

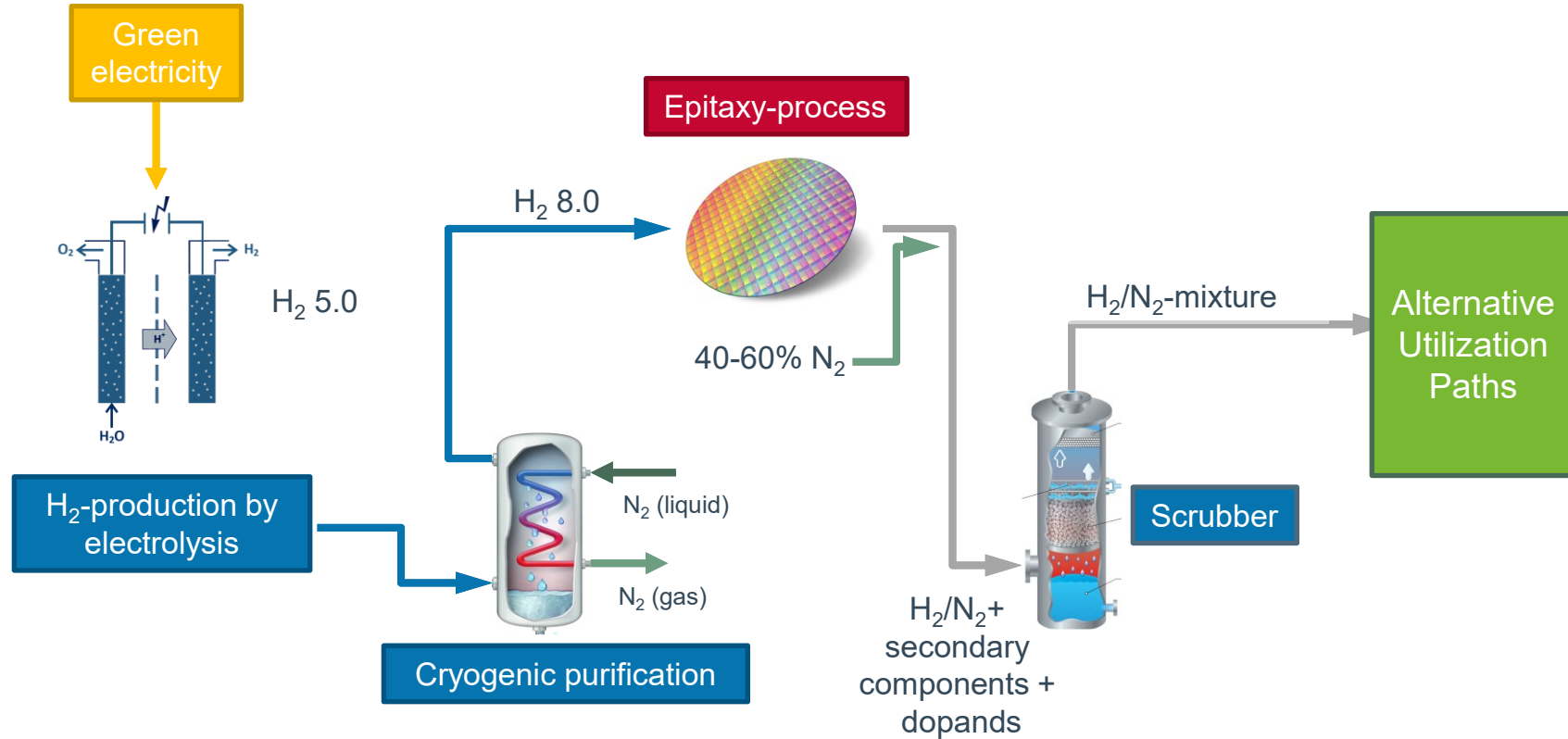
# RECYCLING AND SECOND USE OF GREEN HYDROGEN FROM SEMICONDUCTOR INDUSTRY

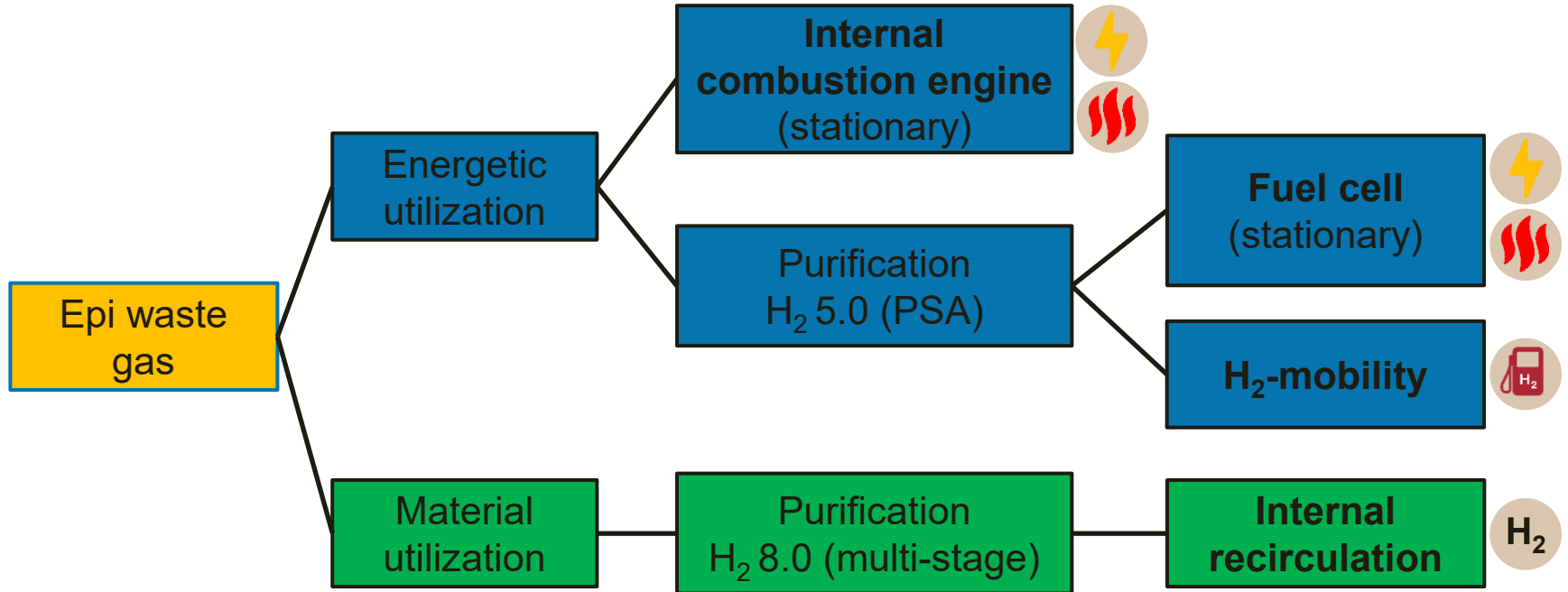
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Linz, October 13<sup>th</sup> 2022

Funded by

- **Hydrogen Production and Use in Semiconductor Industry**
- **Second Utilization Paths for Hydrogen**
  - Technical Analysis
  - Emission Balance
- **Implementation Project**
