

Summer Research Seminar – Cork 2025

Welcome: *Juniata College, PA, USA.*

“We want Juniata students to have unique opportunities that change their lives”



Pathway to Green Hydrogen Fuel through Novel Materials, Water & Light



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Funded by the
European Union

Tuesday, 27 May 2025

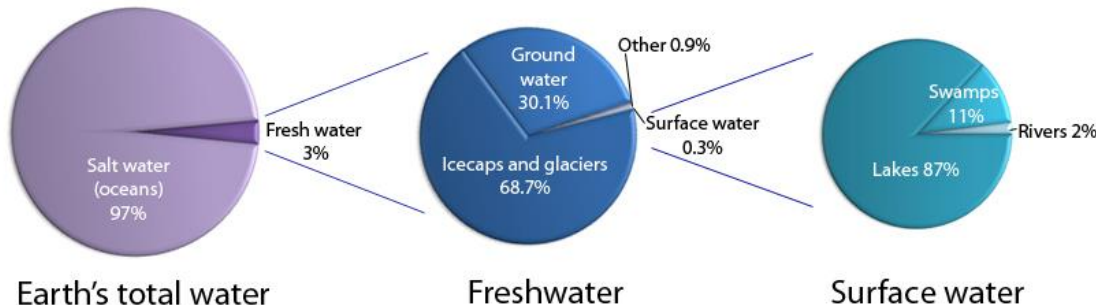
Horizon Europe, Cluster 5
~€3.8M, 40 Months



Introduction – Energy in Water



<https://www.earth.com>



Earth is ~70 % water!

A water molecule (H_2O)

- 2 hydrogen (2H)
- 1 oxygen (1O)

If we can split water

- $2\text{H} \rightarrow \text{H}_2$ gas
- Endless fuel source
- Energy storage

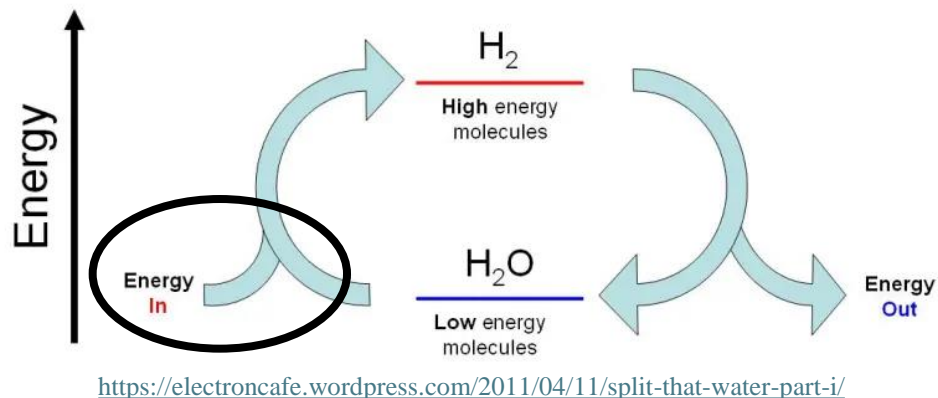
H_2 gas is the most efficient fuel in the universe, and with no harmful emissions!



In the
FreeHydroCells
project, we aim
to split water
and make H_2 !
But...?

Introduction – Energy in Light for H₂ Fuel

BUT...splitting water needs ENERGY input!?



What free source of ENERGY could we use?
Sunlight!

