A PUBLIC AGENCY
NCPA
NORTHERN CALIFORNIA POWER AGENCY

12745 N. Thornton Road
Lodi, CA 95242

phone (209) 333-6370
fax (209) 333-6374
web www.ncpa.com

Notice – Call of Special PPC Meeting

To: NCPA Lodi Energy Center Project Participant Committee

From: Cori Bradley, Chair

Subject: **March 25, 2025 LEC PPC Special Meeting Notice & Agenda**

PLEASE TAKE NOTICE that pursuant to Government Code section 54956, a special meeting of the Northern California Power Agency Lodi Energy Center Project Participant Committee is hereby called for **Tuesday, March 25, 2025 at 9:00 AM** to discuss those matters listed in the attached Agenda. The meeting will be held at the Northern California Power Agency Headquarters, 651 Commerce Drive, Roseville, California.

If you are unable to attend the meeting in person at the Roseville location and wish to attend via teleconference, in accordance with The Brown Act, you must attend at one of the locations listed on the Agenda and post the Agenda at that location by 9:00 AM no later than 24 hours prior to the meeting commencement date and time, in a location that is accessible to the public until the completion of the meeting.

Cori Bradley
Cori Bradley (Mar 17, 2025 12:58 PDT)

Cori Bradley, Chair

12745 N. Thornton Road
Lodi, CA 95242

phone (209) 333-6370
fax (209) 333-6374
web www.ncpa.com

LEC PPC Agenda

Subject: March 25, 2025 Special Lodi Energy Center Project Participant Committee Meeting

Location: 651 Commerce Drive, Roseville, CA and/or Posted Teleconference Locations

Time: 9:00 AM Pacific Standard Time

***** In compliance with the Brown Act, you may participate in person at the meeting location or via teleconference at one of the locations listed below. <u>In either case</u>, please: (1) post this notice at a publicly accessible location at the <u>participation</u> location at least 72-hours before the meeting begins, and (2) have a speaker phone available for any member of the public who may wish to attend at your location.**

NCPA 651 Commerce Drive Roseville, CA 95678	NCPA 12745 N. Thornton Road Lodi, CA 95241	CITY OF HEALDSBURG 401 Grove Street Healdsburg, CA 95448
BAY AREA RAPID TRANSIT 2150 Webster Street, 1st Floor Oakland, CA 94612	CITY OF GRIDLEY 685 Kentucky Street Gridley, CA 95948	CITY OF LOMPOC 100 Civic Center Plaza Lompoc, CA 93436
CITY OF BIGGS 465 C Street Biggs, CA 95917	PLUMAS-SIERRA RURAL ELECTRIC COOP 73233 Highway 70 Portola, CA 96122	CITY OF AZUSA 729 N. Azusa Avenue Azusa, CA 91702
CITY OF LODI 1331 S. Ham Lane Lodi, CA 95242	SILICON VALLEY POWER/CITY OF SANTA CLARA 881 Martin Avenue Santa Clara, CA 95050	CITY OF UKIAH 411 W. Clay St. Ukiah, CA 95482

Persons requiring accommodations in accordance with the Americans with Disabilities Act in order to attend or participate in this meeting are requested to contact the NCPA Secretary at 916.781.3636 in advance of the meeting to arrange for such accommodations.

The Lodi Energy Center Project Participant Committee may take action on any of the items listed on this Agenda regardless of whether the matter appears on the Consent Calendar or is described as an action item, a report, or an information item. If this Agenda is supplemented by staff reports, they are available to the public upon request. Pursuant to California Government Code Section 54957.5, the following is the location at which the public can view Agendas and other public writings: NCPA, 651 Commerce Drive, Roseville, CA or www.ncpa.com

1. **Review Safety Procedures**

2. **Call Meeting to Order and Roll Call**

PUBLIC FORUM

Any member of the public who desires to address the Lodi Energy Center Project Participant Committee on any item considered by the Lodi Energy Center Project Participant Committee at this meeting, before or during the Committee's consideration of that item, shall so advise the Chair and shall thereupon be given an opportunity to do so. Any member of the public who desires to address the Lodi Energy Center Project Participant Committee on any item within the jurisdiction of the Lodi Energy Center Project Participant Committee and not listed on the Agenda may do so at this time.

INFORMATIONAL/ DISCUSSION ITEMS

3. **Lodi Energy Center Hydrogen Project Workshop** – NCPA Staff will lead PPC Members through a discussion regarding the potential hydrogen upgrade project at the Lodi Energy Center.

ADJOURNMENT

Next Regular Meeting: April 7, 2025 at 10:00 AM Pacific Standard Time

Persons requiring accommodations in accordance with the Americans with Disabilities Act in order to attend or participate in this meeting are requested to contact the NCPA Secretary at 916.781.3636 in advance of the meeting to arrange for such accommodations.

GHD

A PUBLIC AGENCY
NCPA
NORTHERN CALIFORNIA POWER AGENCY

LEC PPC Special Workshop

→ Global Hydrogen Prospectives

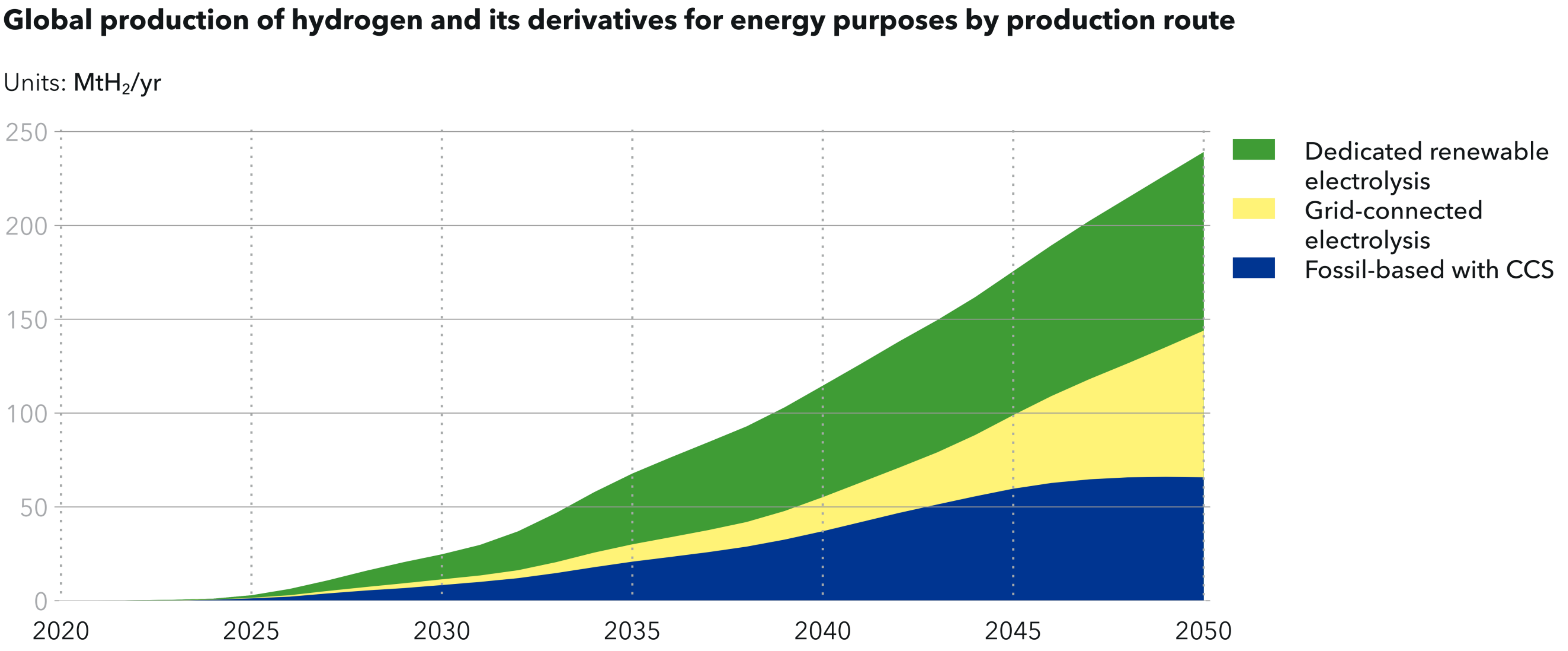
March 25, 2025 Workshop

Contents

- Current and Future Low Carbon Hydrogen Production
- Global/US Project Landscape
- Challenges and Opportunities
- Market Pricing

Current and Future Low Carbon Hydrogen Production (ENR)

FIGURE 2

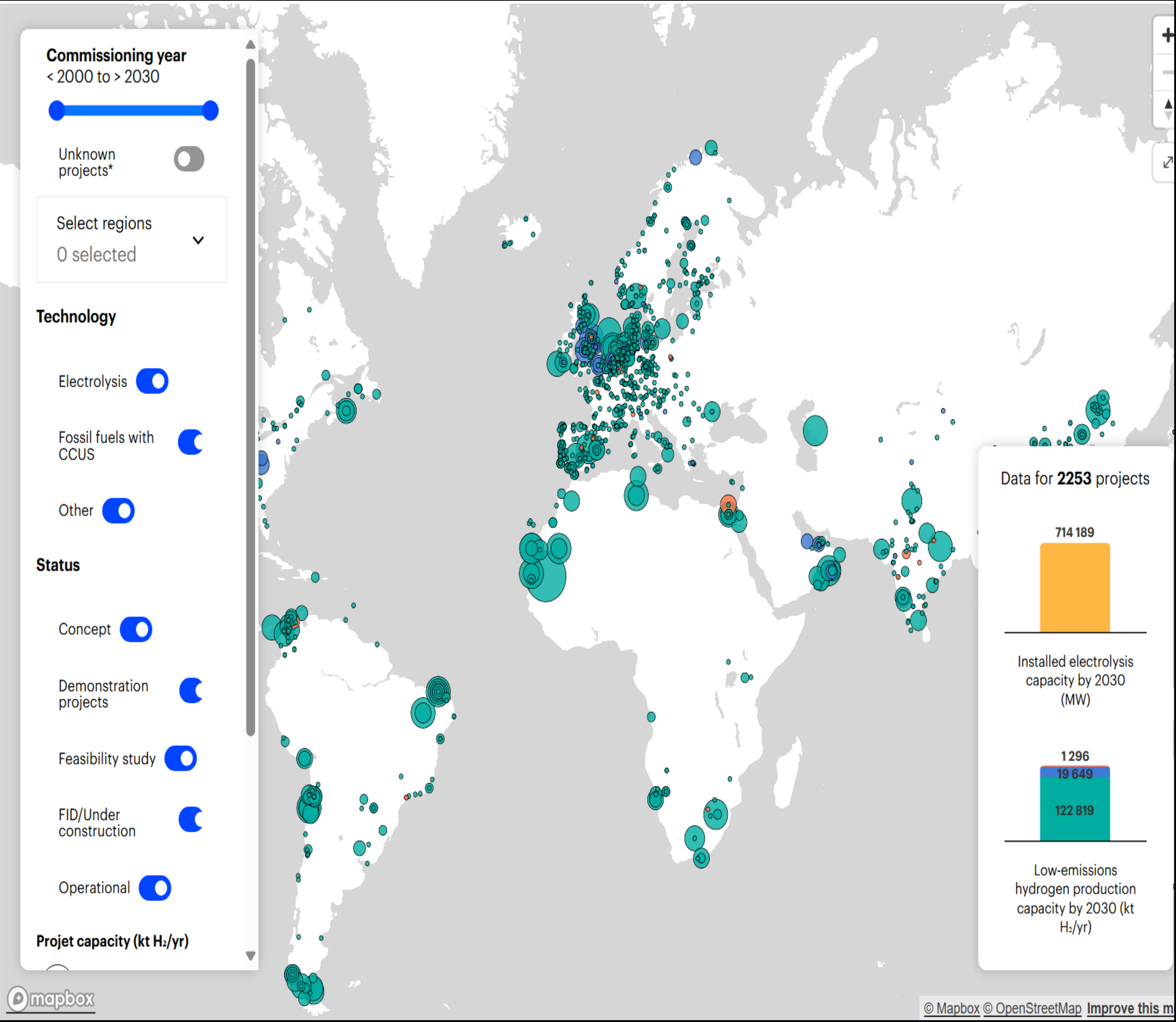


Global Hydrogen Projects

Hydrogen production projects interactive map – Data Tools - IEA

Global Summary

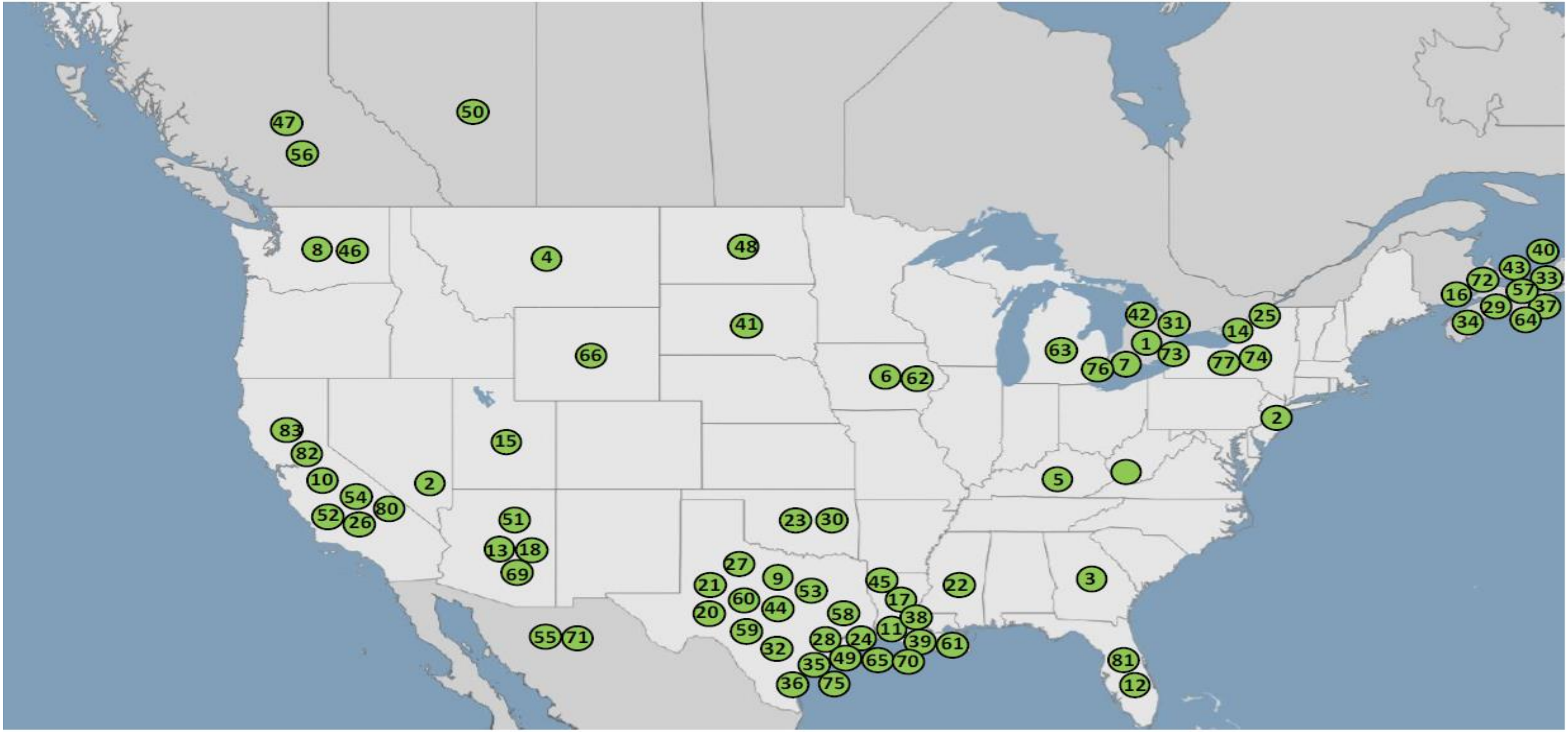
- Over 3,000 projects in development
- 63% are in or completed concept/feasibility stage
- 11% have completed FID
- Delays due to risks, funding mechanisms, market uncertainties
- Same viewpoint for electrolyzer gigafactories



