Assessment of hybrid solar-fossil processes - exemplified by a solar reforming process

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DLR

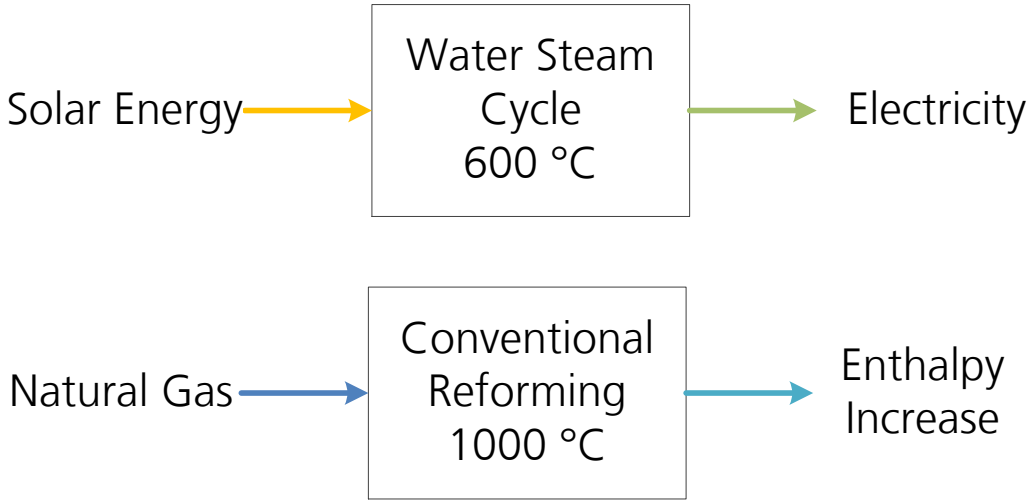
Motivation of Solar Reforming

$$CH_4 + H_2O + \text{☀} \leftrightharpoons 3H_2 + CO$$
$$CH_4 + CO_2 + \text{☀} \leftrightharpoons 2H_2 + 2CO$$

