

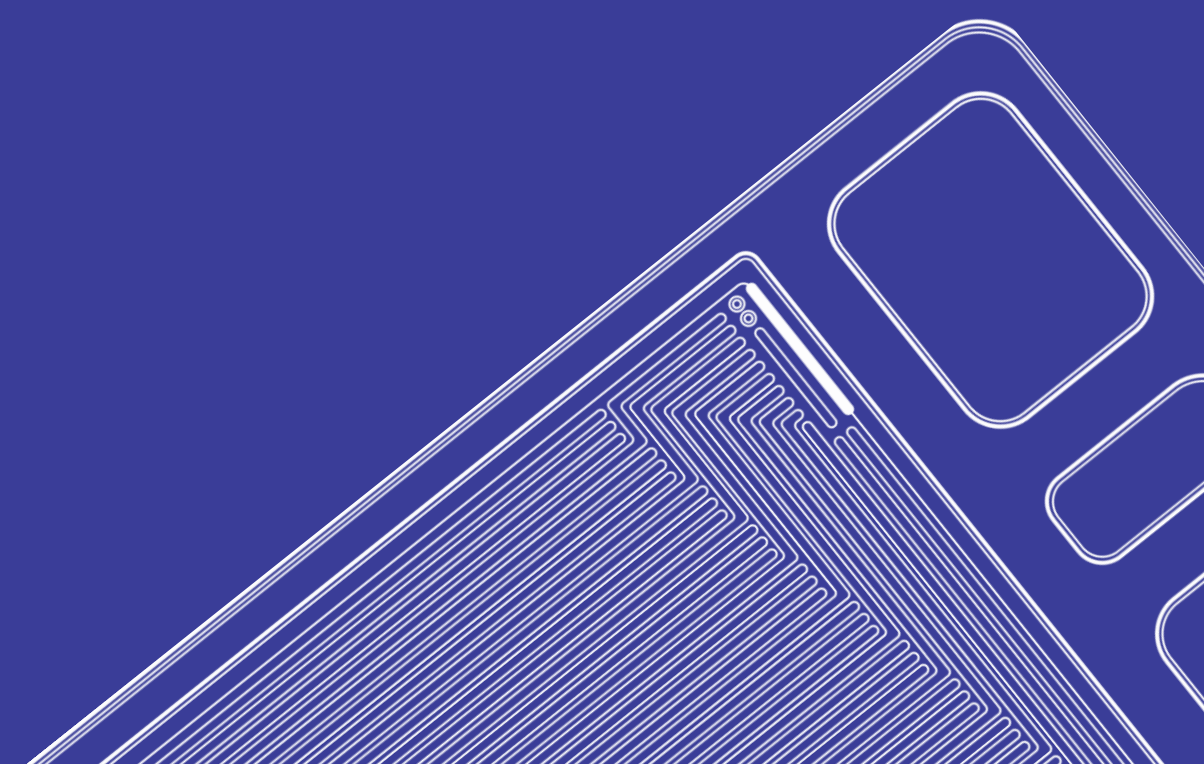
Development of reformer unit

MALTHE LINDQUIST 11 OCTOBER



● AGENDA

- 1 Development of reformer unit
- 2 Blue World Technologies
- 3 The physical reformer
- 4 Unit Operations of COUSCOUS library
- 5 CAPE-OPEN Python unit operation
- 6 Thank you for your attention

