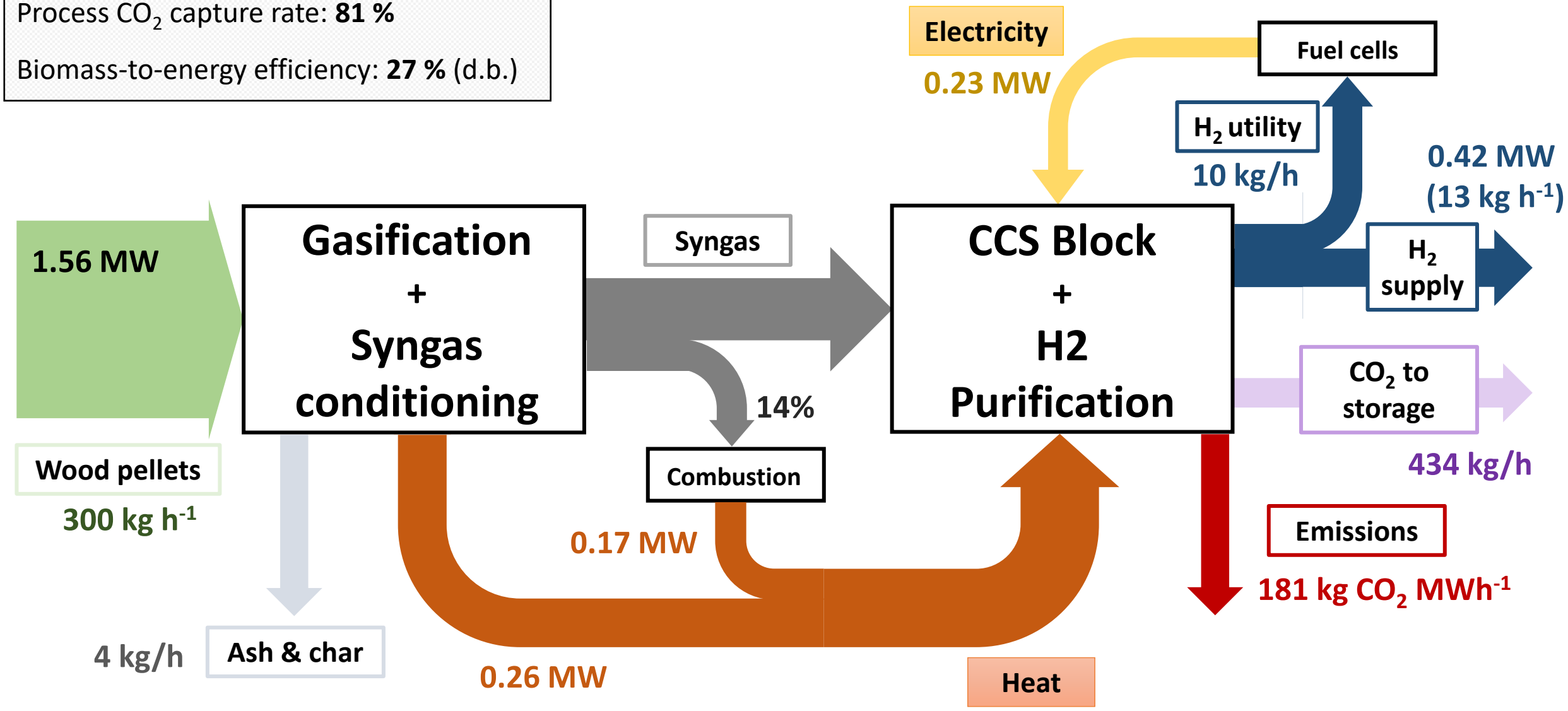




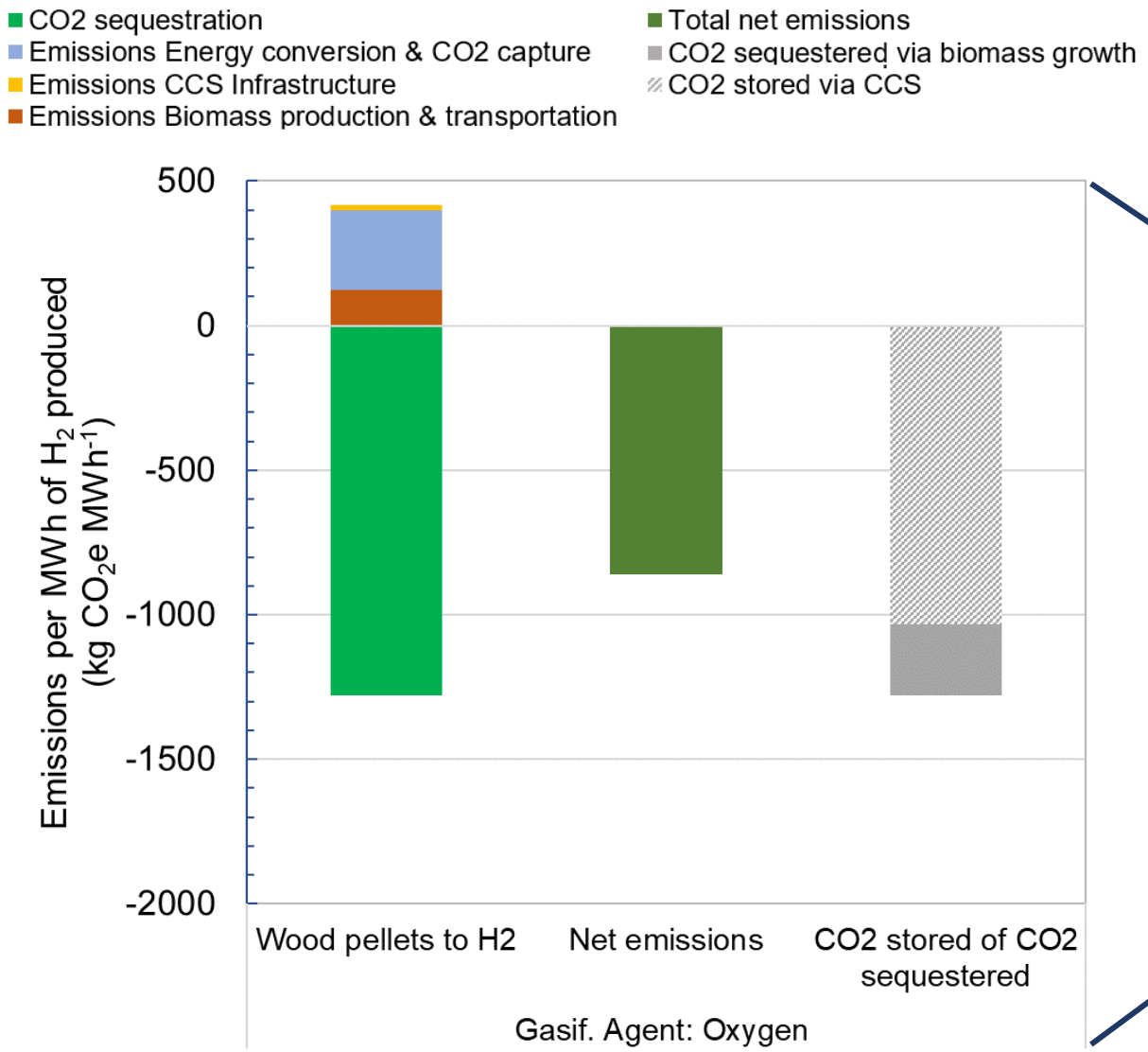
Process modelling (ASPEN)

Process CO_2 capture rate: **81 %**

Biomass-to-energy efficiency: **27 %** (d.b.)



