

Assessing Uruguay's Green Hydrogen Potential: A Comprehensive Analysis of Electricity and Hydrogen Sector Optimization

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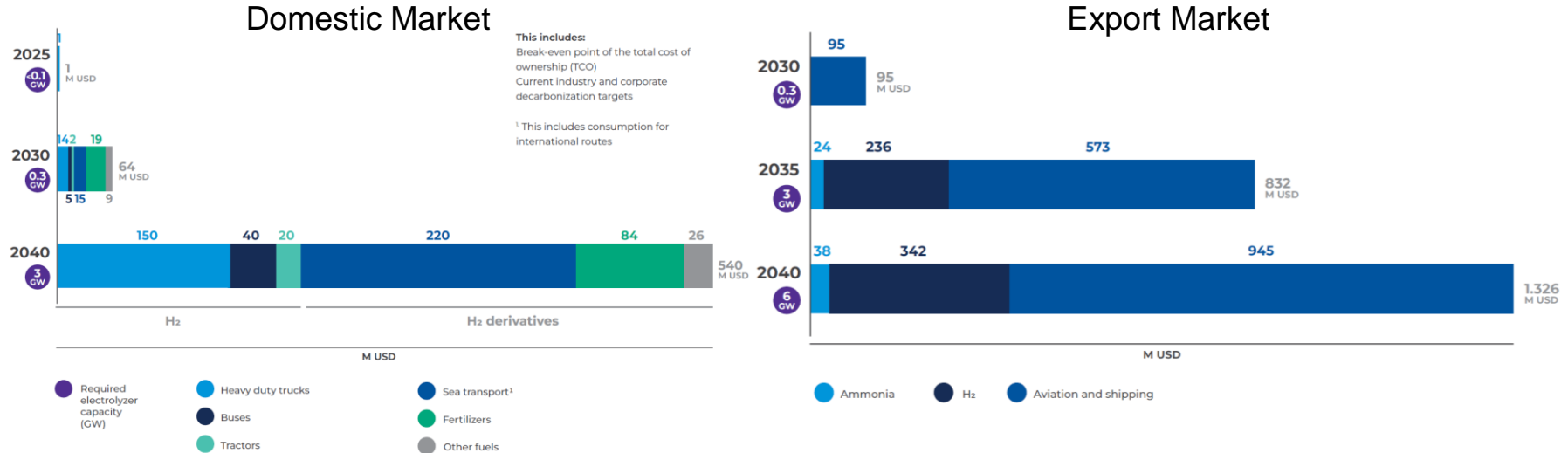
Chair of Renewable and Sustainable Energy Systems

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Uruguay Hydrogen Roadmap

Final version published in October 2023

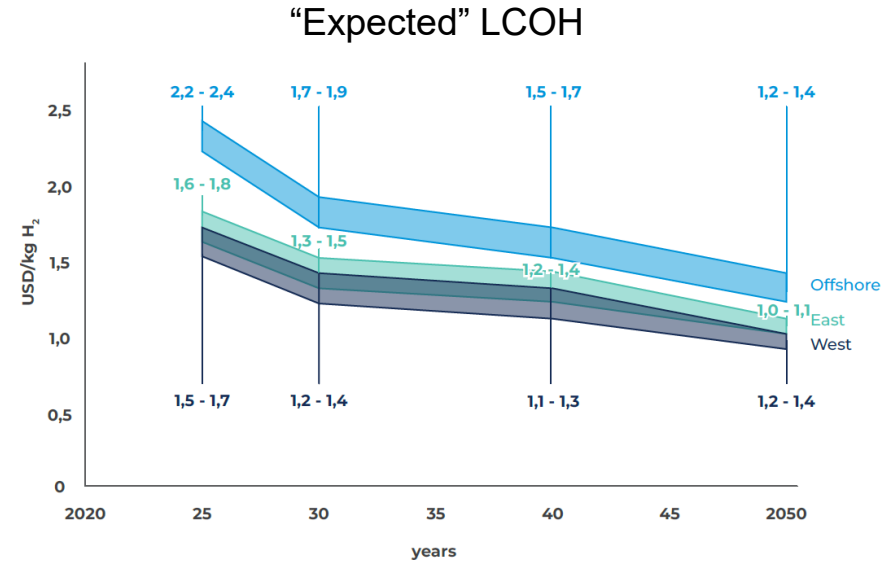
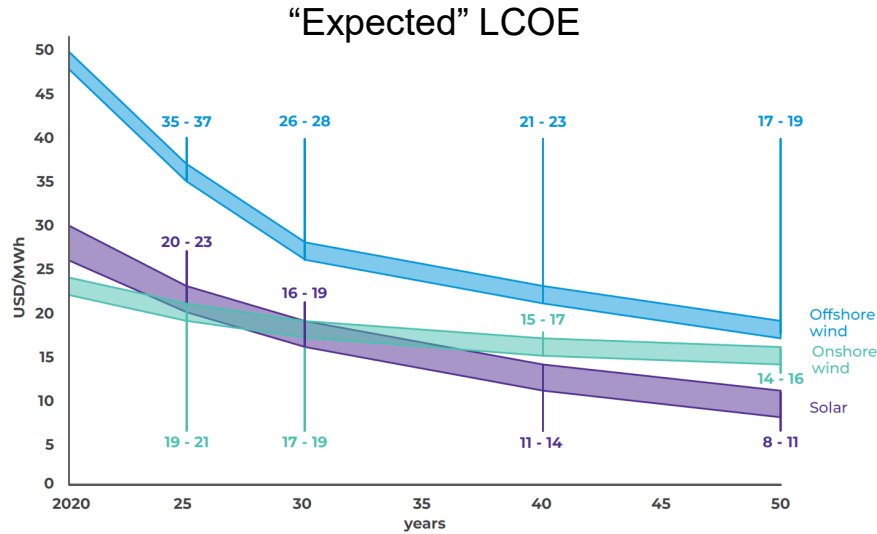


