AI applications in the power-to-methanol process and fuel cells: a short discussion

Xiaoti Cui

Assistant professor
Aalborg University
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AALBORG UNIVERSITY
DENMARK

ONE UNIVERSITY – THREE CAMPUSES

AALBORG
– approximately **19,720** students and **2,980** staff

COPENHAGEN
– approximately **2,870** students and **440** staff

ESBJERG
– approximately **470** students and **80** staff

Fuel Cells and Electrofuels Laboratory

Testing
Fuel cells, and electrolyzer cells, stacks

Fuel processing
Methanol reformer, methanol synthesis(CO_2 and H_2)

Serenergy®
The Power of Simplicity

BALLARD®
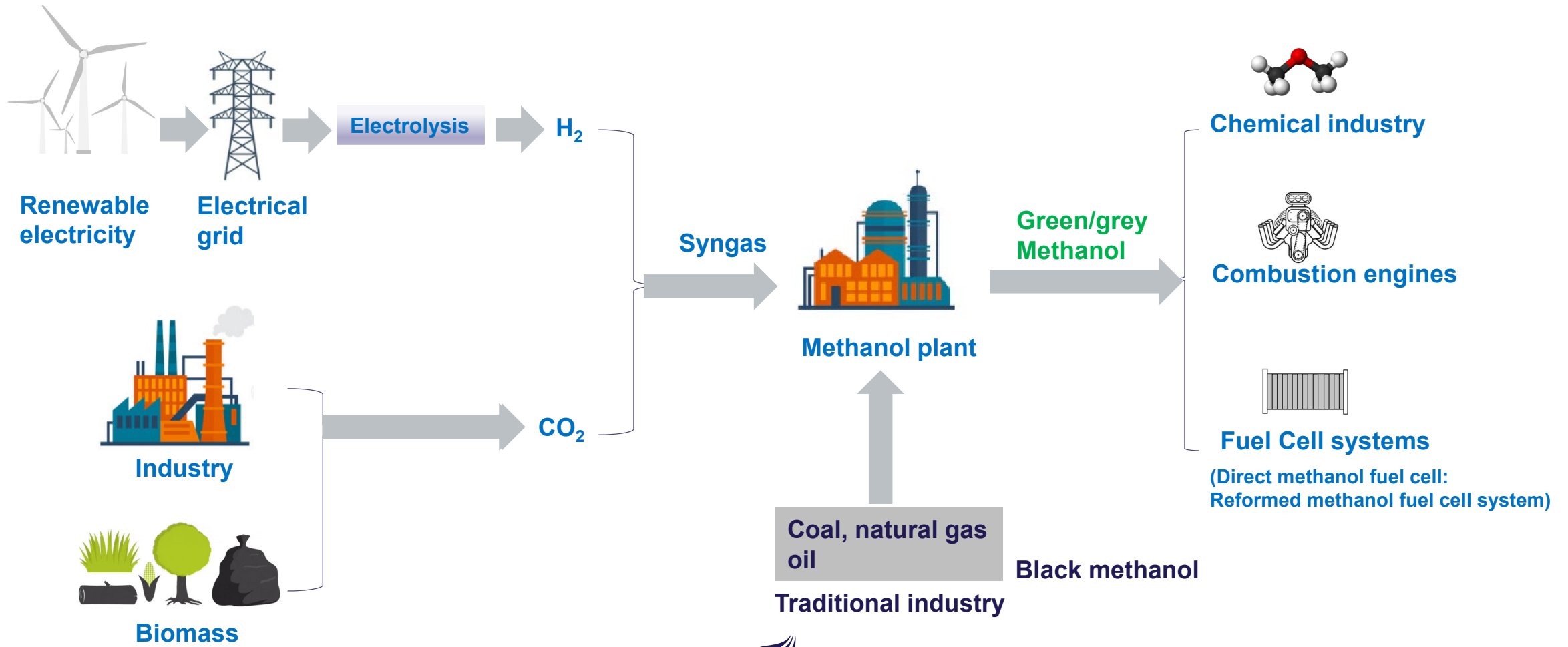
HYDROGEN VALLEY®

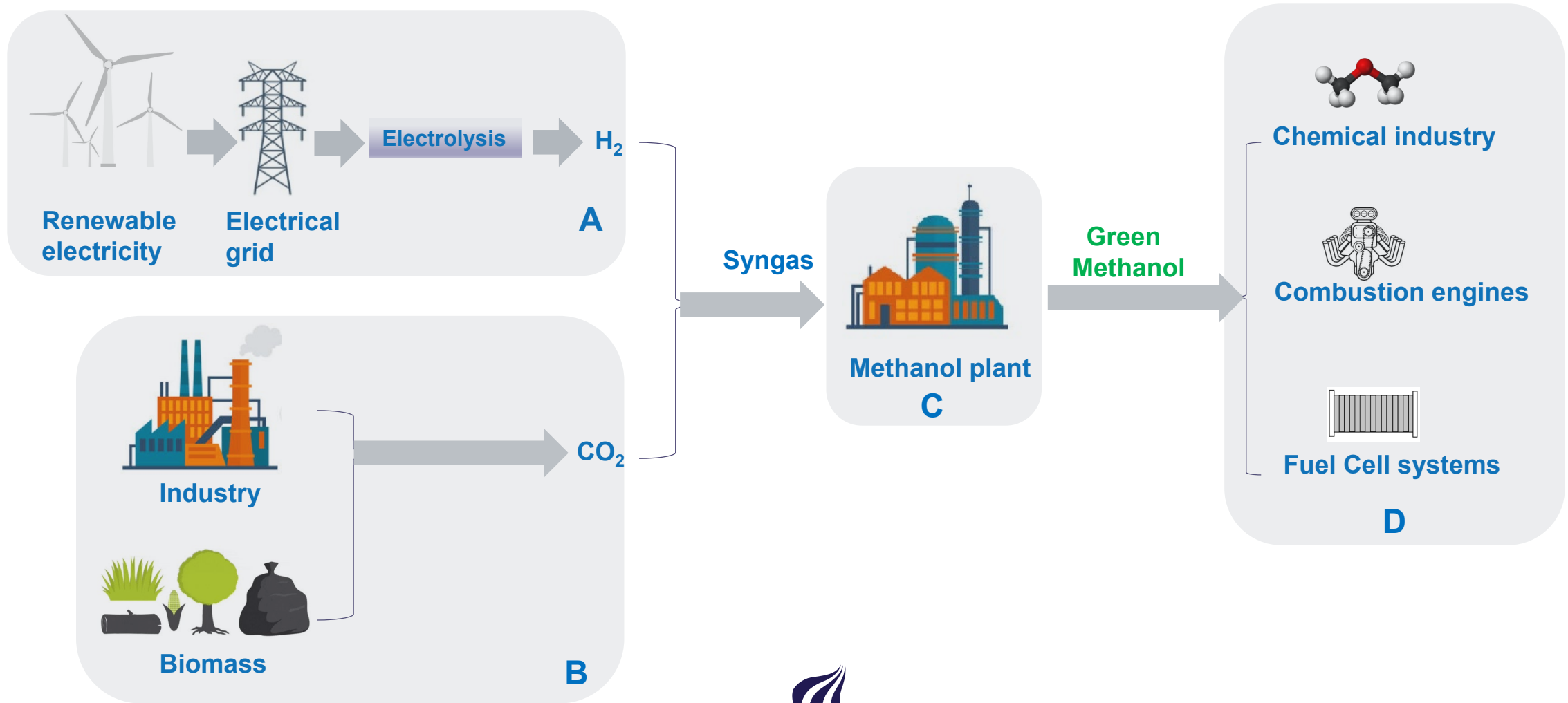**Blue.World**
Technologies

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An example of power-to-methanol

Renewable electricity → Electrical grid → Electrolysis → H_2

Industry → CO_2

Biomass

Syngas → Methanol plant → Green/grey Methanol

Coal, natural gas oil → Black methanol
Traditional industry

Chemical industry

Combustion engines

Fuel Cell systems
(Direct methanol fuel cell:
Reformed methanol fuel cell system)

AI applications?

