Ecole polytechnique fédérale de Lausanne

Small-scale demonstration of the conversion of renewable energy to synthetic hydrocarbons

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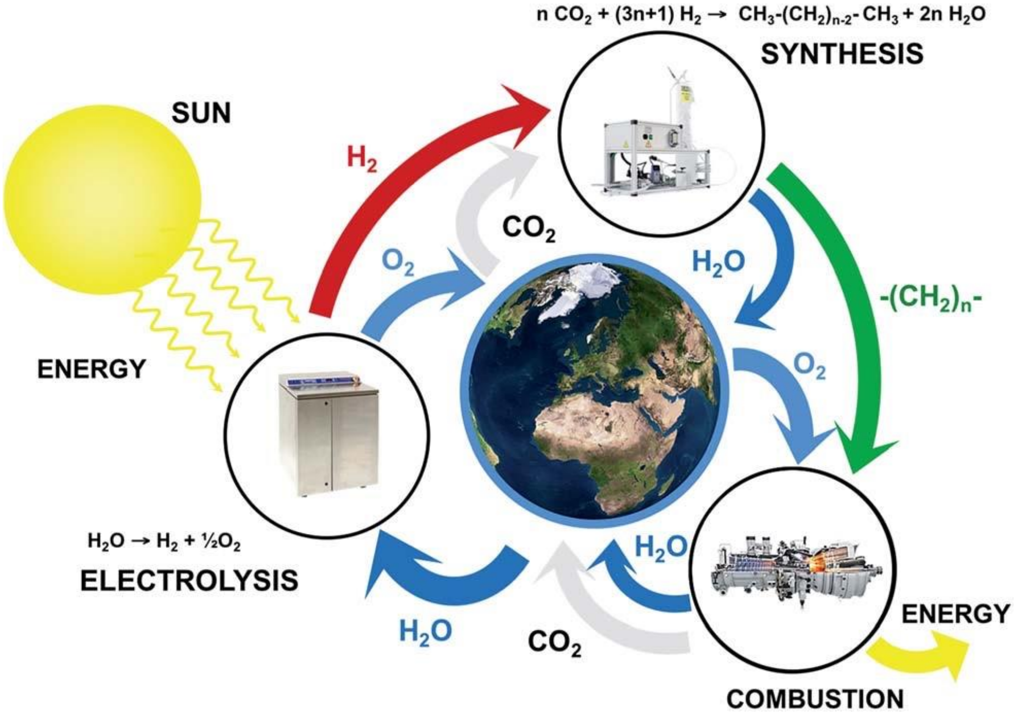
Basic considerations



- Carbon based economy
- Sustainability in closing the carbon circle
- Solar energy to hydrogen
- Synthesis of hydrocarbons from CO_2 and H_2
- Combustion and CO_2 recovery

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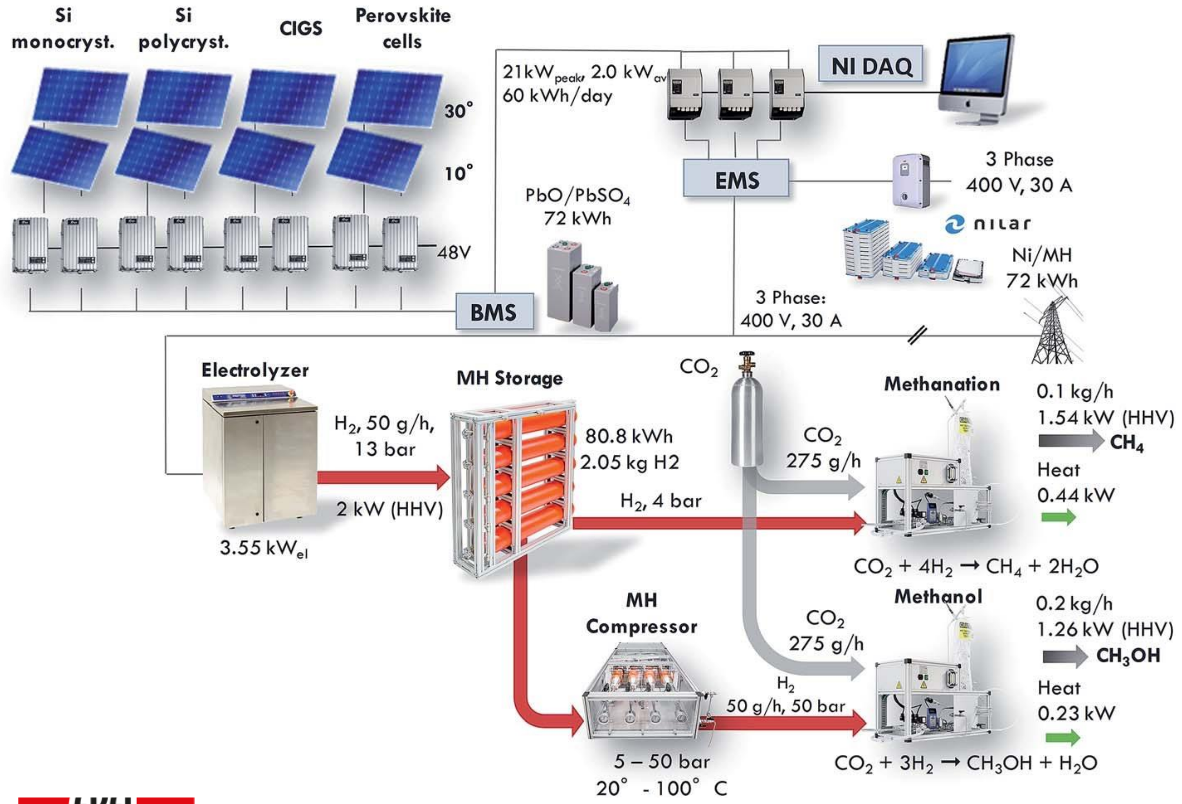
What do we do