“By 2040, hydrogen production could amount to one million tons per year. This will require the installation of approximately 18 GW of renewables and 9 GW of electrolyzers”

Uruguay's Roadmap for Green Hydrogen and Derivatives, MIEM 2023

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Uruguay Hydrogen Roadmap



Potentials
 PV: 60 GW of Level I
 Wind: 30 GW Level I Onshore, 275 GW Offshore

Uruguay's Roadmap for Green Hydrogen and Derivatives, MIEM 2023

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Research questions



What is the impact of implementing the hydrogen roadmap on the electricity sector?



What are the possible export quantities if selling costs are based on expected production costs?



What would be the average LCOH?



Optimization
model for unit
commitment
and capacity
expansion

- Electricity system of the country (One node)
- Intertemporal (2021, 2025, 2030, 2040, 2050)
- Internal electricity demand projections
- Domestic H₂ demand from the roadmap (constant through the year)
- Export expectations based on different “Sell” prices or mandatory demand
- LCOE and LCOH include integration costs (storage)

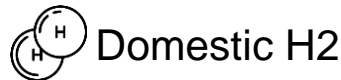
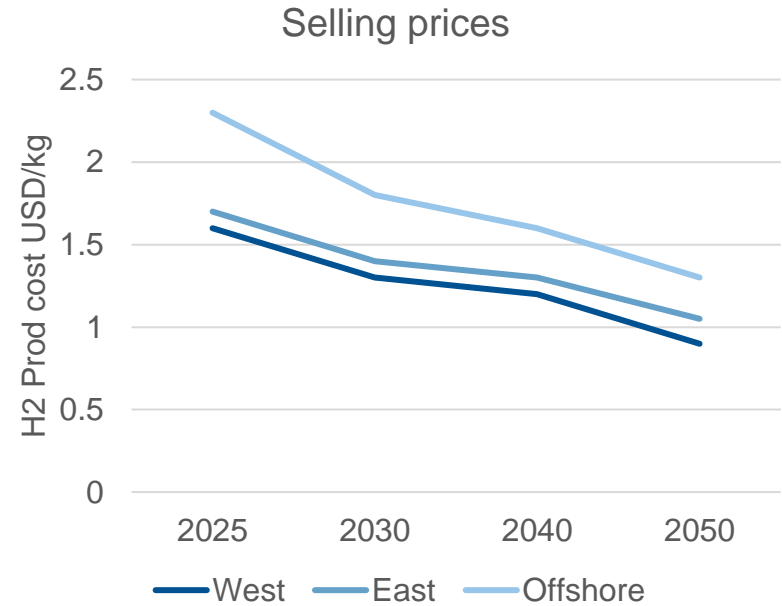
<https://github.com/tum-ens/urbs>