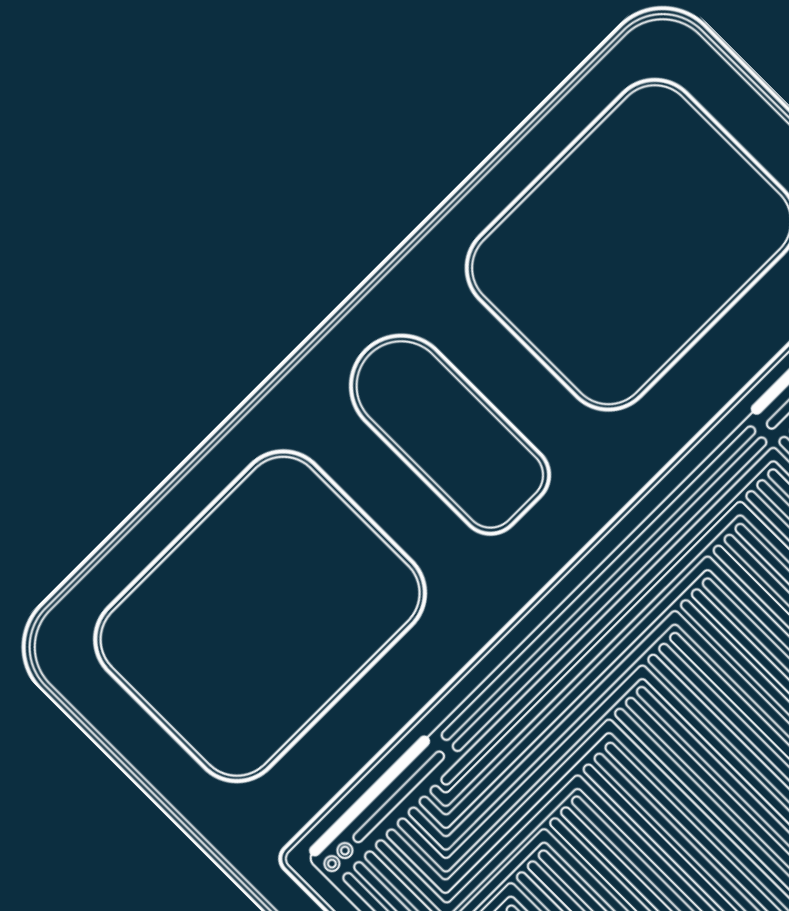


ABOUT

Blue World Technologies

- Blue World Technologies is an ambitious and visionary developer and manufacturer of methanol fuel cells.
- The methanol fuel cell is designed to reduce both fuel consumption and CO2 emission while also ensuring long range, fast refuelling, zero harmful emissions, and a low fuel cost making it a strong sustainable alternative to conventional combustion engines and generators for a wide variety of applications.
- The Blue World Technologies fuel cells are based on high-temperature PEM-technology combined with methanol-reforming. A combination that ensures a simple system design with high energy conversion efficiency.

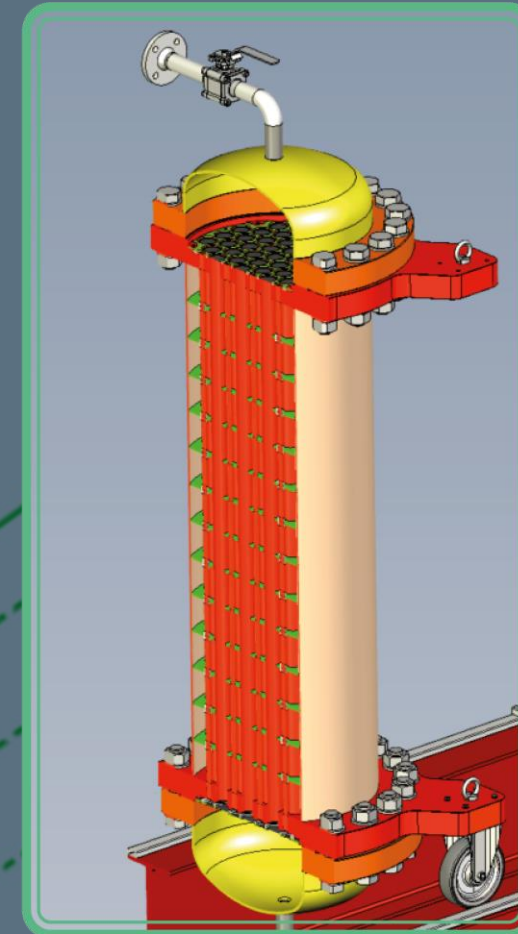
- The physical reformer



THE PHYSICAL REFORMER

The reformer

- The reformer is built as a shell and tube heat exchanger.
- Inside there are several tubes creating the reformer bed.
- On the shell side, a heated medium flows with the objective to raise the temperature to the desired level and enable the reactions.