- **Conclusions**

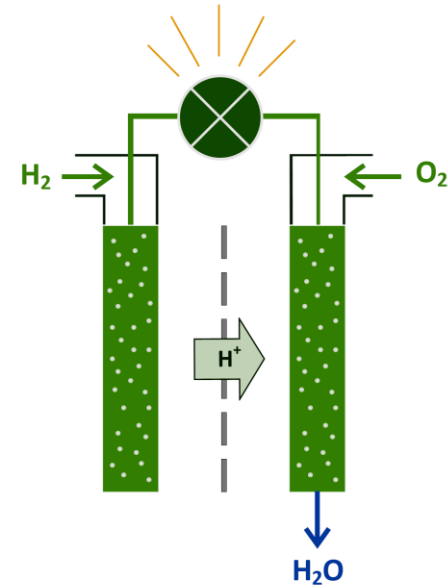




- Smallest number of components, well-established technology
- Gas mixture system to ensure >50% N<sub>2</sub> content (avoid backfiring)
- ICEs: e.g. agenitor406 from 2G Energy AG, 178 kW<sub>el</sub>,  $\eta_{el,max}=39\%$ ,  $\eta_{tot}=81\%$
- 20% of electric energy for electrolysis; additionally, 14 MWh<sub>th</sub> per t H<sub>2</sub>