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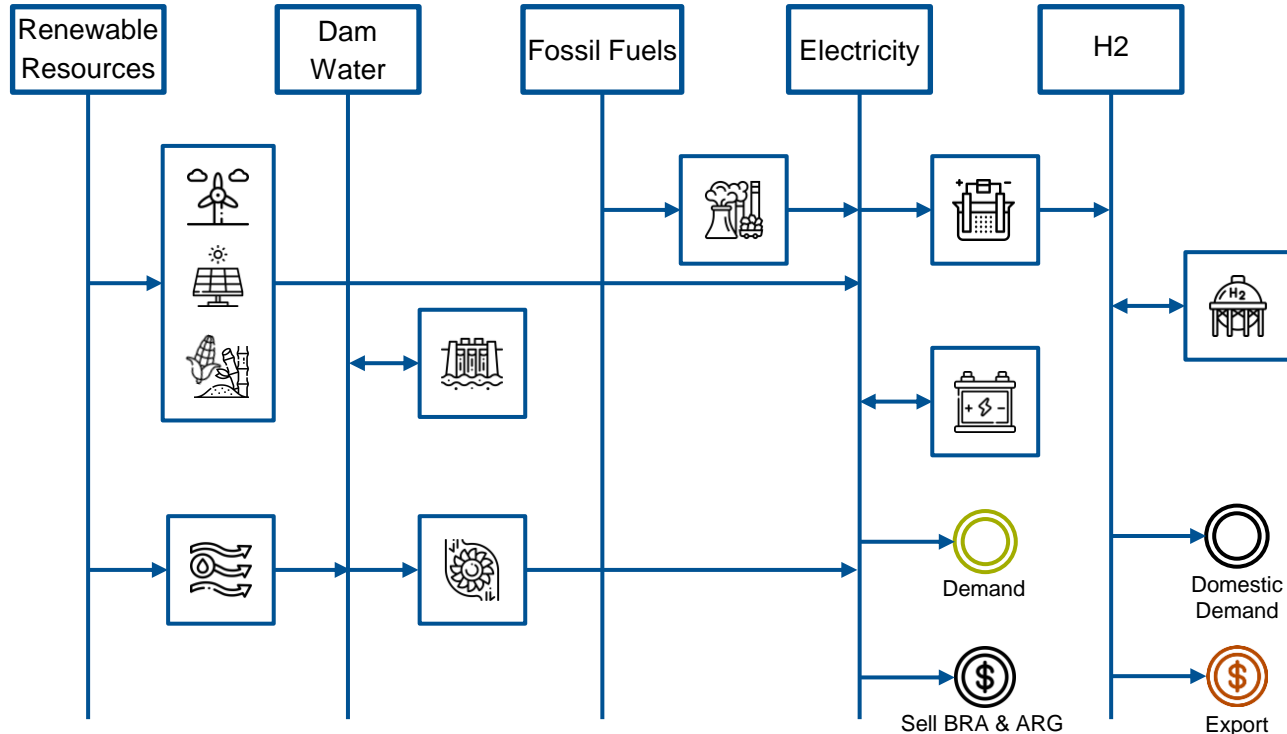
Methodology - Scenarios definition

Scenario	Demand
Only Elec	
West prices	+ +
East prices	+ +
Offshore prices	+ +
Export	+ +