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Uncertainty of wind power

Wind power

Electrical grid

Energy storage (e.g., H$_2$ prodcution by electrolysis)

AI regression for power prognosis

Wind power production in 2019

GWh

Jan. | Feb. | Mar. | Apr | May | Jun. | Jul. | Aug. | Sept. | Oct. | Nov. | Dec. | Jan.

Data from *Nord Pool* https://www.nordpoolgroup.com/

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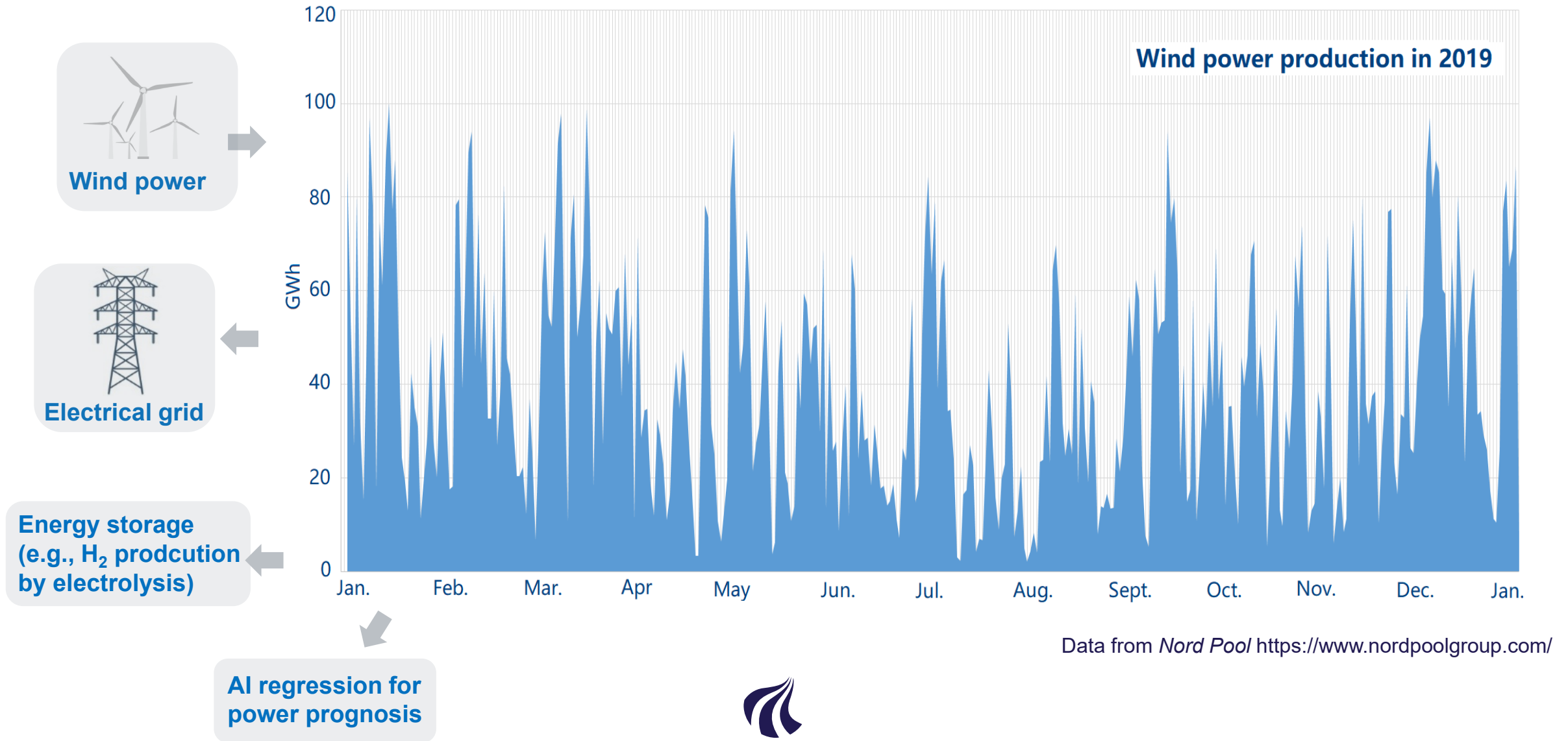
Flexible methanol production & AI

