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California Energy Commission

Hydrogen Potential - Electric Generation and Transportation (2025 IEPR)

Presenter: Max Solanki and Sammy Sallam (Low Carbon Fuels Lead)

Date: July 29, 2025

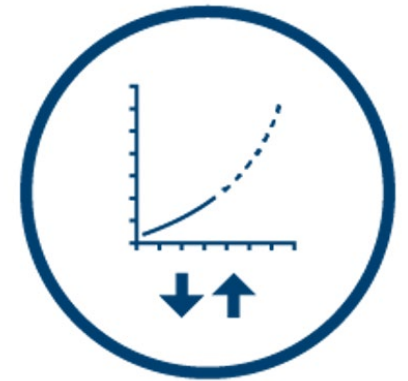
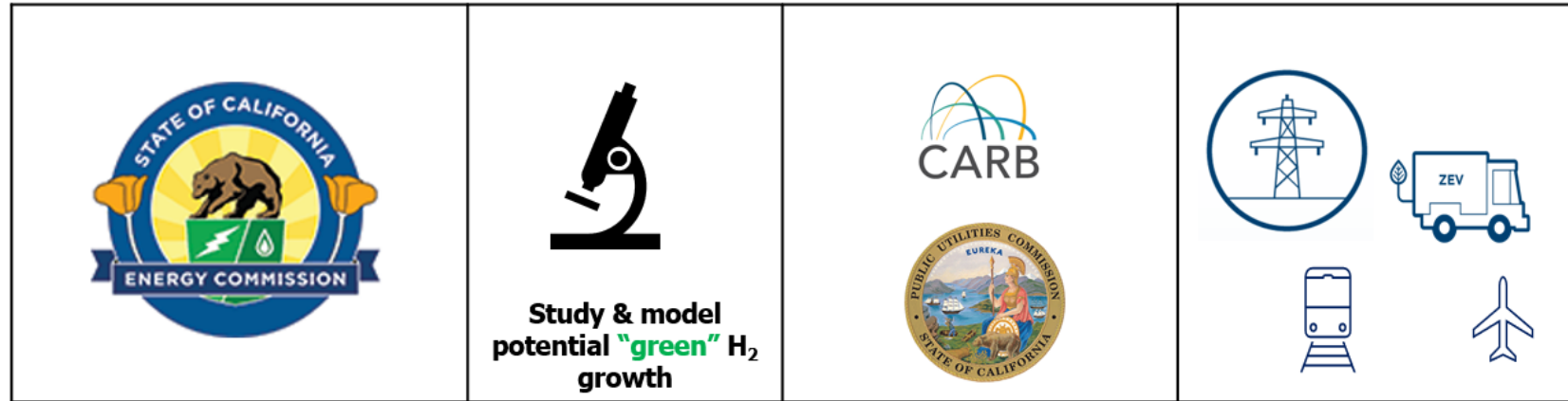


Agenda

- **SB 1075 Overview**
- **2023 Lookback & results**
- **2025 IEPR – Expands on 2023**
- **2025 Demand scenarios**
- **2025 Analysis**
- **Results**
- **Takeaways**
- **Q&A**



SB1075 requires multiple agency assessments





What 2023 IEPR considered...

Power Generation

- 2022 AB 32 CARB Scoping Plan & CEC-funded UCI study,
- Hydrogen potential, electricity, storage, delivery & costs
- Challenges

Transportation

- IEPR Freight and Truck
- Varying hydrogen and FCEV price
- Results - FCEV & Hydrogen demand

Technology Focus

- Proton Exchange Membrane (PEM)
Renewable Energy

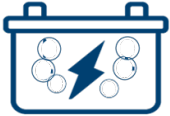


2023 IEPR report looked at bookend scenarios

				
	Electric High	Electric Low	Transportation High	Transportation Low
Parameter	2022 Scoping Plan Update	UCI Study	2022 Scoping Plan Update	Modified AATE3
H2 Consumed Metric Tonnes/year	1,883,960	350,000	971,000	307,700
Electrolyzers needed @ 65%	921	171	475	151
Capital (Billion Dollars)	\$16.20	\$3.00	\$8.30	\$2.60
Water (Billion Gallons/year)	4.4	0.8	2.3	0.7
Electricity (Terawatt hours/year)	94	17.5	48.5	15.3
Cost/kWh @ \$0.20/Kilo Watt Hours (Billion Dollars/Year)	\$18.80	\$3.50	\$9.70	\$3.0
Renewables Capacity for H2 Gigawatts (assuming 30 percent capacity factor)	35.8	6.6	18.4	5.8
Acres for renewable generation (assuming all solar)	250,900	46,610	129,325	40,990



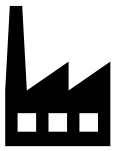
2025 IEPR Expands...



