Chair of Renewable and Sustainable Energy Systems
TUM School of Engineering and Design
Technical University of Munich

Leitprojekt H_2Giga
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Prospective Life Cycle Assessment of Hydrogen production with next-generation low-iridium PEM Electrolyzers

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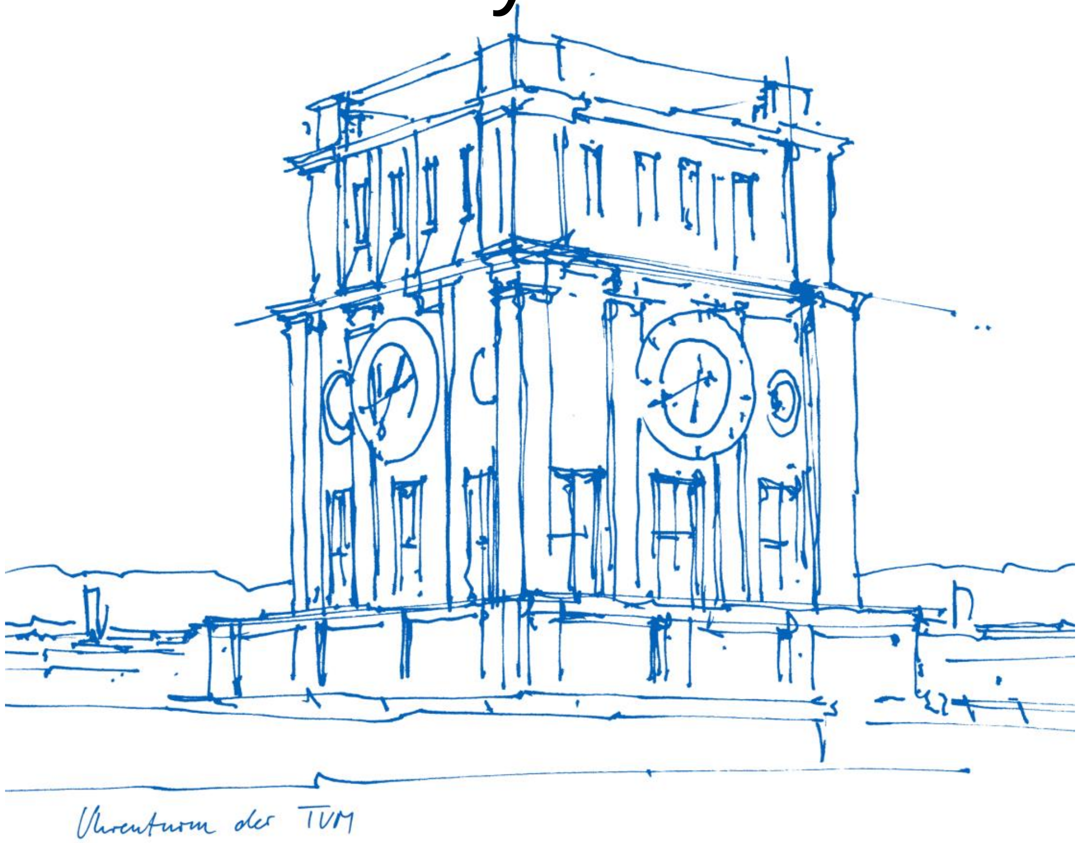