Wind power → Electrical grid → Flexible H$_2$ & MeOH production →

- Electrical grid stability
- Low cost electricity
- Low cost green MeOH

Historical data of wind power production & electricity price → AI application for wind power prognosis → Production load

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An example of fuel cell & AI

—— Fault diagnosis

High temperature PEM fuel cell stack

Cathode gas
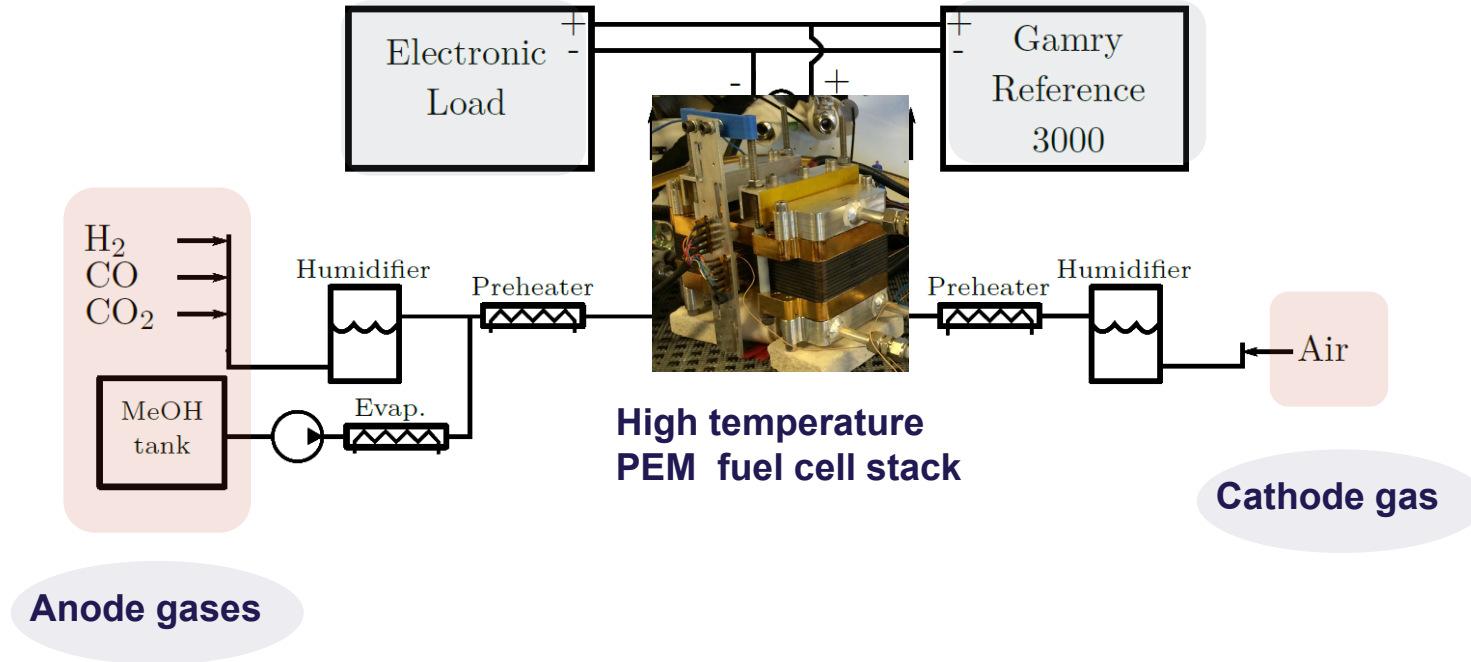
Anode gases

5 faulty conditions

Cathode gases:
1. Stoichiometry decrease (air)
2. Stoichiometry increase (air)

Anode gases:
3. CO increases (than normal level)
4. Methanol vapor content appears
5. stoichiometry decrease (H_2)

Jeppesen, Christian, Araya, Samuel Simon, Sahlin, Simon Lennart, Thomas, Sobi, Andreasen, Søren Juhl Kær, Søren Knudsen. Fault detection and isolation of high temperature proton exchange membrane fuel cell stack under the influence of degradation. Journal of Power Sources 2017 (359):37-47.