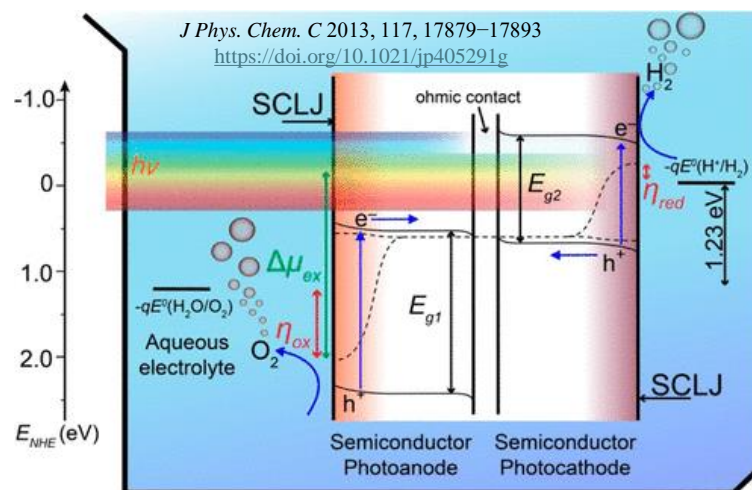
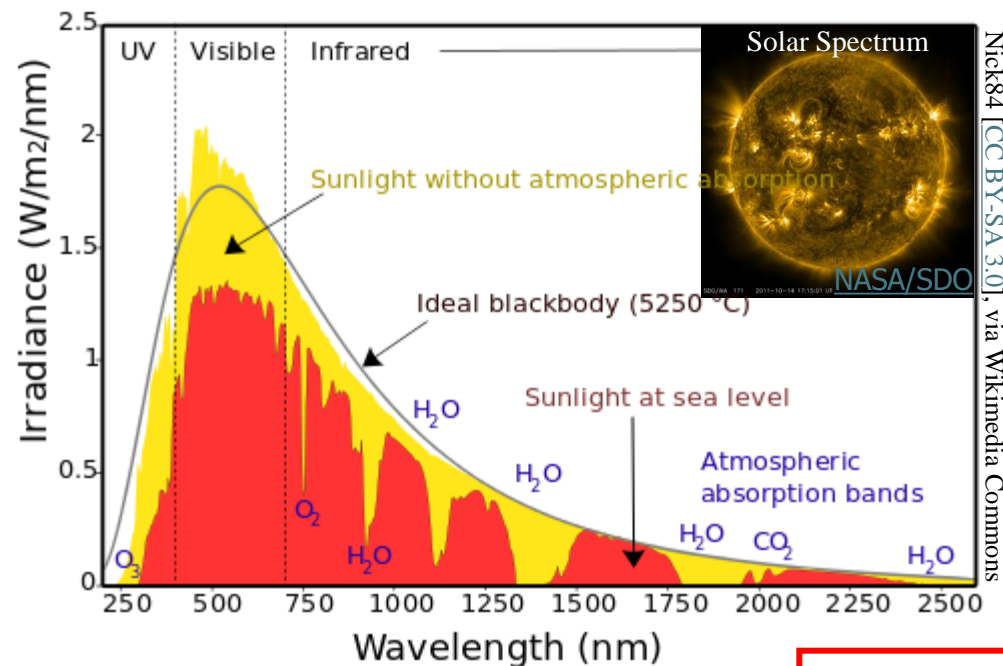
Energy Conversion 1: Solar – Electrical – Chemical

Photoelectrochemical (PEC)

Solar thermochemical

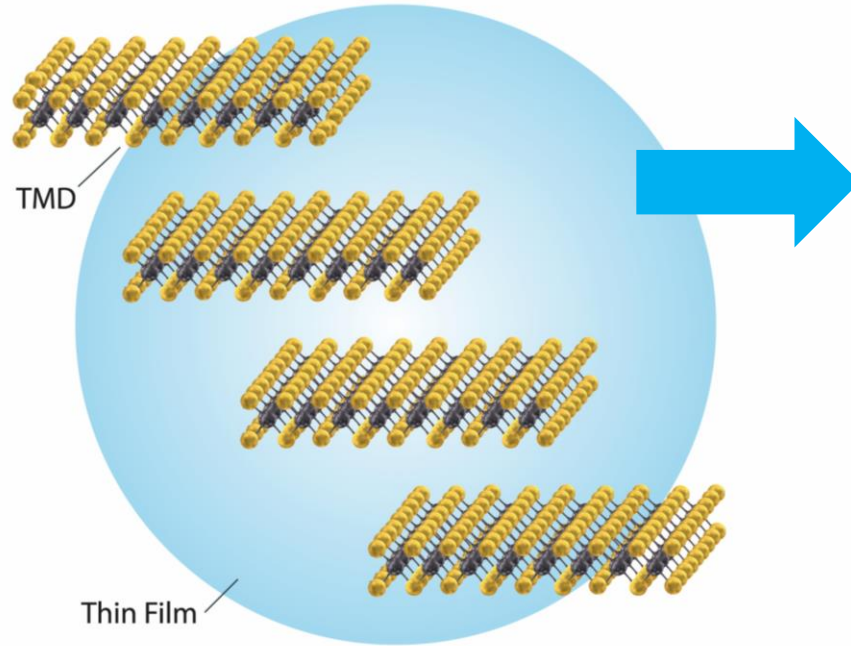
Energy Conversion 2: Solar – Thermal – Chemical