- Gas purification needed (according to ISO14687)
- Compressor + cooler, Pressure Swing Adsorption (PSA) for purification (simulated loss of 26% H<sub>2</sub>)
- FC: e.g. PowerCell MS-100 system, 260 kW<sub>el</sub>,  $\eta_{el,max}=62\%$ ,  $\eta_{tot}=94\%$
- 11.5% of electric energy for electrolysis; additionally 10.9 MWh<sub>th</sub> per t H<sub>2</sub>
  
- But: economically not viable



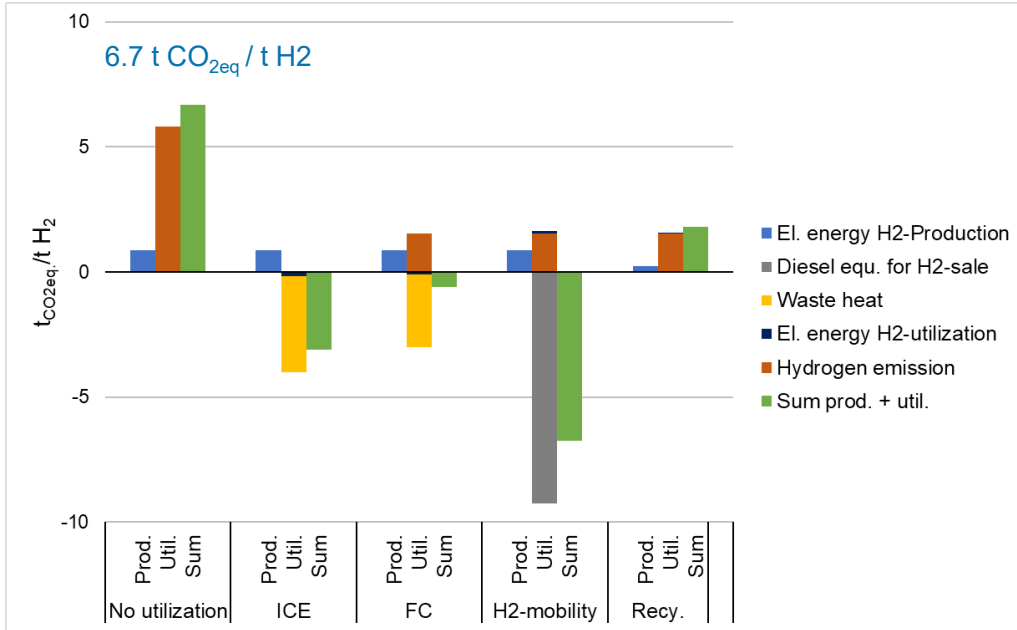
- Gas purification needed (according to ISO14687)
  - Compressor + cooler, Pressure Swing Adsorption (PSA), additional compressor + cooler for refuelling at 350/700 bar
  - H<sub>2</sub> busses: need ca. 7.5 kg<sub>H<sub>2</sub></sub>/100km (replacing ca. 30 l diesel)
- Ca. 13 300 km per t purified H<sub>2</sub>



- Gas purification with PSA to 5.0 H<sub>2</sub>
- Mixing with H<sub>2</sub> from electrolyser and cryogenic purification to 8.0 H<sub>2</sub>
- 74% of hydrogen can be re-used
  
- But: inadequate resolution of online measurements to exclude accumulation of impurities → intolerable risk for epitaxy production process