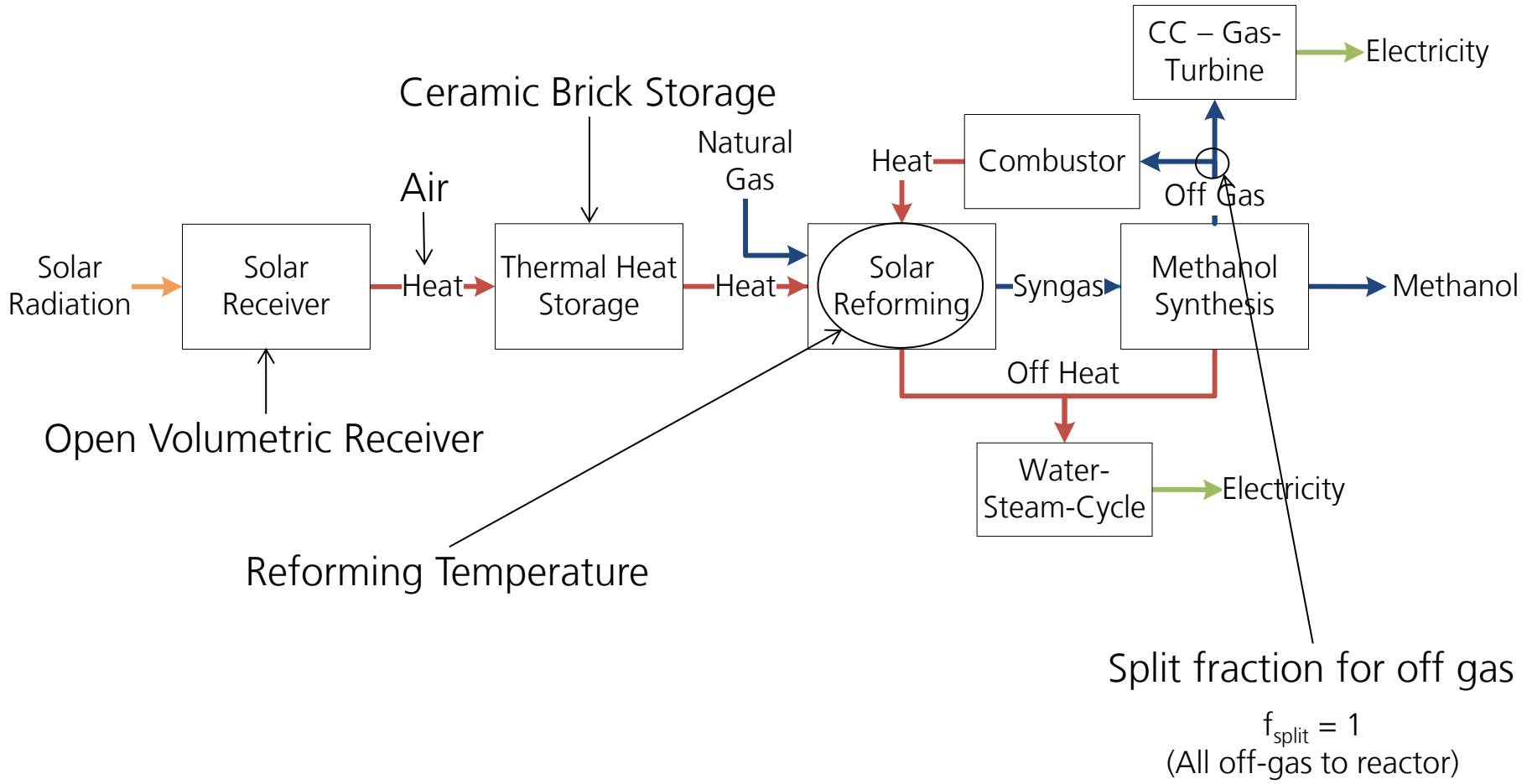
700 – 1000°C

Carnot Efficiency!

State of the Art / Reference System



Methanol Production via Solar Reforming (SOLME)