Spectrum of Solar Radiation (Earth)



In the *FreeHydroCells* project, we aim to capture enough sunlight to provide the energy to split water and make H₂ fuel!

The *FreeHydroCells* Project



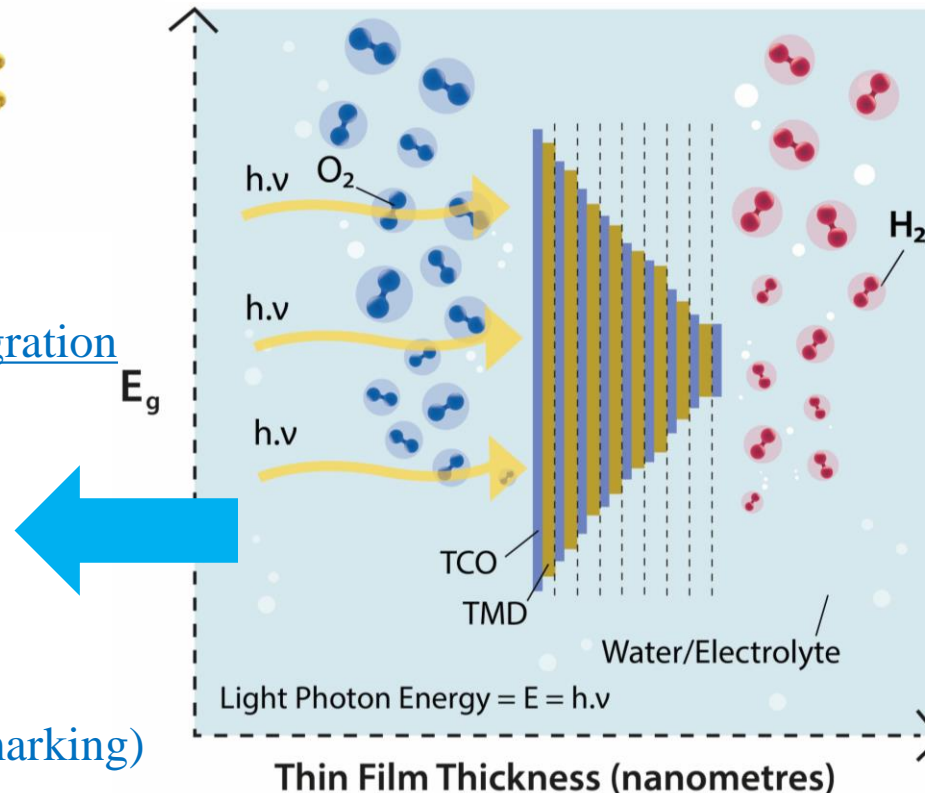
Novel Materials

- Thickness, bandgap, conductivity
- Defect saturation, recombination reduction
- Solar irradiation & absorption optimisation
- Doping as N-type or P-type semiconductor



Photoelectrochemical (PEC) Materials Integration & Device/Cell Engineering

- Maximum light absorption
- Cascading bandgap alignment
- Redox alignment
- PN-junctions
- STH Efficiency (diagnostics and benchmarking)

