Large-scale Hydrogen Electrolyzer Plant Concept Design and EPC Cost Analysis

2025 Fuel Cell Seminar

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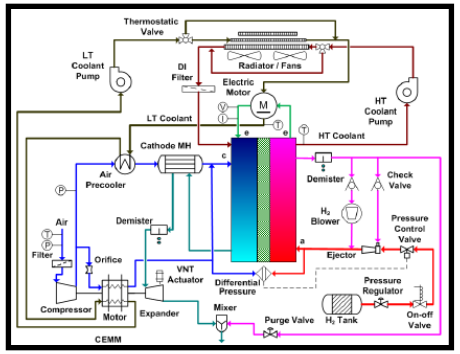
This approach has been used successfully for estimating the cost of various technologies for commercial clients and the DOE.

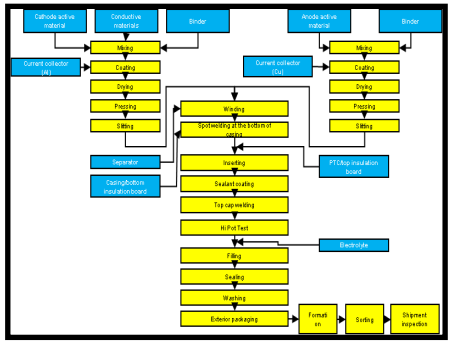
Technology Assessment

- Literature research
- Definition of system and component diagrams
- Size components
- Develop bill-of-materials (BOM)



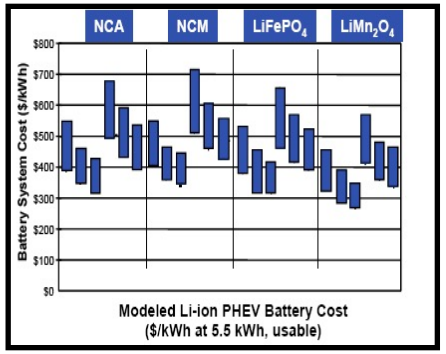
Manufacturing Cost Model

- Define system value chain
- Quote off-shelve parts and materials
- Select materials
- Develop processes
- Assembly bottom-up cost model
- Develop baseline costs



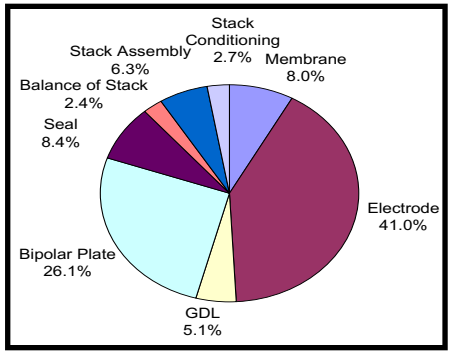
Scenario Analyses

- Technology scenarios
- Sensitivity analysis
- Economies of Scale
- Supply chain & manufacturing system optimization
- Life cycle cost analysis



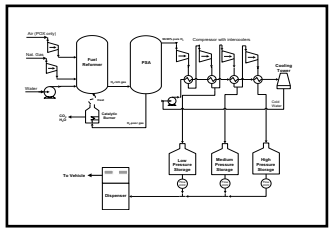
Verification & Validation

- Cost model internal verification reviews
- Discussion with technical developers
- Presentations to project and industrial partners
- Audition by independent reviewers



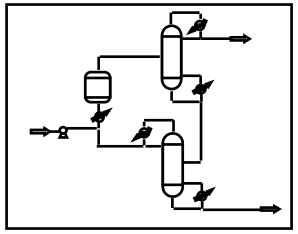
Combining performance and cost models will easily generate cost results, even when varying the design inputs.

Conceptual Design



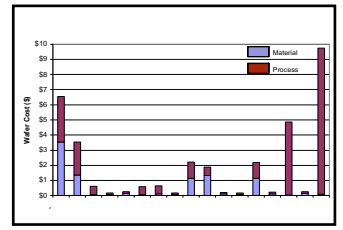
- System layout and equipment requirements

Process Simulation



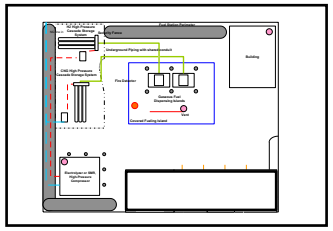
- Energy requirements
- Equipment size/ specs

Process Cost Calcs



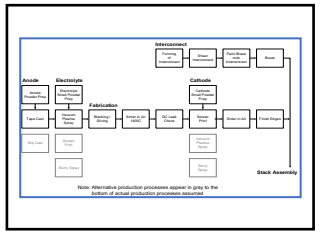
- Process cost
- Material cost

Site Plans



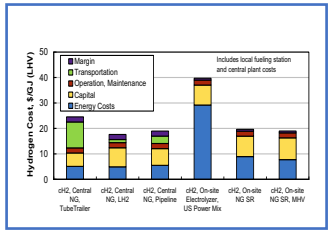
- Safety equipment, site prep, land costs