North American Green Hydrogen Projects

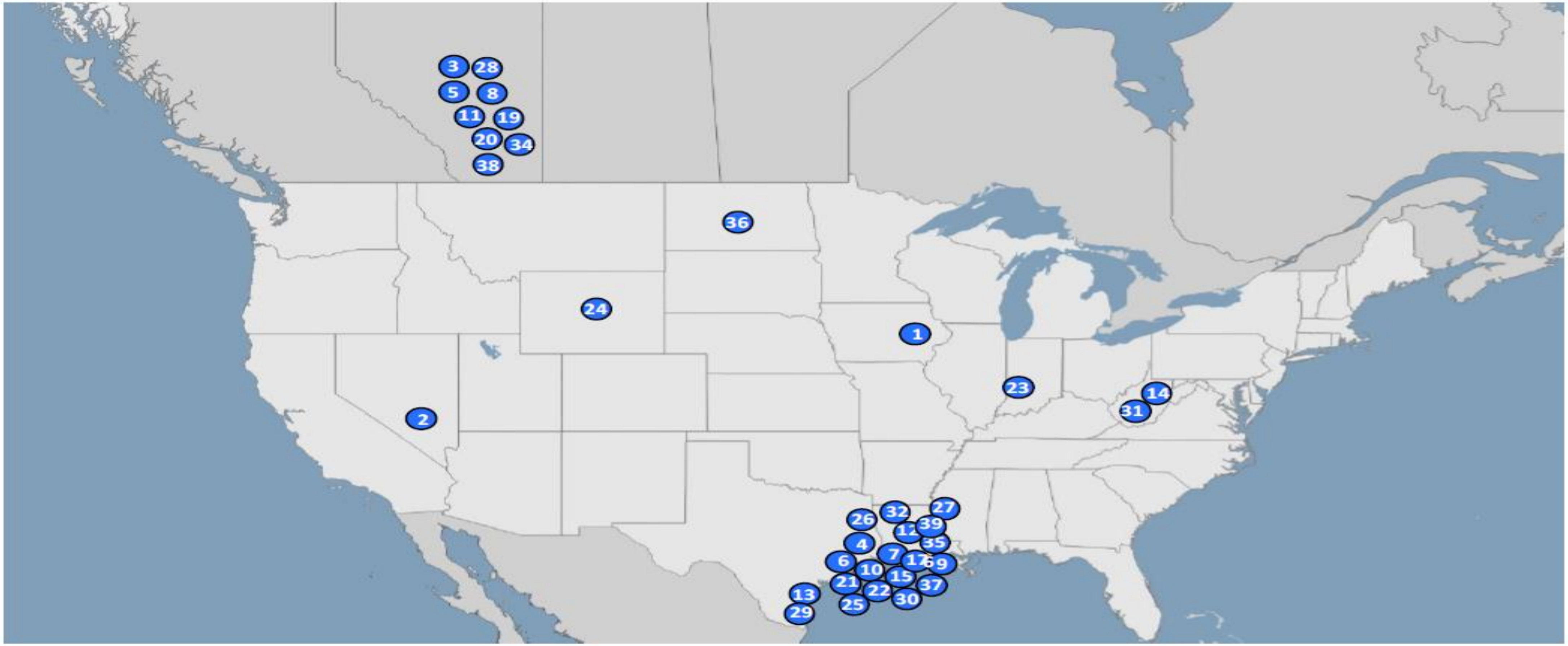
RBN ENERGY HYDROGEN BILLBOARD March 12, 2025

Figure 1: North America Green Hydrogen Hubs



North American Blue Hydrogen Projects

Figure 2: North America Blue Hydrogen Hubs



US Summary Green (Blue)

- Over 80 (39) projects in development
- 66 (65) % are in or completed concept/feasibility stage
- 22 (28) % have completed FID/in construction/operation
- Delays due to risks, funding mechanisms, market uncertainties
- Same viewpoint for 4 electrolyzer gigafactories
- 2 new liquid plants on-line recently
- 6 gas plant pilot tests
- Total 13M (10M) tons per day (current 10M TPD Gray)

GREEN HYDROGEN

Table A: North American Green Hydrogen Production Capacity (Major Projects)

	Existing	Operator	Status	Technology	Capacity MW	kg/d (RBN)	MMcf/d	MMBtu/d	End Use	Location	Start Date
1	Bécancour	Air Liquide	Operational	PEM	20	8,050	3	915	5, 6	Québec	Q1 2021
2	Howell	NJ Resources	Operational	PEM	175	30,319	13	3,447	8	Howell, NJ	Q4 2021
3	Peachtree	Plug Power	Operational	PEM	37	15,000	6	1,706		Woodbine, GA	Q1 2023
4	MT Renewables	Calumet	Operational	TBA	TBA	50,571	21	5,750		Great Falls, MT	Q1 2023
5	Plug Tennessee, Phase 1	Plug Power	Operational	PEM	TBA	16,000	7	1,819		Charleston, TN	2008, 2021
6	Iowa Ammonia Project	Talus/Landus	Operational	Electrolysis	427	202,581	84	23,033	2	Boone, Iowa	2025
7	RCV	Hydro-Québec	FID/Construction	Electrolysis	87	35,019	15	3,982		Varennes, QC	2025
8	Wells Dam	Douglas PUD	FID/Construction	PEM	5	2,013	1	229		Pateros, WA	TBA
9	Fort Worth	Plug Power	FID/Construction	PEM	274	112,500	47	12,791		Fort Worth, TX	2025
10	Plug Power CA	Plug Power	FID/Construction	PEM	120	48,302	12	3,411	6	Fresno, CA	TBA
11	CF Industries	CF Industries	FID/Construction	Alkaline	20	9,560	4	1,087	2	Donaldsonville, LA	TBA
12	Cavendish	NextEra	FID/Construction	PEM	25	10,063	4	1,228	7	Okeechobe, FL	TBA
13	Casa Grande	Air Products	FID/Construction	Alkaline	21	10,000	4	1,137	6	Casa Grande, AZ	TBA
14	Niagara Hydrogen	Atura Power	FID/Construction	PEM	20	8,050	3	915	5, 6, 7	Niagara Falls, ON, CAN	TBA
15	ACES	ACES	FID/Construction	Alkaline	220	102,157	42	11,615	7	Delta, UT	2025
16	Saint John Refinery	Irving Oil	FID/Construction	PEM	5	2,054	1	234	1	Saint John, NB, CAN	TBA
5	Plug Tennessee, Phase 2	Plug Power	FID/Construction	Electrolysis		15,000	6	1,706		Charleston, TN	TBA
17	Hidrogenii	Plug Power/Olin	FID/Construction	Electrolysis		15,000	6	1,706		St. Gabriel, LA	H1 2025
18	Phoenix Hydrogen Hub	Fortescue	FID/Construction	Electrolysis	50	32,877	14	3,738	6	Buckeye, AZ	2026
19	Plug Power/Apex	Plug Power	Feasibility Study	PEM	75	30,000	12	3,411		TBA	TBA
20	Pecos County	MMEX	Feasibility Study	PEM	406	166,667	69	18,950		Pecos County, TX	TBA
21	Roadrunner	Enel	Feasibility Study	Alkaline	20	9,560	4	1,087		Upton County, TX	TBA
22	Mississippi Hydrogen Hub	Hy Stor	Feasibility Study	Electrolysis	635	301,370	125	34,266		Mississippi	2025
23	H2OK	Woodside	Feasibility Study	Alkaline	290	134,661	56	15,311		Ardmore, OK	2025
24	Zero Parks, Phase 1	New Fortress	Feasibility Study	PEM	100	40,252	21	5,685		Beaumont, TX	2025
25	Linde Niagara	Linde	Feasibility Study	PEM	35	14,088	6	1,602		Niagara Falls, NY	2025
26	Ontario Green	Linde	Feasibility Study	PEM	5	2,054	1	234	6	Ontario, CA	TBA
27	Clear Fork, Phase 1	CEH	Feasibility Study	Electrolysis	250	118,667	49	13,492		Sylvester, TX	2025
28	Matagorda eFuels	HIF	Feasibility Study	PEM	1,800	739,385	307	84,068	12	Matagorda, TX	2026
29	Bear Head	BAES	Feasibility Study	PEM	5,197	2,466,740	1,024	280,468	2	Nova Scotia	2028
30	Verdigris	CF/NextEra	Feasibility Study	PEM	100	40,252	17	4,577	2	Verdigris, OK	TBA
31	Project Maurice	TES Canada H2	Feasibility Study	Electrolysis	500	237,333	99	26,985	6, 12	Quebec	2028
32	Hydrogen City, Phase 1	GHI/Inpex	Feasibility Study	Electrolysis	2,000	949,333	394	107,939	2, 6, 7, 12	South Texas	2030
33	Exploits Valley	Abraxas Power / EDF	Feasibility Study	Electrolysis	3,500	452,055	188	51,399	2, 7	Newfoundland, CN	2030
34	Point Tupper, Phase 1	EverWind Fuels	Feasibility Study	PEM	421	173,105	72	19,682		Nova Scotia, CN	2026
35	Star E-Methanol	Orsted/Maersk	Feasibility Study	Electrolysis	675	320,400	133	36,429	3	Texas Gulf Coast	2025
36	Horizons Clean Hydrogen Hub	Port of Corpus Christi	Feasibility Study	Electrolysis	1,200	569,600	237	64,764	2, 5, 6, 7	Corpus Christi, TX	2030
37	North Atlantic Green Energy Hub	North Atlantic	Feasibility Study	Electrolysis	1,433	684,932	284	77,877	1	Placentia Bay, CN	TBA
38	Gron Fuels Renewable Energy Complex	Fidelis New Enegy	Feasibility Study	Electrolysis	1,000	474,667	197	53,970	12	Baton Rouge, LA	2030
39	DG Fuels	DG Fuels	Feasibility Study	Alkaline	839	389,558	162	44,293	12	St. James Parish, LA	2028
40	Nulo'qonik Green Hydrogen, Phase 1	World Energy GH2	Feasibility Study	Alkaline	650	301,826	125	34,318	2, 7, 8	Newf. & Labrador, CN	2027
40	Nulo'qonik Green Hydrogen, Phase 2	World Energy GH2	Feasibility Study	Alkaline	650	301,826	125	34,318	2, 7, 8	Newf. & Labrador, CN	2030
41	Net-Zero 1	Gevo	Feasibility Study	Electrolysis	586	278,042	115	31,613	6, 12	Lake Preston, SD	2026
42	Teal	Teal	Feasibility Study	Electrolysis	520	247,674	103	28,161	2	Sept-Iles, QB	2029
43	Braya Renewable Fuels	Come by Chance Refinery	Feasibility Study	Electrolysis	508	239,726	100	27,257	1, 12	Newf. & Labrador, CN	2027

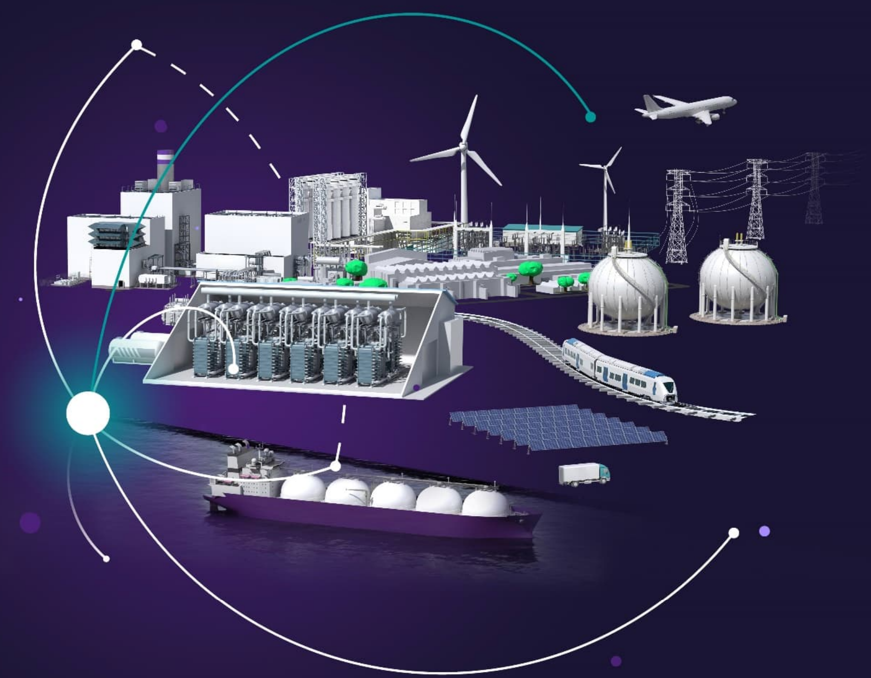
Global Hydrogen Pricing

Note : Current CA Hydrogen Pricing for vehicles ranges from $29 to $38/kg given infrastructure capacity and issues. Comparatively, LEC models show $3.5 to $11.5/kg ($28 to 94/MMBTU) for 45 to 100% H2 usage

Region	Hydrogen Type	Production Cost ($/kg)	CSD Cost ($/kg)	End-User Price ($/kg)
U.S.	Grey	1–2	3–5	4–7
	Blue	2.8–3.5	3–5	5.8–8.5
	Green	3–6	4–6	7–12
Canada	Grey	1.5–2.5	3–5	4.5–7.5
	Blue	3–4	3–5	6–9
	Green	4–7	4–6	8–13
Europe	Grey	1.5–2.5	3–5	4.5–7.5
	Blue	3–4	3–5	6–9
	Green	4–8	4–6	8–14
Asia	Grey	1–2.5	3–5	4–7.5
	Blue	2.5–3.5	3–5	5.5–8.5
	Green	3.5–7	4–6	7.5–13
Australia	Grey	1–2	3–5	4–7
	Blue	2.5–3.5	3–5	5.5–8.5
	Green	3–6	4–6	7–12

LODI - NCPA

Dan Restrepo (Head of Sales, Americas)
Sustainable Energy Systems
March 25 2025



Major successes in our electrolyzer development

SIEMENS energy

Since 1995
Testing in Lab-Scale and Short-Stacks

2011
Lab-scale demo

2015
World's largest Power-to-Gas plants with **PEM electrolyzers** in 2015 and 2017 built by Siemens Energy

2019
World's **largest Power-to-Gas plant** with PEM electro-lysis in operation

2021
World's first integrated & commercial large-scale plant for **e-Fuel** production
First fuel produced

2022
E-Methanol Kassø: First largest e-Methanol plant for shipping
Under construction

2023

Continuous laboratory and test operation

Silyzer 100 & Silyzer 200 in test rig and commercial operation

Elyzer P-300[1] in test rig and commercial operation

1 The product name was changed from Silyzer 300 to Elyzer P-300. It is a trademark of Siemens Energy GmbH & Co. KG or its affiliates registered in one or more countries.