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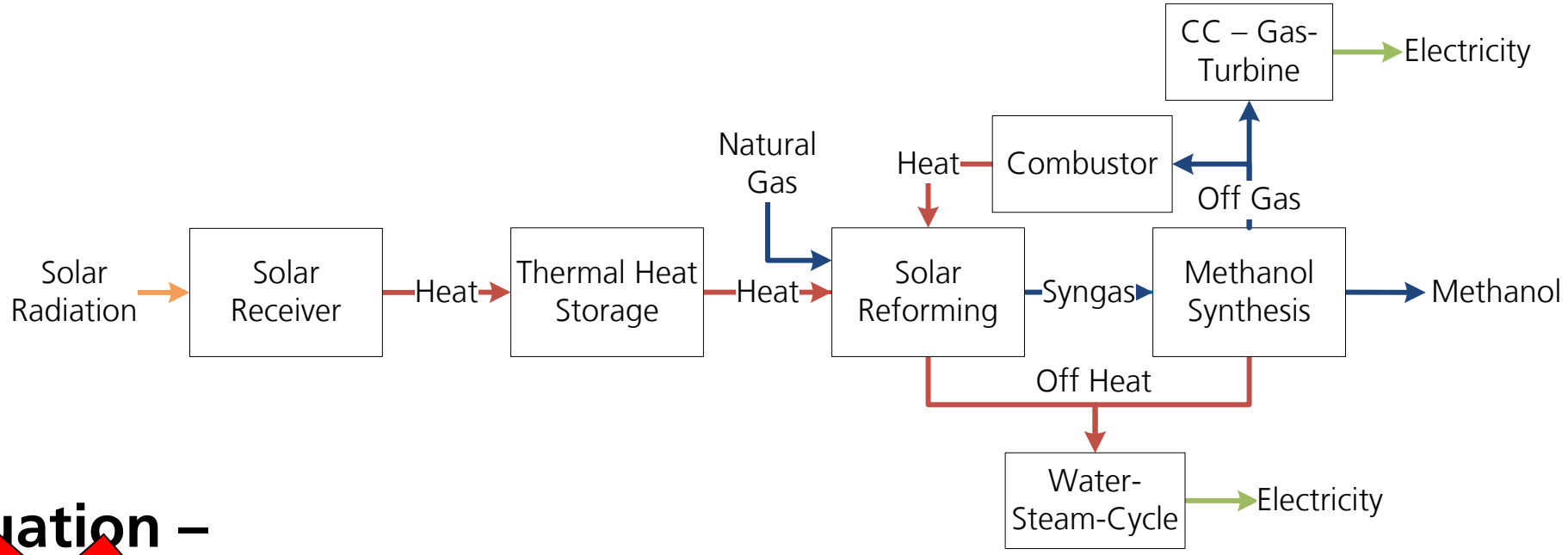
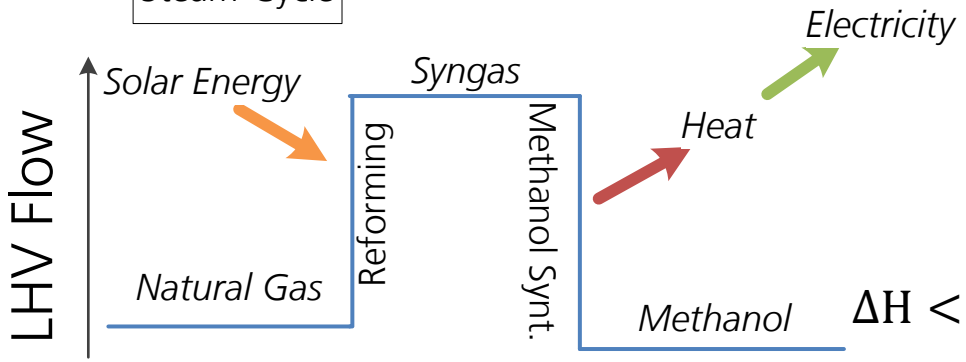


Evaluation –

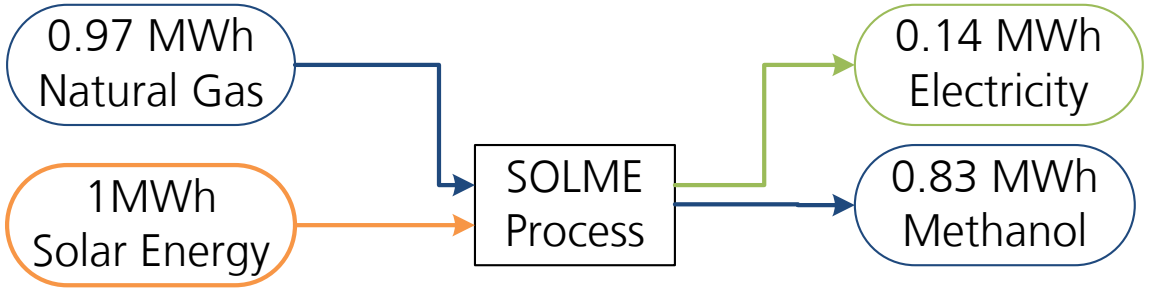
$\eta = \frac{\dot{m}_{MeOH} \cdot LHV_{MeOH}}{\dot{Q}_{sol} + \dot{m}_{NG} \cdot LHV_{NG}}$ **??**

How can we evaluate such processes?



Proposing an Evaluation Criterion

- Global aim: Reduce GHG-emissions by implementation of renewable energies
  - Relevant question: How can we use our renewable energy resources most efficiently?