Capital Cost Estimates



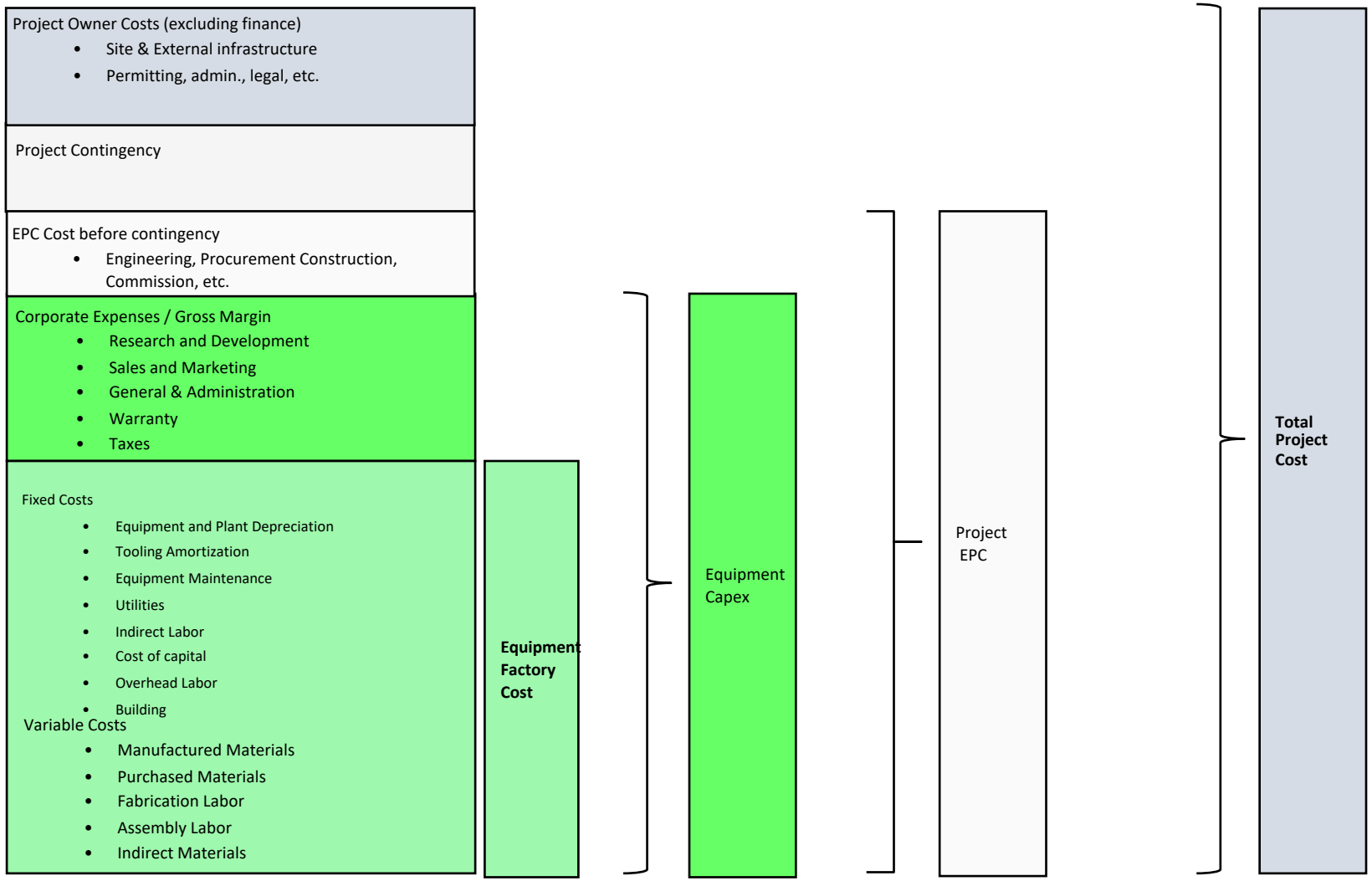
- High and low volume equipment costs

Product Costs

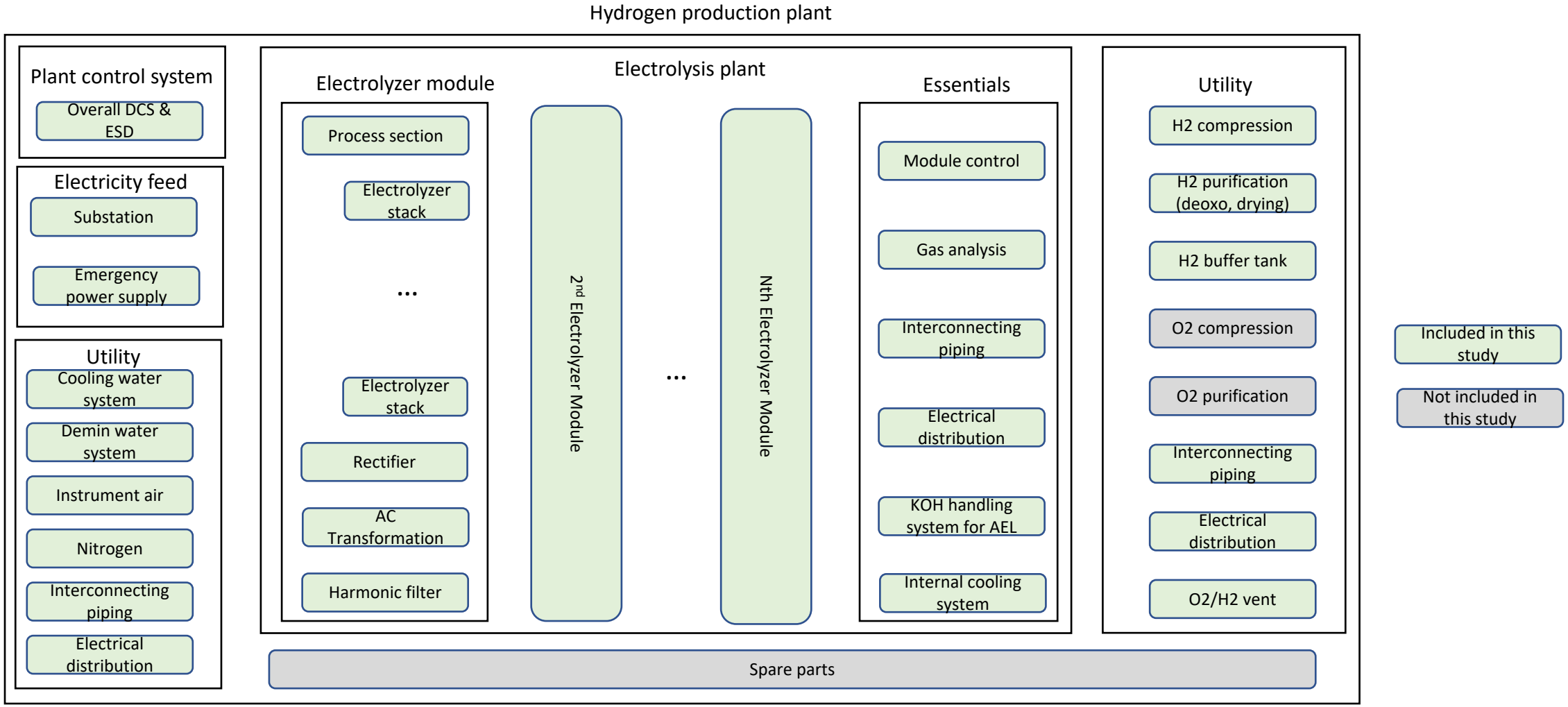


- Product cost (capital, O&M, etc.)