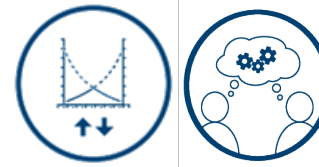
- **Electrolysis (Alkaline)**



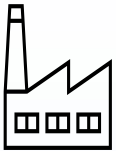
- **Impact of variability of demand on the need for storage**



- **Steam Methane Reformation**
- **Natural Gas + Carbon Capture**
- **Steam Methane Reformation**
- **Renewable Natural Gas**



- **Exploration of the balance of production and storage under different demand scenarios**



- **Gasification of Biomass (3 types)**



- **Pyrolysis - Natural Gas**
- **Pyrolysis - Renewable Natural Gas (RNG)**



2025 IEPR "bookends" of H₂ demand in 2045



Power Sector



High – Scoping Plan level of fossil gas replaced with H₂
1.59 Million Tonnes of H₂ per year

Low – CEC Sponsored UC Irvine study
0.35 Million Tonnes of H₂ per year

Transportation



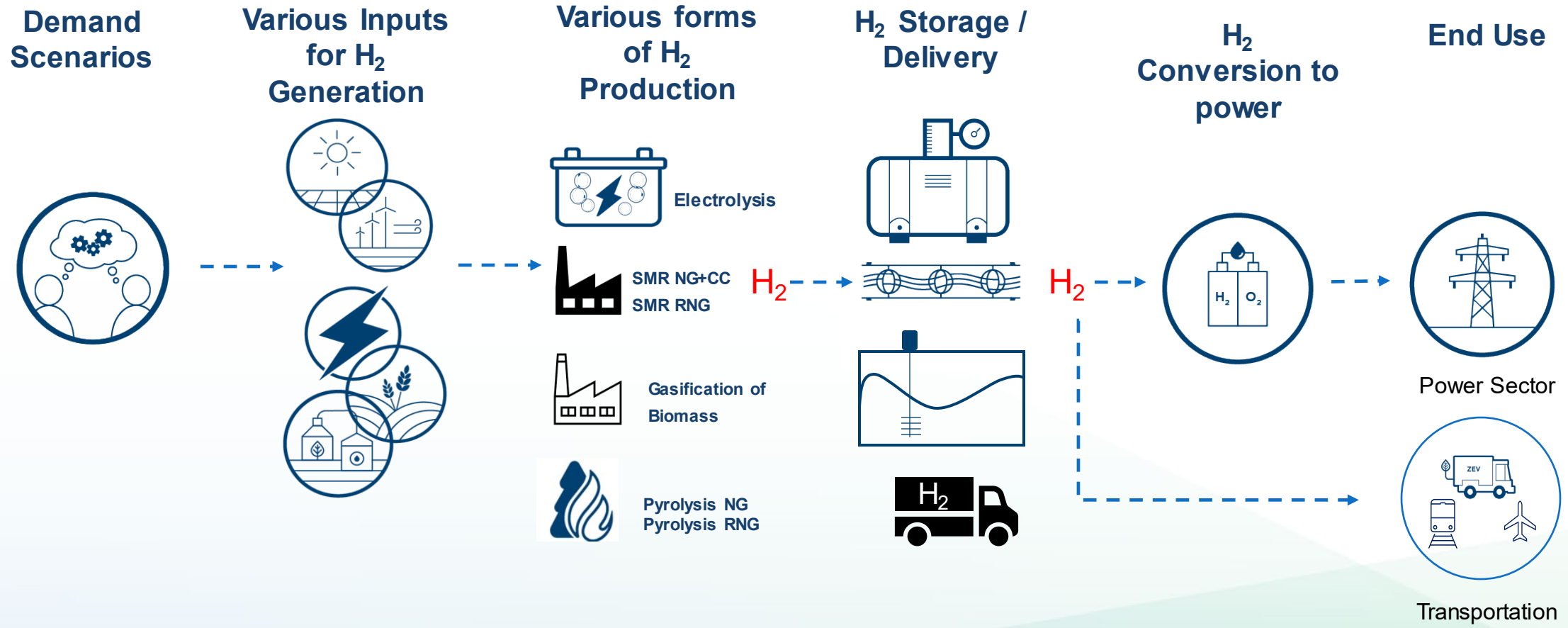
High – SB 100 High H₂ Use (HHU) CEC Policy Scenario
1.40 Million Tonnes of H₂ per year

Low – CEC SB 100 Policy Scenario
0.81 Million Tonnes of H₂ per year

Results presented are based on the **High Electric Power** Sector and **High Transportation** Sector bookends