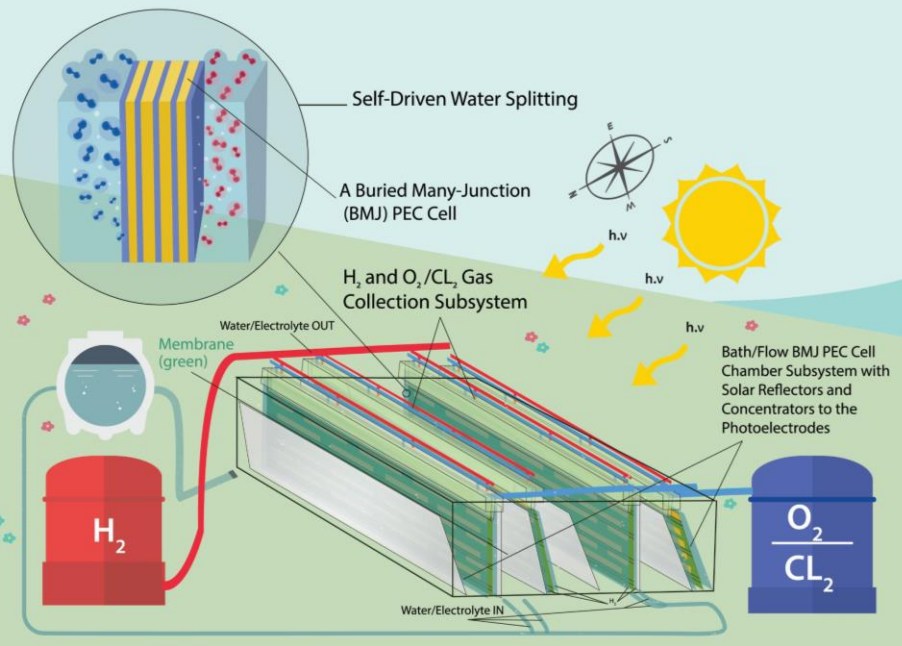


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The *FreeHydroCells* Project

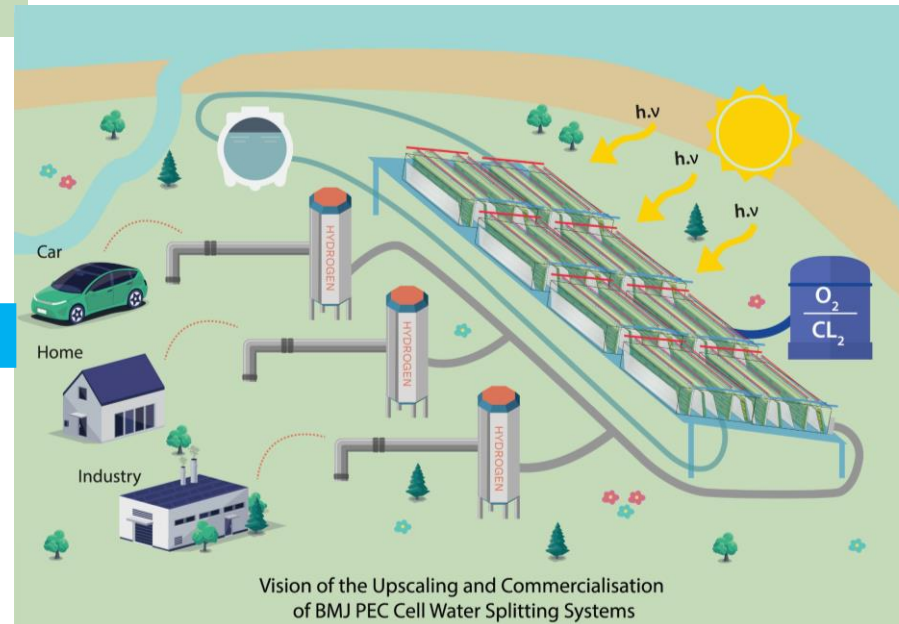
PEC Cell-to-System Development and Benchmarking

- System Integration
- Operationally efficiency
- Viable for H₂ gas collection
- Durable with long service life
- Good STH efficiency benchmark