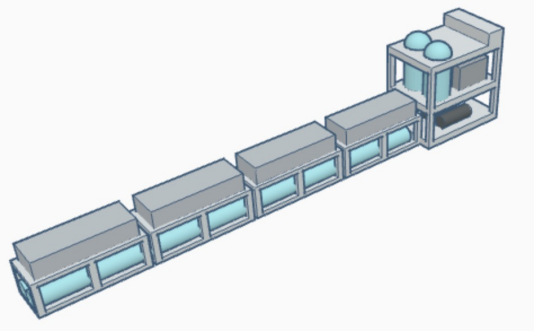
Cost structures / categories used in our analysis:



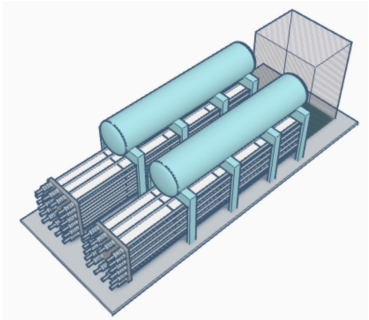
Large hydrogen electrolyzer plant boundary limits:



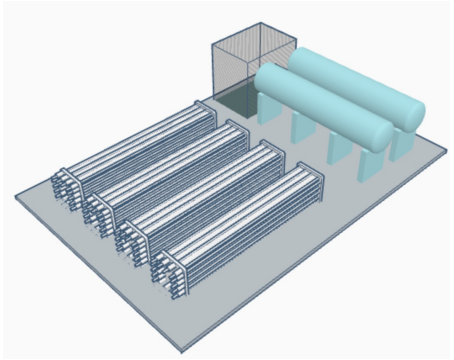
We have developed multiple stack modules with bottom-up manufacturing cost models for scenario analyses.



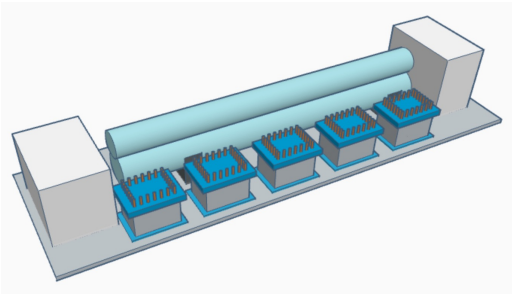
Current 20 MW Stack Module (Baseline)



Future 20 MW Stack Module



Current 20 MW Stack Module



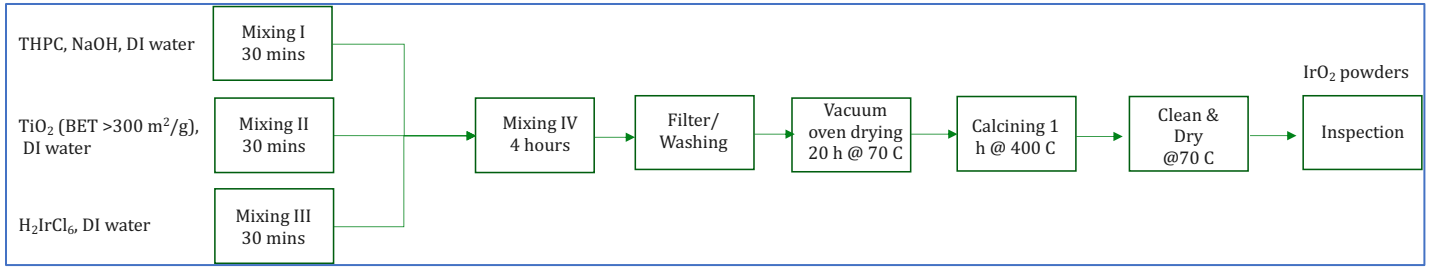
Current 5 MW PEM Stack Module (Baseline)

Alkaline Stack Modules

Project	Alkaline based	PEM based
Stack	AEL Current	PEMEL Current
Stack size	20 MW	1 MW
Stack module size	20 MW	5 MW
Stack pressure	Atm. Pressure	30 bar
Output capacity (Nm^3/h)	210,000	50,000
Output capacity (kg H2/day)	454,054	100,000
H2 gas output	99.99% Pure; O2 < 5ppm; H2O: -65 C Dew Point; 30 bar	99.99% Pure; O2 < 5ppm; H2O: -65 C Dew Point; 30 bar
Project region	Western Europe	Western Europe

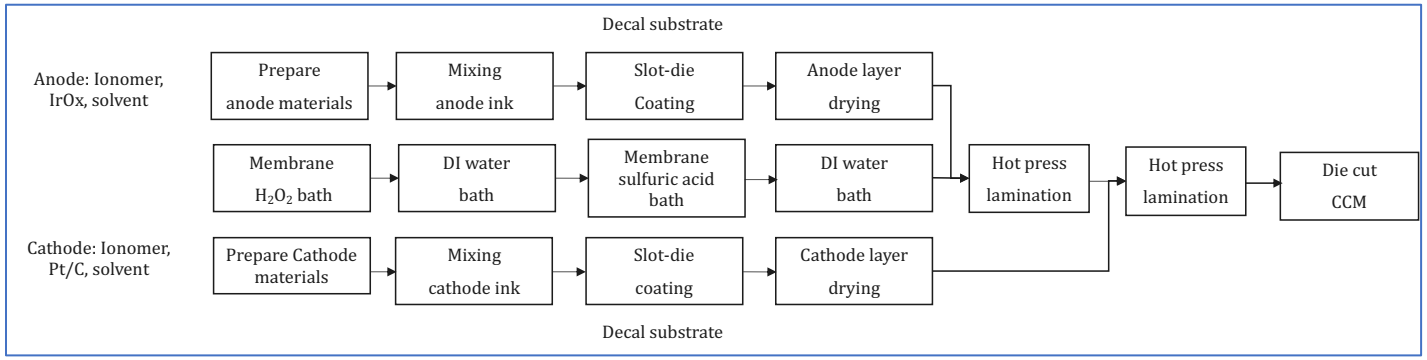
We estimate the PEM electrolyzer capex using a bottom-up approach.

