Novel biobased H_2 production routes

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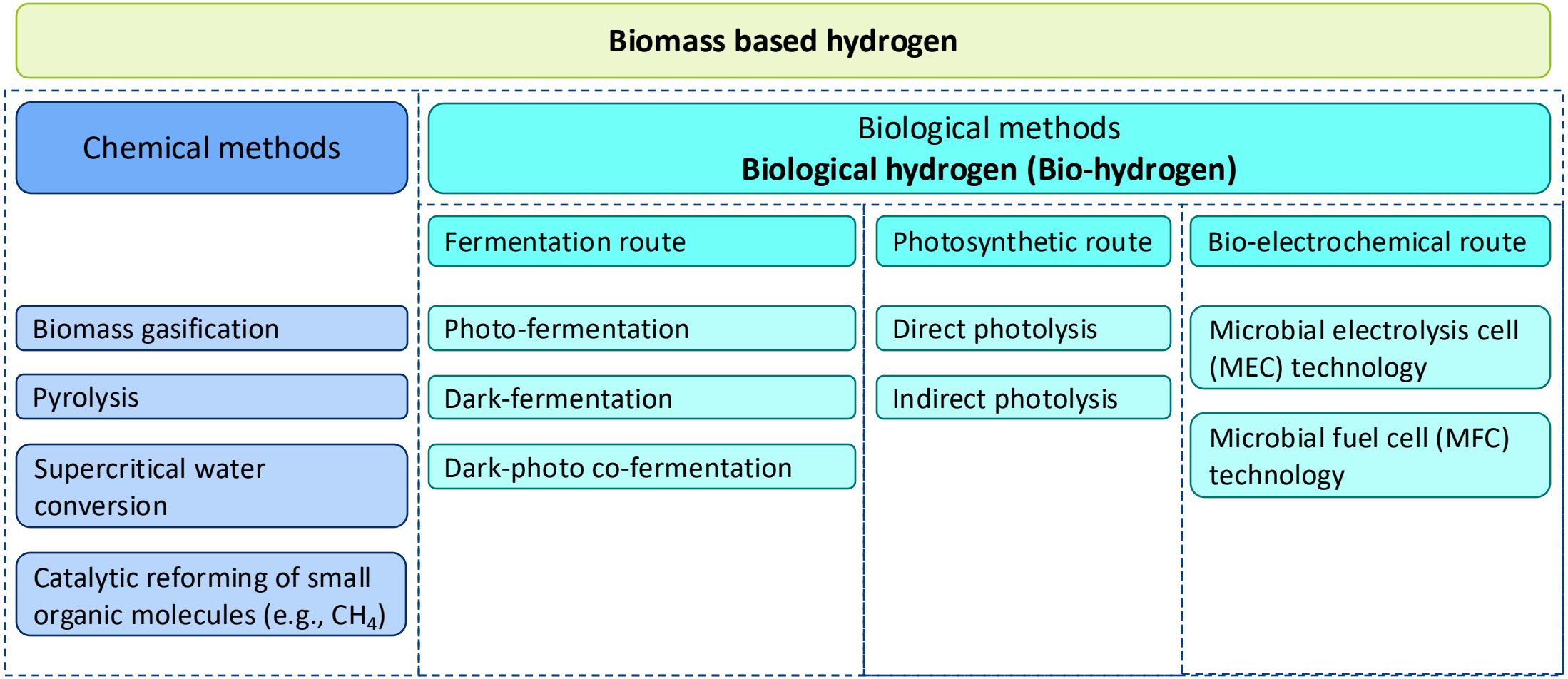
Background

- This work is part of the WP1 “Review of transition and bottlenecks”
  - Overall goal is to get a holistic view on energy production needs and supply capacity, H_2 production now and in future as well as finding possibilities for matching different production routes
- In this task “Geographical distribution of resources” review is made about the geographical distribution of H_2 production resources in Finland
  - In collaboration with LUT-university
- In order to combine wind and solar with biobased H_2 production, some simplifications must be made