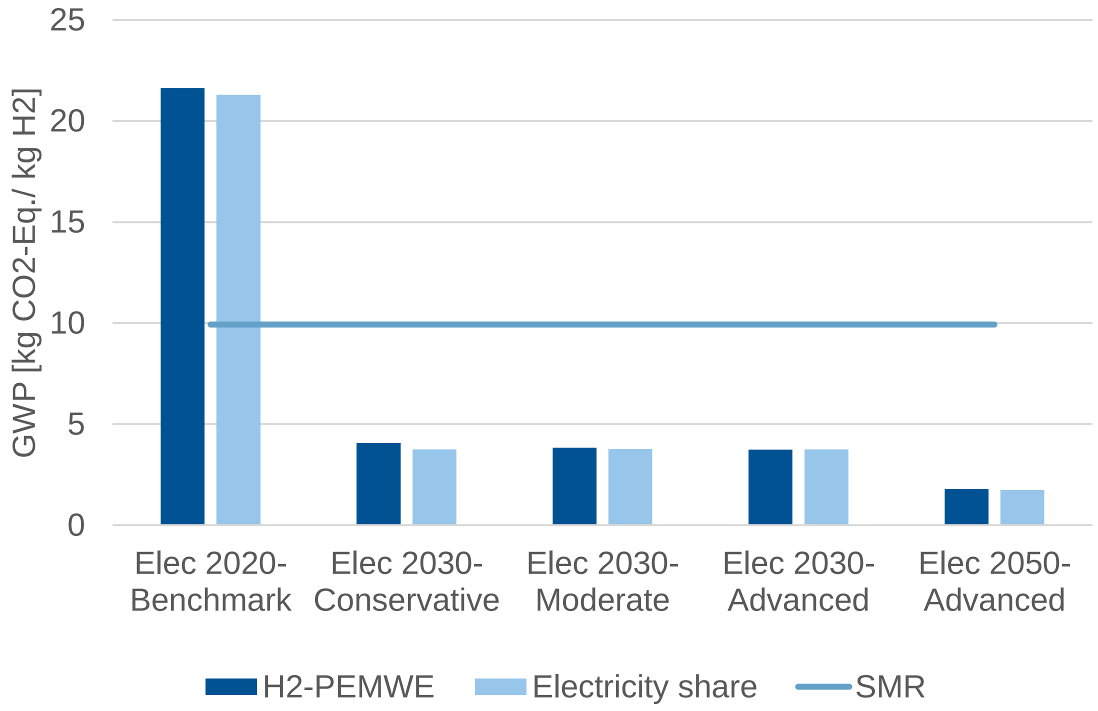
Hypothesis & Research Question

Reducing the iridium content in PEM electrolyzers is required for their scale-up and widespread implementation. [1][2]

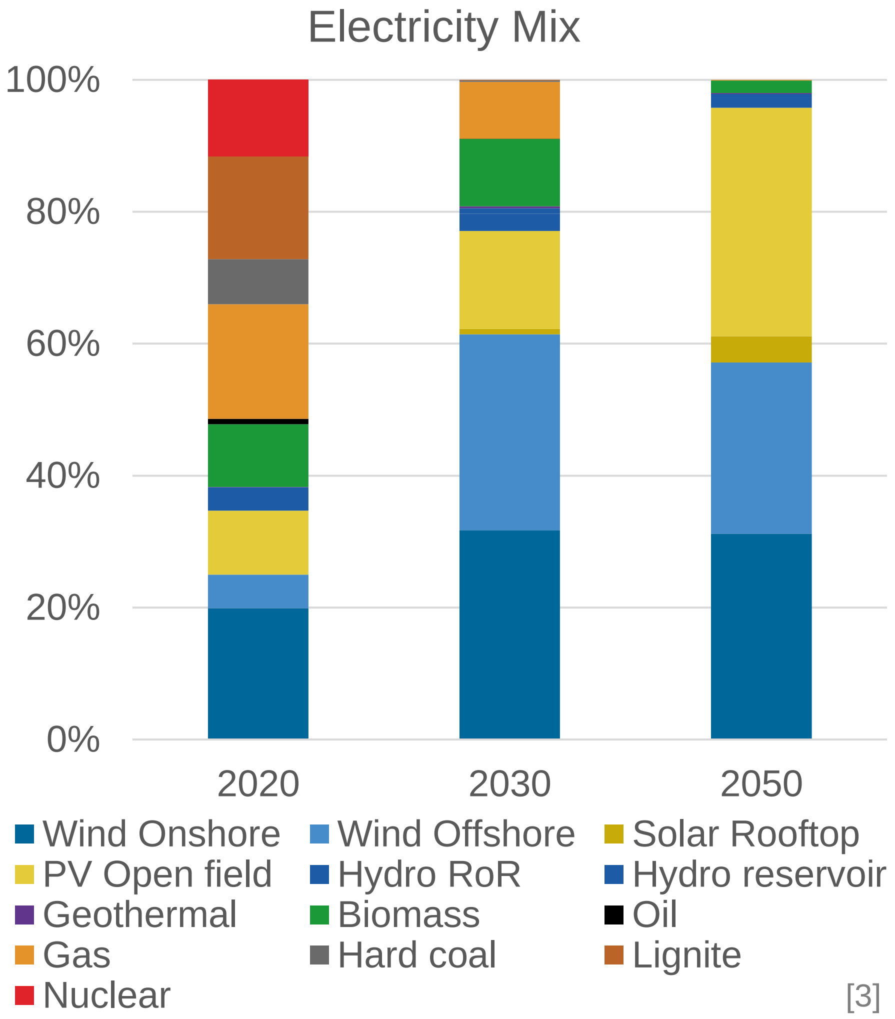
How does the reduction of iridium content in PEM electrolyzers impact the sustainability of hydrogen production?