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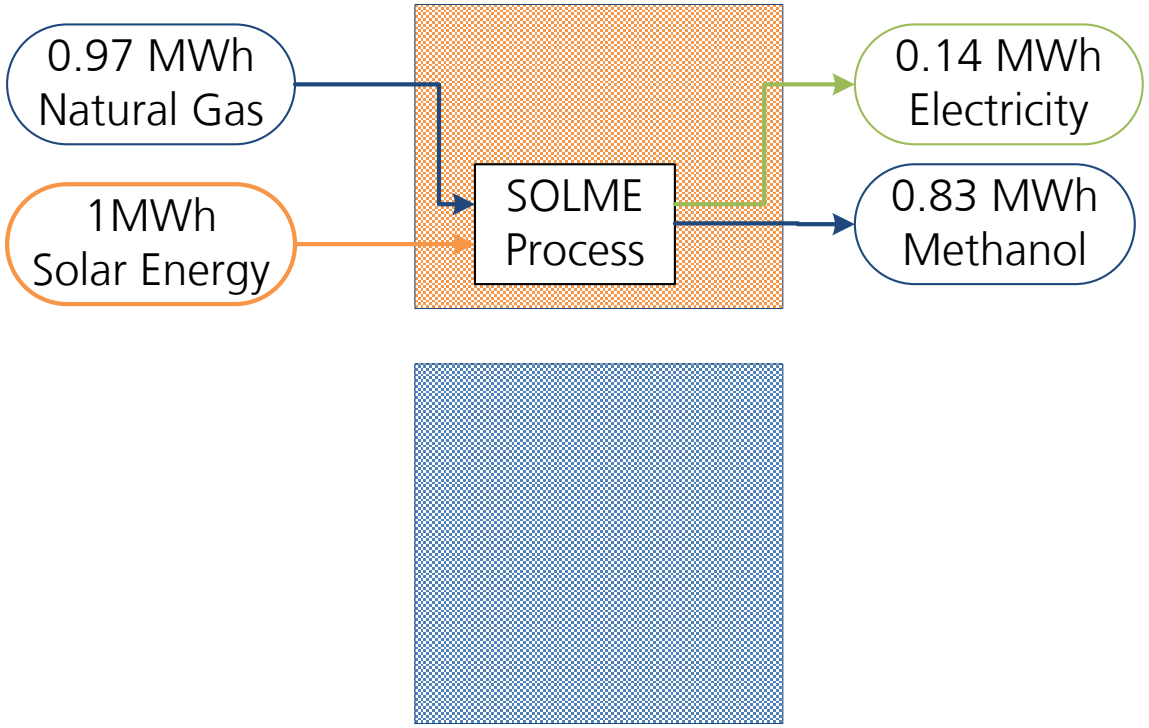

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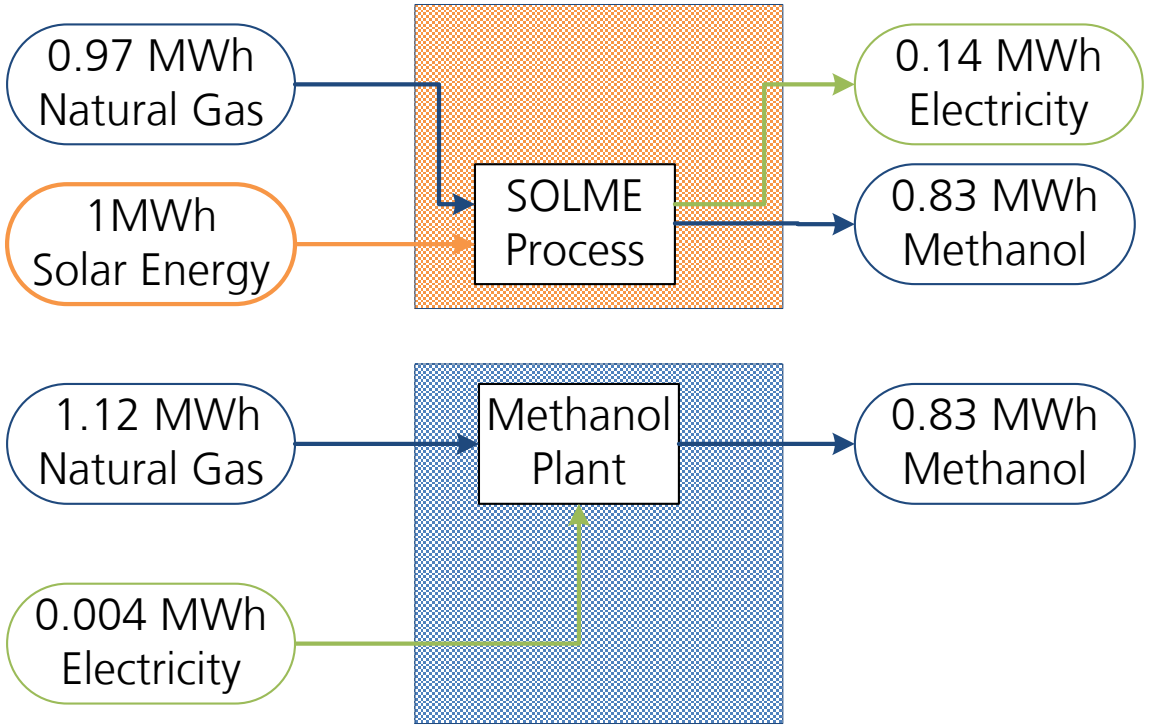