Industrial-scale series production of electrolyzer stacks

2,000 square meters in Berlin Huttenstraße

€30m investment in new production line

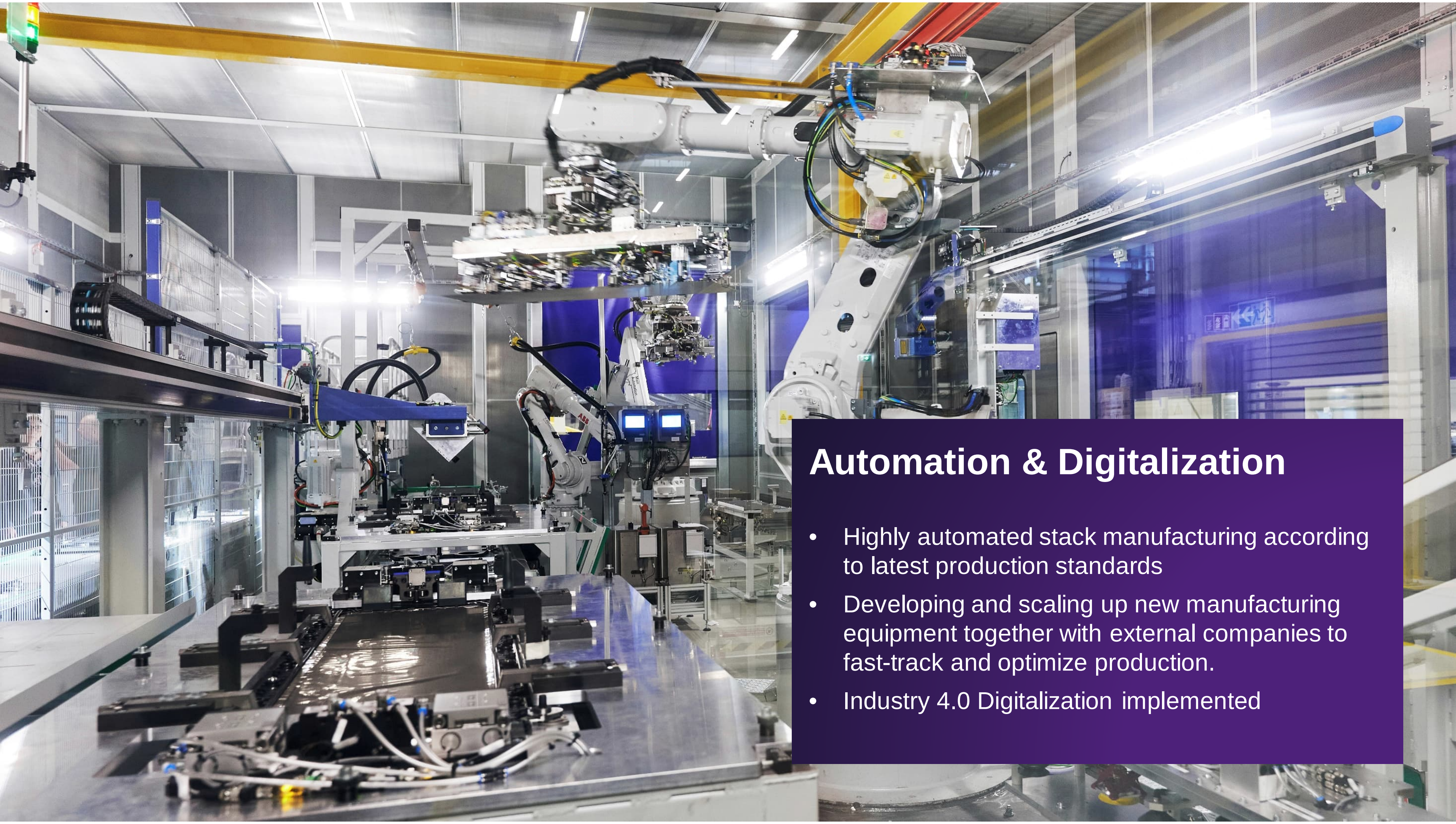
1GW production capacity in 2023

3GW production capacity space with a potential for more

March 2025

Membrane Electrode Assembly

- Coating machines apply thin electrode layers to the membrane
- Highly efficient and unique electrode design, perfectly matching the membrane properties and the Gas Diffusion Layer (GDL)



Automation & Digitalization

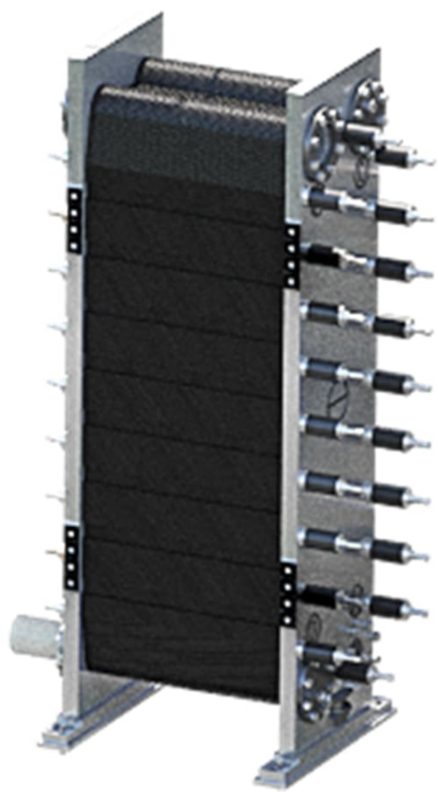
- Highly automated stack manufacturing according to latest production standards
- Developing and scaling up new manufacturing equipment together with external companies to fast-track and optimize production.
- Industry 4.0 Digitalization implemented

Module Heritage and Evolution

Elyzer P-300[1] Module

Design philosophy

- ✓ Moderate current density
- ✓ Two-sided cooling
- ✓ Atmospheric pressure
- ✓ No differential pressure
- ✓ Low operation temperature
- ✓ Rectangular cell
- ✓ Vertical cell



Design features

- ✓ High efficiency w. thick membrane
- ✓ Low thermal load w/o hot spots
- ✓ Low H_2 to O_2 diffusion and no leaks
- ✓ No mechanical membrane load
- ✓ Long membrane stability
- ✓ Homogeneous load distribution
- ✓ No trapped gases

1 The product name was changed from Silyzer 300 to Elyzer P-300. It is a trademark of Siemens Energy GmbH & Co. KG or its affiliates registered in one or more countries.

Elyzer P-300[1] production concept

Electrolyzer reference plant

- Pre-engineered basic design
- Integrated solution with strong partner approach
- Turn-key possible with partners

Electrolysis System

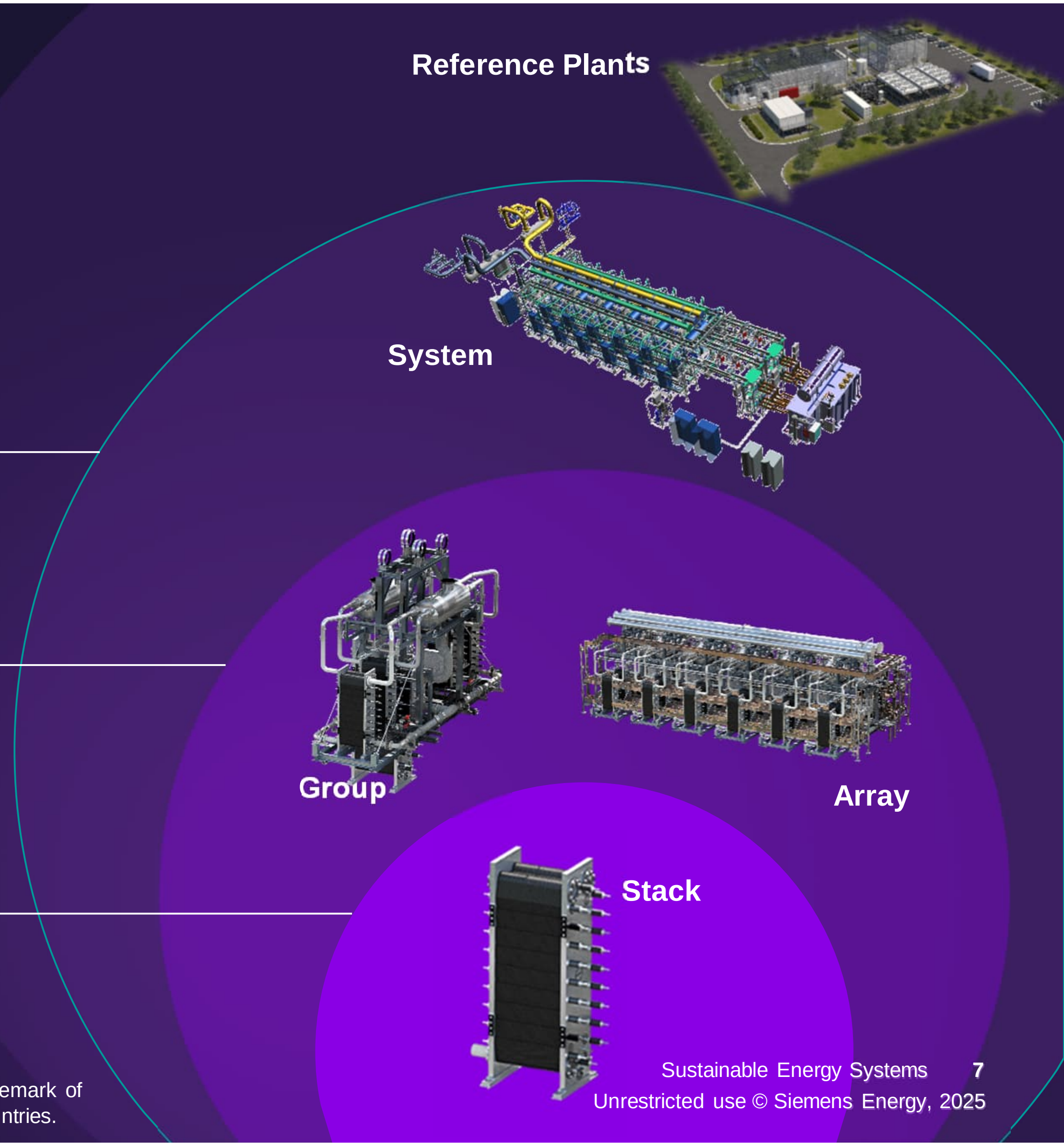
- Minimize on-site installation
- Maximum of standardization by defined interfaces
- Build to print pre-engineered

Localized decentral packaging

- High quality by pre-assembling
- Transportable units
- Strong local content

Cost efficient central stack factory

- High level of Automatization
- Large quantities and strong supply chain management
- Strong partner relation of key components



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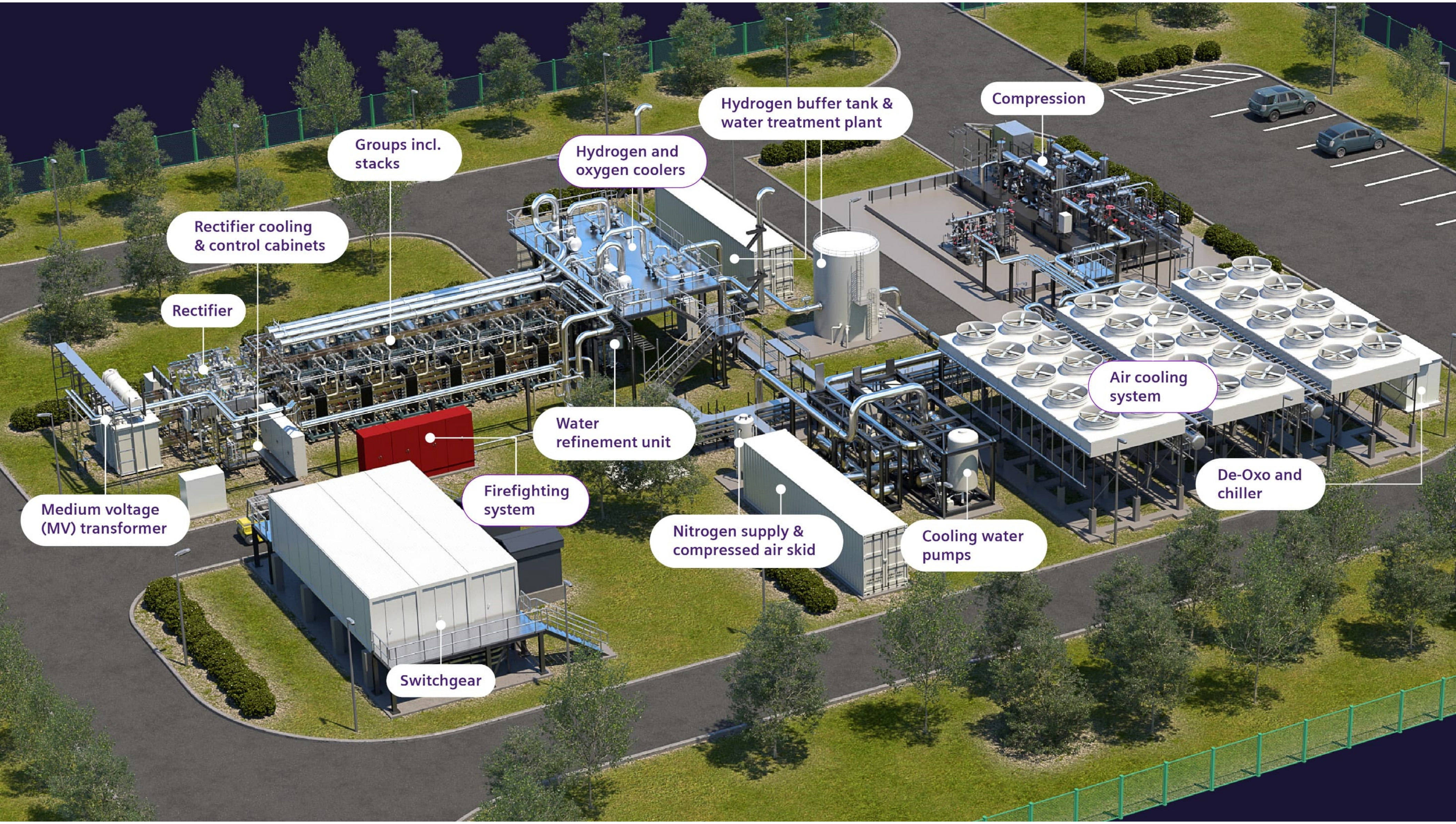


Groups incl. stacks
Rectifier cooling & control cabinets
Rectifier
Medium voltage (MV) transformer
Hydrogen and oxygen coolers
Hydrogen buffer tank & water treatment plant
Compression
Water refinement unit
Firefighting system
Switchgear
Nitrogen supply & compressed air skid
Cooling water pumps
Air cooling system
De-Oxo and chiller

HARU ONI PILOT PROJECT

First integrated plant for climate-neutral e-fuel production from wind and water

SIEMENS energy

750,000 liters

of e-methanol per year from 2023
(130,000 liters of e-gasoline)

Project

Customer:	HIF (Highly Innovative Fuels)
Off-taker:	Porsche AG
Country:	Chile, Patagonia
Installation:	2022
Product:	Power-to-methanol solution based on SE Electrolyzer

Use cases

E-Fuel for Porsche cars

Potential for adding Kerosene or Diesel production in future phases

Methanol for ship motors

Challenge

- Huge wind energy potential in Magallanes
- Existing industry and port infrastructure

→ Perfect conditions to export green energy from Chile to the world

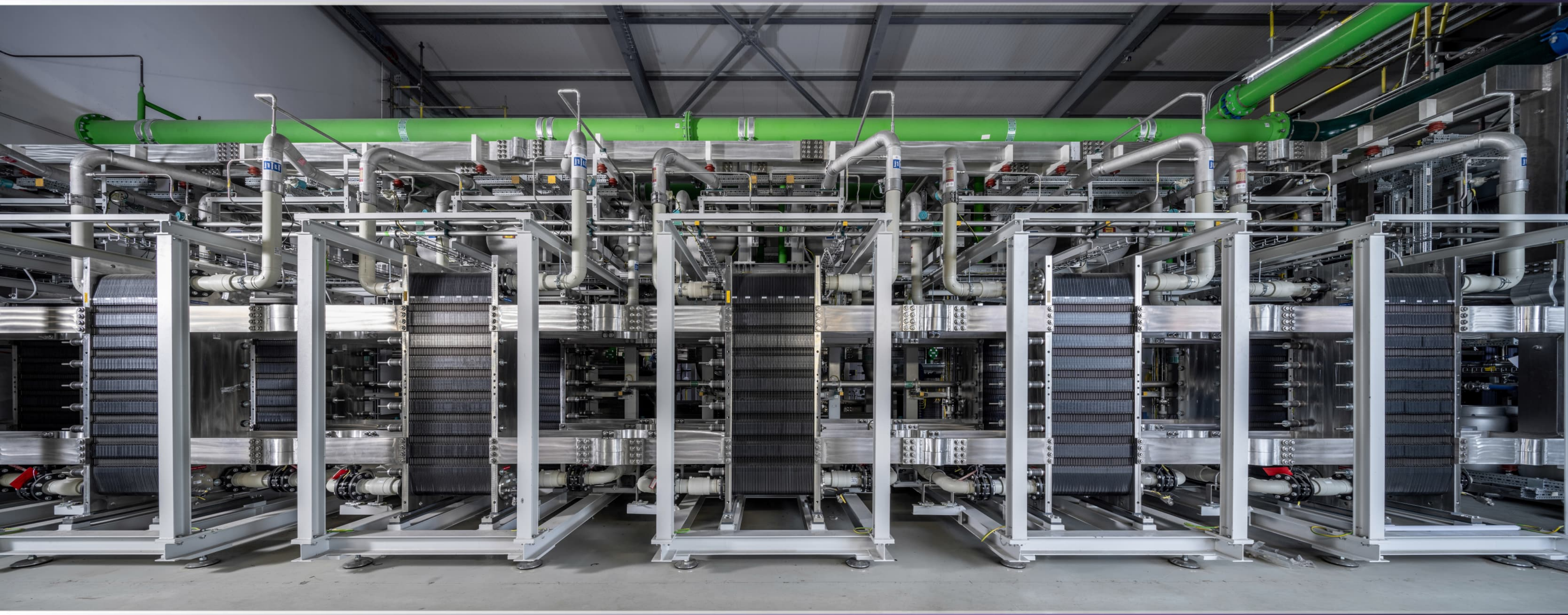
Solutions

- Production of e-gasoline and e-methanol at one of the best spots worldwide for wind energy
- Co-developer Siemens Energy realizing the system integration from wind energy to e-fuel production
- International Partners like Porsche and AME

Supported by:
Federal Ministry for Economic Affairs and Energy
on the basis of a decision by the German Bundestag

March 2025

BASF Hy4Chem, Ludwigshafen:
3x Elyzer P-300 (52.5 MW)
Just went into operation in March ‘25



50 MW

Power demand based on Elyzer P-300[1]

1000 kg

of green hydrogen per hour

March 2025

KASSØ POWER-TO-X
First large-scale e-Methanol project in Europe

Project

- Partner: Solar Park Kassø ApS (100% owned by European Energy)
- Country: Denmark
- Site: Kassø Solar Park
- Installation: expected 2024
- Commercial operation: expected 2024
- Product: Elyzer P-300[1]

Use cases

Hydrogen for e-Methanol (MAERSK)

Hydrogen for fuel blending (Circle K)

Challenge

- Fast track project (bid and execution)
- First 3 Array plant
- First large-scale e-Methanol plant build by customer

Solutions

- 3 full Arrays Elyzer P-300[1]
- Transformers, rectifiers, Arrays and demin water plant. T3000 automation for Elyzers
- Supervision for installation, commissioning by SE Denmark
- Powered by largest solar park in Scandinavia

1 The product name was changed from Silyzer 300 to Elyzer P-300. It is a trademark of Siemens Energy GmbH & Co. KG or its affiliates registered in one or more countries.