Context:

- Most of the environmental impacts of hydrogen production are attributed to electricity.
- Minimal impact from the production of the electrolyzer.
    - Analysis of the impacts of hydrogen production.
    - Analysis of the impacts of electrolyzer production.



Approach



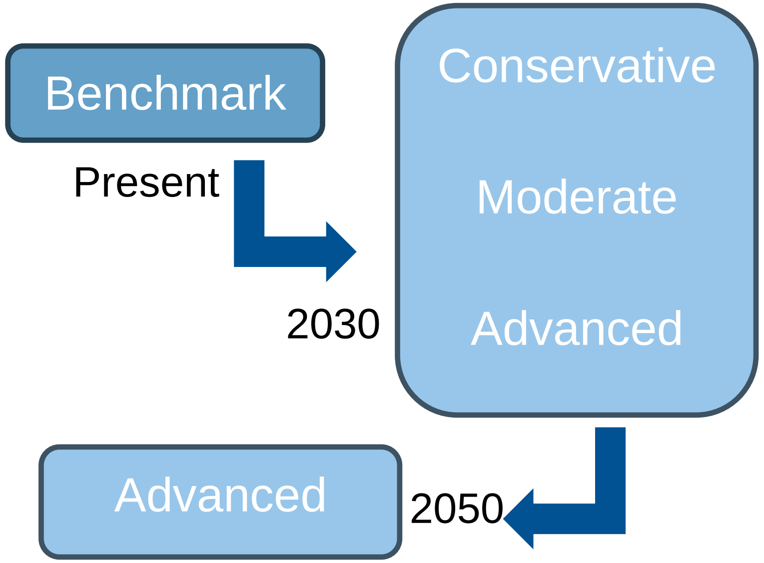
[3]

	Benchmark	Conservative	Moderate	Advanced
Membrane Thickness	180 µm (Nafion 117)	125 µm (Nafion 115)	90 µm (Aquivion)	50 µm (reinforced)
Ir loading	2 mg/cm^2	0.5 mg/cm^2	0.25 mg/cm^2	0.1 mg/cm^2
Pt loading	0.3 mg/cm^2	0.3 mg/cm^2	0.1 mg/cm^2	0.05 mg/cm^2
2030 Feasibility	✗	✓	✓	✓
2050 Feasibility	✗	✗	✗	✓

2030 Feasibility (≤ 0.15 t_{Ir}/GW), 2050 Feasibility (≤ 0.025 t_{Ir}/GW)

[4]

Methods



- **Functional Unit**: 1 kg of hydrogen at 30 bar
- **Impact Assessment Method**: ReCiPe 2016 (H)
- **Key Categories**: GWP: Global warming,
  OPD: stratospheric ozone depletion,
  LOP: land use,
  FFP: fossil resource scarcity,
  WCP: water use,
  SOP: mineral resource scarcity.