2025 analysis includes more pathways to meet demand





Integrated Value Chain Analysis



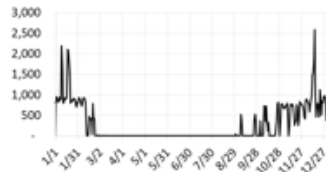


Integrated Value Chain Analysis (IVCA) - Electricity

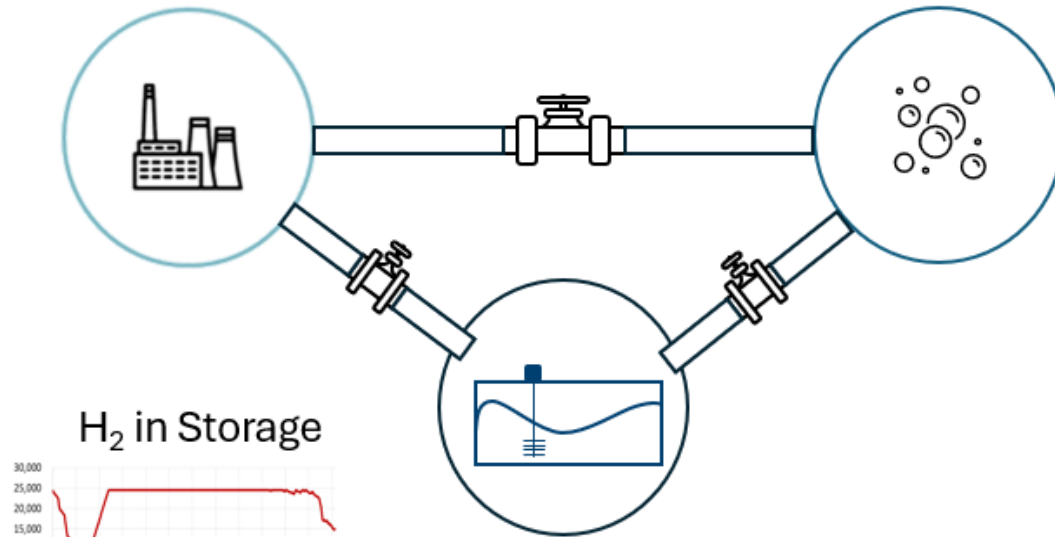
Infrastructure

How much & Type

Demand



Amount H₂ produced



H₂ in Storage



Resources



Electrolysis



SMR NG+CC
SMR RNG



Gasification of
biomass



Pyrolysis NG
Pyrolysis RNG



Compared Three Portfolios of Hydrogen Production Pathways

- **Electrolysis-Heavy**

- Electrolysis is the majority of production.
- Natural gas pathways are de-emphasized.

- **Biogenic Full**

- Biogenic feedstocks are deployed at 100% of their estimated statewide potential.
- Pathways involving natural gas develop moderately, but not to the level of the Balanced portfolio.

- **Balanced**

- All major pathways, fuels, and feedstocks contribute.

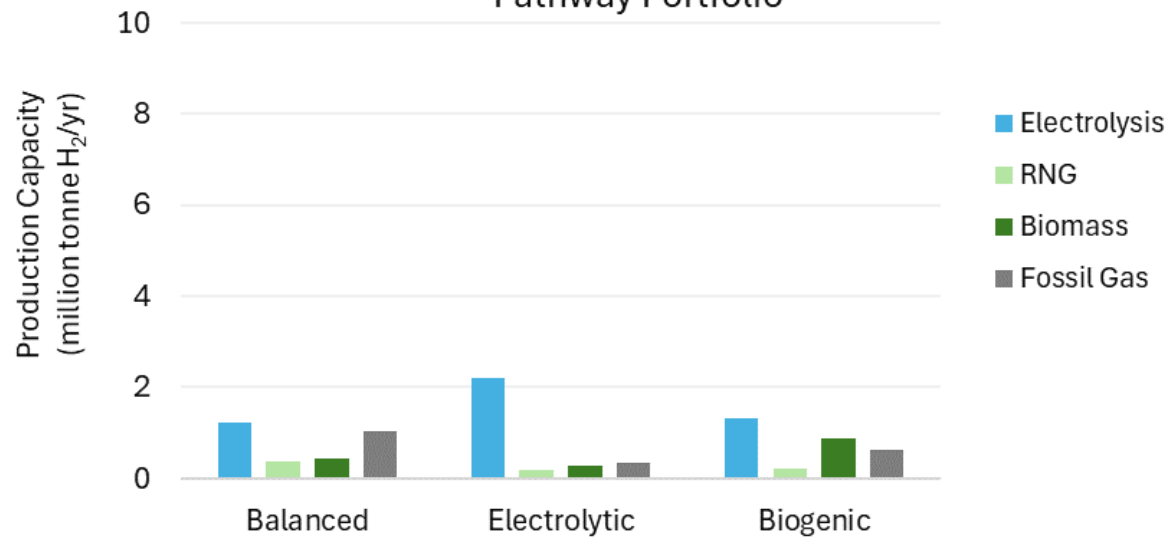
Feedstock	Electrolysis-Heavy	Biogenic Full	Balanced
Water (electrolysis)	72%	44%	40%
Natural gas (SMR+CC and pyrolysis)	12%	22%	40%
Biomass (gasification)	9%	28%	14%
RNG (SMR and pyrolysis)	6%	6%	6%

Assumption: use of fossil natural gas when combined with carbon mitigation technologies (CCS or pyrolysis) is permissible.