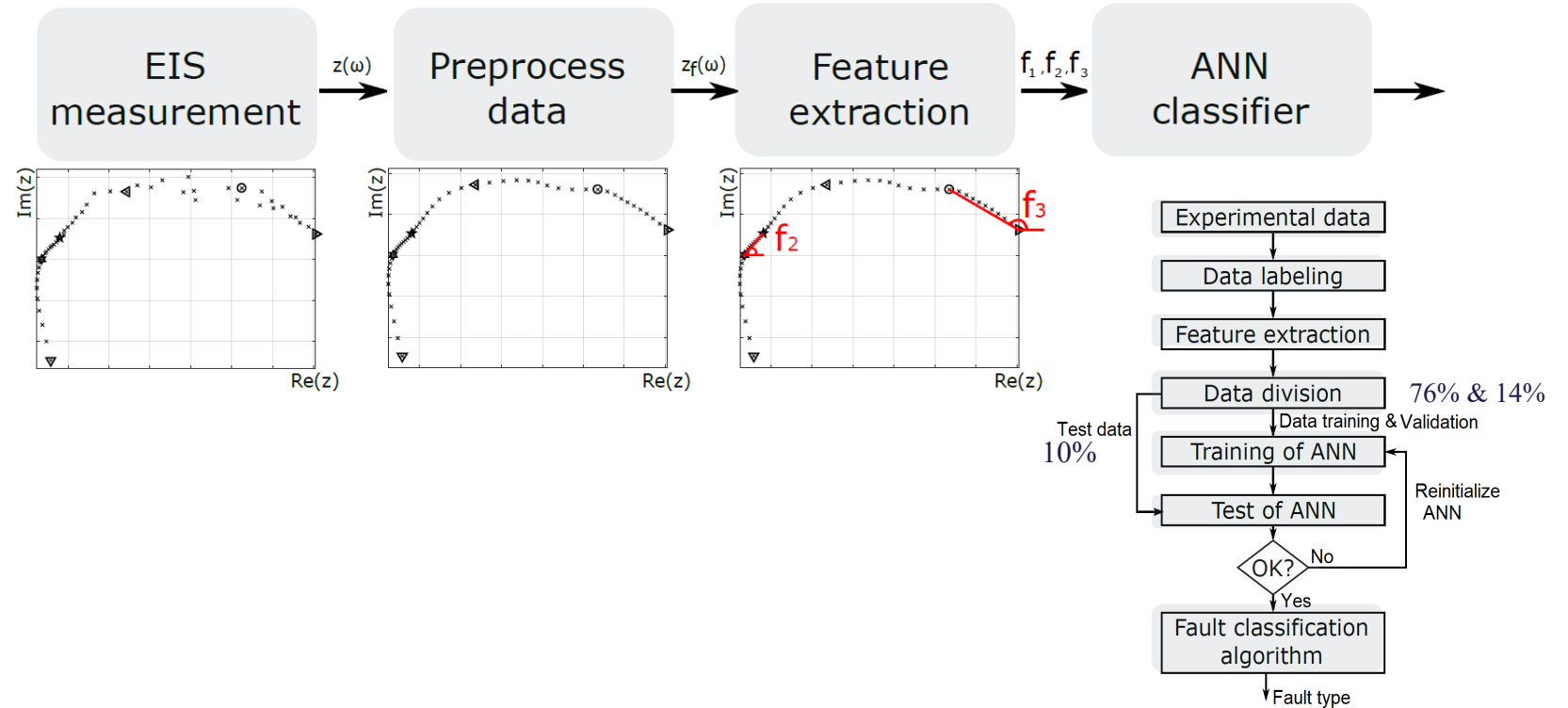AALBORG UNIVERSITY
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An example of fuel cell & AI

—— Fault diagnosis

5 faulty conditions + normal condition

2010 EIS measurements
(electrical impedance spectroscopy)

Jeppesen, Christian, Araya, Samuel Simon, Sahlin, Simon Lennart, Thomas, Sobi, Andreasen, Søren Juhl Kær, Søren Knudsen. Fault detection and isolation of high temperature proton exchange membrane fuel cell stack under the influence of degradation. Journal of Power Sources 2017 (359):37-47.

