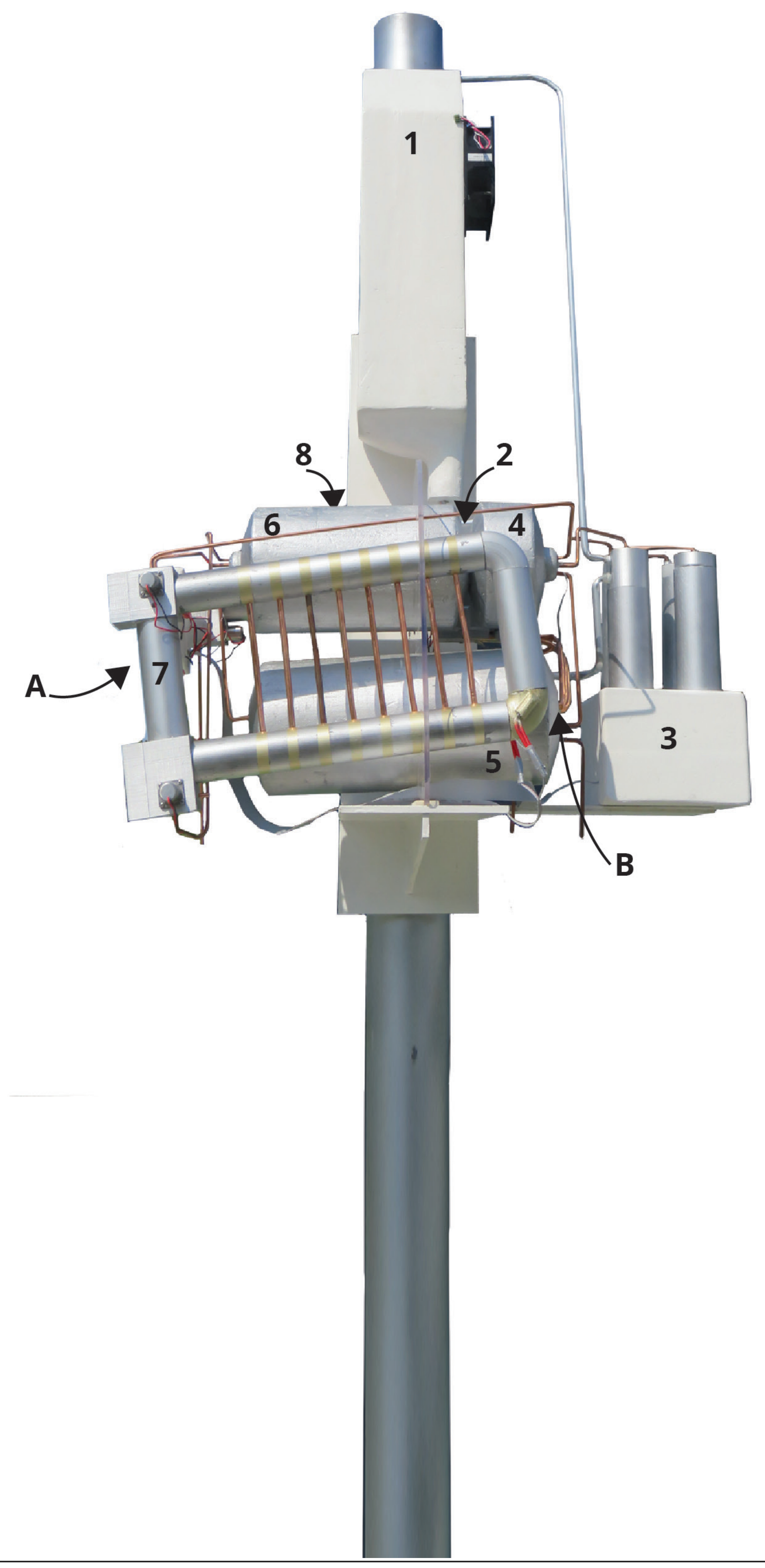
METHANOL AS A ZERO EMISSION FUEL

A SYSTEM INTEGRATION FOR SOLAR POWERED METHANOL SYNTHESIS

With the rising renewable energy demand, sustainable energy storage systems become more important. Zero Emission Fuels (ZEF) is developing a solar powered methanol micro-plant that produces methanol, using water and carbon dioxide, out of the air. ZEF's focus this far was on developing the subsystems for the micro-plant. This graduation project is about the integration design of the different subsystems. The main integration challenge was to design a functional micro-plant concept that produces methanol at a low cost. The state-of-the-art subsystem designs were researched, and a base-case cost estimation was conducted. Next, in a scaling research it appeared optimal to implement one micro-plant per three solar panels, instead of one plant per panel. A functional configuration architecture was designed and conceptual mass producible subsystem designs were developed. These designs were used for building a scale 1:1 integration prototype and for conducting a cost analysis of the concept. The micro-plant concept would produce methanol at a significantly lower cost compared to the base-case. Consequently, the micro-plant reached the target cost.

CONFIGURATION ARCHITECTURE

The designed product configuration architecture optimises the material flows, pressure relations, spatial requirements between components and heat integration. For the conceptual micro-plant prototype the material flows and configuration architecture are presented below:



1: ABSORPTION
Air is fanned in and water and carbon dioxide are absorbed in a sorbent. This sorbent flows down the absorption system on gravity.

2: DESORPTION
Water and carbon dioxide are desorbed from the flown down sorbent. The desorption's gas outlet is above the compressor's inlet

3: COMPRESSOR
The compressor creates the vacuum in the desorption system and compresses the water and carbon dioxide to about 55 bar

4: CO_2 & H_2O BUFFER
The compressed carbon dioxide gas and liquid water are buffered here. This buffer is located above the electrolyzer for gravitational water flow.

5: Electrolyzer
The water goes through an electrolysis process and becomes hydrogen. This system embeds a degasser to purify the water input.