Avg. Selling



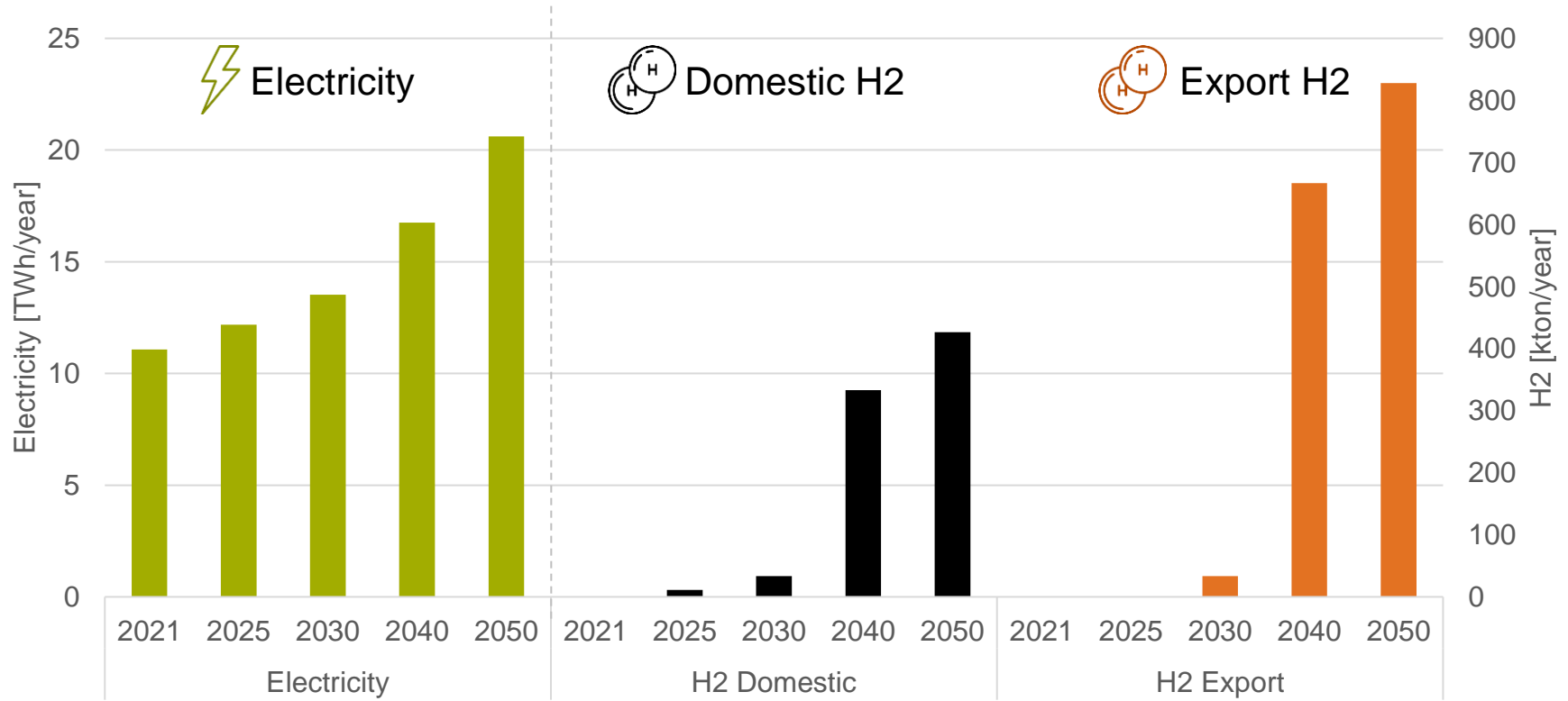
Methodology - Reference Energy System



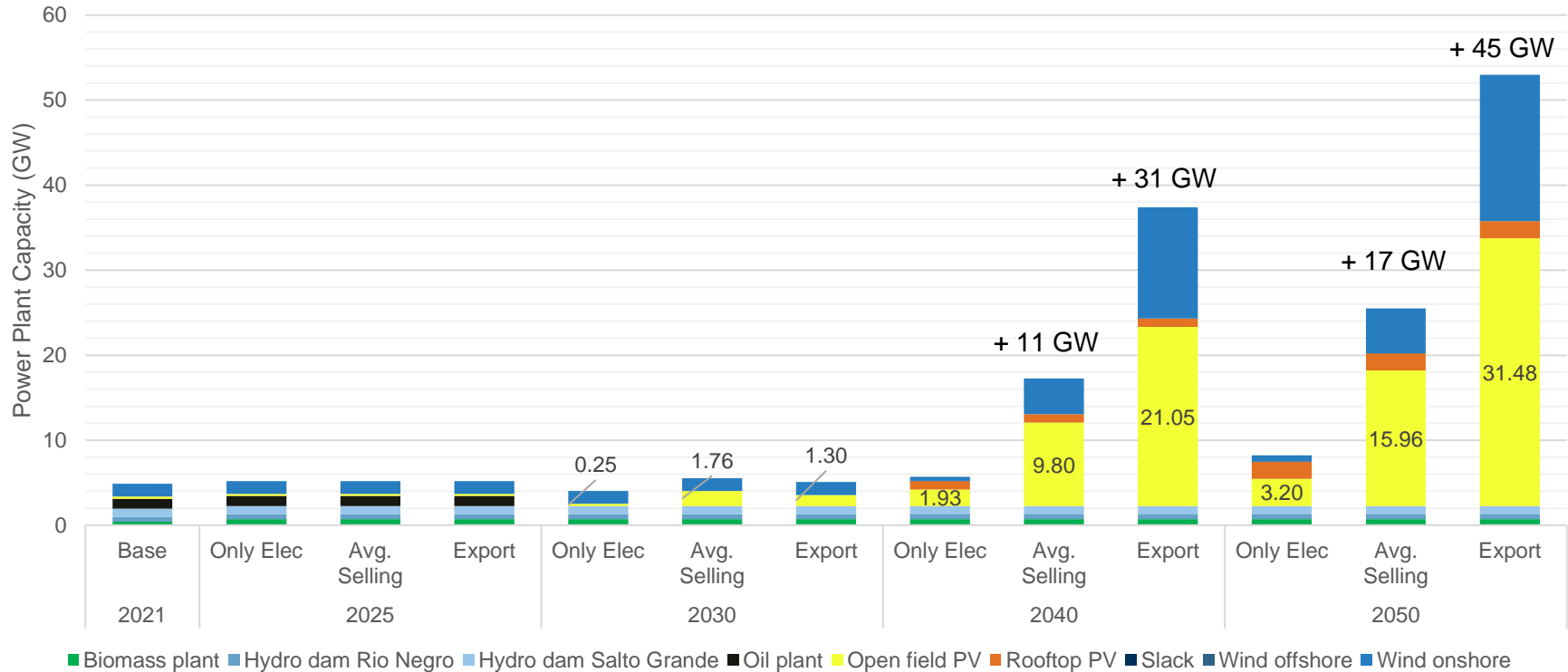