- **Tools**: *premise* tool for updating Ecoinvent database. [5][6]
- **Prospective Database**: SSP1-RCP1.9 Scenario (remind - SSP1-PkBudg500 for 2020, 2030 and 2050) [7]

- **Further Study Functional Unit**: 10 MW PEM Electrolyzer Stack

GWP - Results

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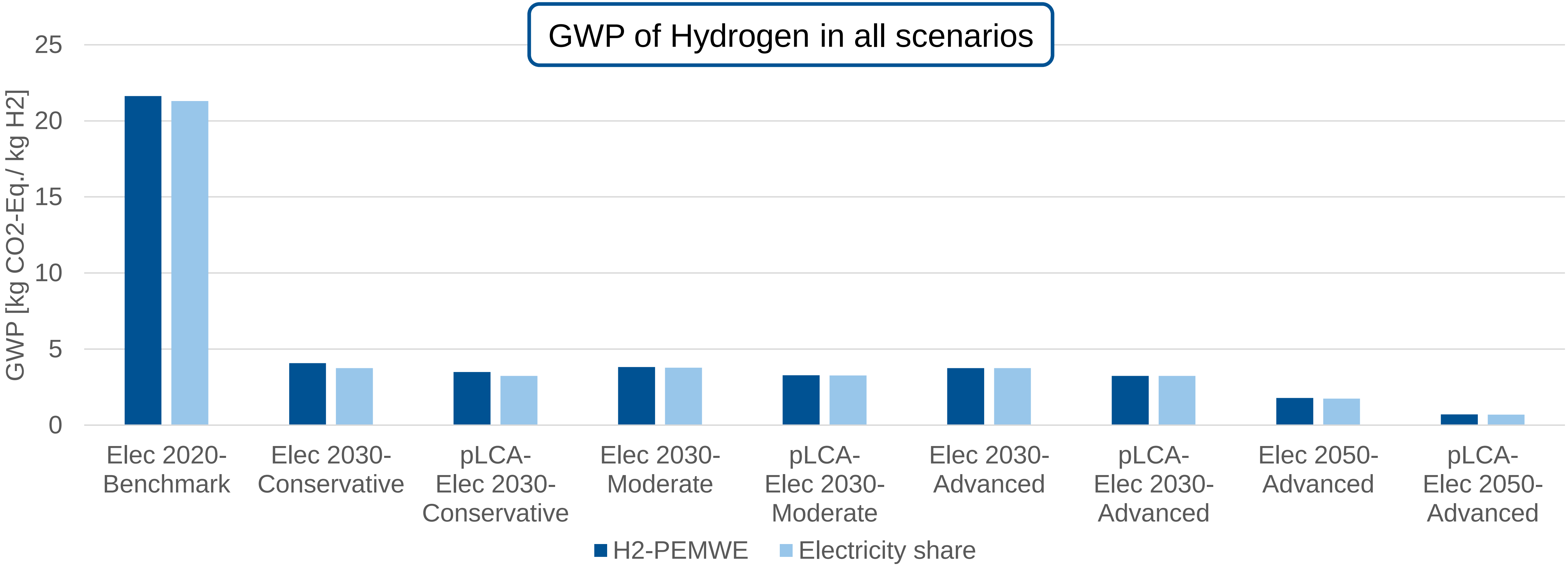

- Significant reduction in greenhouse gas emissions by 2050.
- Importance of electricity generation impacts.
- Further reduction when considering the prospective database → average 14% in 2030, 60% in 2050.