6: H_2 BUFFER
The produced hydrogen is buffered. This buffer is located above the electrolyzer. The hydrogen gas can move upwards.

7: METHANOL SYNTHESIS (MS)
Carbon dioxide and hydrogen react to methanol and water. This system is tilted a few degrees to stimulate flow.

8: DISTILLATION (DS)
Methanol is distilled from the water. The DS works on a low pressure and can therefore be located above the MS outlet. The middle tube is horizontal.

A. CONTROL
The main electronics are located in the control chamber. This system is cooled by the atmosphere and the location is chosen to minise wire lengths.

B. HEAT INTEGRATION
From the electrolyzer, heat pipes move to the desorption and distillation systems. The heatpipes move upwards for optimal heat flow.

MICRO-PLANT SCALING

Initially, the aim was to have one micro-plant per 300W solar panel. Scaling cost analysis showed that it would be more favourable to have one micro-plant per three solar panels.

One micro-plant per three (300W) solar panels

SYSTEM EMBODIMENT

Based on the integration research and technological developments, all subsystem designs were further developed to conceptual mass-producable designs. These designs were used to construct a 1:1 integration prototype and to conduct a concept cost analysis. The 1:1 prototype was intended to inspire, teach and communicate the micro-plant's concept decisions. ZEF uses the prototype to explain the system, and ZEF members better know now what they are actually working on.

COST ANALYSIS

Cost analyses were conducted for ZEF's base-case subsystem designs in mass production scenarios. In the most optimal base-case scenario one 300W micro-plant would cost €270. The conceptual 900W micro-plant design would cost €525. The system scaling and embodiment modifications result in a capex saving of almost €80 per ton methanol production. The conceptual micro-plant's cost is within the target of ZEF.

PRODUCTION	*ASSEMBLY*	*INSTALLATION*
€ 405	**€ 95**	**€ 25**

TOTAL COST **€ 525**
900W EMBODIMENT DESIGN, MICRO-PLANT

David van Nunen
A System Integration for Solar Powered Methanol Synthesis
June 4, 2019
Integrated Product Design

Committee Prof. ir. J.E. Oberdorf
Dr. ir. F.E.H.M. Smulders
J. van Kranendonk
Company Zero Emission Fuels

TU Delft

Faculty of Industrial Design Engineering
Delft University of Technology