Projects on Elyzer P-300 platform

Scale-up is happening

SIEMENS energy

6 MW

H2Future Linz

- Green hydrogen for the steel making process
- Our partners: VERBUND, voestalpine, Austrian Power Grid (APG), TNO, K1-MET

OPERATIONAL SINCE 11/2019

8.5 MW

WUNH2 Wunsiedel

- Green hydrogen for industry, grid services and mobility
- Our partners: Siemens AG, WUNH2, SWW Wunsiedel GmbH

OPERATIONAL SINCE 09/2022

up to **20 MW**

Trailblazer Oberhausen

- Green hydrogen for Air Liquide pipeline infrastructure
- Our partner: Air Liquide

OPERATIONAL SINCE 08/2024

50 MW

e-Methanol Kassø

- Green hydrogen for CO_2-neutral shipping at large-scale
- Our partner: European Energy

OPERATIONAL IN 04/2025

54 MW

Hy4Chem-El Ludwigshafen

- Hydrogen as feedstock for chemical plant to produce e.g. ammonia, methanol or vitamins
- Our partner: BASF

OPERATIONAL SINCE 03/2025

200 MW

NormandHy Le Havre

- Green hydrogen as feedstock for refinery
- Our partner: Air Liquide

IN EXECUTION

280 MW

Clean H_2 Coast-line, Emden

- Green hydrogen for steel industry in northern Germany
- Our partner: EWE

IN EXECUTION

100 MW

Green Hydrogen Hub, Hamburg

- Green hydrogen for various industry off-taker around Hamburg
- Our partners: Hamburg Green Hydrogen Hub with Luxcara and Hamburger Energiewerke

IN EXECUTION

up to **200 MW**

ELYgator Rotterdam

- Green hydrogen for various industry and mobility off-taker in Maasvlakte, Netherlands
- Our partner: Air Liquide

IN EXECUTION

Digital value add through data collection and enhanced processing

Data collection of fleet & manufacturing

Project Sites in operation (selected number shown)

Future project sites (exemplary)

Gigafactory Berlin (stack manufacturing data)

For Electrolyzers

>300.000
accumulated operating hours worldwide[2]

Longest running Stack with
>40.000 operating hours

Data collection & processing

>110
outages performed

Monitor

What is the current status of your plant? Enable predictive maintenance and plant optimization

Improve

Optimize operations to optimize costs, cash flow and minimize degradation? How can the performance be improved?

Plan & Predict

When does the system need to be serviced? When does a stack need to be exchanged?

*OH: operating hours

Siemens Energy
The right partner to lead green hydrogen solutions

Proven industrial-grade large-scale electrolyzer systems
>300,000 OH in commercial operation in MW range

Scalable solutions
Pre-fabricated and pre-engineered packages

Energy Consulting & Digital Services
H_2 value chain design and optimization

Siemens Energy green hydrogen solutions

Fully integrated solutions
from green electrons to green molecules with our strong partner ecosystem

Global G2M setup and customer domain know-how
configuration of industry-specific solutions

Reliable technology and reliable partner
with highest standards in safety and project excellence

Explore the potential of green hydrogen

Green Hydrogen Production Website
www.siemens-energy.com/electrolyzer

Haru Oni App
www.haruoni.com

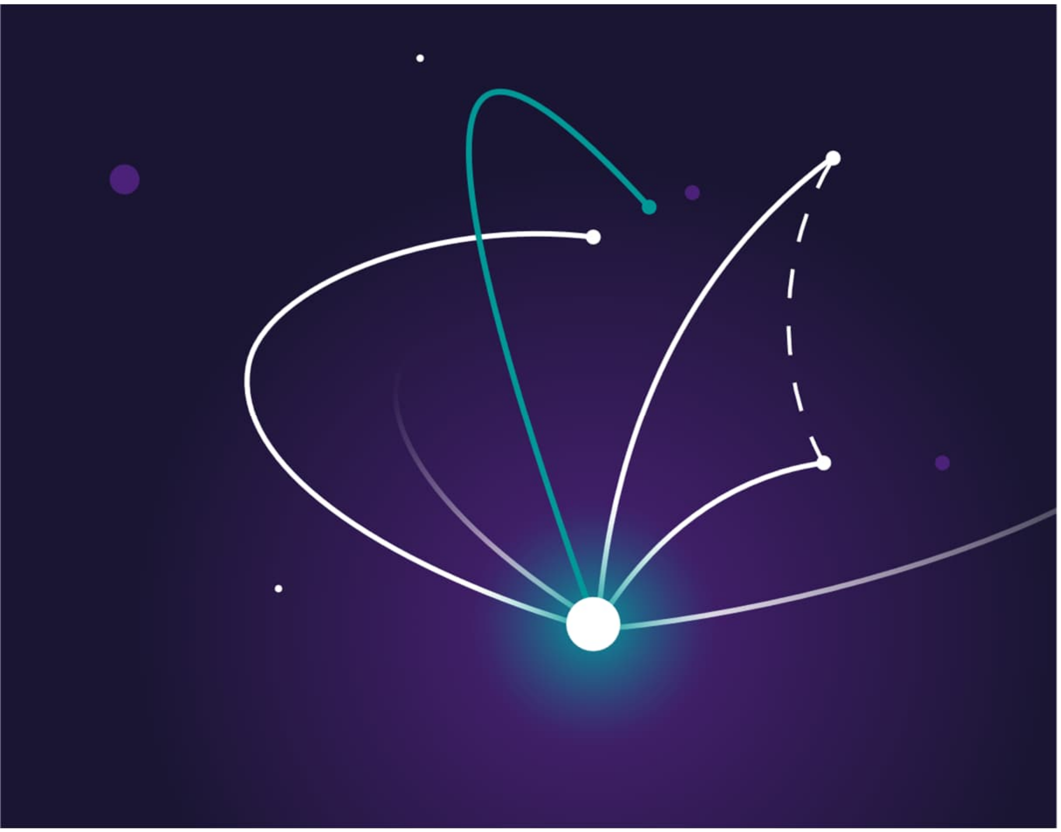
Haru Oni Project Website
Haru Oni hydrogen plant | 2021 | Siemens Energy Global (siemens-energy.com)

ESD Website
Energy System Design | Power plant solutions | Siemens Energy Global

Hybrid Power Solutions Website
Hybrid power solutions | Power plant solutions | Siemens Energy Global

Hydrogen Website
Hydrogen | Future Technologies | Siemens Energy Global

Contact page



Published by Siemens Energy

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Disclaimer

SIEMENS energy

NCPA – Lodi Hydrogen Co-Firing

Pathway to H2 Operation at Lodi Energy Center

March 25, 2025

Siemens Hydrogen Gas Turbine Portfolio

The mission is to burn 100% hydrogen

SIEMENS energy

	Gas turbine model	Power Output[1]	H_2 capabilities in vol. %	100% H_2 flow*	30% H_2 flow*
50Hz	SGT5-9000HL	595 MW	50	41512 kg/h	4748 kg/h
50Hz	SGT5-8000H	450 MW	30	32767 kg/h	3748 kg/h
50Hz	SGT5-4000F	329 MW	30	24073 kg/h	2753 kg/h
50Hz	SGT5-2000E	187 MW	30	15370 kg/h	1758 kg/h
60Hz	SGT6-9000HL	440 MW	50	30556 kg/h	3495 kg/h
60Hz	SGT6-8000H	310 MW	30	23020 kg/h	2633 kg/h
60Hz	SGT6-5000F	215 to 260 MW	30 / 45	19500 kg/h	2230 kg/h
60Hz	SGT6-2000E	117 MW	30	9915 kg/h	1134 kg/h
50Hz or 60Hz	SGT-800	48 to 62 MW	75	4539 kg/h	519 kg/h
50Hz or 60Hz	SGT-750	40/34 to 41 MW	40	2936 kg/h	336 kg/h
50Hz or 60Hz	SGT-700	33/34 MW	75	2760 kg/h	316 kg/h
50Hz or 60Hz	SGT-A35	27 to 37/28 to 38 MW	15 / 100	2530 kg/h	289 kg/h
50Hz or 60Hz	SGT-600	24/25 MW	75	2151 kg/h	246 kg/h
50Hz or 60Hz	SGT-400	10 to 14/11 to 15 MW	10 / 65 / 100 Hyflex Power	1214 kg/h	139 kg/h
50Hz or 60Hz	SGT-300	8/8 to 9 MW	30	774 kg/h	89 kg/h
50Hz or 60Hz	SGT-100	5/6 MW	30 / 65	515 kg/h	56 kg/h
50Hz or 60Hz	SGT-A05	4 to 6 MW	2 / 15	524 kg/h	60 kg/h

Values shown are indicative for new unit applications and depend on local conditions and requirements. Capability to operate on 100% natural gas is maintained (full fuel flexibility). Some operating restrictions/special hardware and package modifications may apply.

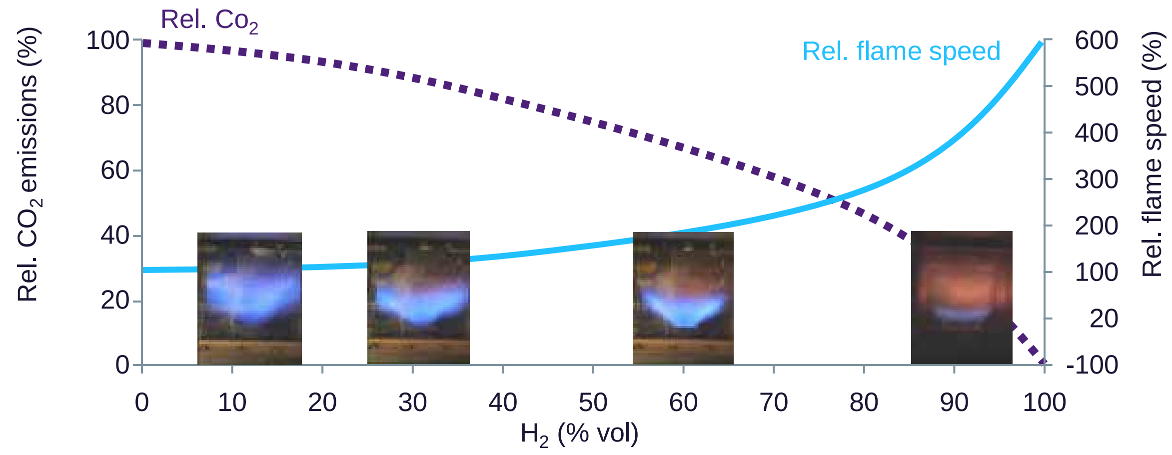
Higher H_2 contents to be discussed on a project specific basis

DLE burner · WLE burner · Diffusion burner with unabated NOx emissions · **1** ISO, Base Load, Natural Gas; Version 5.1, May 2021 · 2) Compared with 100% natural gas operation

Heavy-duty gas turbines · Industrial gas turbines · Aeroderivative gas turbines · In Validation · *** Approximate values, Site and Frame Specific Supply rates will vary**

Hydrogen does not produce CO_2 emissions, but challenging physical properties require rapid design and testing cycles

SIEMENS energy



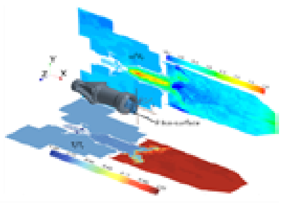
Values shown are relative to natural gas (indicative only)

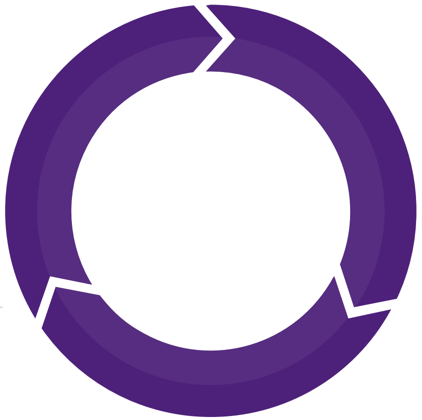
Challenges

- **H2 embrittlement** requires upgrade to stainless steel materials
- **Lower volumetric energy content** requires larger flows to be handled by fuel system
- **Higher diffusivity** requires changes/re-certification of sealing and flanges
- **Higher reactivity and flame velocity** pushes flame towards burner and increases risk of explosion or flashback
- **Higher flame temperature** can lead to local hotspots if imperfectly mixed and thus increased NOx emissions

1. High fidelity CFD
High fidelity CFD tools like LES can provide automated optimized designs

2 Rapid prototyping using AM
Additive manufacturing reduces lead time and enables better designs

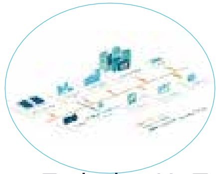




3. High-pressure testing at engine conditions
High-pressure burner tests combined with full engine tests

Combustion Test Center in Berlin

Burner Tests



Zero Emission H_2 Test center (Finspong)

Engine Tests

Hydrogen as a Gas Turbine Fuel

SIEMENS energy

100% H_2 DLE requires extensive combustion technology developments.
0%-100% H_2 in Natural Gas DLE was demonstrated in SGT-400 in 2023.