Methanol steam reforming process

- The reforming process consists of three reactions which all need to be accounted for.
- Furthermore, as this is an endothermic set of reactions, the energy from the heating medium is required to be calculated as well.

1. Methanol steam reforming:
 $\text{CH}_3\text{OH} + \text{H}_2\text{O} \rightarrow 3\text{H}_2 + \text{CO}_2$
2. Methanol decomposition:
 $\text{CH}_3\text{OH} \rightarrow 2\text{H}_2 + \text{CO}$
3. Reversed water gas shift:
 $\text{CO}_2 + \text{H}_2 \rightarrow \text{H}_2\text{O} + \text{CO}$

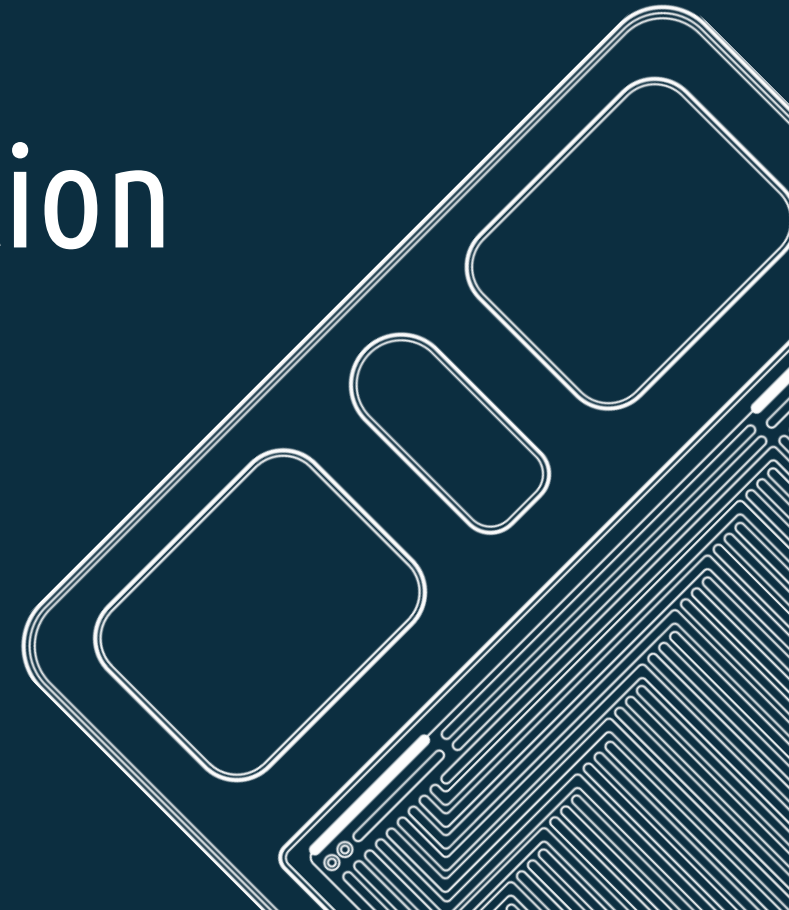
- Unit Operations of COUSCOUS library



Fixed conversion reactor or Plug flow reactor

- **THE FIRST MODEL** was made with the plug flow reactor. As it could simulate a shell and tube.
 - However, this reactor was inverted and would require additional work for it to function as intended.
- **ANOTHER OPTION** is the fixed conversion reactor.
 - For this reactor model, the user sets conversion rates of specific reactants of a reaction. This is an easy way to start. However, we ran into problems with fixing conversion rates.
 - So, if a model which easily calculates the conversion rates is to be used, it should be made up.
- **FURTHERMORE**, the energy needed for the reactions to occur was not to our satisfaction.