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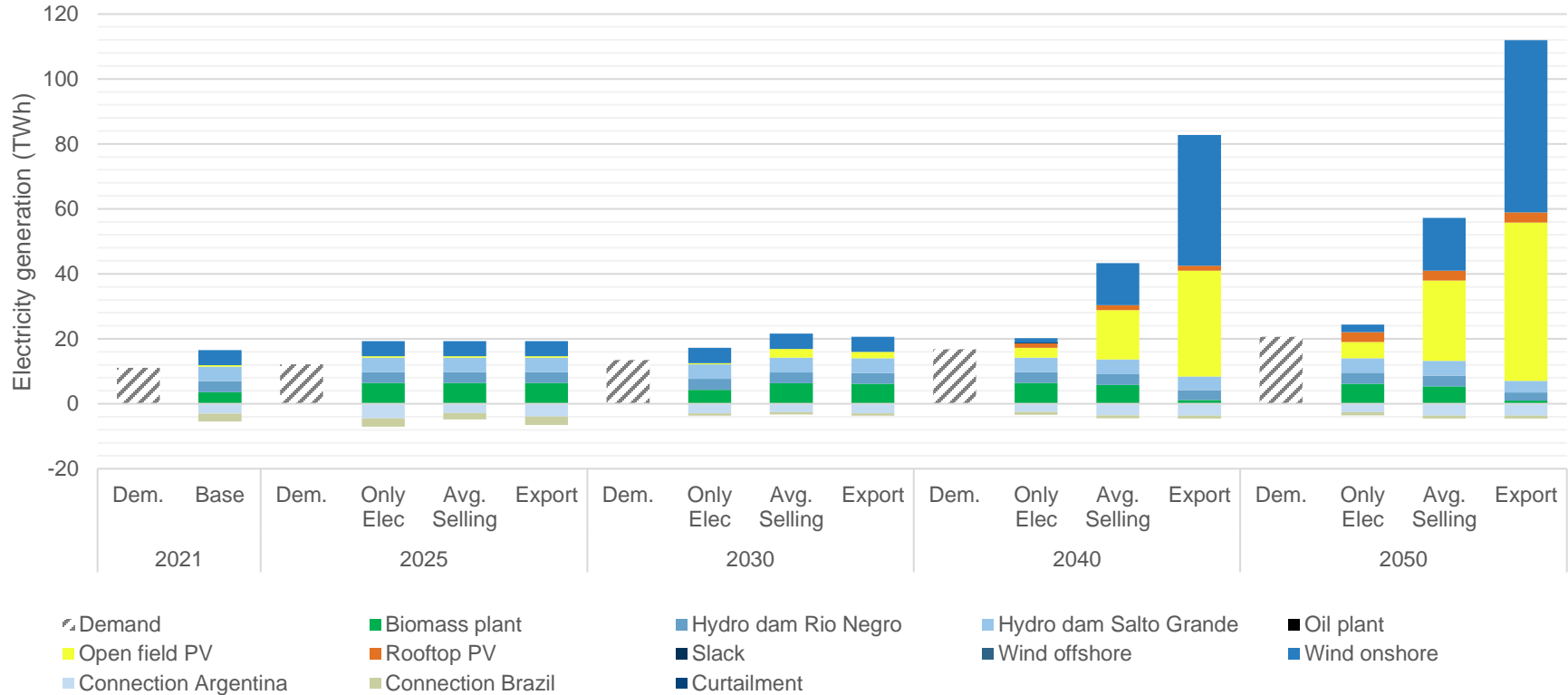
Methodology - Demand