Iridium catalyst fabrication



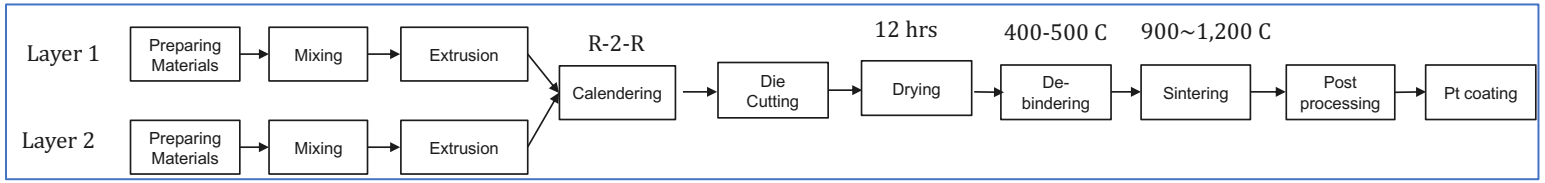
- 1 gram IrO_2(75 wt%)/TiO_2 process cost: $10~30/gram
- Current Iridium metal price ($4,375/troz or $141/gram)

CCM fabrication



- Cell voltage 1.9V @2 A/cm^2
- CCM cost is about $4,000~$7,000/m^2

PTL fabrication



- PTL costs about $300~$800/m^2 (W/O Pt coating) depending on Ti particle shape, forming, drying, debindering, and sintering processes, etc.

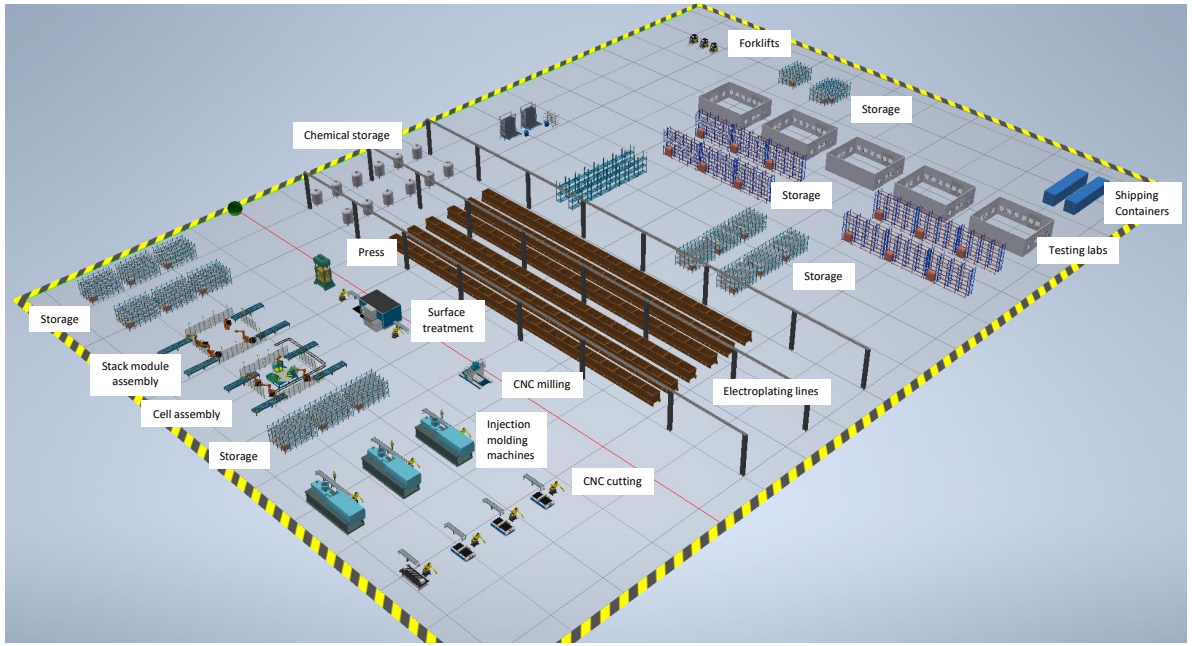
A robotic assist semi-automated alkaline stack assembly line was assumed for stack assembly.

- The cathode coating process cost (W/O substrate) could be as low as approximately $100~200/m^2

Electroplating lines

Stack assembly

Industry stack assembly examples



Industry alkaline stack factory examples

Current alkaline and PEM electrolyzer stack, BOS, and PCU price is about $600~$700/kW at the production volume of 1 GW/a.

Capex Estimation	2024 Alkaline	2024 PEM
Stack ($/kW)	$300	$350
BOS ($/kW)	$80	$80
PCU ($/kW)	$100	$140
Stack & BOS total ($/kW)	$480	$570
Gross margin	25%	23%
Stack & BOS price ($/kW)	$600	$700
Efficiency (kWh/kg)	50	50
Stack module (MW)	20	1 x 5