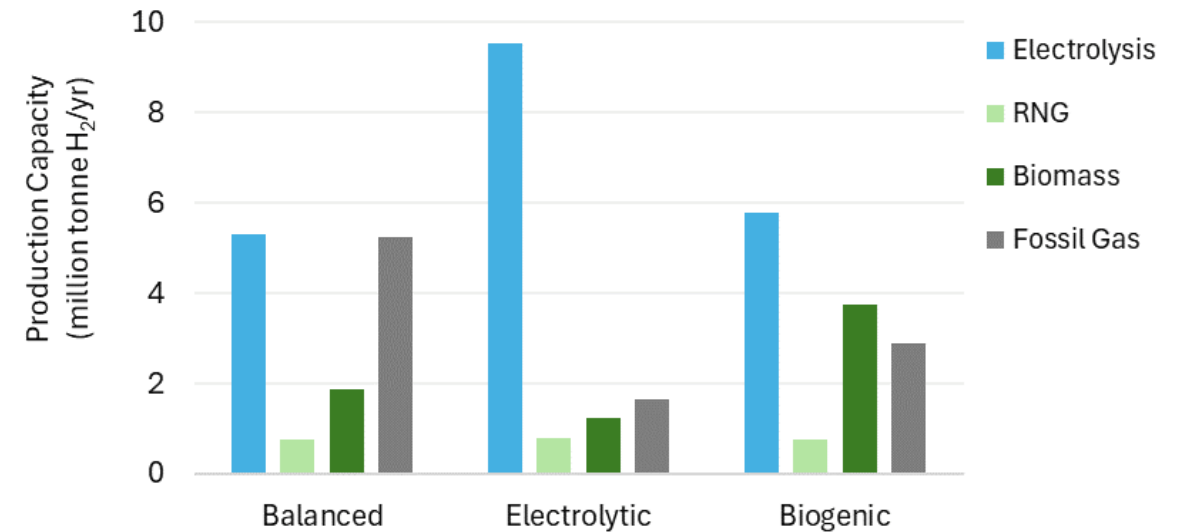


Production Capacity Requirement for Clean H₂ Production – Combined High Electric + High Transportation Bookends

H₂ Production Capacity Required, **Full Storage**, by Pathway Portfolio



H₂ Production Capacity Required, **No Storage**, by Pathway Portfolio

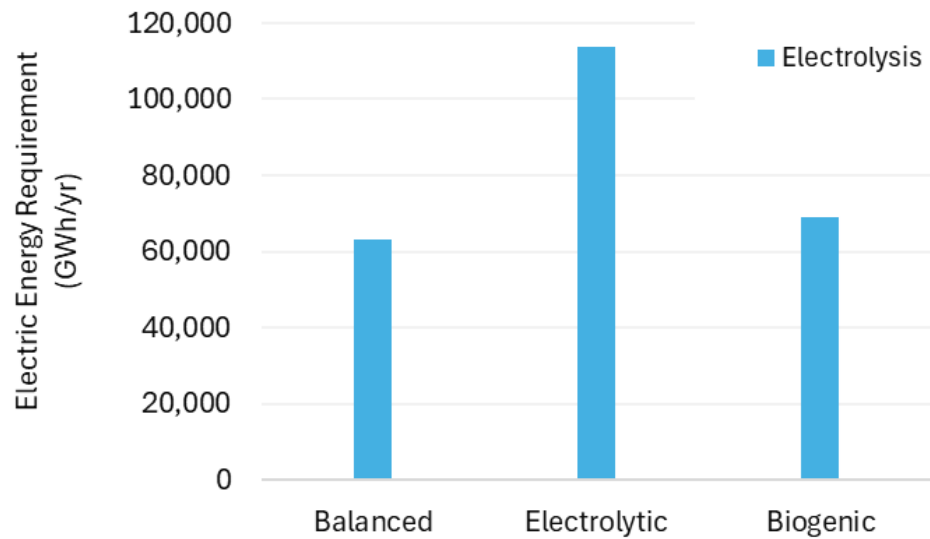


Full Storage is *1 million Tonnes of hydrogen* for the combined high electric + high transportation bookends.