2004

SGT6-4000F
Burner Rig-Tested up to 40% H_2

SGT-5000F
Modified Burner Rig-Tested with up to 30% H_2

H_2-DOE Program
Focusing on LGT combustion technology, 2005 – 2015

SGT-8000H
Modified Burner Rig-Tested up to 40% H_2

BMWI Program
Focus on High Temperature Combustion with H_2, 2006 – 2009

SGT-9000HL
Combustion Technology tested for H_2 admixtures

2012

SGT-2000E
Modified Burner Rig-Tested up to 40% H_2

SGT-200
H_2 Engine Tests

2011

A45, A65
Atmospheric Combustion Tests up to 100% H_2

SGT-400
Continuous operation on coke oven gas >60%H_2

2008

DLE Technology development for Industrial Gas Turbines
Atmospheric and high pressure tests for Industrial Gas Turbines

SGT-700
First H_2 Tests in Full Engine Setup

SGT-700
Continuous Operation since Sept. 2014 (10% H_2)

SGT-800
50% H_2 admixture at Base Load

2018

SGT-600
Up to 80% H_2 admixture in Full Engine Test

2019

Start of cross-frame technology development for 0-100% H_2 GTs

100% H_2
In Full Pressure Combustion Test at CEC Test Center for SGT-600

DLE Technology for High Temperature Combustion
Extending technology towards 100%-H_2

2023

100% H_2 in an SGT-400 Industrial Gas Turbine
HYFLEXPOWER
Using Dry Low Emission Technology

Prototype applications
First customers for 100%-H_2 in Industrial Gas Turbines expected mid-late 2020s

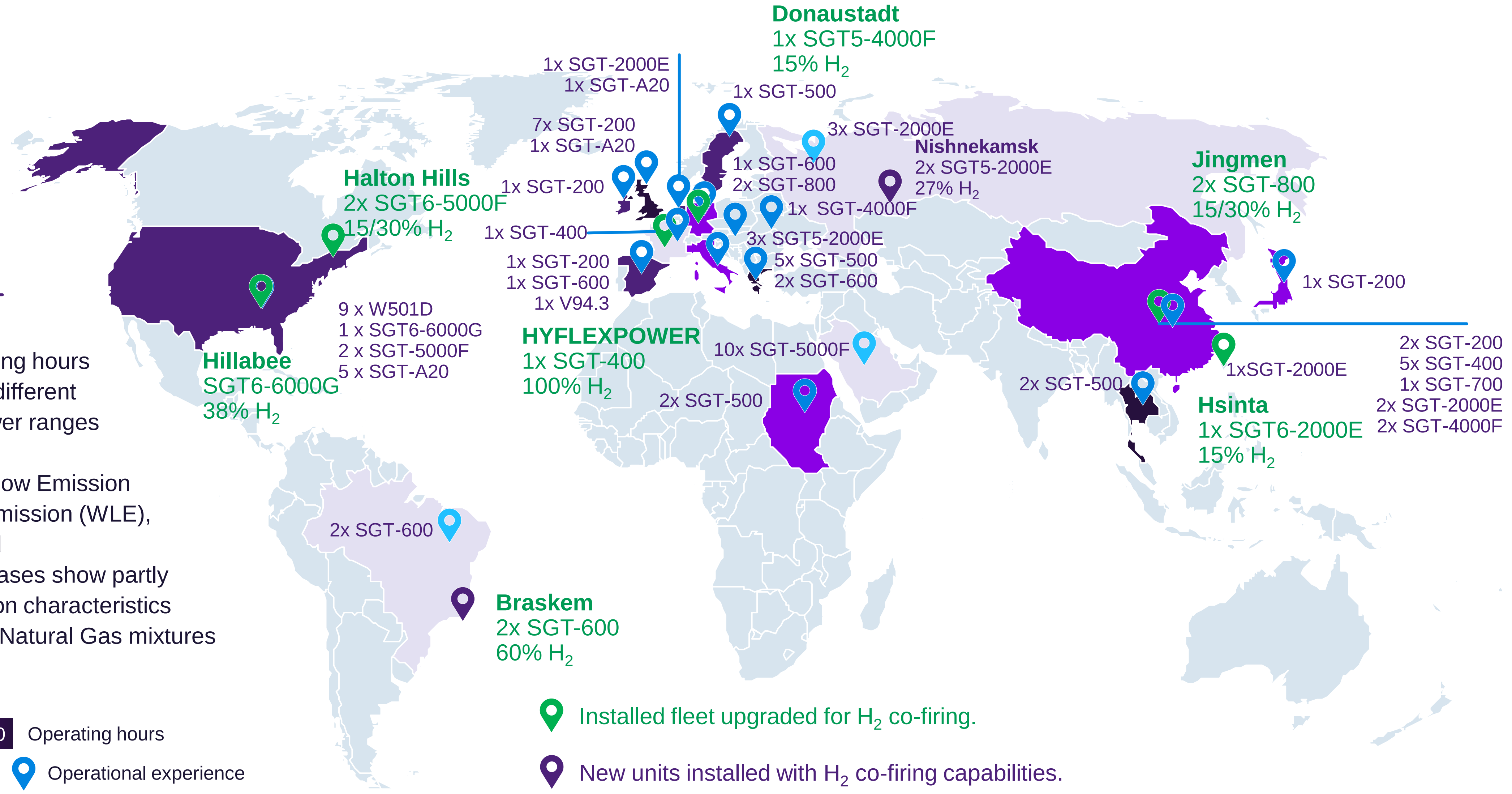
100% H_2 in Heavy-Duty and Industrial Gas Turbines Using Dry Low Emission Technology

100% **Green Gas Turbines**

20 Mar 2024

World fleet experience on H_2 and H_2 syngases

- Over **56 units and 2.5 million** operating hours worldwide across different industries and power ranges since **1979**
- Combustion: Dry Low Emission (DLE), Wet Low Emission (WLE), Diffusion unabated
- Note: H_2-rich syngases show partly different combustion characteristics compared with H_2-Natural Gas mixtures



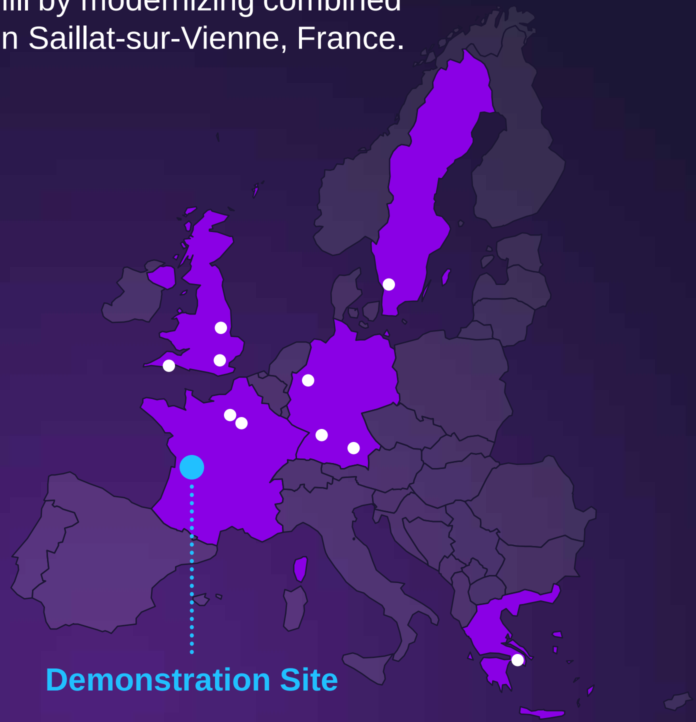
HYFLEXPOWER Project
Introduction

Smurfit Kappa SGT-400 Cogeneration Plant
Saillat-sur-Vienne, France

- Siemens Energy led consortium with Project funding of €15.2 m
- Project Start: May 1, 2020 – Duration: 4 years
- Partners include: Engie Solutions, Centrax Ltd., Siemens Energy, Arttic, German Aerospace Center. Universities: Duisburg-Essen, Lund-Sweden, University College London, National Technical University of Athens

World-first demonstration of a **power-to-H_2-to-power path for CO_2-free** power generation pilot including an advanced **H_2 gas turbine**

Decarbonizing papermill by modernizing combined heat and power plant in Saillat-sur-Vienne, France.

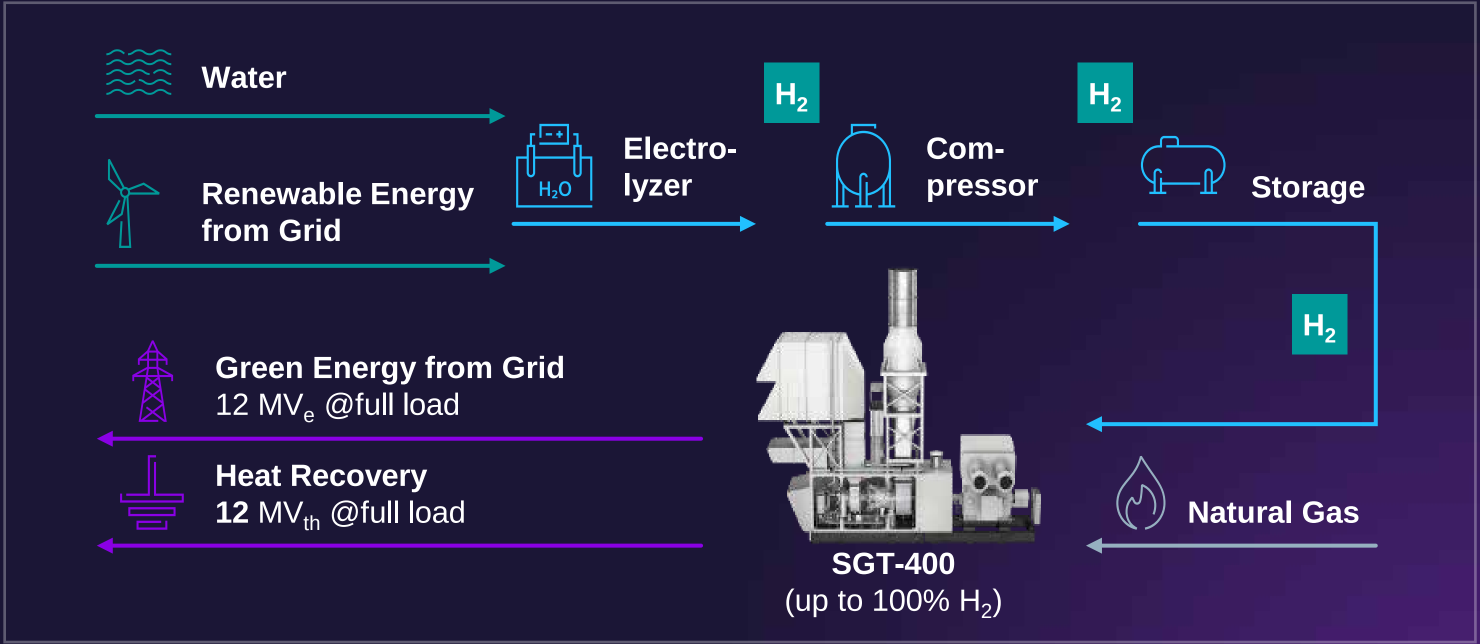


Customer, academia and OEM formed strong consortium demonstrating CO_2-free power generation

HYFLEXPOWER has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 884229

http://www.hyflexpower.eu/

Advanced Power-to-H_2-to-Power Plant Concept
Overview



2021

Installation of the **H_2 production, storage** and supply facility at site

2022 | 30% H_2

Initial demonstration of **advanced plant concept** with NG/H_2 mixtures

2023 | 100% H_2

Pilot up to **100% H_2 for carbon-free energy production** from stored excess renewable energy (CO_2 saving 65,000t/yr.)*

Objective and Impacts

- Industrial scale power-to-H_2-to-power solution pilot
  - Importance of H_2 as long-term energy storage technology on high renewable grid
  - Utilization of existing assets to produce green energy and process heat
- Validation of SGT-400 dry low emissions high H_2 technology with up to 100% H_2
- Economic, environmental and social assessments for business case evaluation, carbon footprint and policy recommendations

* Calculated result for base-load operation; actual results may vary

9000HL for Mission H_2 Power

Finlay McCutcheon, Managing Director of SSE Thermal, said: *"… bold action which is why we're entering into this* ***collaboration with Siemens Energy****, a long-standing partner of SSE. We know hydrogen-fired power stations will be an essential element of the energy mix in a* ***net zero world and Mission H2 Power*** *… ."*

Sarah Jones, Minister for Industry, said: *"We want the UK to be a global* ***leader on hydrogen****. This* ***partnership by SSE and Siemens Energy*** *takes us another step towards that ambition. ."*

SSE and Siemens Energy announce hydrogen power partnership

2025 → 2030

Collaboration announced to deliver large-scale gas turbine technology **capable of running on 100% hydrogen**

Testing of 100% hydrogen capability to take place at Siemens Energy's **Clean Energy Centre**

Project focused on 9000HL gas turbine and supports the **UK´s net zero decarbonisation efforts**

For more information please visit: [SSE and Siemens Energy announce hydrogen power acceleration partnership]

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Project Overview / Benefits / Schedule

Project Overview

- Blending Skid
- Hydrogen Production Facility
- Hydrogen Storage Facility
- Interconnecting Pipeline
- Transmission Interconnection Facilities

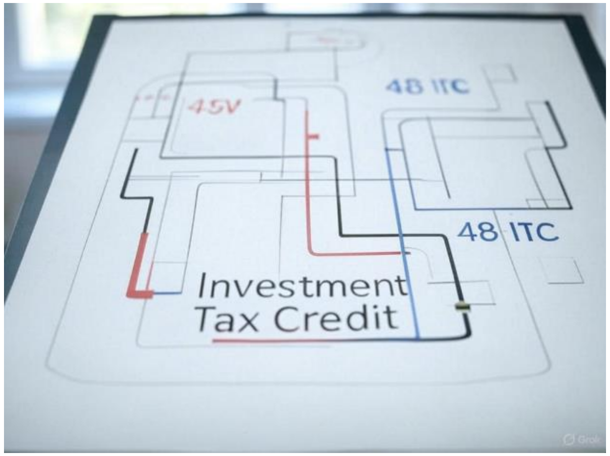
Project Benefits

- Carbon Free Combustion
  - Reduced GHG Offset Purchases
- Energy Storage
  - Hedge to solar purchase
- Repurpose existing assets
- System Reliability
- Diversification of Resources
- Clear backup strategy
- Transfer to transportation
- Less waste over time

Project Risks

- Administration Changes
  - Hydrogen Hub
  - 45V continuation and carbon intensity
- CAISO treatment
  - TAC
- Regulatory Treatment
  - RPS and RECs vs New Carbon-free discussions
  - Power Content Labels

Attempting to Connect the Dots



- Projects cannot receive both 45V and ITC
- 45V seems to draw fence around production facilities, i.e., electrolyzers and carbon capture
- ITC seems to recognize hydrogen storage

Why It's Important

- Project Cost $225M
- $35M Hydrogen Hub Grant (net $190M)
- 50% Production 50% Storage
- $95M Each Project
- 30% ITC for Storage ($28.5M)
- Project Net $161.5M

- These are estimated costs splits and the project has not been optimized.

Schedule

- PPC Approval July 2025
  - Flexible, pending results of outstanding items
- Early activities include
  - Interconnection Study
  - CEQA / NEPA
  - Engineering
- Commercial Operation
  - January 2029
  - 1:1 slip based on actual start date

Tax Credits Highlights 3/25/25 -- I

- Credits are a subsidy that is realized through tax savings
- *Producing Hydrogen*: There's a production tax credit (PTC) based on production of kg of Hydrogen (up to $3) or an investment tax credit (ITC) based on the cost of the facility (up to 30%). Cannot claim both.
- Use GREET (Greenhouse gases Regulated Emissions and Energy use in Technology) or petition DOE to use PER (Provisional Emissions Rate) to establish greenhouse gases
- The credits are scaled back based on greenhouse gas emissions and whether you pay prevailing wages for construction, additions and repairs. Speical rules for blending
- "3 Pillars" – Incrementality, temporal matching, geographic correlation. Special rules for Qualifying States (CA and WA). Use EACs/RECs, but cannot double count

Forrest Milder, Nixon Peabody, fmilder@nixonpeabody.com, 617-824-0803

Tax Credits Highlights 3/25/25 – II

- Credits can be "monetized" with
  - Direct pay (governments and tax-exempts)
  - Partnership allocations
  - Sales of credits
- Begun construction can be important because it locks in statutory provisions and GREET model.
- *Storing Hydrogen*: Storage is entitled to a 30% ITC with potential increases for domestic content and energy communities. Liquification and pipes are eligible for the credit, but not transportation
- Political concerns –
  - Administrative or congressional scale back
  - Congress can review IRS's regulations

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NCPA
NORTHERN CALIFORNIA POWER AGENCY

Project Challenges

March 25, 2025

LEC Hydrogen Workshop

Topics for Discussion

- ARCHES and Hydrogen Hub Funding
- 45V Eligibility
  - What is it, how does it work, potential benefits
- CAISO / PG&E
  - Market participation
  - Transmission Access Charge
  - Interconnection
- RPS and REC Eligibility
- Tax Incentives
  - Plant vs. Storage Equipment

ARCHES and Hydrogen Hub Funding

- Key Question: Will the LEC Hydrogen project be eligible for Hydrogen Hub Funding?
- Alliance for Renewable Clean Hydrogen Energy Systems (ARCHES) background
- NCPA's role in ARCHES
- Status of Hydrogen Hub Funding
- LEC Hydrogen Project Eligibility
- Next Steps

Clean Hydrogen Production Tax Credit

The Section 45V Clean Hydrogen Production Tax Credit, established by the Inflation Reduction Act, offers a credit of up to $3 per kilogram of qualified clean hydrogen produced, with the amount varying based on the lifecycle greenhouse gas emissions of the production process.

Credit Amount:

The credit is a tiered system, with the highest credit available for hydrogen produced with very low lifecycle greenhouse gas emissions (less than 0.45 kg CO2e per kg of hydrogen), reaching $3.00/kg.

Lifecycle Emissions:

The credit is tied to the lifecycle greenhouse gas emissions of the hydrogen production process, measured using the 45VH2-GREET model.

Qualifying Facilities:

The credit applies to clean hydrogen produced at qualified clean hydrogen production facilities, which must be placed in service after December 31, 2022, and before January 1, 2033.

Clean Hydrogen Production Tax Credit

10-Year Period:

The credit is available for 10 years from the date the qualifying facility is placed in service.