Supply chain emissions balance



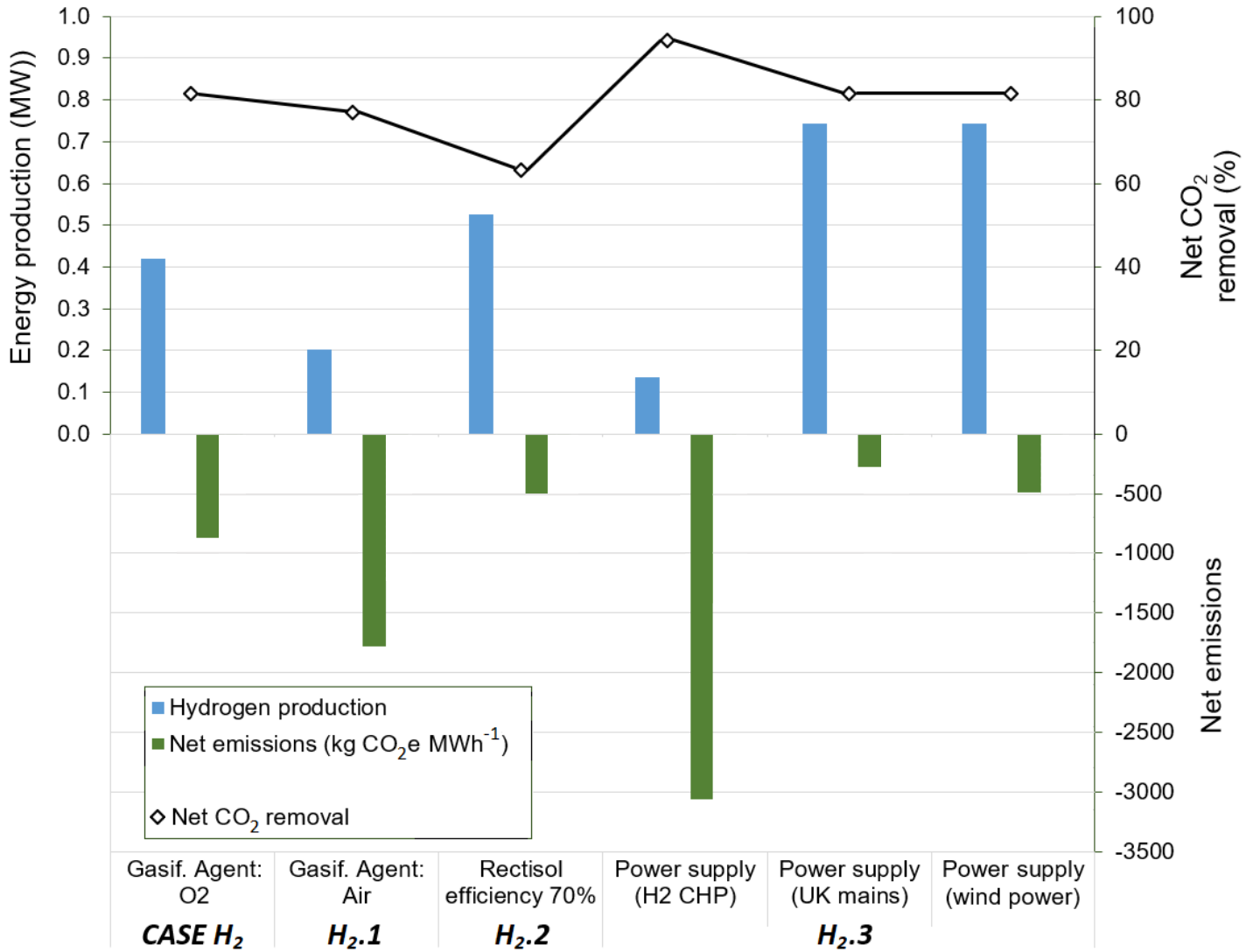
	kg CO_2e MWh^{-1}
CO_2 biological sequestration	-1,277
Emissions – Biomass supply chain	123
Emissions – Bioenergy conversion	275
Emissions – CCS Infrastructure	20
Net emissions	-859

Different operational alternatives

Operating modes assessed in the study:

- **Scenario H_2** (benchmark): **O_2** as gasification agent.
- **Scenario 1**: **Air** as gasification agent.
- **Scenario 2:** Lower **(70%) Rectisol efficiency**.
- **Scenarios 3**: Alternative power supplies.
  - (i) **Hydrogen CHP.**
  - (ii) Power to gas: **UK grid**.
  - (iii) Power to gas: **100% renewable** (wind power).