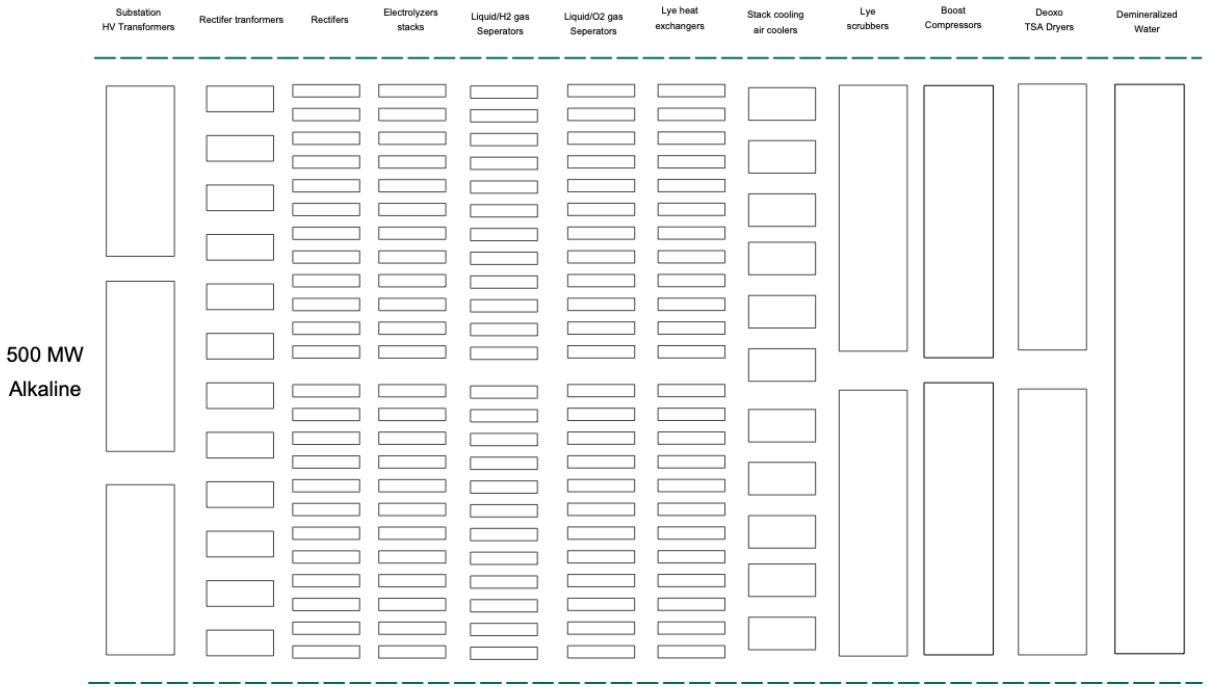
* The capex of electrolyzers made in China could only have ¼ or 1/3 of the capex of Western-made electrolyzers

Project EPC and owners' costs typically are much higher than equipment Capex in Europe and USA.

EPC	Owner's Cost
• Engineering and supervision	• Service facilities (installed)
• Purchased-equipment installation	• Permit, licensing, legal expense
• Instrumentation and controls (installed)	• Contractor's fee (pre-engineering, contract drafting,etc.)
• Piping (installed)	• Financing cost
• Electrical (installed)	• Contingency
• Buildings (including services)	• Land Cost
• Yard improvements	
• Construction expense	

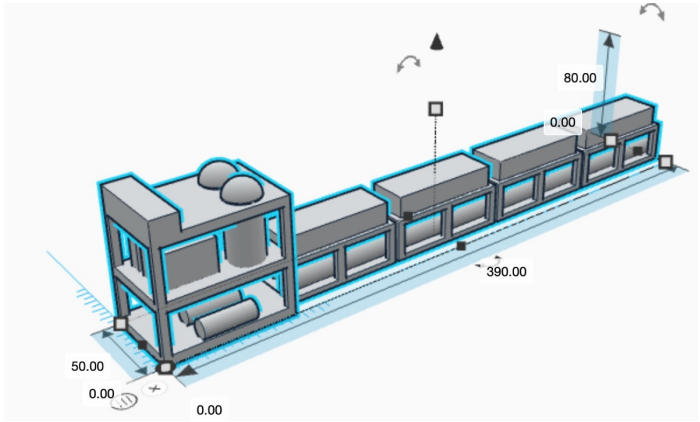
Overview of major components required in the 500 MW alkaline electrolyzer project.

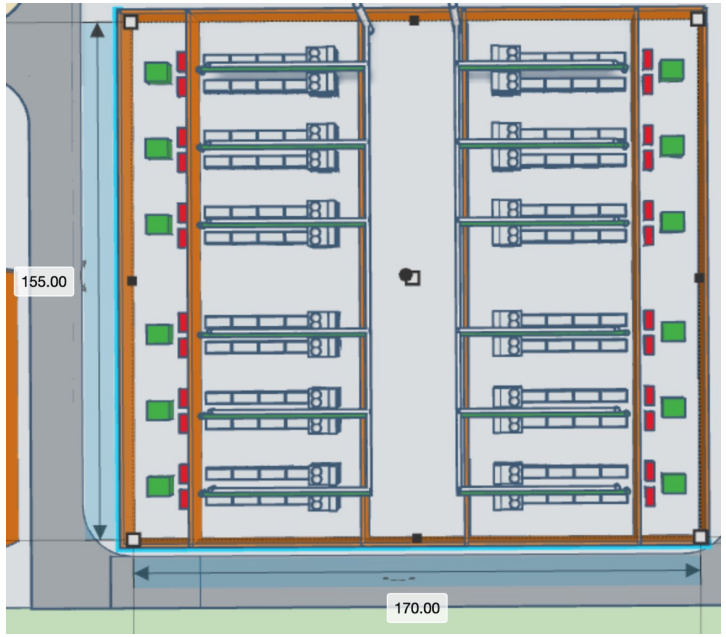
Project modular units



Components	Substations	Rectifier transformer	Rectifier	Stack module	Liquid/H2 separator	Liquid/O2 separator	Lye heat HX	Stack cooling wet water cooler	Lye scrubber	Boost compressor	Deoxo – TSA dryer	Demin. water
Description	230 kV / 66 kV 600 MVA	46 MWAC / 35 kV	452 V/ 39,823 A	20 MW	For 20 MWDC stack module	For 20 MWDC stack module	For 20 MWDC stack module	Wet water cooling tower	Remove lye in H2 stream	Oil-free compressor	H2 purification	626 GPM for H2 production
# of modules x capacity	3 X 50%	12	20 MWDC x 24	24	24	24	24	11	2 x 50%	2 x 50%	2 x 50%	1 x 100%

An example to estimate a 500 MW plant stack area building dimensions.