Biomass based hydrogen

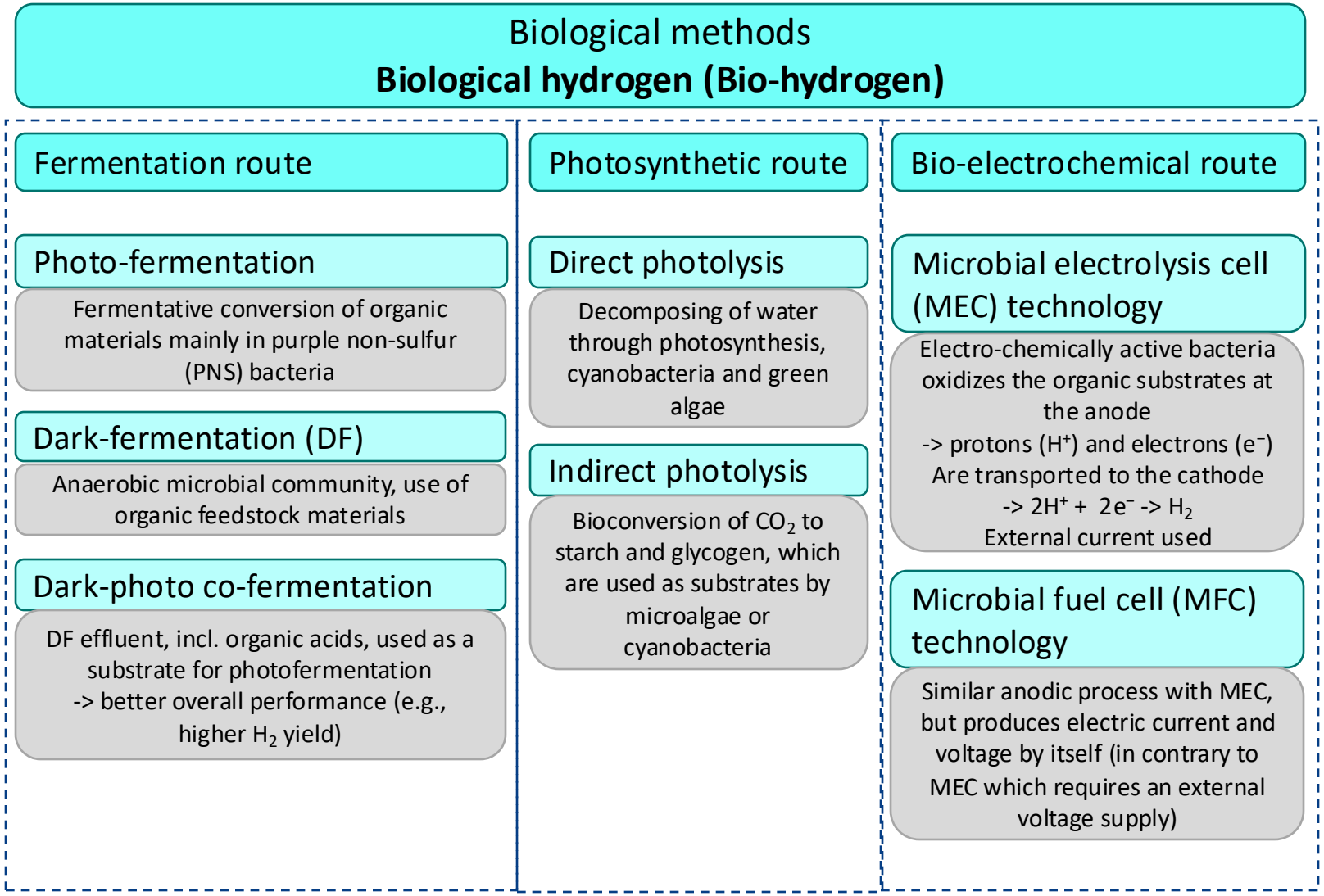
- Must be noted the difference between biomass-based hydrogen and biohydrogen. Biomass based hydrogen refers only to raw materials but can be produced by “non-biological” methods, such as gasification.
- Biohydrogen, on the other hand, also refers to processing technology.
- Many biological methods are still at a low TRL level, while thermochemical conversion routes are more advanced, both are still widely studied.

Definition and classification of processing routes to produce biomass-based hydrogen



Literature:
Akhlaghi and Najafpour-Darzi, 2020; Gautam et al., 2023; Saravanan et al., 2021; Senthil Rathi et al., 2022; Xu et al., 2022