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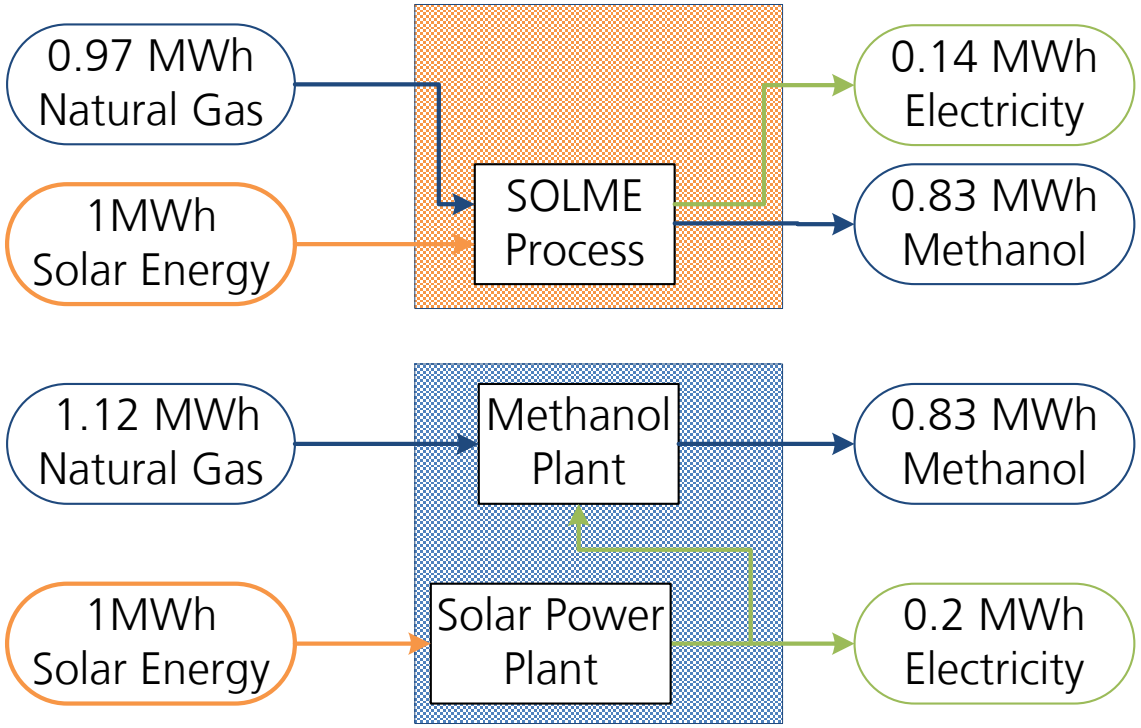