- CAPE-OPEN Python unit operation



CAPE-OPEN PYTHON UNIT OPERATION

Selection of CAPE-OPEN option

```
214  
215  
216  
217 def Configure(unit):  
218     #example: add a feed and product  
219     unit.add_port("Feed",unit.PortType.MATERIAL,unit.PortDirection.FEED)  
220     unit.add_port("Product",unit.PortType.MATERIAL,unit.PortDirection.PRODUCT)  
221  
222  
223  
224  
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227  
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237
```

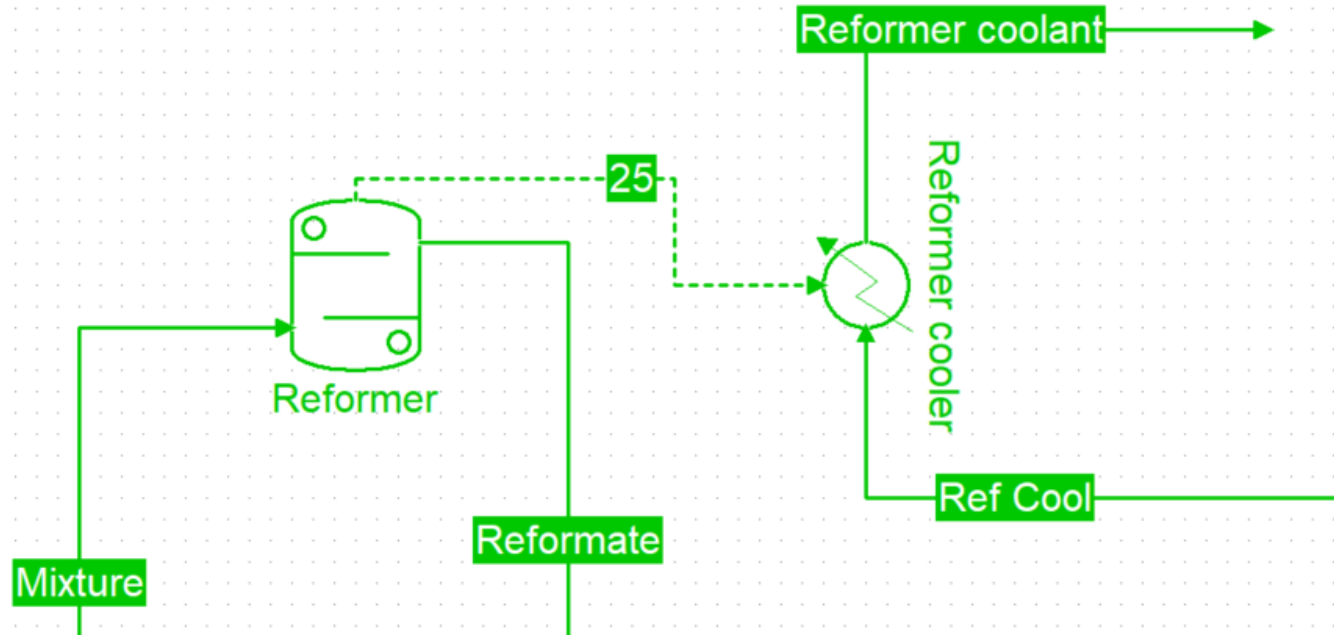
Of all the different CAPE-OPEN options e.g., **MATLAB**, **PYTHON**, **EXCEL**, etc.

PYTHON was the most appealing option in this case.

The program is somewhat easy to handle and we at Blue World already have a reformer model, which only needs a small twist to fit our case.

The Python block

- The block was integrated with the flowsheet to model the reformation process and calculate the energy needed from the heating medium.



● Thank you for your attention