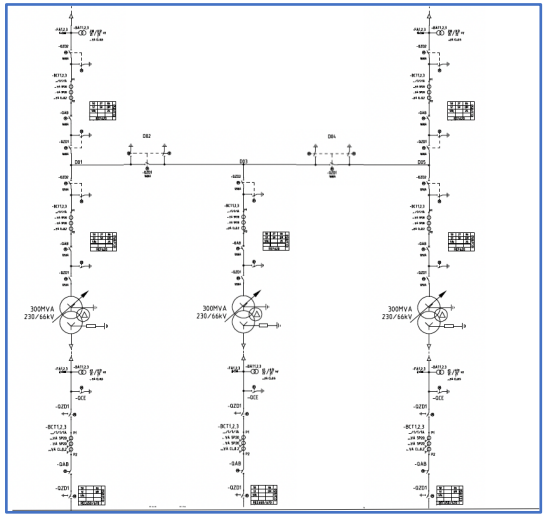




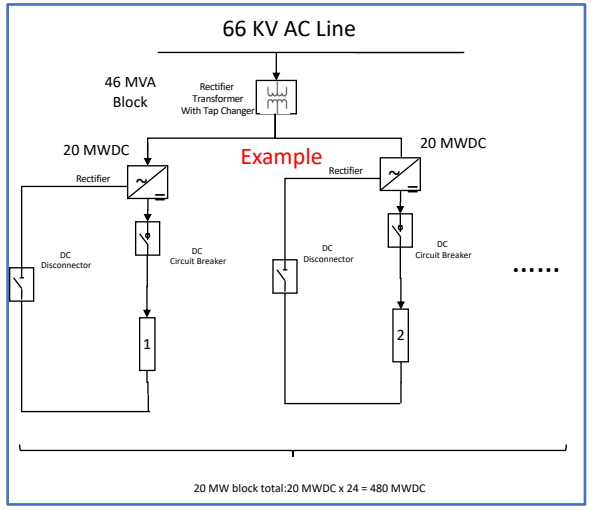
TN stack area:	26350	m^2				
Width	155	Meter				
Length	170	meter				
Width	Wall	Distance (meter)		Length	Wall	Distance (meter)
	1st stack start	10			1st row PCU start	7
	1st stack end	15			1st row PCU end	17
	2nd stack start	17.5			1st row stack left wall	20
	2nd stack end	22.5			1st row stack start	23
	3rd stack start	32.5			1st row stack end	62
	3rd stack end	37.5			1st row stack right wall	70
	4th stack start	40			2nd row stack left wall	100
	4th stack end	45			2nd row stack start	108
	5th stack start	55			2nd row stack end	147
	5th stack end	60			2nd row stack right wall	150
	6th stack start	62.5			2nd row PCU start	153
	6th stack end	67.5			2nd row PCU end	163
					Wall	170
	7th stack start	87.5				
	7th stack end	92.5				
	8th stack start	95				
	8th stack end	100				
	9th stack start	110				
	9th stack end	115				
	10th stack start	117.5				
	10th stack end	122.5				
	11th stack start	132.5				
	11th stack end	137.5				
	12th stack start	140				
	12th stack end	145				
	Wall	155				

We size the sub-systems and estimate the capex.