Prevailing Wage and Apprenticeship Requirements:

Meeting prevailing wage and apprenticeship requirements can increase the credit value.

45VH2-GREET Model:

The Department of Energy (DOE) developed a specific version of the GREET model (45VH2-GREET) to assess the lifecycle emissions of hydrogen production.

Multiple Hydrogen Production Methods:

Several methods of clean hydrogen production can qualify, including electrolysis using low-carbon electricity and certain carbon-based production methods with carbon capture and storage.

Upstream Emissions:

The 45V credit considers upstream emissions, including emissions from the electricity used in the production process.

Clean Hydrogen Production Tax Credit

Renewable Energy Certificates (RECs):

Hydrogen producers using electricity from power plants for which they buy RECs or similar "energy attribute certificates" (EACs) will be treated as using electricity from those power plants for emissions tracking purposes.

Anti-Abuse Rule:

The final regulations contain an "anti-abuse" rule, preventing the credit from being granted if the sale or use of qualified clean hydrogen is primarily for the purpose of obtaining the credit in a wasteful manner.

Treasury Department Guidance:

The U.S. Department of the Treasury released final rules for the 45V clean hydrogen production tax credit on January 3, 2025.

Key Dates:

- **Facilities Placed in Service:** After December 31, 2022, and before January 1, 2033.
- **Construction Start:** Projects must be under construction by the end of 2032 to qualify.
- **Credit Period:** Available for 10 years from the date the qualifying facility is placed in service.
- **Final Regulations Released:** January 3, 2025.

CAISO / PG&E Project Challenges

- Key Questions:
  - What is the LEC Hydrogen project, storage or load?
  - How will the project be interconnected to the grid?

- Does the LEC Hydrogen project qualify as storage per the CAISO Tariff?
  - Based on the current CAISO Tariff requirements, the LEC Hydrogen project does not currently count as storage
    - Storage is defined as being a facility that charges and discharges energy at a single point of interconnection
  - Key objective: avoid Transmission Access Charge (TAC); storage is not subject to TAC when charging from the grid

CAISO / PG&E Project Challenges

- LEC Hydrogen project as load
  - Wholesale load in PG&E System?
  - Participate in CAISO market as Participating Load?
- Participating Load
  - Eligible to submit Bids for supply of energy and ancillary services
  - Subject to Participating Load Agreement
  - Eligible for nodal settlement
- Subject to PG&E interconnection process
- Subject to TAC

CAISO / PG&E Project Challenges

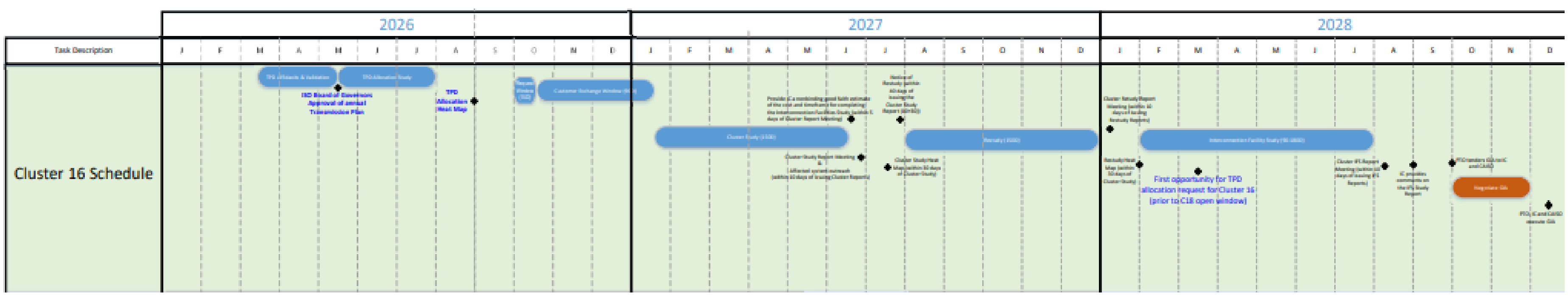
- Qualifying the LEC Hydrogen project as storage
- Annual policy initiatives roadmap process – 2024
  - NCPA submitted request to qualify the LEC Hydrogen project as storage
  - Link to presentation: NCPA Presentation
- Result, project placed in Demand and distributed energy market integration stakeholder initiative

Potential working group topics for scoping include 2024 Policy Catalog items

2024 Catalog Submission Title	Submitted by
Real-time load bidding	California Department of Water Resources
RDRR minimum on time and fixed cost dispatch	California Large Energy Consumers Association
Modified PDR – hybrid PDR with BTM storage	Joint Demand Response Parties
Revision of DR control group settlement methodology	Pacific Gas & Electric
PDR program enhancements	PacifiCorp, Portland General Electric, NV Energy
Evaluating and addressing market rule inconsistency among 5/15/60 min bid options for DR resources	Southern California Edison
Remove RDRR discrete dispatch limit of 100 MW	Southern California Edison
Hydrogen electrolyzer market participation	Northern California Power Agency
DERs for external BAAs	Sacramento Municipal Utility District

CAISO / PG&E Project Challenges

- Interconnection
  - If the LEC Hydrogen project is storage, then it will need to seek interconnection via the CAISO generator interconnection process
  - Cluster 16 Schedule



CAISO / PG&E Project Challenges

- Interconnection
  - If the LEC Hydrogen project is not storage, but rather load, it will need to seek interconnection via the PG&E Wholesale Transmission Service (WDAT) Tariff
  - Key objective: interconnected the LEC Hydrogen project as a wholesale load or defined market participant
  - Ensure the LEC Hydrogen project can transact directly in the CAISO; eligible for wholesale settlements (LMP pricing)

Study Process	Eligibility	Studies	Timelines	Process Costs	Deliverability Eligibility
Application Fee	**All generator interconnection requests**	All	N/A	$800 (non-refundable)	N/A
Fast Track (FT)	**Rule 21:** no size limit for Fast Track **WDT Gen:** Certified, Advisory limit of 2MW on 12kV and 3MW on 21kV	Initial Review (IR) & Supplemental Review (SR)	IR — 15 BD SR — 20 BD	**Rule 21:** Nonrefundable fee **WDT**: IR: $1,000 study deposit SR: $2,500 deposit	Energy Only
Independent Study Process (ISP)	Must pass both EIT screens: **Rule 21:** no size limit but, given current programs, rare to *exceed* 20MW **WDT Gen:** No size limit	System impact Study (SIS) & Facilities Study (FAS)	SIS— 60 BD FAS — 60 BD	**For 5MW or less:** SIS - $10K deposit and FAS - $15K deposit **For >5MW:** $50K + $1K/MW up to $250K	**Rule 21:** Energy Only **WDT:** Energy Only or Full Capacity
Distribution Group Study Process (DGSP)	Must pass Transmission EIT Screen **Rule 21:** no size limit but, given current programs, rare to *exceed* 20MW **WDT Gen:** No size limit	Phase I Study & Phase II Study	Phase I – 60 BD Phase II – 60 BD	**For 5MW or less:** Ph. I -$10k; Ph. II - $15k **For >5MW:** Ph. I & Ph. II: $50K + $1K/MW up to $250K	**Rule 21:** Energy Only **WDT:** Energy Only or Full Capacity
Cluster Study Process (CSP)	For projects that fail EIT Transmission screen. **Rule 21:** N/A; Use WDT process. **WDT Gen:** No size limit	Phase I Study & Phase II Study	Phase I — 170 CD Phase II — 205 CD	$50K + $1K/MW up to $250K	**Rule 21=** Go to **FERC** process **WDT:** Energy Only or Full Capacity
Deliverability Study Options					
Full Capacity Deliverability Study (FCDS)	**Rule 21:** Not eligible. **WDT Gen:** Any ISP, DGSP, or CSP wholesale project	Phase I Study & Phase II Study	Phase I – 170 CD Phase II – 205 CD	$50K + $1K/MW up to $250K	**N/A**
Distributed Generation Deliverability (DGD)	**Rule 21:** Exporting projects only **WDT Gen:** Any active wholesale project	Single application and project review to determine allocation, if any	When offered, process is about 3 months from application to result	Free	**N/A**

CAISO / PG&E Project Challenges

Resource Type	2026**	2027**	2028**	2029**	2030	2035	2040	2045
Natural Gas		19.00						
Geothermal								
Biomass								
Hydrogen Conversion								
Hydrogen Storage		60.00						
Wind-NorCal								
Wind-SoCal								
Wind-WY								
Wind-PNW								
Wind-ID								
Wind-NM								
Offshore Wind								
Solar-NorCal			150.00					
Solar-SoCal								
Li-ion Battery (4 hr)			150.00	200.00				
Li-ion Battery (8 hr)								
Pumped Hydro Storage (12 hr)								
Other LDES (8-24 hr)*								
Shed Demand Response								
Gas Capacity Not Retained								
Total								

* Long-duration energy storage (LDES) technologies include Flow Batteries (8 hr) and Compressed Air Energy Storage (24 hr)
** If there is planned resources in the early years before 2030, please also include a separate Resources by Substation tab for each year

CAISO / PG&E Project Challenges

California ISO **Points of interconnection heatmap**

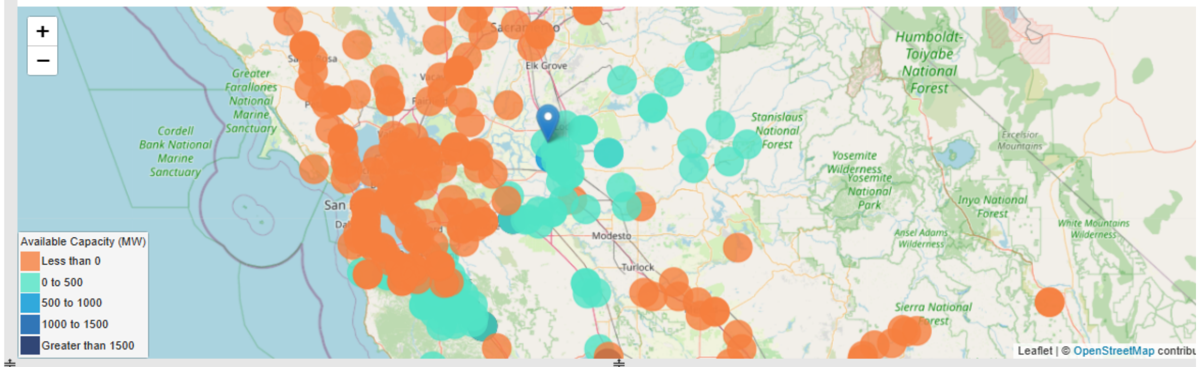
Scenario: 2024_TPD

MW Injection: 0

Point of Interconnection — X Clear table filters

Substation	KV	Available ...	PTO	Study Area
KELSO 230 kV	230	0.00	PG&E	PG&E GBA
LAS POSITAS 230 kV	230	0.00	PG&E	PG&E GBA
EIGHT MILE 230 kV	230	186.63	PG&E	PG&E GBA
NEWARK DIST 230 kV	230	0.00	PG&E	PG&E GBA
SAN FRAN Z (EMBA...	230	0.00	PG&E	PG&E GBA
EGBERT 230 kV	230	0.00	PG&E	PG&E GBA
SAN FRAN H (MARTI...	230	0.00	PG&E	PG&E GBA
SAN FRAN A (POTRE...	230	0.00	PG&E	PG&E GBA
SAN MATEO 230 kV	230	0.00	PG&E	PG&E GBA
RAVENSWOOD 230 ...	230	0.00	PG&E	PG&E GBA
RAVENSWOOD 115 ...	115	0.00	PG&E	PG&E GBA
HUMBOLDT 115 kV	115	0.00	PG&E	PG&E NGBA
BRIDGEVILLE 115 kV	115	0.00	PG&E	PG&E NGBA
JANES CREEK 60 kV	60	0.00	PG&E	PG&E NGBA
ARCATA 60 kV	60	0.00	PG&E	PG&E NGBA
FAIRHAVEN 60 kV	60	0.00	PG&E	PG&E NGBA
HUMBOLDT 60 kV	60	0.00	PG&E	PG&E NGBA
HARRIS 60 kV	60	0.00	PG&E	PG&E NGBA
EUREKA E 60 kV	60	0.00	PG&E	PG&E NGBA
MAPLE CREEK 60 kV	60	0.00	PG&E	PG&E NGBA
HUMBOLDT BAY PP ...	60	0.00	PG&E	PG&E NGBA
BRIDGEVILLE 60 kV	60	0.00	PG&E	PG&E NGBA
GARBERVILLE 60 kV	60	0.00	PG&E	PG&E NGBA

Auto Re-Center Enabled



Substation: EIGHT MILE 230 kV

Monitoring Facility	Contingency	Available ...	Dfax	MW Impact	%Loading (before)	%Loading (after)
30622 EIGHT MI 230 30495 STAGG-J1 23...	Contingency 36	186.63	0.5699	0	**72.61**	**72.61**
30622 EIGHT MI 230 30624 TESLA E 230 ...	Contingency 22	205.46	0.6135	0	**65.91**	**65.91**
30622 EIGHT MI 230 30495 STAGG-J1 23...	Base Case	325.68	0.3244	0	**67.85**	**67.85**
30496 STAGG-H 230 30497 STAGG-F 230 ...	Contingency 36	373.90	0.5699	0	**55.42**	**55.42**
30497 STAGG-F 230 30498 STAGG-D 230 ...	Contingency 36	429.97	0.5699	0	**48.73**	**48.73**
30622 EIGHT MI 230 30624 TESLA E 230 ...	Base Case	529.19	0.4010	0	**32.23**	**32.23**
30489 STAGG-J2 230 30624 TESLA E 230 ...	Contingency 36	564.67	0.5360	0	**22.07**	**22.07**
30496 STAGG-H 230 30497 STAGG-F 230 ...	Base Case	845.44	0.3244	0	**42.63**	**42.63**
30495 STAGG-J1 230 30496 STAGG-H 23...	Contingency 36	904.29	0.5699	0	**35.33**	**35.33**
30497 STAGG-F 230 30498 STAGG-D 230 ...	Base Case	943.96	0.3244	0	**35.94**	**35.94**
30489 STAGG-J2 230 30624 TESLA E 230 ...	Base Case	1003.02	0.3026	0	**7.65**	**7.65**
300551 GT_MW_11 500 30060 MIDWAY 5...	Base Case	1117.68	0.2120	0	**87.73**	**87.73**

California Renewable Portfolio Standard

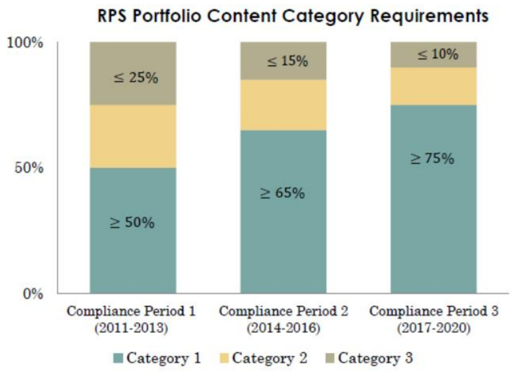
California's load-serving entities are required to procure electricity from eligible renewable resources to meet the following goals:

- 33 percent by the end of 2020
- 44 percent by the end of 2024
- 52 percent by the end of 2027
- 60 percent by the end of 2030