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An example of fuel cell & AI

—— Fault diagnosis

Conclusions

- The artificial neural network together with the suggested features, is feasible for fault detection and isolation.

- It can be concluded that the proposed algorithm has difficulties distinguishing between the high methanol vapor concentration in the anode gas fault and normal operational data.

Jeppesen, Christian, Araya, Samuel Simon, Sahlin, Simon Lennart, Thomas, Sobi, Andreasen, Søren Juhl Kær, Søren Knudsen. Fault detection and isolation of high temperature proton exchange membrane fuel cell stack under the influence of degradation. Journal of Power Sources 2017 (359):37-47.

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From fuel cell to systems

Fault diagnosis

HT-PEM stack

Automotive
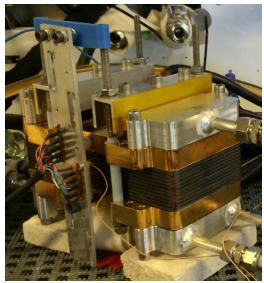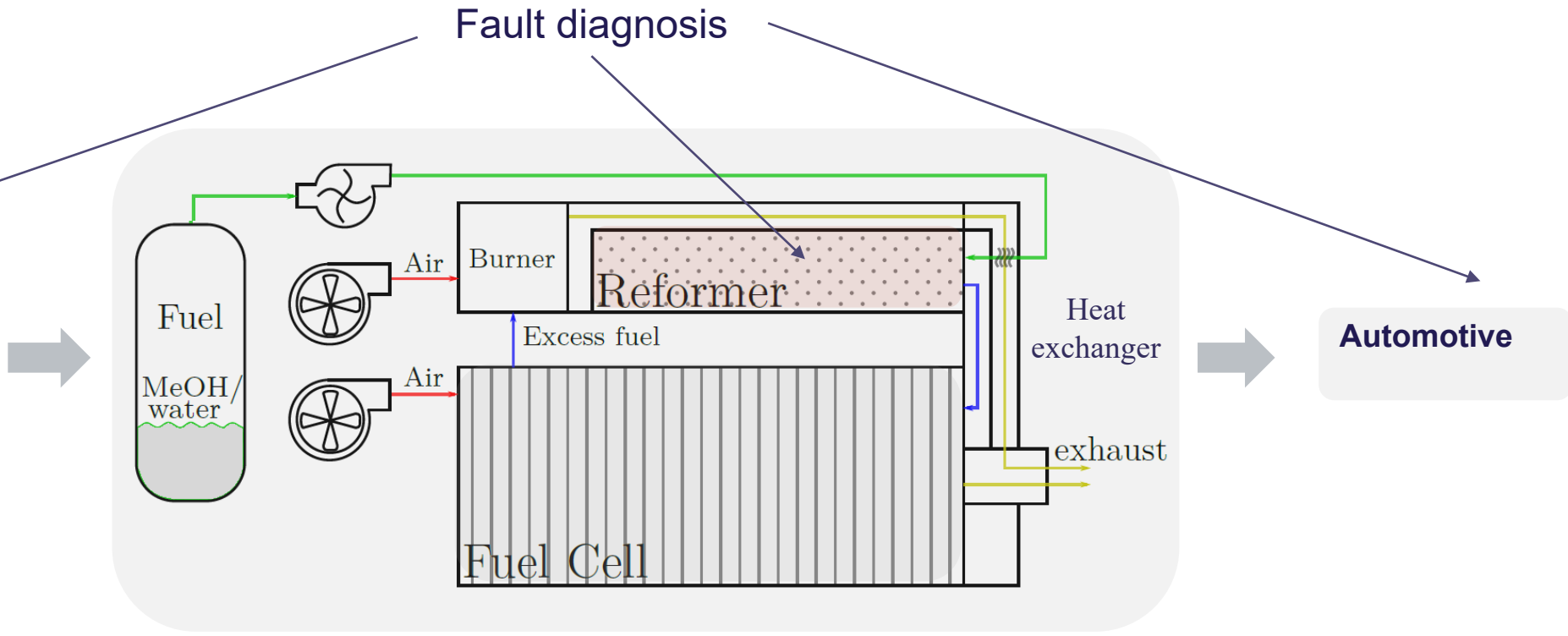
Reformed methanol fuel cell system