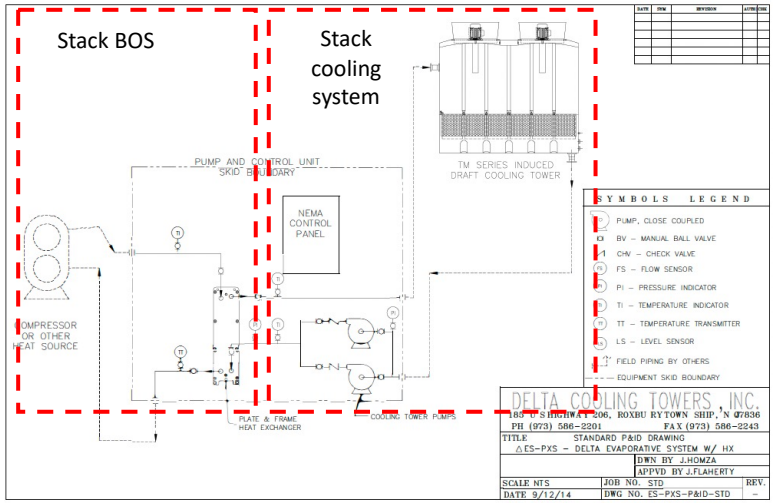
Substation



Transformer/rectifier

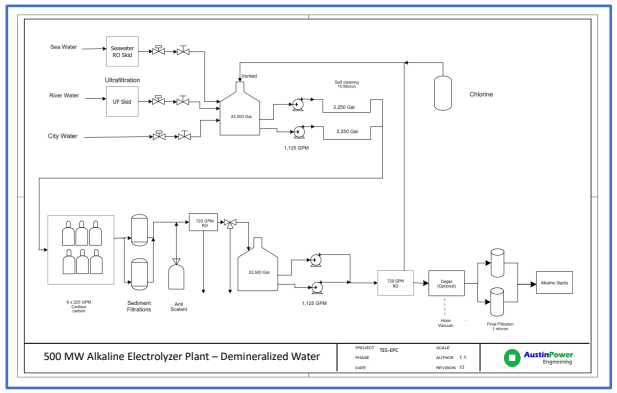


Stack cooling

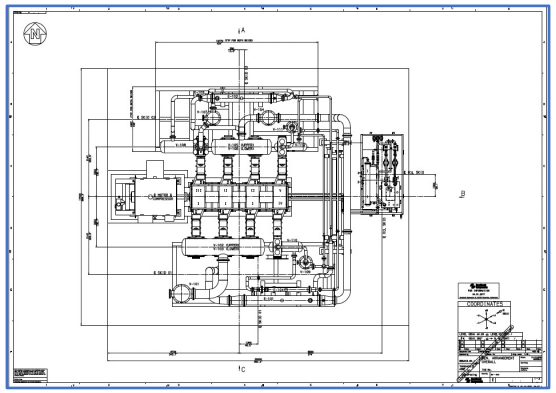


TM Series

Water purification



H2 compression



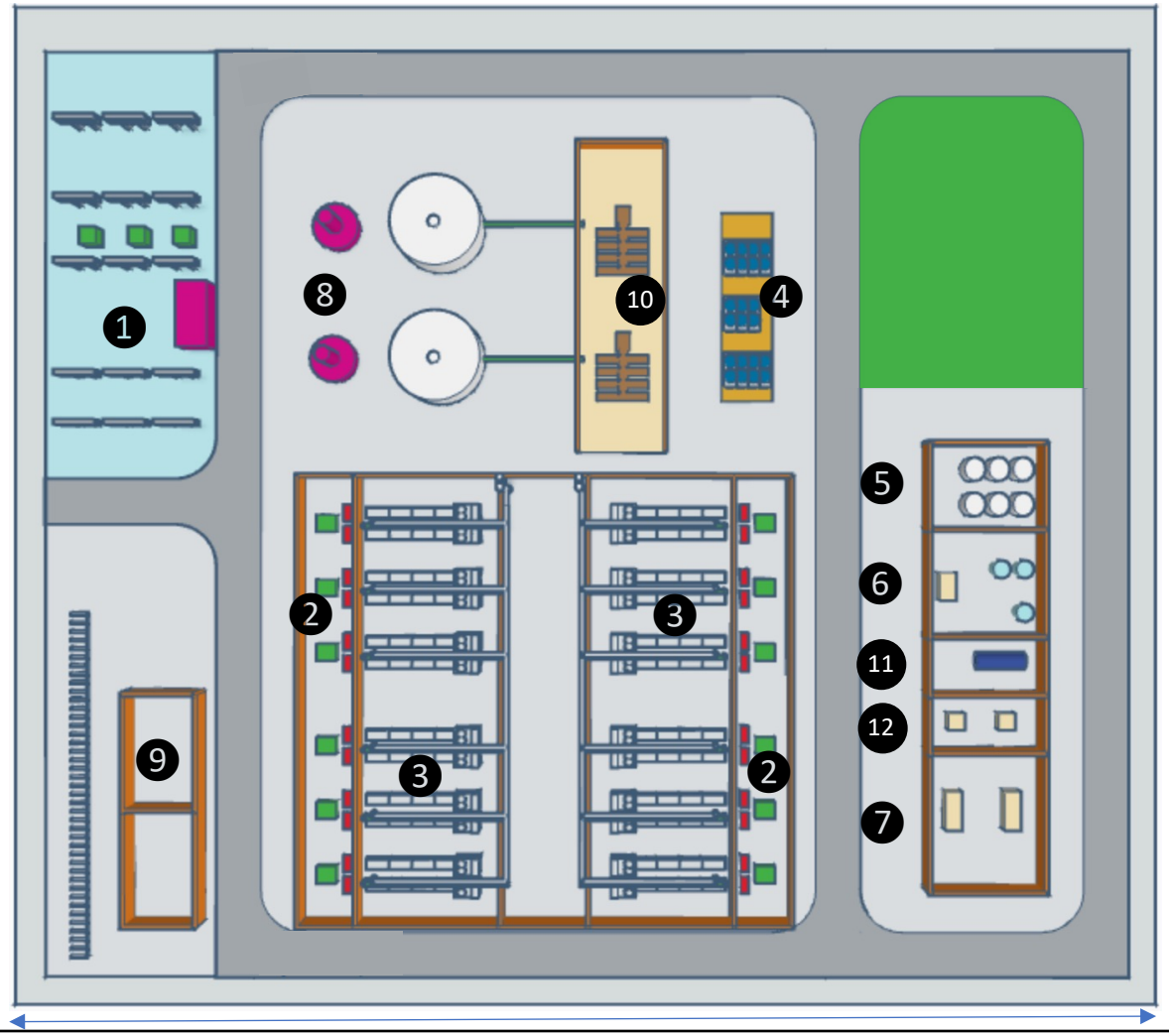
N2 supply

TN 500 MW alkaline electrolysis plant layout:

140,000 m²

26,350 m²

1. Substation
2. Transformer / rectifier
3. 20 MW alkaline stack module x 24
4. Stack cooling water tower
5. DI water
6. Compressed air
7. Nitrogen generation
8. Lye scrubber
9. Control (include, admin, lab, warehouse, maintenance)
10. Booster H2 compressor
11. Lye supply
12. Chiller