Results – Electrical installed capacity



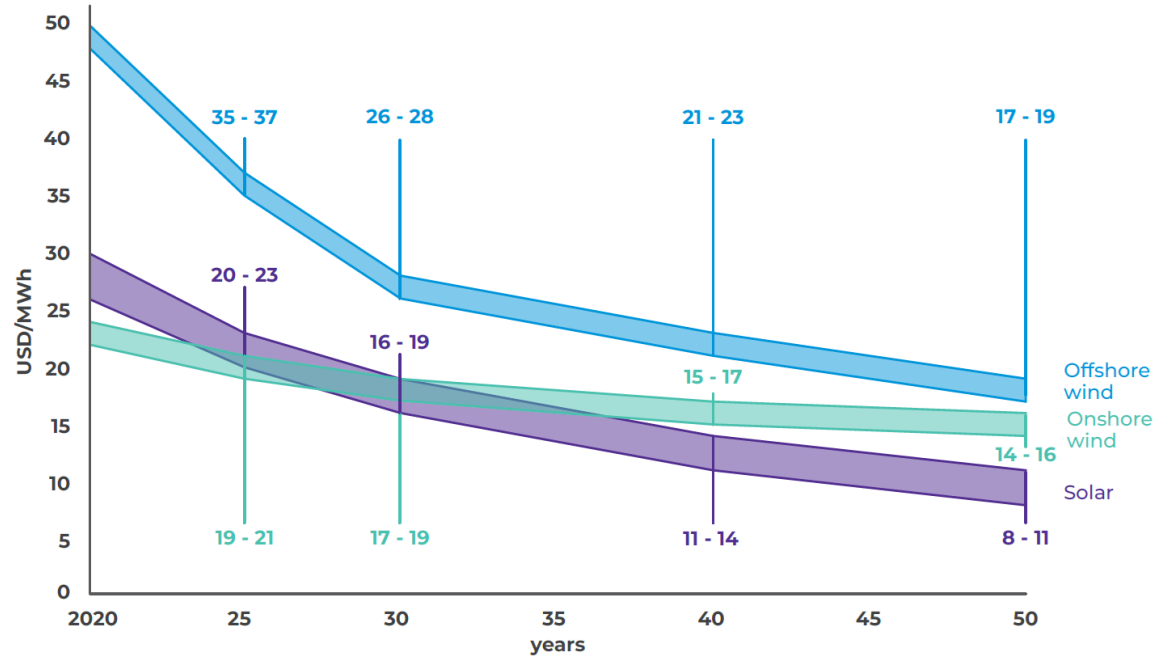
Results – Electricity Generation



Results - LCOE

LCOE	
Year	(USD/MWh)
2021	73.15
2025	73.37
2030	36.20
2040	19.97
2050	6.32

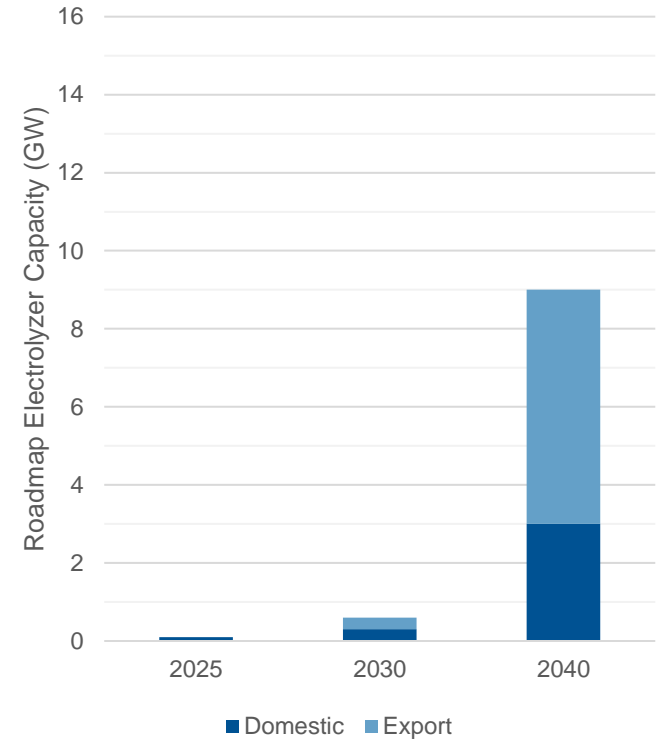
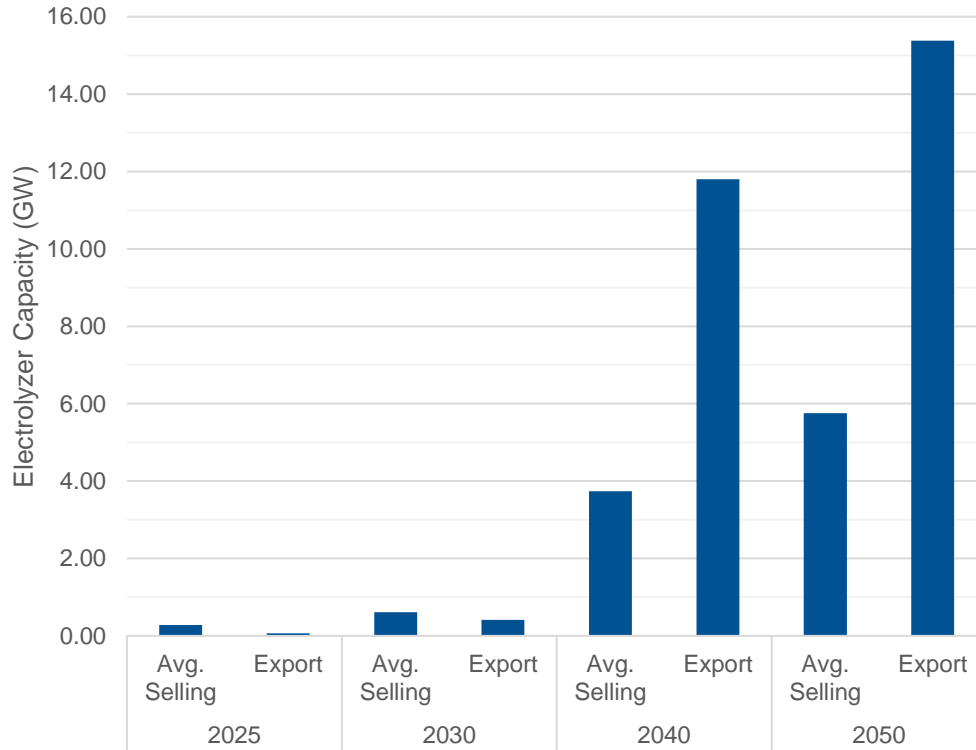
Including integration costs



