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# Methanol production via solar mixed reforming

Fig. 1: Solar tower Jülich

## Introduction & Aim

- Chemical storage of solar energy and $CO_2$ utilization by **solar mixed reforming of methane**
- Intermediate product is further processed into **methanol** for transportability and storability → **solar fuel**
- Endothermal reaction is carried out in **solar power tower**

→ The solar methanol process (SOLME) is developed

- Optimum operating parameters and process performance are determined

## The SOLME process

- Simplified flowsheet in Fig. 2
- Quasi stationary operation with heat storage
- Significant amounts of off-heat
  - Heat integration
  - Conversion into electricity in Rankine cycle (RC)
- Off-gas can be used to supply high temp. heat to reformer or for electricity generation
  - Heat supply to reformer allows for reduction of solar receiver temperature
  - Efficient electricity generation in CCGT
- Optimization parameters are (cf. Fig. 2)
  - Split fraction $f_{\mathrm{Split}}$
  - Reforming temperature $T_{\mathrm{Ref}}$

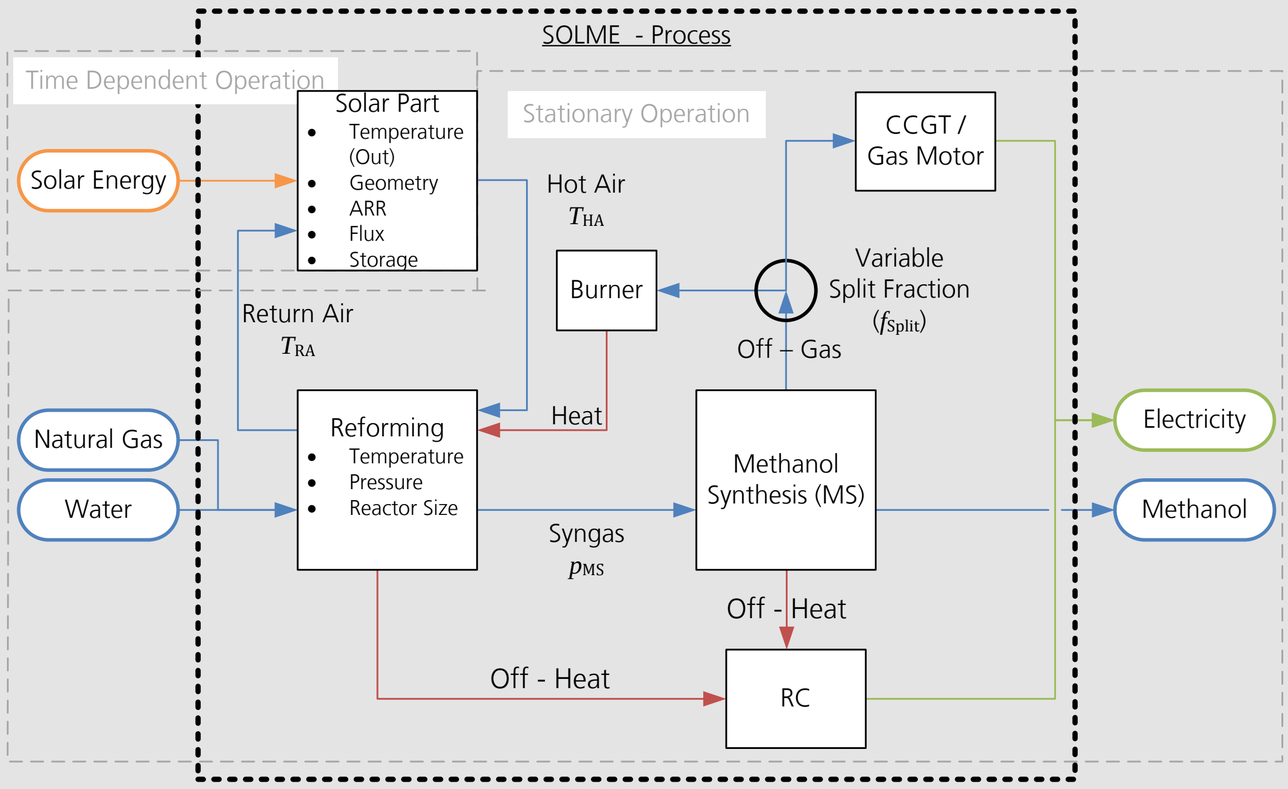


Fig. 2: Simplified flow sheet of SOLME process

## Evaluation Procedure

- Conventional evaluation criteria (e.g. energy efficiency) do not apply due to the different forms of energy involved
- **New evaluation procedure** is developed for solarized industrial processes
- The solarized process is **compared to a reference system** that produces the same products and uses the same amount of solar energy (cf. Fig. 3)
- For solarized industrial processes, the criterion ***h*** will be called **the *efficiency of solarization***, it is defined as the ratio of fuel savings to solar energy input:

$$h = \frac{\Delta E_{\mathrm{Fuel}}}{E_{\mathrm{Solar}}}$$

- In Figure 3, the difference in fuel consumption is $\Delta E_{\mathrm{Fuel}} = F + G - \mathrm{B}$
- $h$ should be maximized and values > 0 imply a benefit compared to the reference system