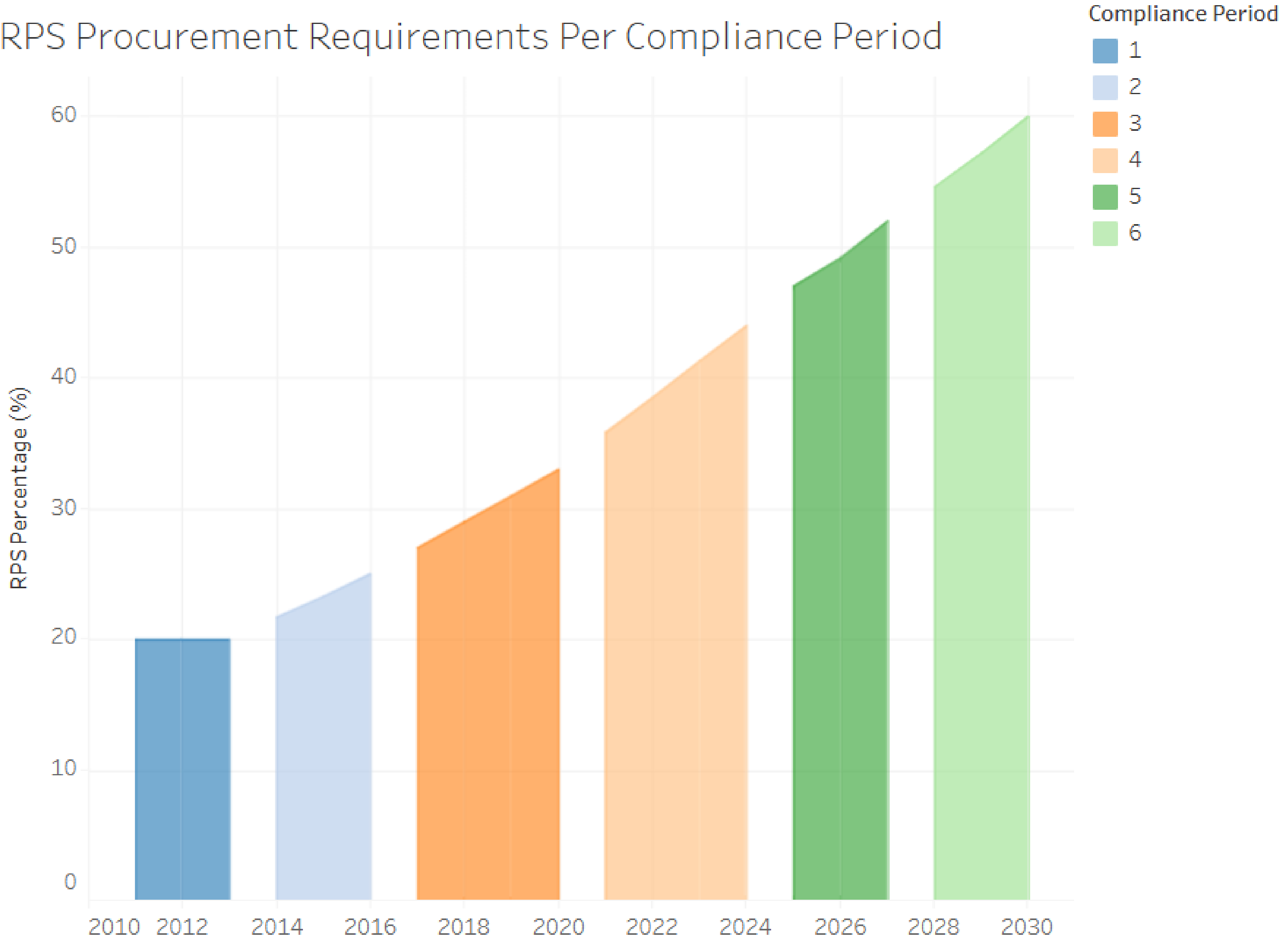
Load-serving entities (LSEs) include POUs, investor-owned utilities (IOUs), electricity service providers (ESPs), and community choice aggregators (CCAs).

RPS targets are verified based on a multiyear accounting period rather than annual accounting. These multiyear periods are compliance periods:

- Compliance Period 1: 2011-2013
- Compliance Period 2: 2014-2016
- Compliance Period 3: 2017-2020
- Compliance Period 4: 2021-2024
- Compliance Period 5: 2025-2027
- Compliance Period 6: 2028-2030



RPS Procurement Requirements Per Compliance Period



RPS Portfolio Content Requirements

- Category 1: Renewable energy and renewable energy credits (RECs) from the facilities with a first point of interconnection within a California Balancing Authority (CBA), or facilities that schedule electricity into a CBA on a hourly or sub-hourly basis.

- Category 2: Renewable energy and RECs with incremental electricity, and/or substitute energy, from outside a CBA. Generally, Category 2 RECs are generated from out-of-state renewable facilities and require a Substitute Energy Agreement that details the simultaneous purchase of energy and RECs from a RPS eligible facility.

- Category 3: RECs that do not include the physical delivery of the energy that generated the REC. Generally, Category 3 RECs are associated with the sale and purchase of the RECs themselves, not the energy.

LONG TERM CONTRACT REQUIREMENT

Pursuant to Public Utilities (PUC) Code Section 399.13(b), CP 4, and subsequent CPs, includes a Long-Term Procurement Requirement requiring that 65% of an LSE's RPS procurement shall be from long-term procurement. Long-term procurement refers to procurement from long-term contracts, ownership, or ownership agreements, as specified in Section 3204(d) of the RPS POU Regulations and further discussed in the Regulatory Advisory RPS POU 2022-09-21.

Clean Hydrogen Production Tax Credit

C. USE OF ENERGY ATTRIBUTE CERTIFICATES

The Treasury Department and the IRS, in consultation with the United States Environmental Protection Agency (EPA) and the DOE, have preliminarily determined that energy attribute certificates (EACs) may be considered under certain conditions in documenting purchased electricity inputs and assessing emissions impacts of electricity used in the production of hydrogen for purposes of the section 45V credit.[9] For purposes of these proposed regulations, the term “EACs” refers solely to EACs that represent attributes of electricity generated by a specific facility or source. The EPA has advised that EACs are an established mechanism for substantiating the purchase of electricity from zero GHG-emitting sources and that the use of EACs with attributes that meet certain criteria is an appropriate way for the Treasury Department and the IRS to document electricity inputs to electrolytic hydrogen production. Such EACs can also serve as a reasonable methodological proxy for quantifying certain indirect emissions associated with electricity for purposes of the section 45V credit. Similarly, the EPA and the DOE have advised that it would be appropriate for EACs with attributes that meet certain criteria to be included as part of the basis for assessing emissions for purposes of the section 45V credit. The Treasury Department and the IRS have preliminarily determined that the use of certain EACs, which satisfy the qualifying EAC requirements (as specified in proposed § 1.45V-4(d)(3)), is consistent with the references to subparagraph (H) of section 211(o)(1) of the Clean Air Act (42 U.S.C. 7545(o)(1)(H)) and the most recent GREET Model, as specified in section 45V(c)(1).

RPS and REC Eligibility

- Key Question: If an Eligible Renewable Resource (ERR) is used to power the LEC Hydrogen Electrolyzer, will energy produced by LEC using hydrogen gas be eligible for RPS credits?

- Current regulations do not contemplate this type of situation
- Regulatory authority: California Energy Commission (CEC)
- May require legislation
- Discuss Next Steps

CALIFORNIA ENERGY COMMISSION

Tax Incentives

- Key Question: Do both the hydrogen electrolyzer equipment and the storage equipment investments qualify for PTC and ITC?

- Section 45V is the production tax credit and Section 48(a)(15) is the Investment Tax Credit
- Section 48(a)(15)(B) states:
  - (B) Denial of production credit
    - No credit shall be allowed under section 45V or section 45Q for any taxable year with respect to any specified clean hydrogen production facility or any carbon capture equipment included at such facility

Tax Incentives

- Specified clean hydrogen production facility. For purposes of this paragraph, the term “specified clean hydrogen production facility” means any qualified clean hydrogen production facility (as defined in section 45V(c)(3)
  - Which is placed into service after December 31, 2022
  - With respect to which
    - No credit has been allowed under section 45V or 45Q, and
    - The taxpayer makes an irrevocable election to have this paragraph apply, and
    - For which unrelated third party has verified that such facility produces hydrogen through a process which results in lifecycle greenhouse gas emissions which are consistent with the hydrogen that such facility was designed and expected to produce under subparagraph (A)(ii)

Questions / Comments

Market Strategy / Value

March 25, 2025

LEC Hydrogen Workshop

Topics for Discussion

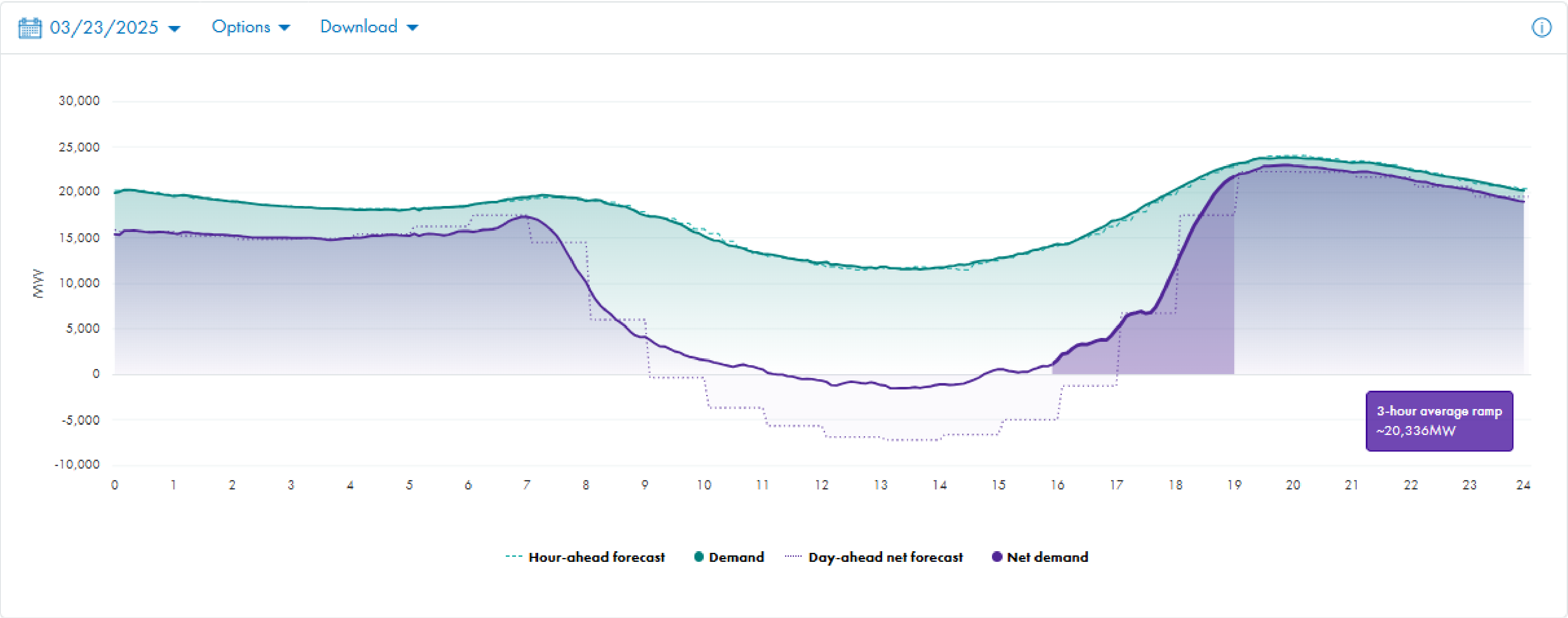
- Discuss key concepts
- Review preliminary analysis
- Develop focused study scenarios
- Next Steps

Dispatchable and Flexible Capacity

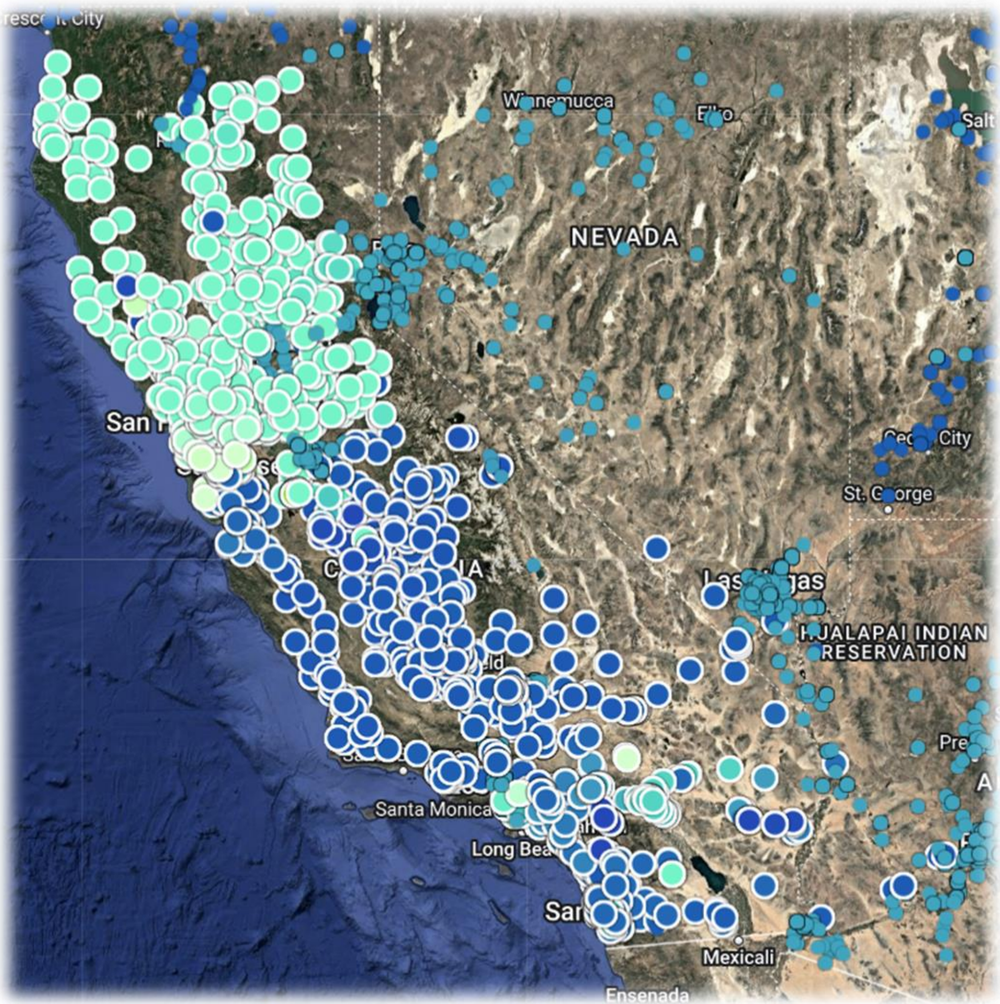
- Targeted electrolyzer have flexible operating characteristics
  - Fuel / energy production
  - Spinning reserves
  - Non-spinning reserves
  - Regulation services
  - Storage capability

- When paired with existing or new dispatchable resources, this can act as the missing “dispatchable renewable resource” in the fleet to support reliability

Renewable Integration



Renewable Integration



Key Concepts

- What is the LEC Hydrogen project
  - Fuel hedge, alternative fuel source to natural gas
- LEC optimization
  - Currently bid based on variable cost of operations
    - Min. Load, Start-Up Cost, Energy Rate
    - Primarily driven by fuel cost; Daily PG&E City Gate Price
  - LEC Bid rate not currently influenced by pre-purchased fuel
- Nodal settlement
  - Settlement based on LMP calculated at point of interconnection
  - Pricing at different locations subject to congestion and losses

How to Power the LEC Hydrogen Project

- Feedstock options
  - Grid power
  - Acquire "dedicated power supply" via PPA or project development
- Key items to consider:
  - Impact to 45V PTC eligibility
  - Incrementality, Temporal Matching
  - Exposure to congestion and losses
  - EAC Eligibility
- Impact to LEC bidding strategy and optimization
- Timing, interconnection process requirements

Scenarios to Consider

- Key Scenarios to Consider:
  - Est. project variable O&M rate
  - TAC; applicable or not
  - REC value; applicable or not
  - V45; applicable or not
    - $1 / kg
    - $2 / kg
    - $3 / kg
    - Only eligible for 10-year period
  - Carbon free value

- Probability of combinations of scenarios and timing
  - Weighting each scenario / assumed escalation values

Scenarios to Consider

The amount of PTC is based on sliding scale tied to the emissions associated with the production as shown in the table below, calculated as: (a) $0.60 per kilogram (kg) of QCH produced at a QCH production facility, multiplied by (b) the "applicable percentage" based on the resulting lifecycle GHG emissions rate, equals (c) the amount of PTC. The amount is increased by five times if construction began before January 29, 2023, or PWA requirements are met.

kgs of CO2e to produce a kg of QCH	Applicable Percentage	Base PTC Value	Increased PTC Value for PWA
At least 2.5 but not greater than 4.0	20%	$0.12	$0.60
At least 1.5 but less than 2.5	25%	$0.15	$0.75
At least 0.45 but less than 1.5	33.4%	$0.20	$1.00
Less than 0.45	100%	$0.60	$3.00

Review High Level Analysis

Develop Focused Study Scenarios

- Define key question the group would like to answer
- Cost of hydrogen production will ultimately drive LEC optimization and production assumptions
  - LEC bid based on daily variable cost of operations
  - LEC bid based on gross or net cost of production?
- Assign probability to key input scenarios
  - TAC, 45V (level), RPS, Carbon Free, Other
- Develop updated production cost model result based on agreed upon assumptions
- Other