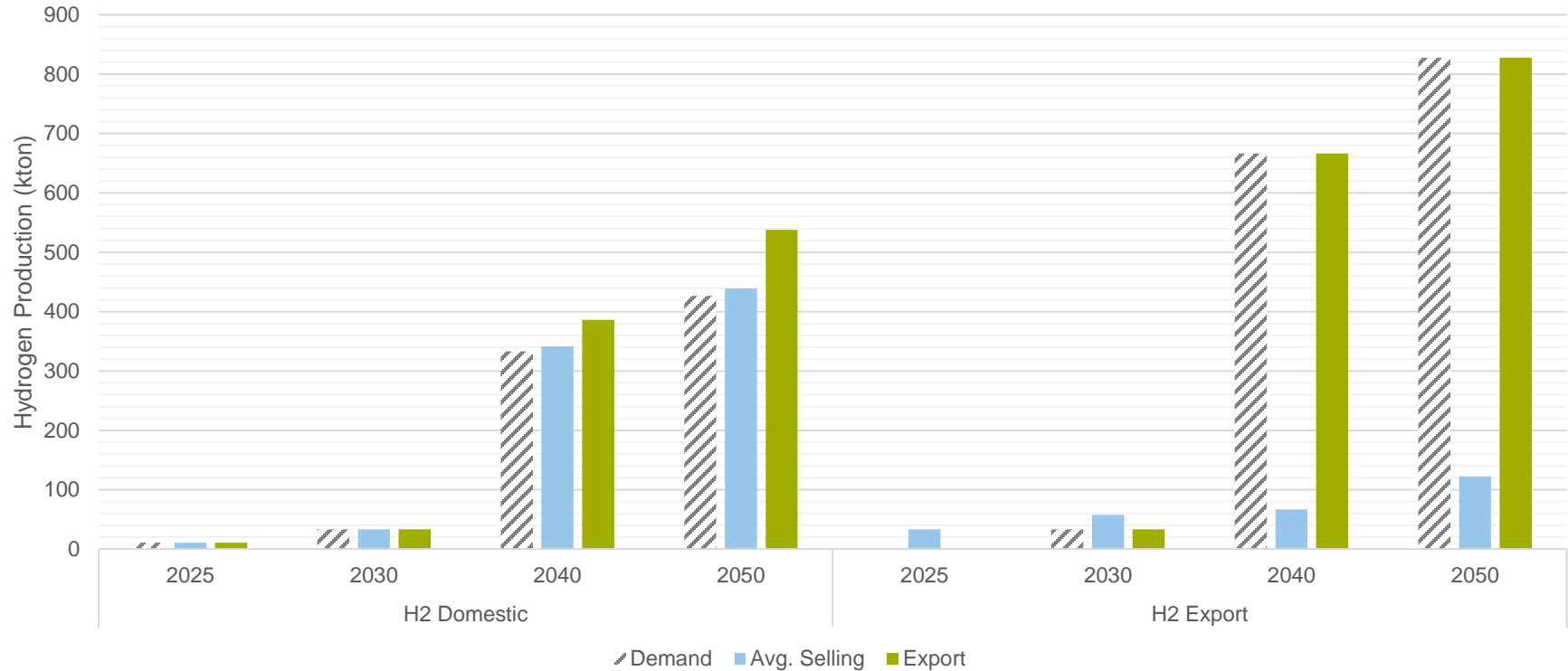
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Results – Electrolyzer Capacity



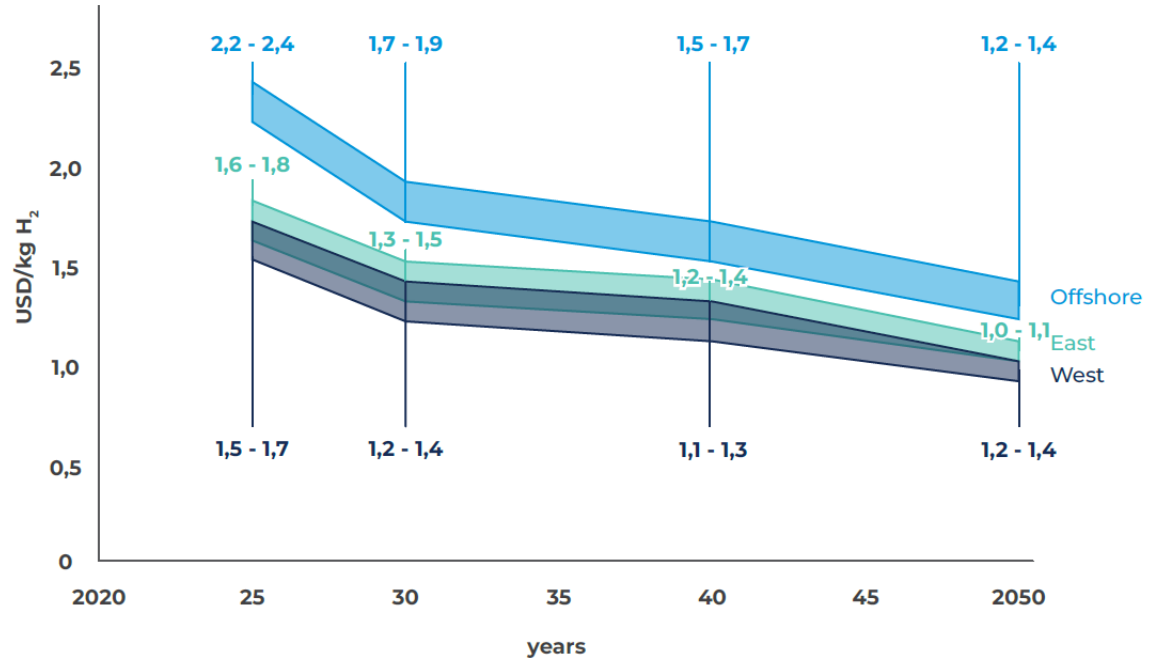
Results – Hydrogen Production



Results –LCOH

Year	Avg. Selling (USD/kg H2)	Export (USD/kg H2)
2025	1.91	1.85
2030	3.37	3.70
2040	2.21	3.14
2050	0.28	0.30