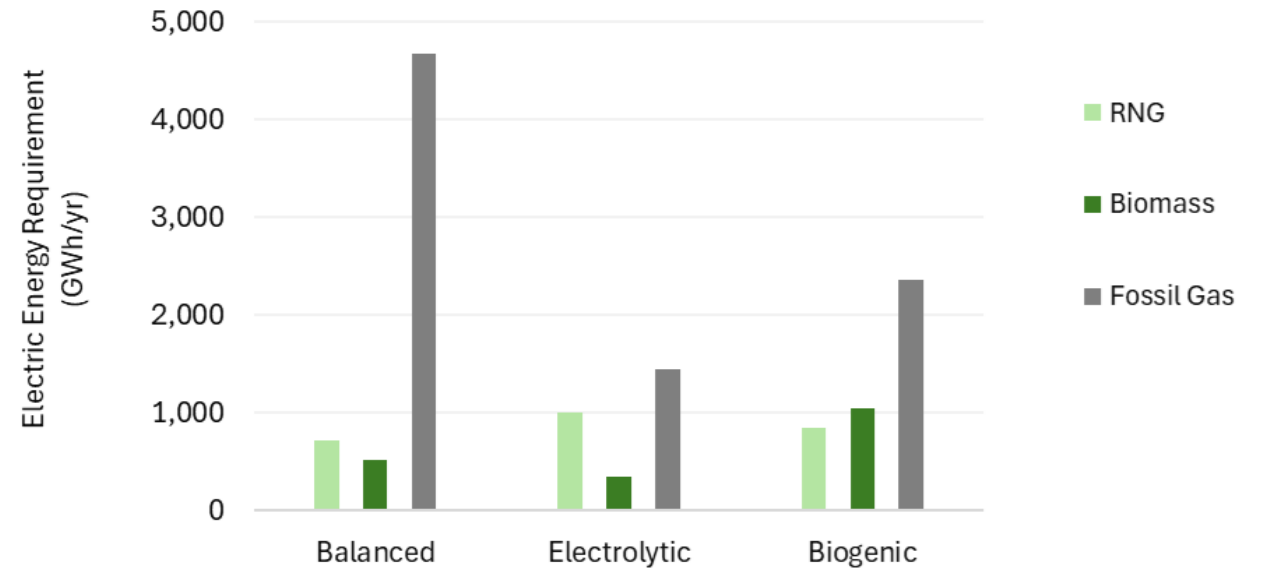


Electricity Requirement for Clean H₂ Production – Combined High Electric + High Transportation Bookends