Questions / Comments

Shaping the Hydrogen Policy Landscape

Key Actions Taken by NCPA

- Secured state/federal funding commitment from ARCHES
- Marshalled Congressional delegation to restore LEC as an ARCHES Tier 1 Project
- Shaped California exemption from "three pillars" provision for 45V hydrogen tax credit
- Defeated state legislation that would have undermined value of hydrogen tax credit
- Mobilized regional and national support for project
- Initiated local education and outreach campaign

NCPA-member engagement has been critical to success of policy efforts

Shaping the Hydrogen Policy Landscape

Next Steps

- Actively lobby Congress to retain federal funding commitments
- Restore CEC grant funding for state share of project funding
- Address state policy surrounding RPS eligibility

LHC H2 Project Technology

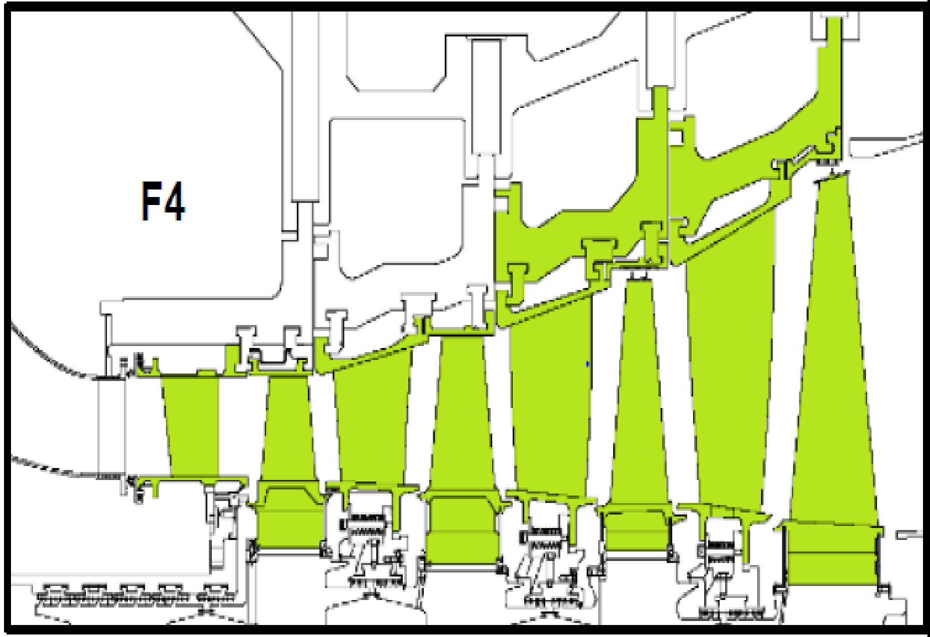
Gordon Loyd
Plant Engineer
March 25, 2025

LEC Existing Upgrades – ULN

- Ultra Low NOx (ULN) combustors
- Installed 4/2022
- Lowered turbine NOx emissions by 300%
- Allowed firing of 30-45% H_2 by volume today
- Minor outstanding BOP upgrades needed

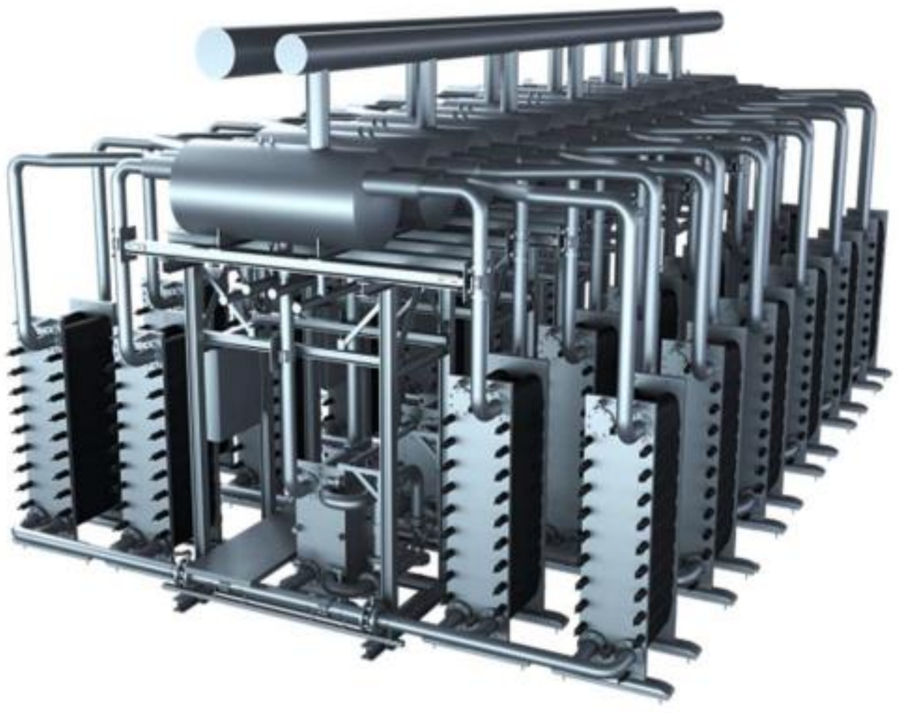
LEC Future Upgrades – FX Hardware

- Advanced Turbine Efficiency Package; derived from Siemens' Advanced Gas Turbine Fleet
- +19MW power output
- -350 BTU/kWhr (less fuel per kWh generated)
- Nullifies normal power loss from hot summer days
- Nullifies slight efficiency loss when burning hydrogen/natural gas blend



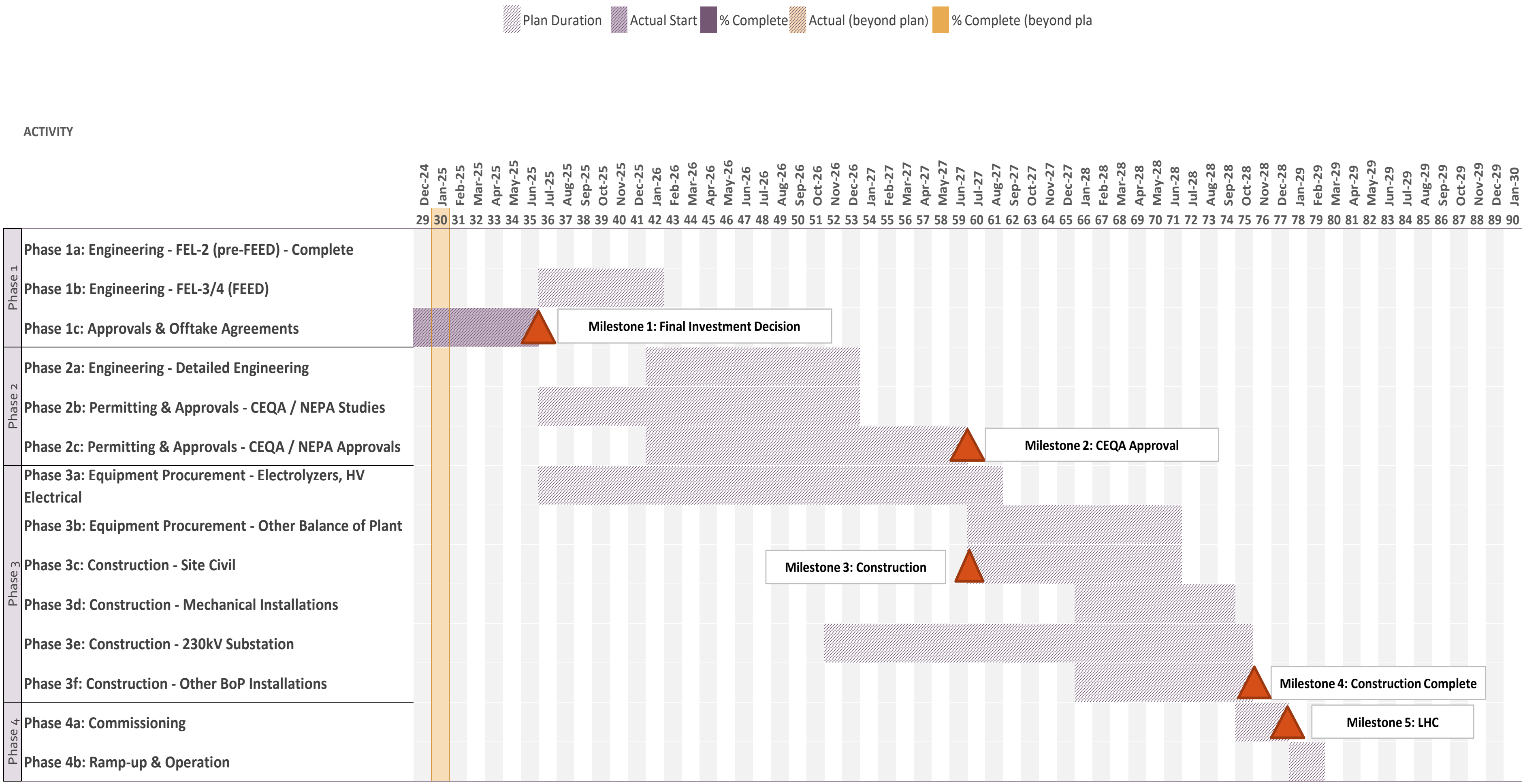
Hydrogen Production – PEM Electrolyzer

- Proton Exchange Membrane (PEM) Electrolyzer
- Feedstocks: Power and Water
- ~80MW load for 1,000kg/hr.
- 5.1 gal-H20 per kg of H2
- Need ~140 acre-feet per year (AFY) of water; LEC's City of Lodi lease offers up to 2,000 AFY additional Title 22 water upon request.



Power Consumed	19 MW
H_2 Production	330 kg/Hr
	44.4 mmBTU/Hr

NCPA Lodi Hydrogen Center Milestone Schedule



Budget and Schedule

Task	Start Date	End Date	Total Budget	Grant Share	NCPA Share	Contingency
Phase 1: Conceptual Design			**$7,609,998**	**$0**	**$7,609,998**	**$323,556**
Design/ Technical Readiness Review		Complete				
Engineering						
5% Design - Pre-FEED Report		Complete				
30% Design - FEED Package	7/1/2025	1/1/2026	$7,236,442			
Logistics & Procurement Plan		Complete				
Sites Permits Tabletop Review		Complete				
Project Costs & Schedule - AACEI Class 4		Complete				
Community Benefits Plan	7/1/2025	1/1/2026				
Insurance	7/1/2025	1/1/2026				
Permitting Kickoff	7/1/2025	1/1/2026	$50,000			
Phase 2 Go/No-Go Decision	**1/1/2026**	**7/1/2026**				

Budget and Schedule

Task	Start Date	End Date	Total Budget	Grant Share	NCPA Share	Contingency
Phase 2: Project Development, Permitting, and Finance			**$33,179,625**	**$13,271,850**	**$19,907,775**	**$4,976,944**
CAISO Interconnection Queue Process	7/1/2026	7/1/2029	$50,000			
Agreements: Offtake & Feedstock	7/1/2026	12/1/2026	$200,000			
Procurement - Long Lead Materials (> 2y lead time, i.e. Electrolyzer, Transformer)	7/1/2026	3/1/2028	$7,653,627			
Engineering - 100%, Including:	7/1/2026	7/1/2027	$18,043,230			
Project Costs & Schedule - AACEI Class 2						
Permitting - Initiate CEQA/NEPA/Air Permit Applications	7/1/2025	6/1/2026	$6,886,324			
Phase 3 Go/No-Go Decision	1/1/2027	7/1/2027				
Phase 3: Construction			**$171,125,906**	**$32,065,153**	**$139,060,753**	**$25,688,886**
Procurement - Remaining BOP Materials	7/1/2027	8/1/2028	$133,550,177			
Staffing - Implement Staff Plan	7/1/2027	9/1/2028	$3,100,701			
Construction; Labor and Supplies	7/1/2027	12/1/2028	$31,047,624			
Construction Safety	7/1/2027	12/1/2028	$3,427,404			
Phase 4: Operations and Sustainment			**$1,525,123**		**$1,525,123**	**$288,768**
Commissioning	10/1/2028	2/1/2029	$812,384			
Develop Operations Procedures and Training	9/1/2027	2/1/2029	$712,739			
Commercial Operation Date		**3/1/2029**				

A PUBLIC AGENCY
NCPA
NORTHERN CALIFORNIA POWER AGENCY

LHC H2 45% and 100% Electrolyzer and Storage Sizing

Gordon Loyd
Plant Engineer
March 25, 2025

Hydrogen Use Scenarios

- Size for “worst case scenario”; summer heat waves and winter cold snaps. Typically: 3-4 days.
- Study both 45% and 100% hydrogen consumption:
  1. Max H2 throughput for 72 continuous hours with no H2 production.
  2. Max H2 throughput for 12 continuous hours with no H2 production for 3 days.
  3. Max H2 throughput for 12 continuous hours, H2 production in middle 8 hours when turbine is not running, 4 hours of neither running. Replenish 75% of H2 demand in 8-hour recharge for 12-hour run.

H2 Storage and Burn Rate

	Units	45% H2 blend	100% H2
Scenario 1			
Duration of extreme cold or heat event	days	3	3
Turbine run time per day	Hours	24	24
Turbine demand	kg/h	3,249	15,331
Hydrogen Produced During Period	Metric Tonne	0	0
Total H_2 to be available from storage per event	Metric Tonne	234	1,104
Scenario 2			
Duration of extreme cold or heat event	days	3	3
Turbine run time per day	Hours	12	12
Turbine demand	kg/h	3,249	15,331
Hydrogen Produced During Period	Metric Tonne	0	0
Total H_2 to be available from storage per event	Metric Tonne	117	552
Scenario 3			
Duration of extreme cold or heat event	days	3	3
Turbine run time per day	Hours	12	12
Turbine demand	kg/h	3,249	15,331
H_2 required by turbine per event	Metric Tonne	117	552
Percentage of turbine load produced during non-running duration	%	75%	75%
Hydrogen Produced During event	Metric Tonne	52.0	245.3
H2 required in storage at start of the event	Metric Tonne	65.0	306.6

Depending on the intensity of power shortages and the duration of peak pricing during those peak periods, any of the storage quantities as proposed in the three scenarios may be more appropriate.

During Autumn and Spring, less hydrogen is required to supply the turbines and hydrogen will be directed to storage to build up reserves for Summer and Winter.

On top of the long-term storage requirements, additional storage is required for daily fluctuations in electrolyzer, and turbine run profiles. This is to be determined later in this memo.

45% H2 Feed Results

Scenario Name	Storage (tons)	Electrolyzers	Recharge Time (days)	Cost (Millions)
72hr. Storage	236	12 (4 tons/hr.)	7	$524
36hr. Storage	118	12 (4 tons/hr.)	3	$360
36hr. Storage w/ recharge	65	12 (4 tons/hr.)	2	$287
72hr. Storage (Alt 1)	236	44 (14 tons/hr.)	2	$976
36hr. Storage (Alt 1)	118	22 (7 tons/hr.)	2	$502
72hr. Storage (Alt 2)	236	6 (2 tons/hr.)	14	$444
36hr. Storage (Alt 2)	118	3 (1 ton/hr.)	14	$236

100% H2 Feed Results

Scenario Name	Storage (tons)	Electrolyzers	Recharge Time (days)	Cost (Millions)
72hr. Storage	1080	54 (18 tons/hr.)	7	$2,436
36hr. Storage	540	54 (18 tons/hr.)	3	$1,663
36hr. Storage w/ recharge	370	54 (18 tons/hr.)	2	$1,320
72hr. Storage (Alt 1)	1080	209 (69 tons/hr.)	2	$4,607
36hr. Storage (Alt 1)	540	105 (35 tons/hr.)	2	$2,371
72hr. Storage (Alt 2)	1080	30 (10 tons/hr.)	14	$2,098
36hr. Storage (Alt 2)	540	15 (5 ton/hr.)	14	$1,116

Takeaways & Outstanding Questions

- Storage:
  - Largest cost driver due to sheer quantity.
  - Predictions say future costs could lower to 1/3 of current.
- Electrolyzers:
  - 2023 pricing used – economies of scale could drop future pricing.
- Power:
  - As always, largest cost driver. Securing low-cost power significantly improves economics.
- Incentives:
  - IRA 45V is back and forth. That alone is $3/kg or $22/mmBTU.
  - TAC, RECs, and Grants
- Scenarios
  - NCPA-built scenarios. Tuning can optimize project size.