Principles of biological methods



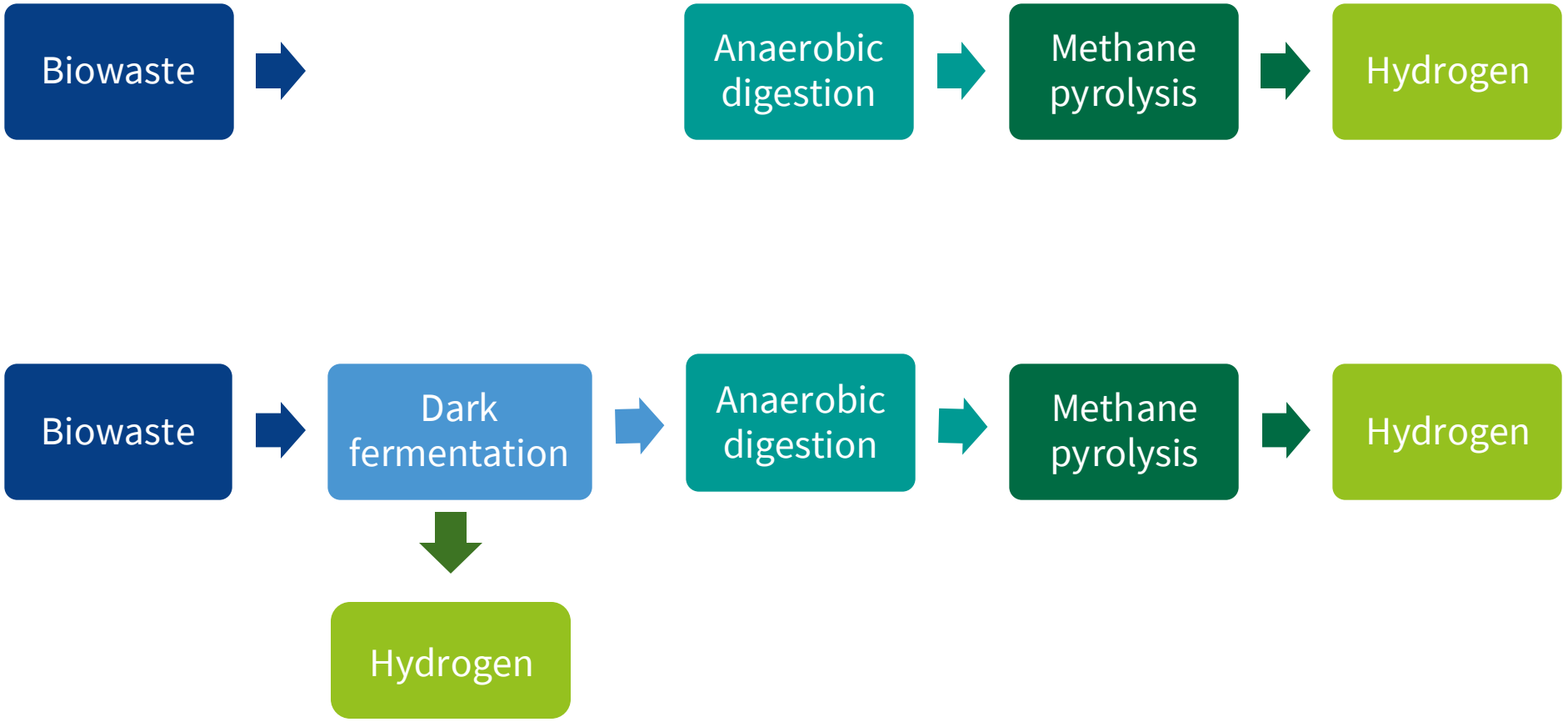
Biological route

- Most advanced technology in biological routes is dark fermentation
- It is based on conventional anaerobic digestion but altering the process conditions the end product is switching from CH_4/CO_2 gas to H_2/CO_2
- Depend on the raw material different kind of pre-treatment is needed to improve the H_2 yield
- Based on the literature the H_2 yield is varying great amount with different kind of pre-treatments
- In example when comparing with the 29 different pre-treatment with food waste, the H_2 yield is varying from 6 to162 Nml/g VS with average of 93 Nml/g VS

Extended process

- In addition of direct routes, biomass based hydrogen can be produced from (biobased) CH_4
  - Different kind of methane pyrolysis or steam reforming can be done for CH_4 streams which increase the hydrogen yield
- Dark fermentation can also be connected with conventional anaerobic digestion
- With fermentation or digestion there are always CO_2 present in the gas stream which need to remove in order to have pure H_2 or CH_4

Examples from biowaste to hydrogen via anaerobic processes



Comparison of selected routes with houshold biowaste

- In Finland aprox. 483 655 t/a ww of household biowaste is produced
- The calculation here includes many estimates and averages, which are highly dependent on the parameters or pre-treatments of the different processes, e.g.
  - Biogas from biological processes is purified before methane pyrolysis
  - Methane pyrolysis conversion rate 100 %
  - Energy values calculated from the CH_4 and H_2
  - Process energy consumption is not taken account

Case: Biowaste

1. Anaerobic digestion
2. Anaerobic digestion → Methane pyrolysis
3. Dark fermantation → Anaerobic digestion
4. Dark fermantation → Anaerobic digestion → Methane pyrolysis

	H_2 t/a	CH_4 t/a	GWh_{LHV}
1	0	39 793	**553**
2	**9 948**	0	331
3	1 801	19 897	337
4	6 775	0	226

Conclusion

- H_2 production from biomasses can be done with various technologies
- The appropriate technology depends on the materials used and the desired end product
- TRL levels of biological processes are still low
- More research needed to get optimized process routes and depend on the materials used and the need of the end product
- In JustH_2Transit project, calculations are done to most common organic waste and side-streams
  - Geographcal distribution
  - Techno-economic calculations and LCA

Thank you!

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