Electric Energy Requirement for H₂ Production

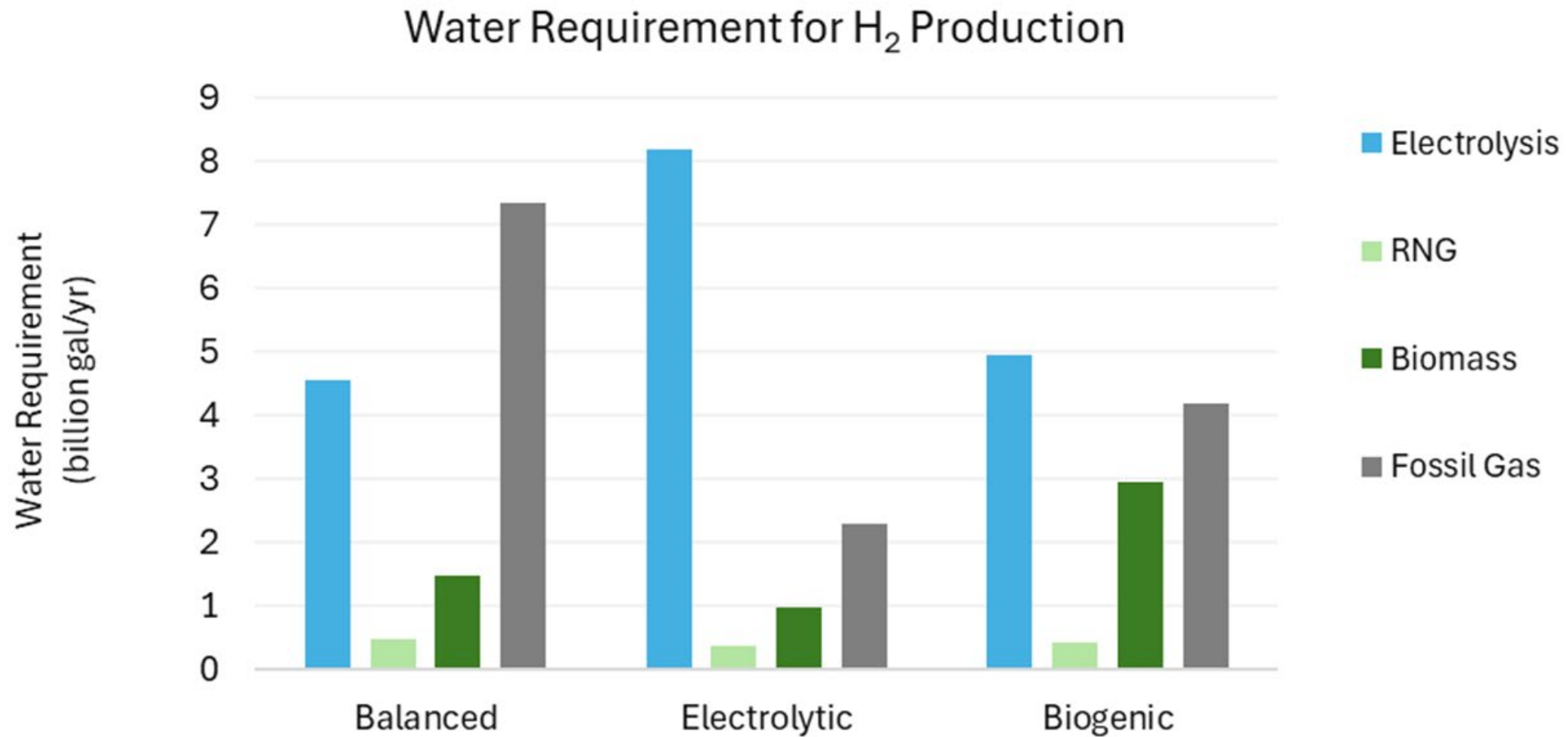


Electric Energy Requirement for H₂ Production





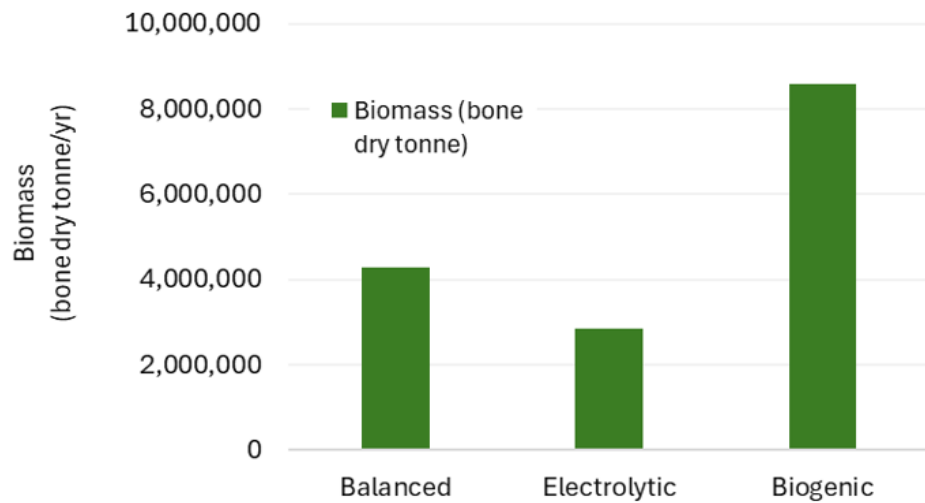
Water Requirement for Clean H₂ Production – Combined High Electric + High Transportation Bookends



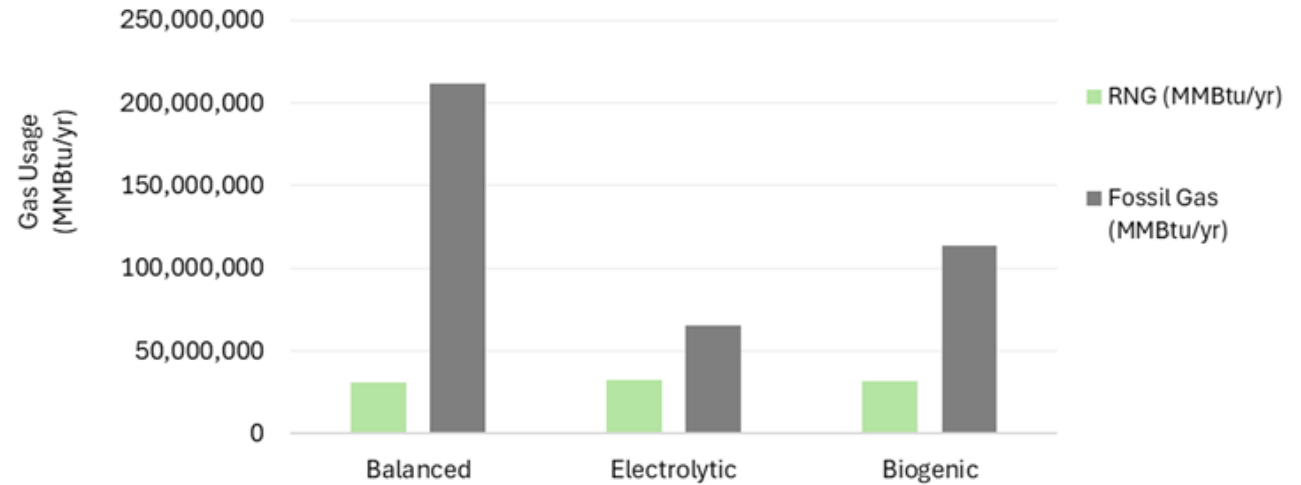


Non-Water Feedstock Requirement for Clean H₂ Production – Combined Upper Electric + Upper Transportation Scenarios

Biomass Feedstock Requirement for H₂ Production



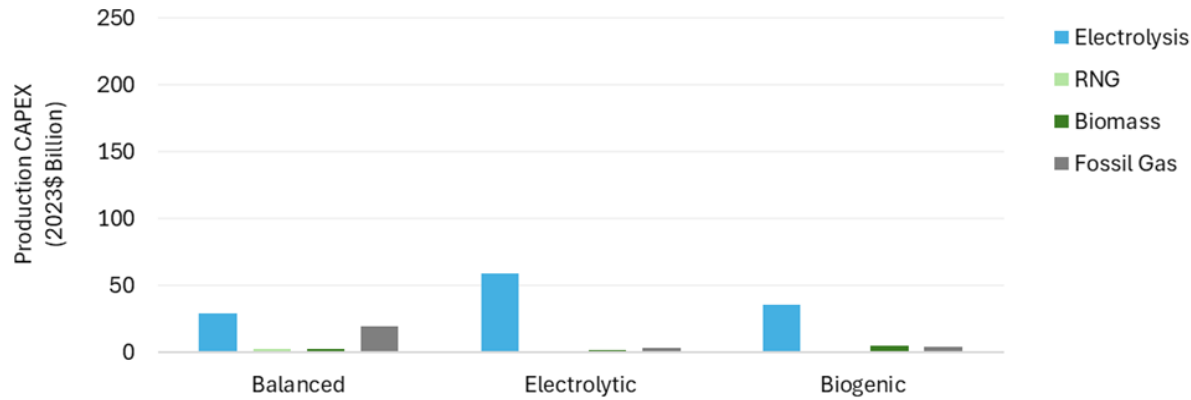
Gas Feedstock Requirement For H₂ Production