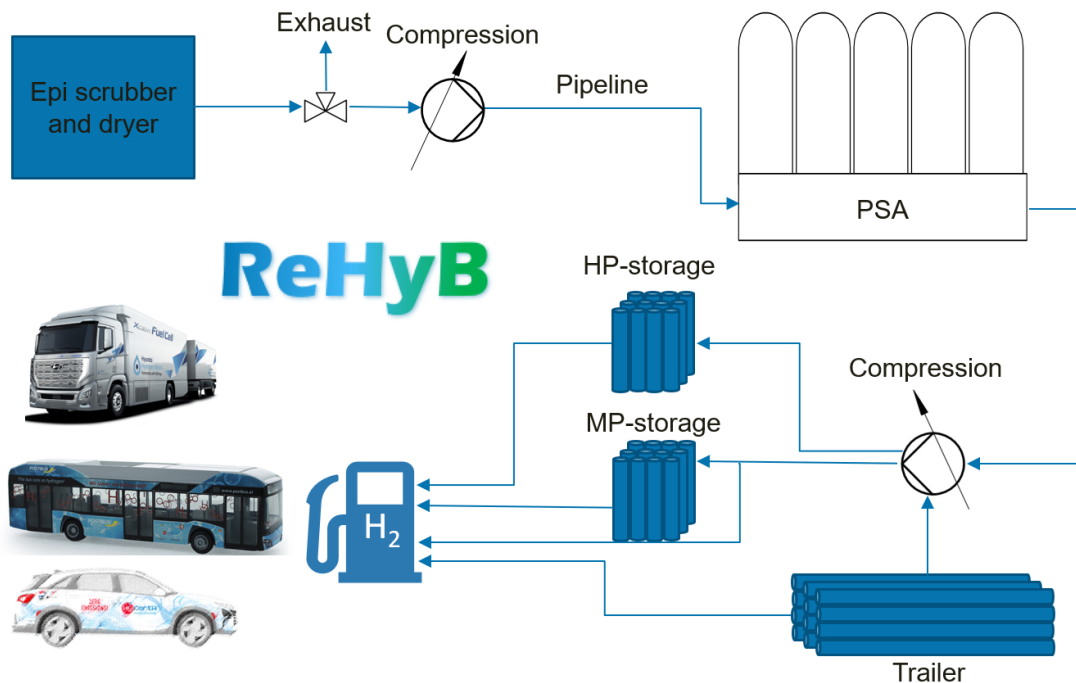




Energy carrier	kg <sub>CO2eq</sub> /MWh
Green electricity	14 [1]
Natural gas	268 [1]
Diesel (incl. 5,6% bio fuel)	321 [1]
Hydrogen	174 [2]

[1] Umweltbundesamt, „Berechnung von Treibhausgas-Emissionen verschiedener Energieträger,“ <https://secure.umweltbundesamt.at/co2mon/co2mon.html>  
 [2] R. Derwent, P. Simmonds, S. O'Doherty, A. Manning, W. Collins und D. Stevenson, „Global environmental impacts of the hydrogen economy,“ IJNHPA, Bd. 1, Nr. 1, p. 57, 2006

**Current process with grey H<sub>2</sub> delivered from Germany: 23.5 t CO<sub>2eq</sub>/t<sub>H<sub>2</sub></sub>**



- ReHyB project started in 2021
- 1<sup>st</sup> five H<sub>2</sub> busses will arrive in 2022
- Interim refueling station until completion of public HRS
- Up to 40 busses planned in and around Villach
- HRS additionally for heavy-duty vehicles and FC cars

- Hydrogen ideal energy carrier for sector-coupling
- Replace wasteful emission of hydrogen with 2<sup>nd</sup> utilization
- All four investigated utilization paths technically possible and ecologically beneficial
- Purification and re-use for H<sub>2</sub> mobility chosen for implementation
- Quadruple emission mitigation:
  - Grey hydrogen → green hydrogen
  - Road transport → local production
  - Emission of hydrogen-containing waste gas → re-use of hydrogen
  - Diesel busses → H<sub>2</sub> busses

# Acknowledgments

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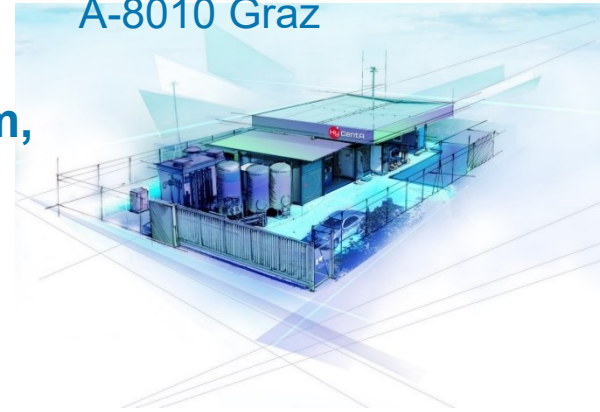
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**Thank you for your attention!**