Serenergy https://serenergy.com/forside-test/technology/reformed-methanol-system/

Methanol plant & AI?

Development of new catalyst with AI (reported)

Catalyst

Reactor

System

Methanol plant

Commercial methanol production since 1923

Natural gas & coal-based
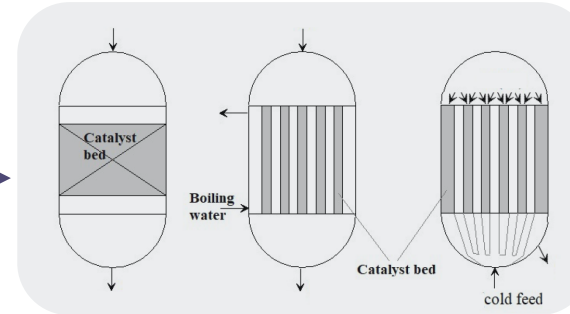
Do we need AI ?

- Data
- Cost
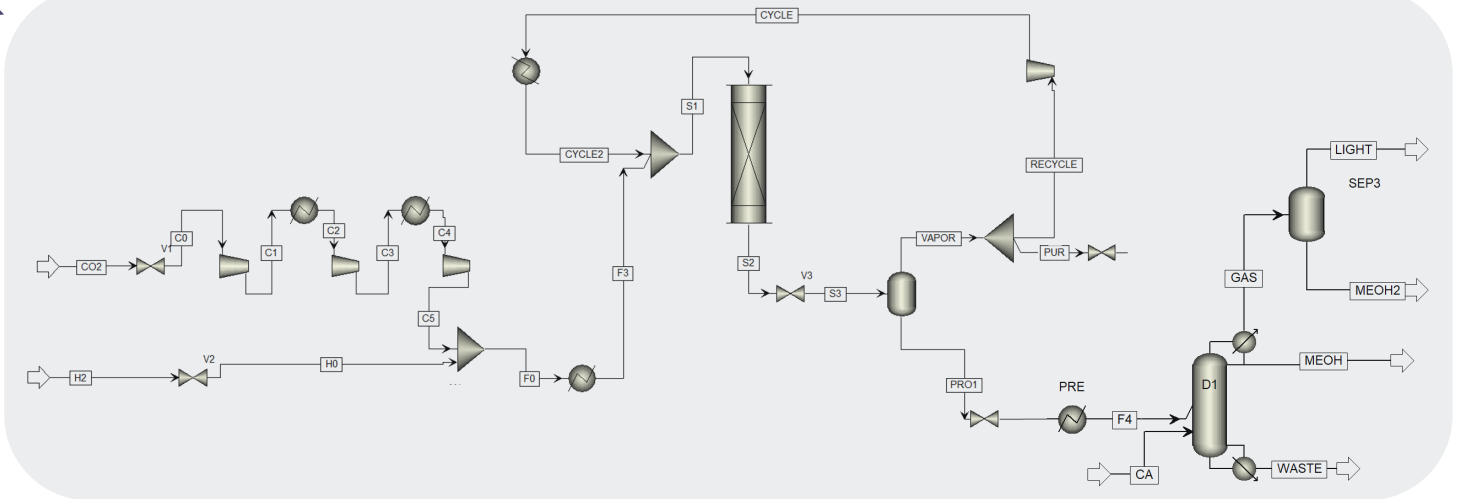
AI applications?