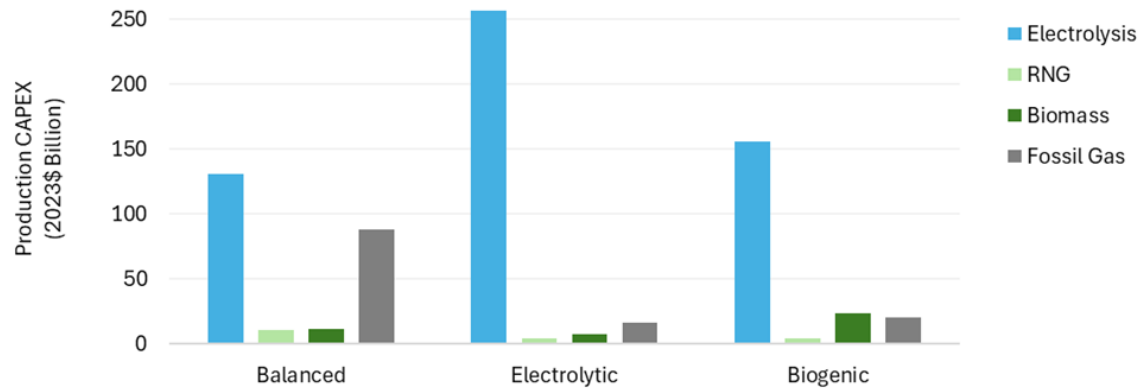


CAPEX, All Production Assets Required for 2045 Clean H₂ Production – Combined High Electric + High Transportation Bookends

Total 2045 H₂ Production CAPEX Required, **Full Storage**, by Production Portfolio



Total 2045 H₂ Production CAPEX Required, **No Storage**, by Production Portfolio



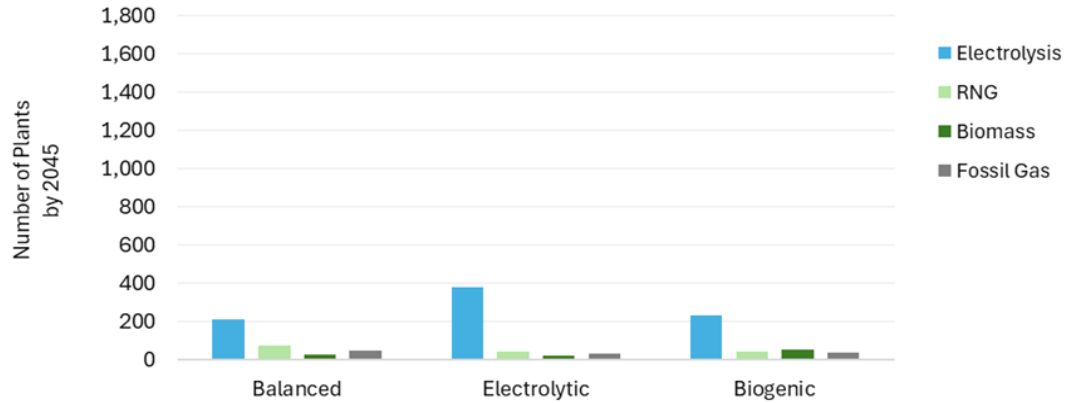
		Total CAPEX (2023\$B) to Meet H ₂ Production Capacity Requirement - FULL STORAGE		
FEEDSTOCK	TECHNOLOGY	Balanced	Electrolytic	Biogenic
Water	PEM electrolysis	\$16.3	\$35.0	\$22.5
Water	Alkaline electrolysis	\$13.1	\$23.2	\$12.8
RNG	SMR	\$1.97	\$0.42	\$0.53
RNG	Pyrolysis	\$0.41	\$0.60	\$0.50
Forest Residue	Gasification	\$0.51	\$0.33	\$1.01
Urban Wood Waste	Gasification	\$0.79	\$0.52	\$1.57
Crop Residue	Gasification	\$1.41	\$0.94	\$2.85
Fossil Gas	SMR	\$14.2	\$3.00	\$3.68
Fossil Gas	Pyrolysis	\$1.77	\$0.54	\$0.81
Total CAPEX (2023\$B):		\$50.48	\$64.54	\$46.25