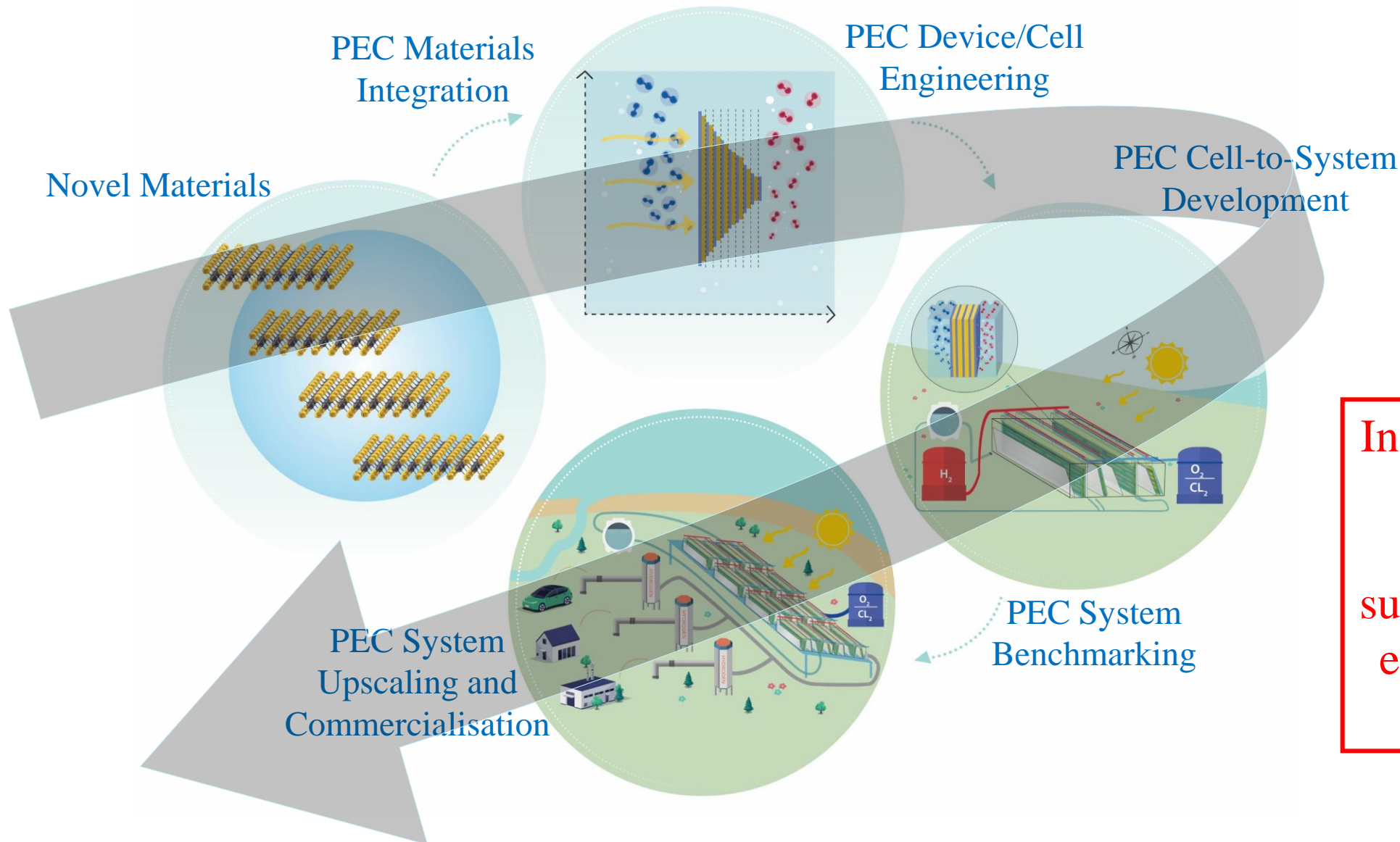
PEC System Upscaling and Commercialisation

- Environmentally-benign
- Cost-effective production
- Sufficient sustainability
- Good life-cycle predictions
- Commercially viable



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The *FreeHydroCells* Project



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Acknowledgements



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The *FreeHydroCells* Project Team

Thank you! Questions?



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