- 2 kW: average energy consumption of individuals
- Location: Sion
- Different PV panels
- Storage in:
  - Batteries
  - Metal-hydrides
- Synthesis of methane-methanol from CO_2 and H_2

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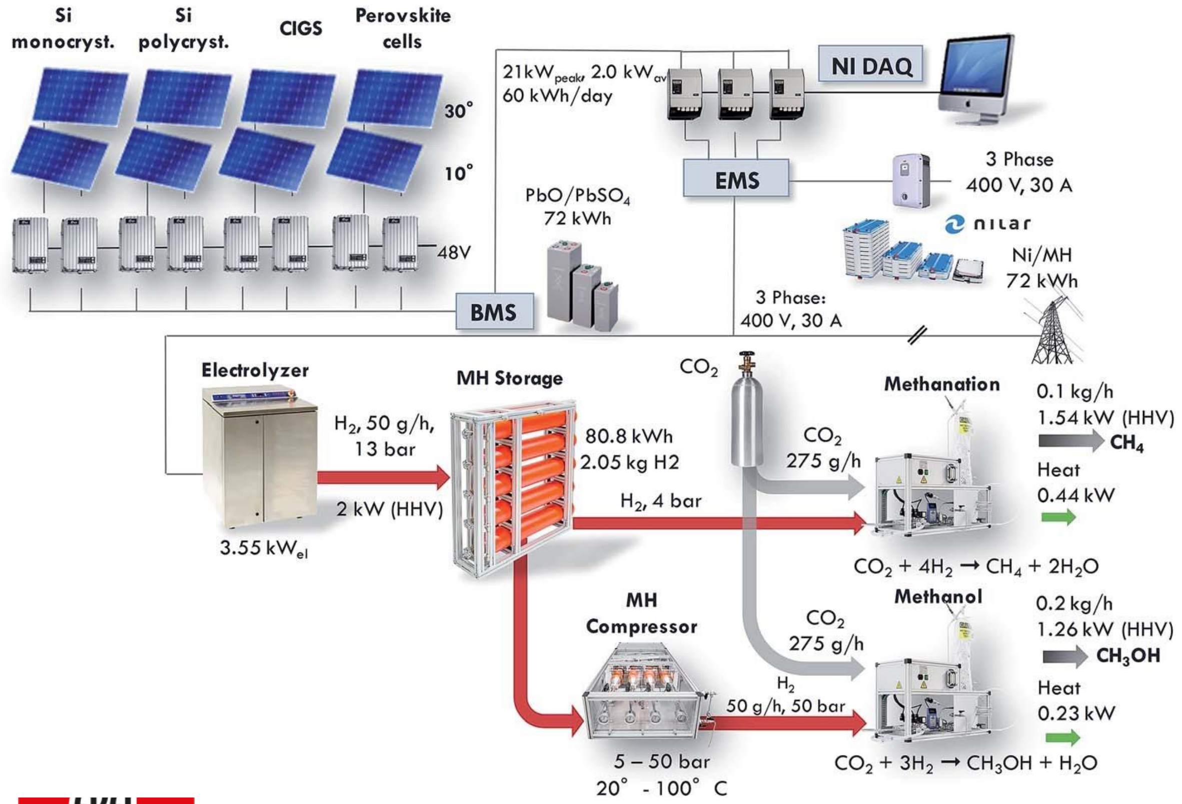
Demonstrator runs