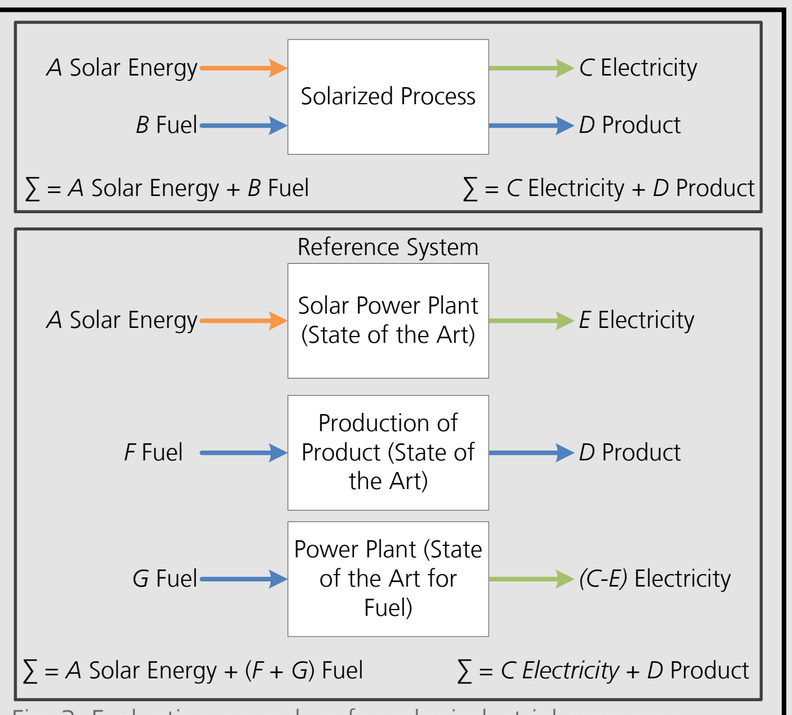


Fig. 3: Evaluation procedure for solar industrial processes

## Results

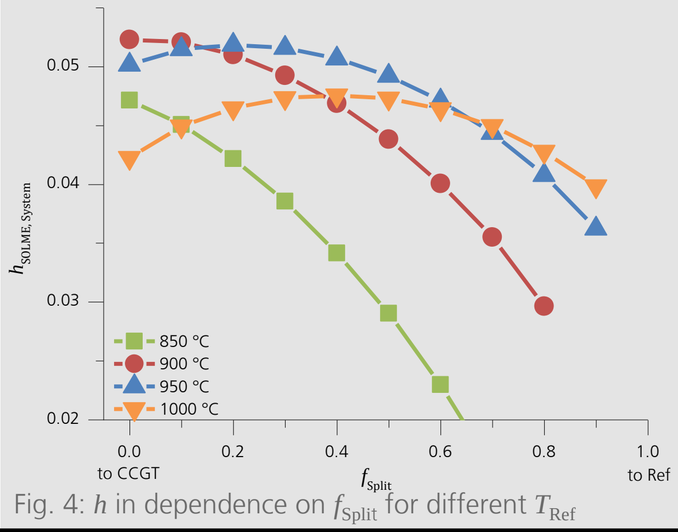


Fig. 4: $h$ in dependence on $f_{\mathrm{Split}}$ for different $T_{\mathrm{Ref}}$

## Conclusions

- The proposed evaluation procedure allows to determine if an industrial process can be efficiently operated with solar energy
- A Process for solar methanol (SOLME) production is developed, results indicate that it uses solar energy more efficiently than conventional solar power plants
- In the SOLME process, the utilization of off-gas for heat supply to the reformer is not - or only to a small extent – beneficial.
- More information in recent publication: von Storch et al., *On the assessment of renewable industrial processes: Case Study for solar co-production of methanol and power*, Applied Energy, 183 (2016, 121 – 132, 10.1016/j.apenergy.2016.08.141

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