Propossing an Evaluation Criterion

SOLME System | Reference System

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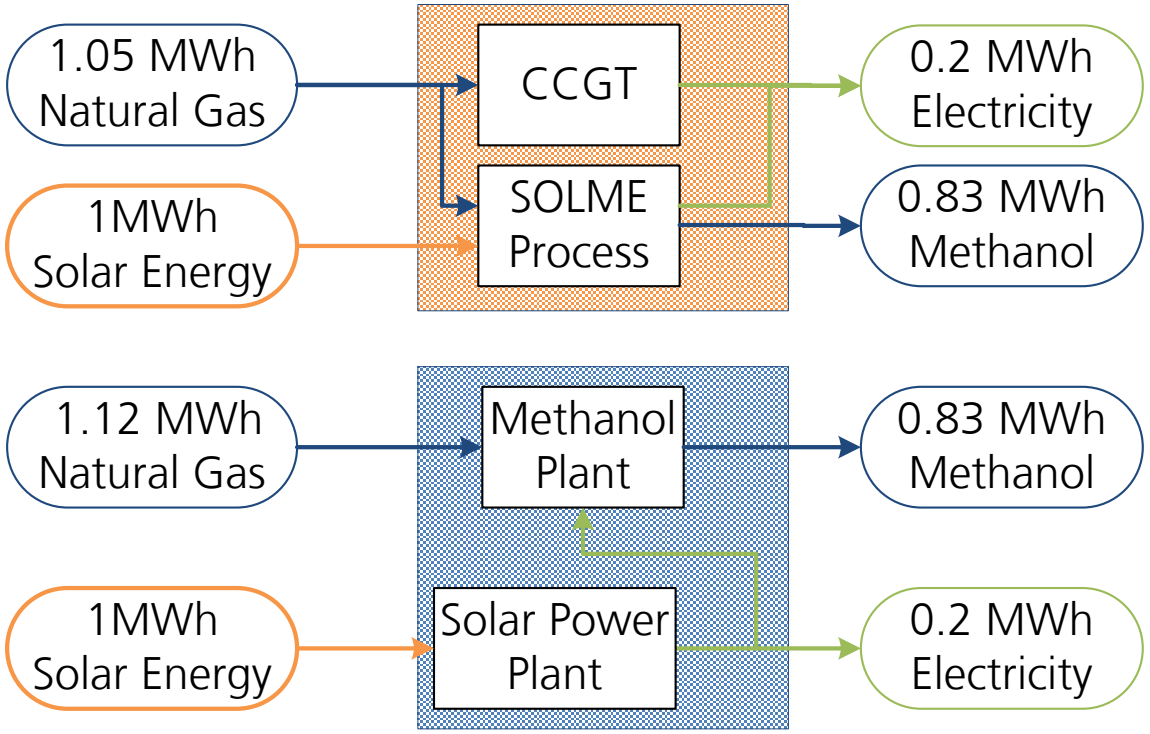


- Two systems with
  - same solar energy input (i.e. Heliostat field size)
  - same methanol production
  - same electricity output
  - different natural gas input

→Efficiency of solar-hybrid processes:

$$h_{\mathrm{Hybrid}} = \frac{\Delta E_{\mathrm{Fuel}}}{E_{\mathrm{Solar}}}$$

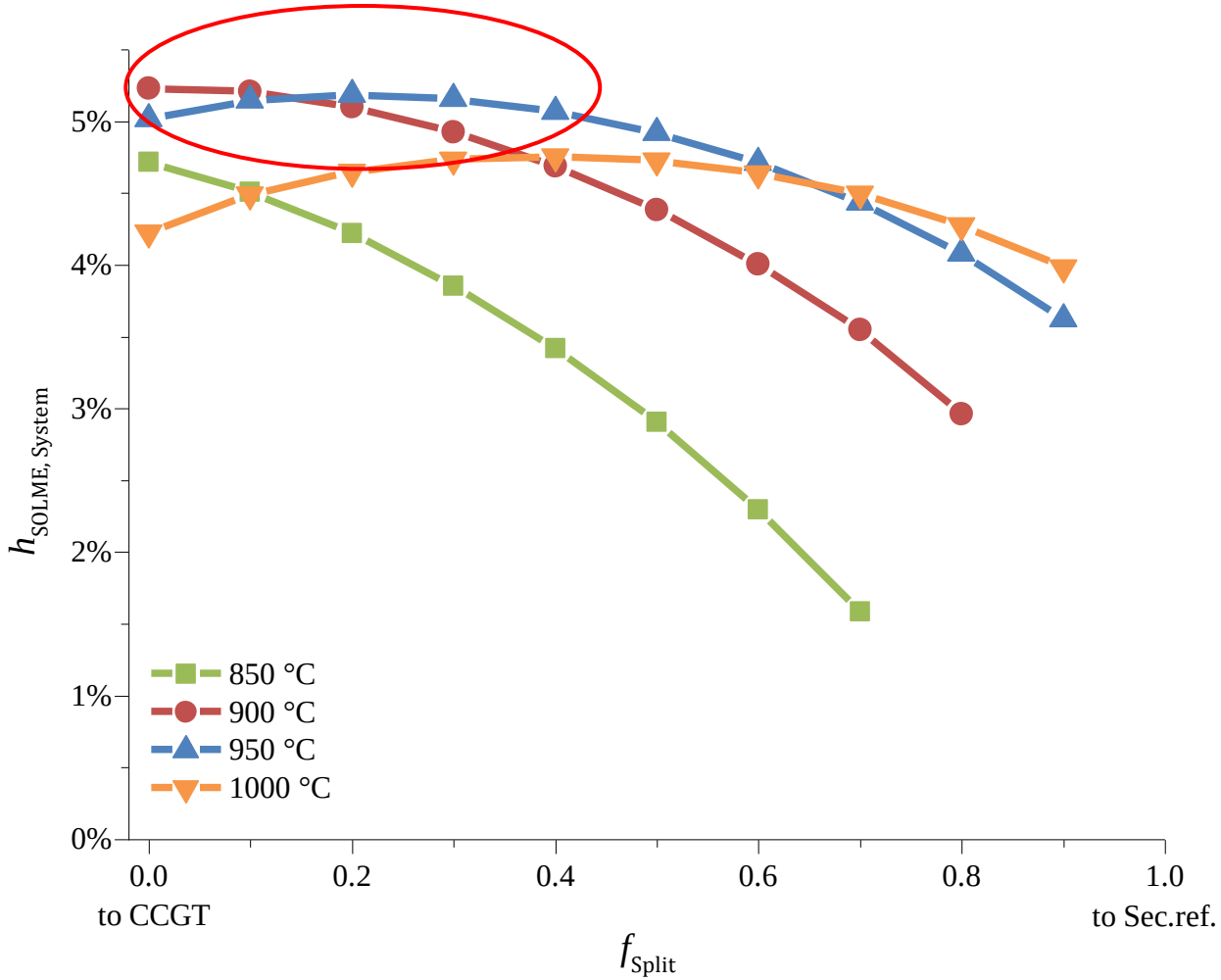
- Should be maximized and > 0

Results for the SOLME process

And what are the results for the SOLME process???

Results based on process simulation in Aspen.:

- All values > 0
  - →More efficient utilization of solar energy than in „conventional“ CSP plants
- Clear influence of f_{Split} on efficiency
  - Optimum value depends on reforming temperature
- “Plateau“ with constant efficiency over varying f_{Split}
  - → Varying ratio of electricity production to methanol production without efficiency loss.



Summary & Outlook

- Process for methanol production via solar reforming
- Solar-Hybrid processes cannot be evaluated with co
  - New criterion proposed
- High efficiency for SOLME process predicted
  →More efficient utilization of solar energy than in

- More information:
  - https://doi.org/10.1016/j.apenergy.2016.08.141

Outlook:
- Work is continued in INDIREF project
  - Development of air heated reforming reactor
  - Demonstration of solar reforming in Synlight in
  - And then…

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