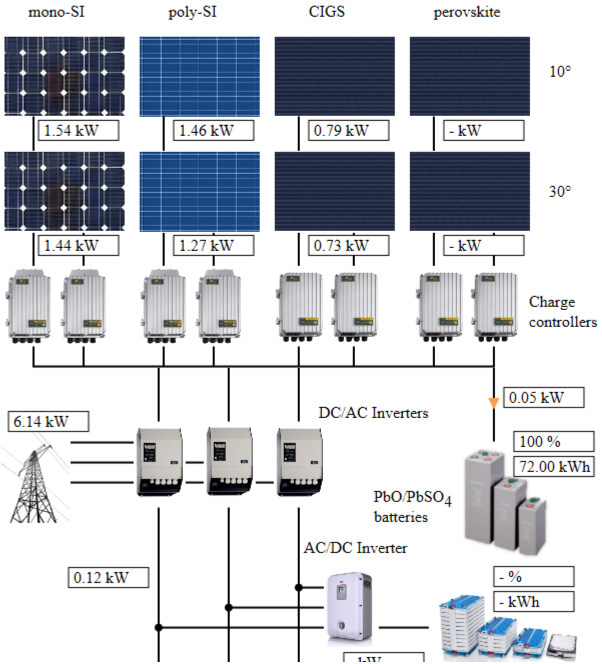
- Production can be monitored live:
- https://ssds.epfl.ch/
- Energy produced and stored in batteries and hydrogen

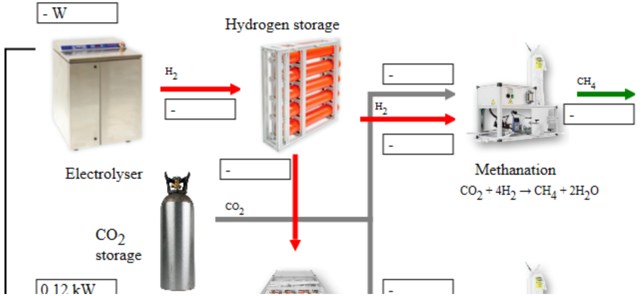
Small Scale Demonstrator Sion (SSDS)

https://ssds.epfl.ch/

sun irradiation: 411.24 W/m^2

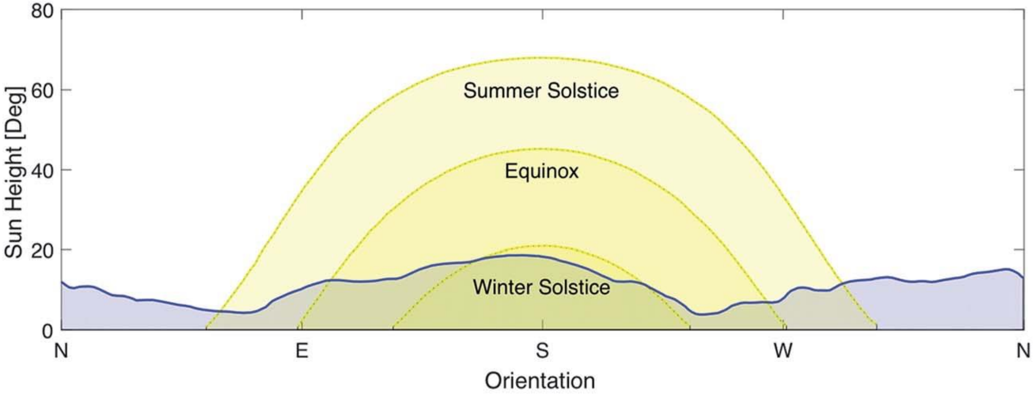
Ref. : Noris Gallandat, Jérémie Bérard, François Abbet and Andreas Züttel. 2017. **Small-scale demonstration of the conversion of renewable energy to synthetic hydrocarbons**. Royal society of Chemistry DOI: 10.1039/c7se00275k





Solar panels-installation

- 3 technologies installed:
  - Si monocristalline
  - Si polycrystalline
  - Copper Indium Gallium selenide
- 1 in delivery:
  - perovskite
- 2 inclinations:
  - 10°
  - 30°



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Solar panels-results

- Type of the solar panels changes radically the properties
- All technologies can be efficiently used for energy production
- Variation in production during the year
  - Higher efficiency at low temperature