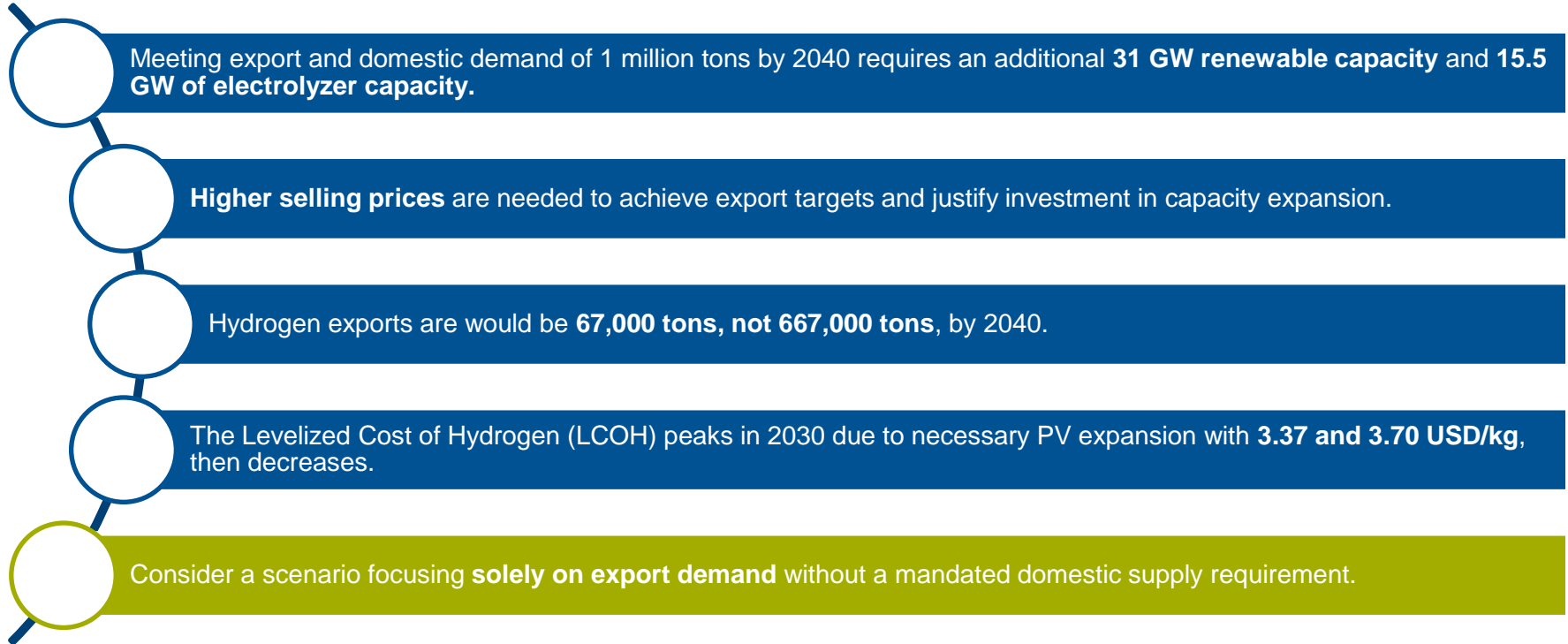
Including integration costs



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Findings and future work



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Thank you for your attention!
Are there any questions?

Technologies		Capital costs (USD/kW)				Annual O&M Costs				Efficiency (gross, LHV)				
Name	Units	2021	2030	2040	2050	2021	2030	2040	2050	2021	2030	2040	2050	
Oil plant	USD/kW	412	408	404	400	USD/kW/a	21	20	20	20	38%	39%	40%	41%
Open field PV	USD/kW	820	450	385	320	USD/kW/a	12	10	10	10	100%	100%	100%	100%
Rooftop PV	USD/kW	640	350	300	250	USD/kW/a	10	8	8	8	100%	100%	100%	100%
Wind onshore	USD/kW	1150	1060	1030	1000	USD/kW/a	28	28	27	26	100%	100%	100%	100%
Wind offshore	USD/kW	4440	2600	2140	1680	USD/kW/a	110	75	65	55	100%	100%	100%	100%
Hydro dam	USD/kW	4839	3926	3013	2100	USD/kW/a	127	93	72	50	100%	100%	100%	100%
Biomass plant	USD/kW	2500	2400	2325	2250	USD/kW/a	85	85	83	80	35%	35%	35%	35%
Electrolysis system (Stack+BOP)	USD/kW	700	402	381	370	USD/kW/a	14.00	8.04	7.62	7.40	69%	69%	69%	69%

Backup

- WACC: 7.38%
- Discount rate: 12%
- Average sell price to Brazil: 29 USD/ MWh
- Average sell price to Argentina: 23 USD/ MWh
- Demand derivation with 0.11 Mton / GW of electrolyzer (McKinsey)