		Total CAPEX (2023\$B) to Meet H ₂ Production Capacity Requirement - NO STORAGE		
FEEDSTOCK	TECHNOLOGY	Balanced	Electrolytic	Biogenic
Water	PEM electrolysis	\$73.35	\$155.97	\$100.11
Water	Alkaline electrolysis	\$58.68	\$103.34	\$57.21
RNG	SMR	\$8.81	\$1.89	\$2.39
RNG	Pyrolysis	\$1.85	\$2.68	\$2.26
Forest Residue	Gasification	\$2.27	\$1.49	\$4.54
Urban Wood Waste	Gasification	\$3.54	\$2.31	\$7.02
Crop Residue	Gasification	\$6.31	\$4.21	\$12.76
Fossil Gas	SMR	\$64.11	\$14.51	\$17.05
Fossil Gas	Pyrolysis	\$7.94	\$2.44	\$3.61
Total CAPEX (2023\$B):		\$226.87	\$288.84	\$206.94

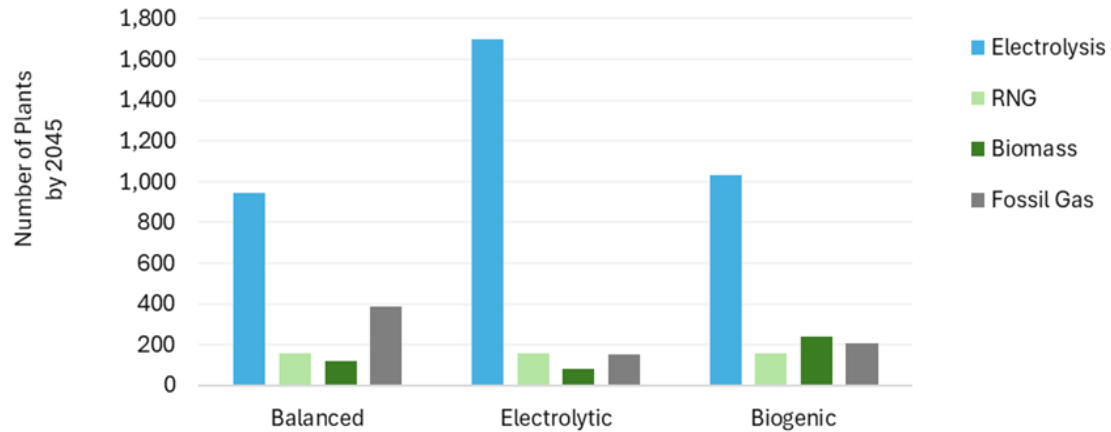


Number of Production Plants Required for 2045 Clean H₂ Production – Combined High Electric + High Transportation Bookends

Number of Production Plants Required, **Full Storage**, by Production Portfolio



Number of Production Plants Required, **No Storage**, by Production Portfolio



		Number of production facilities - FULL STORAGE		
FEEDSTOCK	TECHNOLOGY	BALANCED	ELECTROLYTIC-HEAVY	BIOGENIC FULL
Water	PEM electrolysis	118	229	147
Water	Alkaline electrolysis	95	152	84
RNG	SMR	22	16	19
RNG	Pyrolysis	14	21	17
Forest Residue	Gasification	5	4	10
Urban Wood Waste	Gasification	8	6	16
Crop Residue	Gasification	14	10	28
Fossil Gas	SMR	28	15	19
Fossil Gas	Pyrolysis	60	19	28
Total number of plants:		364	472	368

		Number of Production Facilities - NO STORAGE		
FEEDSTOCK	TECHNOLOGY	BALANCED	ELECTROLYTIC-HEAVY	BIOGENIC FULL
Water	PEM electrolysis	525	1021	656
Water	Alkaline electrolysis	420	677	375
RNG	SMR	96	69	84
RNG	Pyrolysis	63	90	75
Forest Residue	Gasification	23	15	45
Urban Wood Waste	Gasification	35	23	69
Crop Residue	Gasification	62	41	124
Fossil Gas	SMR	122	72	85
Fossil Gas	Pyrolysis	266	82	121
Total number of plants:		1612	2090	1634



Preliminary Takeaways

- **Electric generation:** If hydrogen is heavily used to replace existing gas fired generation (e.g., meeting daily and seasonal demand when renewable electricity generation is not sufficient), there would be large swings in seasonal demand for hydrogen. **Transportation:** end uses would not have dramatic changes in demand but do have seasonal variations.
- **Seasonal changes in hydrogen use** driven by electricity production needs would require strategic hydrogen storage facilities (large and centralized - likely geological underground) or, alternatively, extra hydrogen production capacity with ability to make timely deliveries. But that extra hydrogen production capacity may be severely under-utilized for significant portions of the year.
- **Onsite hydrogen production** is limited to applications with modest needs - 7 acres of solar PV yields only about 140 kg H₂ per day.
- **Biogenic feedstock** availability may be a limiting factor. Must have processes to efficiently collect, stockpile, and process them to meet the demand.
- **Fossil gas reforming with CCS** can use significantly more water (primarily as cooling water) than electrolysis (more equally split between process and cooling) when deep purification is not needed for electrolysis.
- **Pipelines** would be needed to meet hydrogen demand beyond limited transportation end uses whose requirements can be met with hydrogen deliveries by trucks.