Trade-offs 2050 in Advanced Scenario

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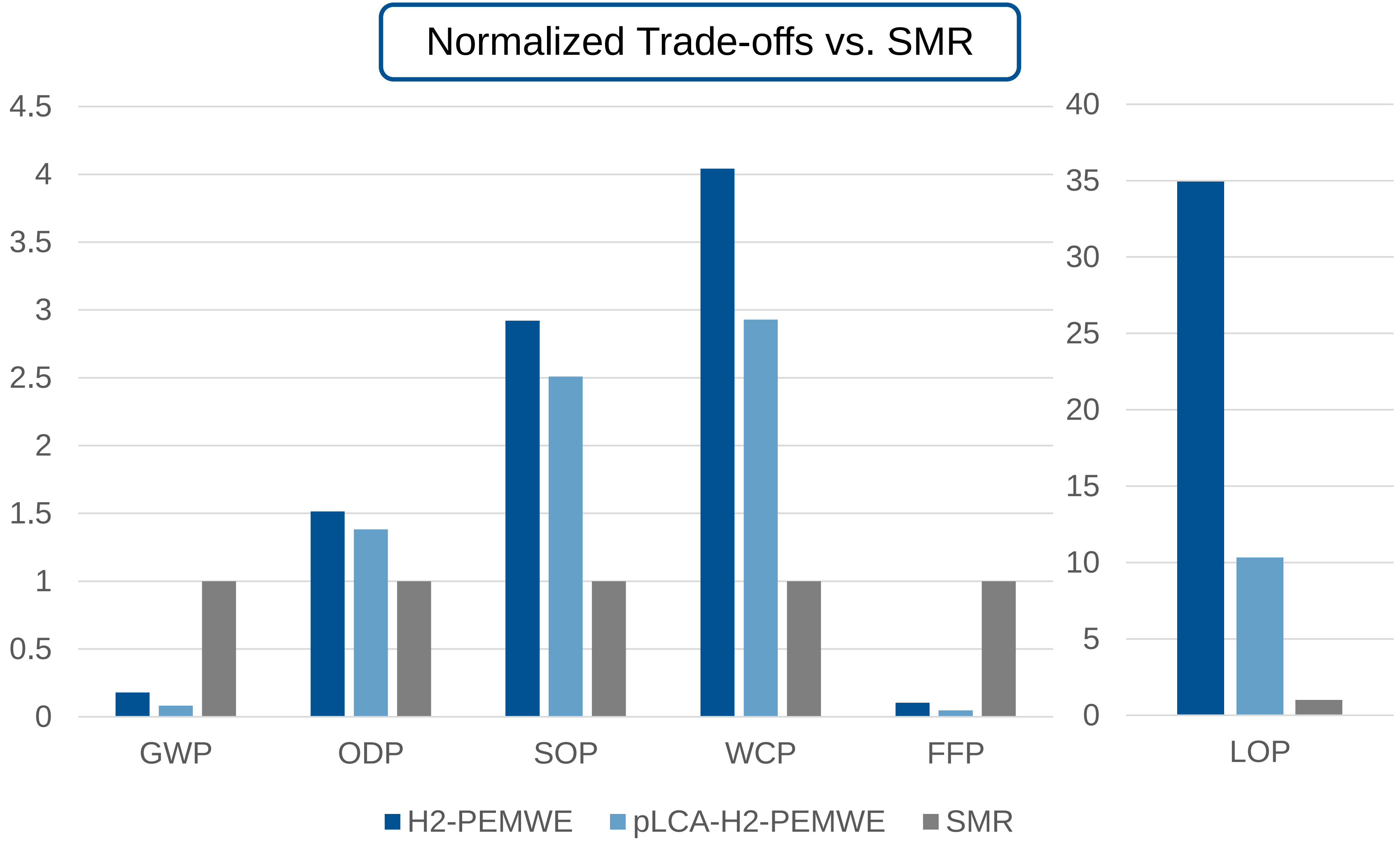
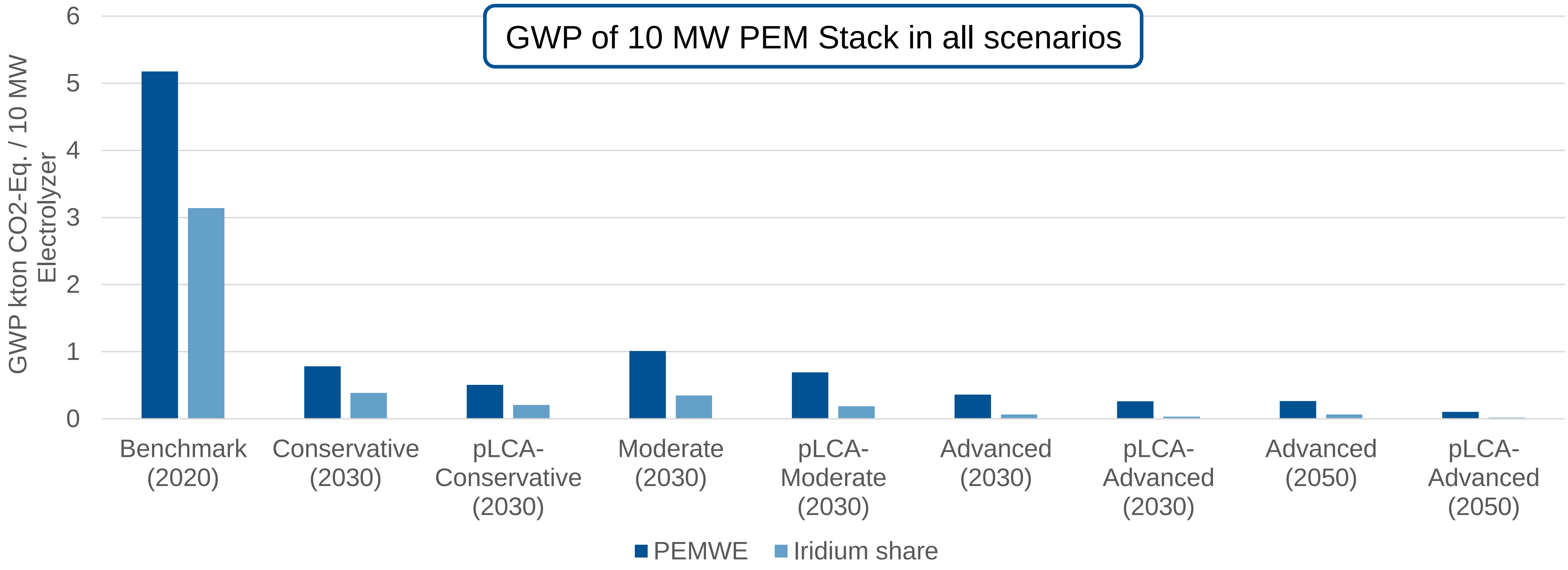
- Significant trade-offs in land use, water use, mineral resource scarcity, and ozone depletion.
- Further reduction when considering the prospective database.
  - Between 8% (ODP) up to 70% (LOP).
- Electricity is still the main contributor in all categories