Type	Efficiency [%]	Peak power [W]	Cost [CHF]
Si mono	16.29	3975	3120
Si poly	15.48	3900	3120
CIGS	13.84	2040	2147

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Energy storage - batteries

Ni - MH batteries

Capacity installed: 72 kWh
Power unit: 1200 Wh
Weight per unit: 29 kg
Cost: 42770 CHF

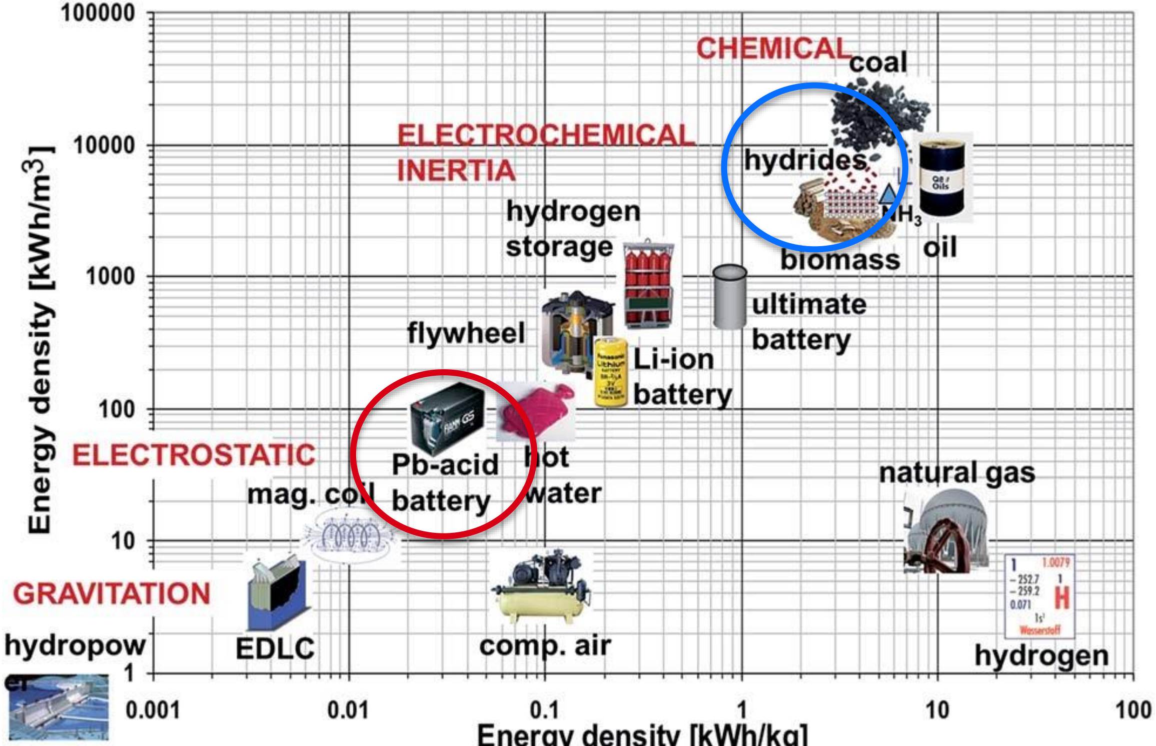
Pb - acid batteries

Capacity installed: 72 kWh
Power unit: 3000 Wh
Weight per unit: 94.6 kg
Cost: 15707 CHF

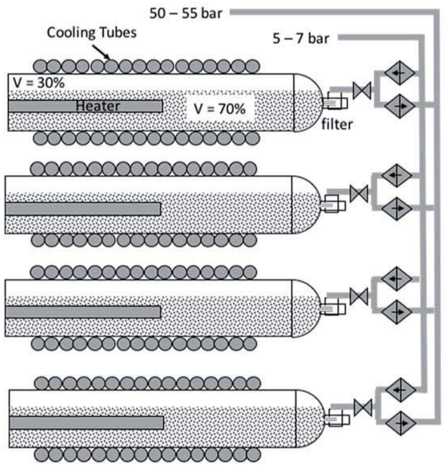
Energy storage – metal hydrides

Capacity installed: 80 kWh
5 units
147 kg/MH – 2 kg/H_2
Power unit: 3000 Wh
Volume: 45 L
Energy density: 0.32 kWh/kg

Energy storage – comparison



Molecular compressor



- Load at low T and low P
- Heating phase
- Discharge: high T and high P
- Ideal when high P is required in process units