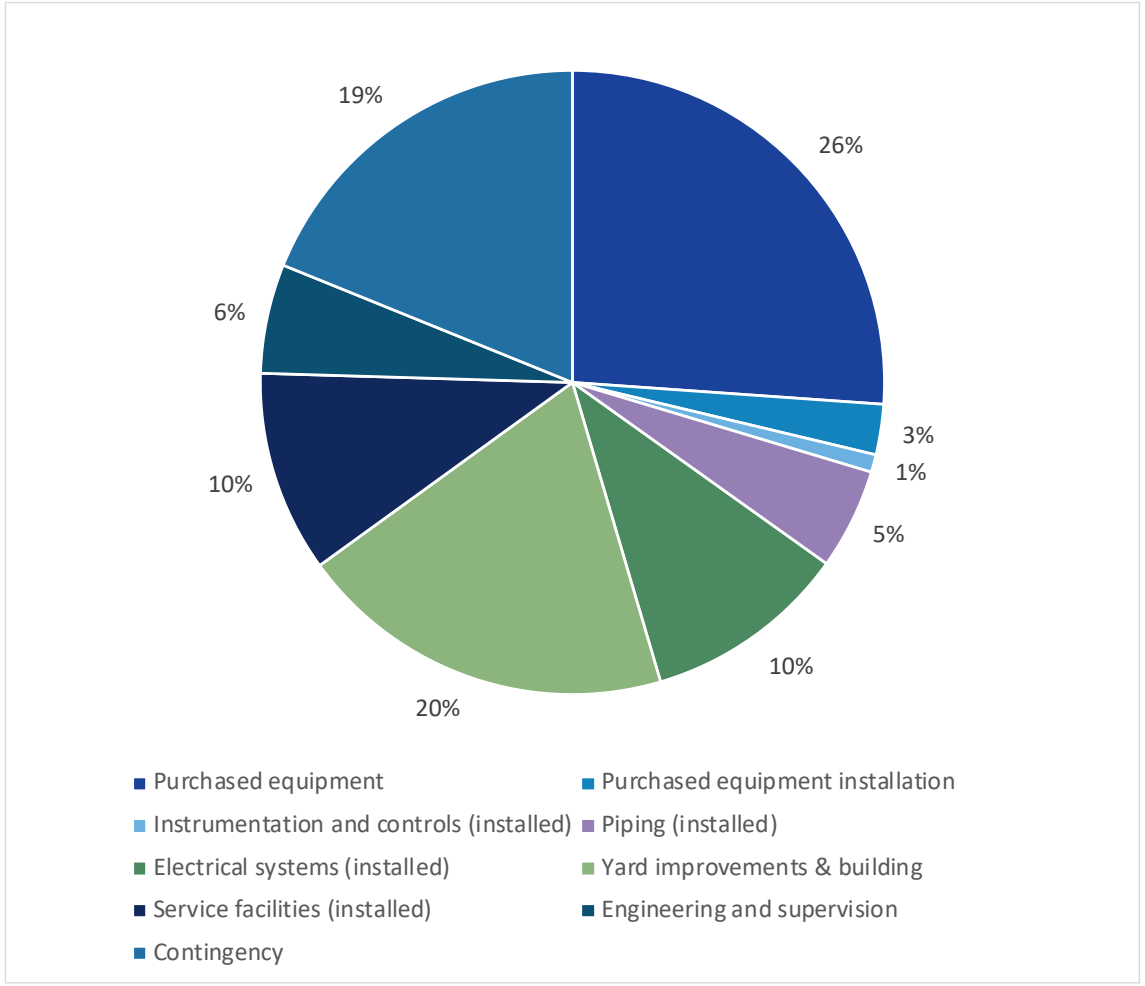


350 m

400 m

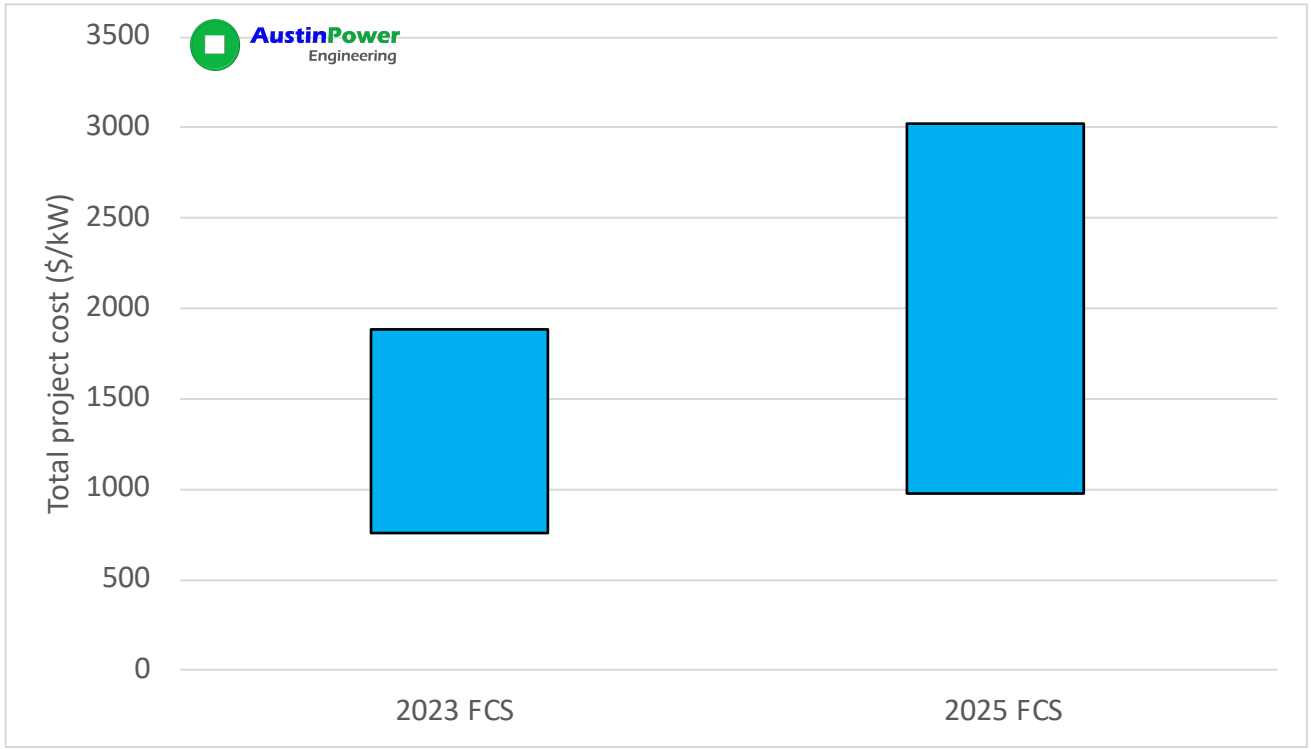
Current large-scale hydrogen electrolysis project total cost is about $2,500/kW.

	Category	($/kW)	(USD)	Comments
EPC	Purchased equipment	**$642**	$321,000,000	Electrolyzer stack, BOS, and PCU; plus logistic, spare parts, and commissioning
EPC	Purchased equipment installation	**$64**	$32,100,000	10% of equipment capex
EPC	Instrumentation and controls (installed)	**$22**	$11,235,000	
EPC	Piping (installed)	**$128**	$64,200,000	
EPC	Electrical systems (installed)	**$260**	$130,000,000	
EPC	Yard improvements & building	**$482**	$240,750,000	All building
EPC	Service facilities (installed)	**$257**	$128,400,000	Water, nitrogen, etc. all utility facilities. Have cost reduction potential
EPC	Engineering and supervision	**$139**	$69,576,375	
Owner	Contingency	**$464**	$231,921,250	25%
	Total project cost	**$2,458**	$1,229,182,625	



Total project cost also includes project “soft” cost, which is highly site and situation-specific.

- We estimate the total project cost ranges from $600 ~1,800/kW in previous analysis
- The large-scale electrolyzer plant (100MW~1GW) total project cost ranges from $1,000/kW to $3,000/kW



Thank You!

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