GWP: Global warming, OPD: stratospheric ozone depletion, LOP: land use, FFP: fossil resource scarcity, WCP: water use, SOP: mineral resource scarcity

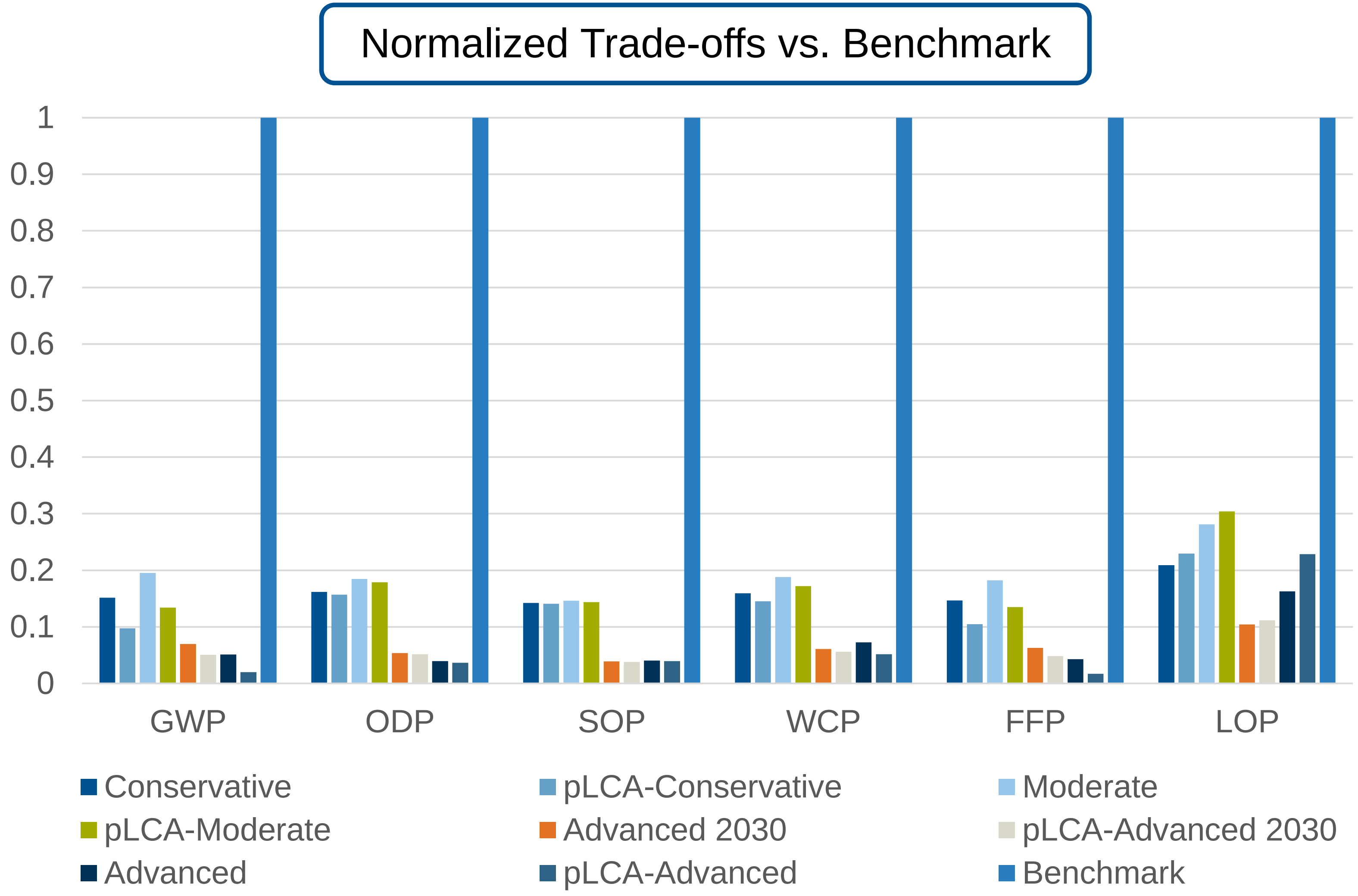
GWP PEM Stack production



- Importance of Iridium production on the impacts and, therefore, the future emissions reduction.
- Significant reduction in greenhouse gas emissions by 2050.
- Further reduction when considering the prospective database.

Trade-offs vs Benchmark

- Significant reductions in all categories.
- Further reduction when considering the prospective database in almost all categories.
    - Even more significant in the 2050 Advanced scenario.
- Increase in the pLCA scenarios in the LOP with an average increase of 8% in 2030 and 40% in 2050 → Iridium and titanium production impacts increase.



GWP: Global warming, OPD: stratospheric ozone depletion, LOP: land use, FFP: fossil resource scarcity, WCP: water use, SOP: mineral resource scarcity

Conclusions & Acknowledgements

- **Conclusions**:
  - In hydrogen production the impacts of the production of the electrolyzer are negligible in comparison to the impacts of the required electricity.
  - Electrolyzer efficiency and electricity consumption are pivotal factors
  - Reduced iridium content enhances the sustainability of PEM electrolyzers and is required for the technology's widespread depletion.
  - Prospective LCA highlights the importance of updating background data for future-oriented environmental impact assessment.

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  - IRIDIOS Project Consortium.
  - Kopernikus-P2X project team for energy model input

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