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Hydrogen production

Electrolyzer	Horgen S20
Producer	Proton on site
Power [kW]	3.55
Production [gh^{-1}]	47.3
Efficiency [%]	53
Cost [CHF]	93000

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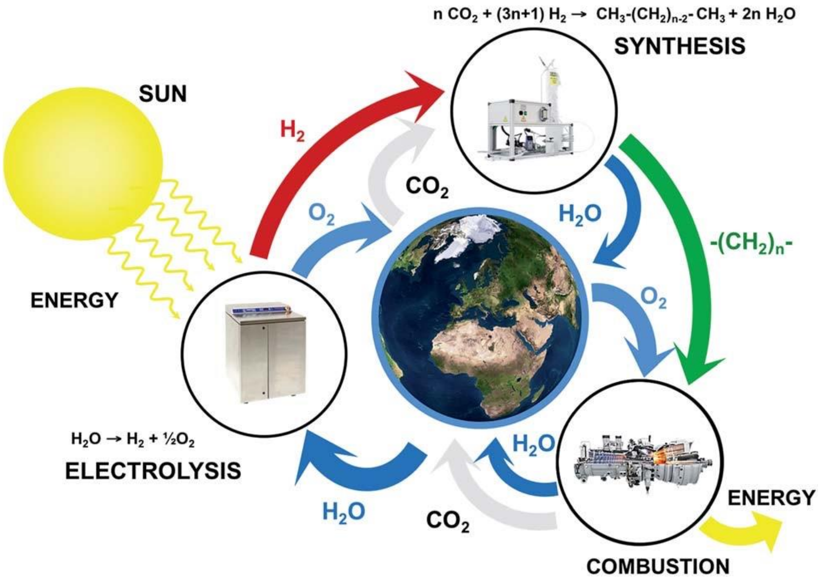
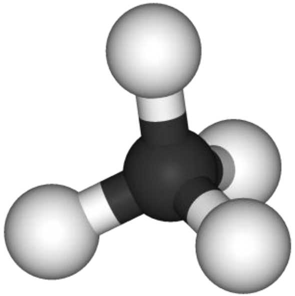
Why synthetic fuels?



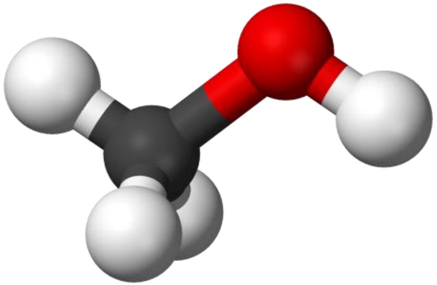
- Close C cycle
- Use existent distribution/utilization systems
- Move towards higher energy density
- Use in mobility

2 sample products:



Methane

- Gaseous
- Use in existing distribution
- Efficient production



Methanol

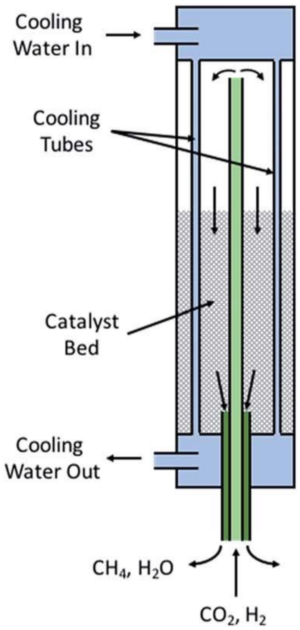
- Liquid
- Distribution as liquid fuels
- More complicated production

Methanation reactor/1

- Fixed bed cooled catalytic reactor
- Catalyst: Ru/Al_2O_3

- Challenges:
  - TD limitation
  - High conversion required

Methanation reactor/2



- Solution:
  - Preheater: stabile functioning
  - Cooled section: heat removal
  - Control of the outlet temperature: adequate conversion with TD equilibrium

- Conversion achieved:
  - > 99.5% of CO_2 at inlet

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Methanol reactor

- Challenges:
  - Operation at high pressure
  - Low conversion - recycle required
  - Only CO_2 in feed: reduced catalyst activity

- Possible solutions:
  - Addition of WGS step
  - Coupling with methanation for energy efficiency

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Outlook

- Set up ready for operation
- Technical evaluation of the operation
- Optimization of the various parts
- Process/heat integration
- Addition of the methanol reactor

Aknowledgments

EPFL – LMER Laboratory of materials for renewable energy

Prof. Andreas Züttel

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Diamond Lite SA
gaz nat
esr énergies sion région

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