When using biomass as feedstock, **mass-specific emissions** factor could be advisable to compare.



Reaching UK targets for BECCS

Operating modes assessed in the study:

- ❑ **Scenario H_2** (benchmark): **O_2** as gasification agent.
- ❑ **Scenario 1**: **Air** as gasification agent.
- ❑ **Scenario 2:** Lower **(70%) Rectisol efficiency**.
- ❑ **Scenarios 3**: Alternative power supplies.
  - (i) **Hydrogen CHP.**
  - (ii) Power to gas: **UK grid**.
  - (iii) Power to gas: **100% renewable** (wind power).

- UK's annual negative emissions target for BECCS: **20 to 70 Mt CO_2 by 2050***
- UK's low-carbon hydrogen production goal: **5 GW by 2030***

Least convenient → ***Most convenient***

	Case	B	1	2	3 (i)	3 (ii)	3 (iii)
Meeting UK net-zero targets (20 Mt CO_2 p.a.)	Number of facilities required to meet UK net-zero targets	7,903	7,946	11,067	6,771	14,188	8,026
	H2 from BECCS (GW)	3.3	1.6	5.8	0.9	10.6	6
	H2 national requirement (GW)	5	5	5	5	5	5
	Biomass requirement (Mt)	16.6	16.7	23.3	14.2	29.8	16.9
*Using the available **wood** in the UK*	Biomass available in the UK (Mt)	10.9	10.9	10.9	10.9	10.9	10.9
	Max. number facilities	4,156	4,156	4,156	4,156	4,156	4,156
	Joint capacity (GW)	1.7	0.8	2.2	0.6	3.1	3.1
	% H2 demand covered	35	17	44	11	62	62
	Total Net emissions (Mt CO_2 p.a.)	-10.5	-10.5	-7.5	-12.2	-5.9	-10.4

** UK Government (2020), The Energy White Paper*

Key messages

- **BECCS** can deliver **net-negative emissions** and **supply low-carbon hydrogen** simultaneously.
- There is **currently** in the UK **biomass available** to start delivering net-negative emissions while contributing to energy supply. **Yet no BECCS facilities are built**.
- Using **all the UK wood production** to supply BECCS **is not enough to meet** CDR and low carbon hydrogen supply **annual targets**.
- **Decentralised BECCS deployment** could represent a **quicker solution** for net-negative emissions providing **flexibility** on the use of technology, enabling **regional biomass supply** and **local energy provision**, involving **low risk for investors** and **generating commercial experience** on BECCS performance to help developing a supplementary large scale deployment.
- **Different operation strategies** for the same process, result in **different CDR performance**. **Policy frameworks** could enhance the operator to run the process **aiming at the highest CDR potential**.
- Since **sustainable biomass** resources are **not unlimited, trade-offs** between energy production and CDR score **must be accounted** when promoting those policies. Consider the **mass-specific metric** when biomass is involved.

Aston University
BIRMINGHAM UK

EBRI
Energy & Bioproducts Research Institute

Thank you for your attention

Alberto Almena-Ruiz, Research Fellow, EBRI
a.almena@aston.ac.uk

Mirjam Roeder, Senior Research Fellow, EBRI
m.roeder@aston.ac.uk

Patricia Thornley, Director of EBRI
p.thornley@aston.ac.uk

Visit us at https://www.aston.ac.uk/research/eps/ebri

FAB-GGR