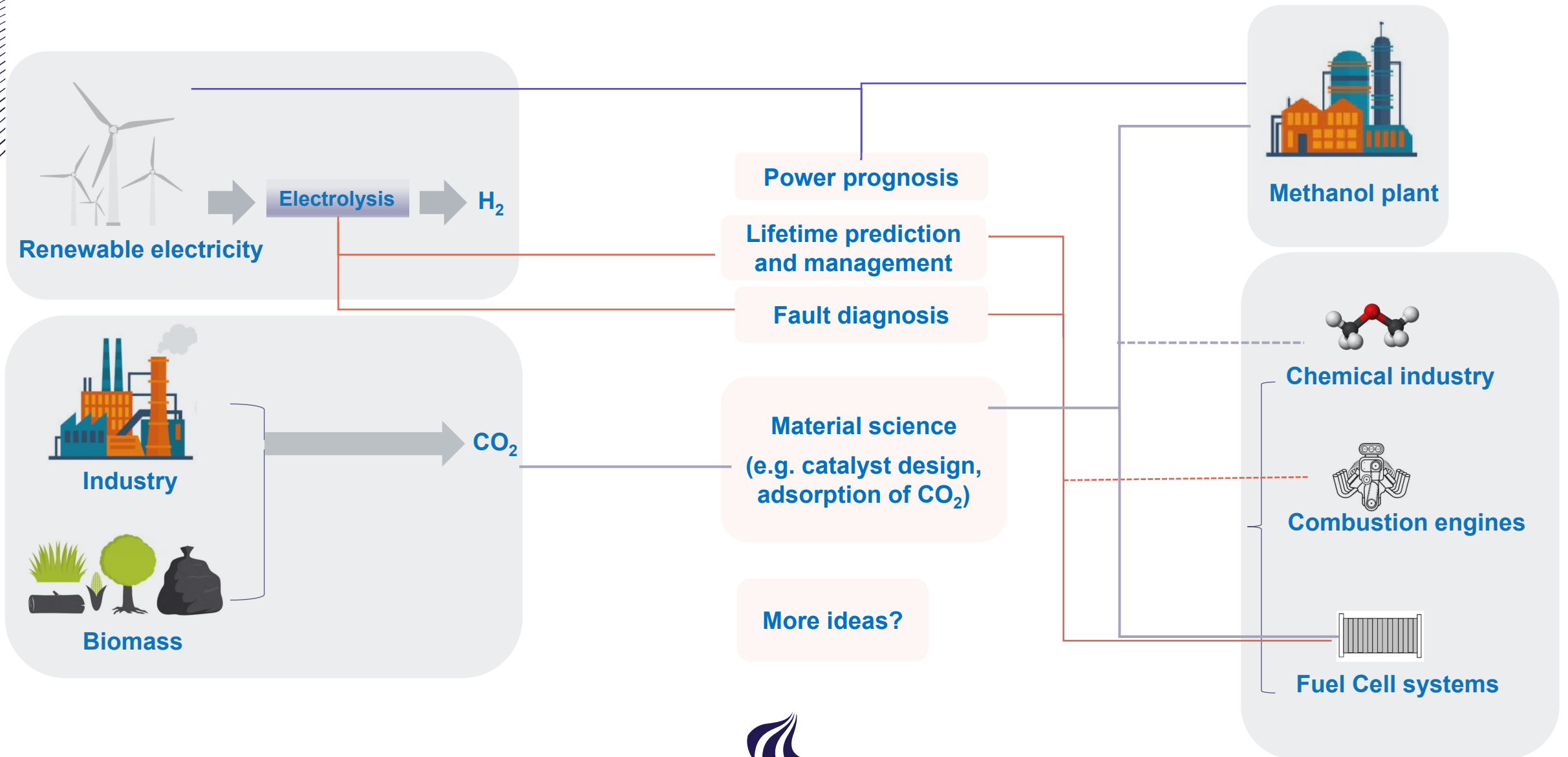# THANK YOU

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