ACT Hydrogen Technology Testing
&
Comparisons to Existing Technologies

NAER Inc. is a Delaware corporation that is in the business of developing power generation projects.   NAER has over 37 years experience in the power generation sector in Engineering, Construction, and Construction Management of power generation facilities globally.   In October of 2022, we became aware of ACT as we were looking for a hydrogen fuel source to supply our own power generating facilities. We have two large gas turbine combined cycle power plants in development in Mexico a 135 MW and a 150 MW we want to ultimately run on hydrogen fuel.

We met with ACT to review and vet their technology as a possible hydrogen solution for our Mexico projects.   We had been looking at various technologies over the previous 4 years and had found a few that could potentially be a solution for our needs. However, due to various reasons, these alternatives did not prove to be viable options.

When we initially met with ACT, we were encouraged by the information that they provided and the technology that we were shown.   Quite frankly, we were skeptical about the claims that were being made as to the production capability of their technology, specifically the power consumption compared to the hydrogen production.

Continued:

We suggested to ACT that NAER Inc. perform an independent test to verify their claims before we could proceed any further. NAER and ACT agreed that we could perform a test on one of their units that was located at the San Juan Capistrano Shop, which we had previously visited. NAER was responsible for writing the test protocol, supplying the test instrumentation, observing the test, recording all the test data, sample testing, and ultimately writing a test report based on the data collected. ACT was responsible for providing the demineralized water, potassium hydroxide, power supply and operating their systems during the test. The NAER test was performed for our own benefit to verify the ACT claims of what their system could do.

The results of the test were impressive and verified the claims ACT had been making about their technology. NAER made it clear to ACT that the testing was only the first step to bring the technology into the power generation sector. The next step would require a field test to prove the technology can operate reliably and safely in a power generation environment. By performing a field test over a period of 4-6 months, the reliability of the system and any system weaknesses could be determined and corrected. Once the field testing is complete and the data collected from the testing, the system would be ready to move to the next step of manufacturing engineering, in preparation for commercial deployment into the power generation sector with NAER's expertise.

Continued:

NAER Inc. has used its relationship with Calpwr to obtain the necessary permission to install an ACT system at Calpwr's Cogeneration plant Oceanside Wastewater Treatment Facility. As a past owner of Calpwr I was involved in the design, construction and operation of the Oceanside Cogen plant. In 2008, I sold my interest in Calpwr to my two partners, Jeff and Joe Silva who are still the owners and operators of this plant. Due to my close relationship with the owners, NAER has been given exclusive rights to install and operate an ACT hydrogen production unit at this facility. This will serve as the pilot plant for the next step of getting the technology fully tested, ready for manufacturing and into the power generation sector.

Technology

Green Hydrogen Facts

- 1 kilogram of hydrogen contains 115,000 BTU Lower Heating Value (LHV)
- There are 8.7 kg per MMBtu of hydrogen (LHV)
- It takes 9 liters of water to produce 1 kg of Hydrogen
- 1 kilogram of hydrogen contains 39.4 kWhr of power (at 100% efficiency in a perfect world)
- 1 kilogram of hydrogen can produce approximately 14.375 kW's of actual power @ 8,000 BTU/kWhr heat rate.
- A 100% efficient electrolyzer can produce hydrogen consuming 39.6 kw, this is known as the Gibbs equation.
- Current Technologies in the marketplace take around 50 kWhr of energy to create 1 kg of hydrogen using an electrolyzers.

Competing Technology Comparison

eCombustible (Current Outlier in the Hydrogen Electrolysis market)

There is a US company, eCombustable located in Florida, that has several facilities in commercial operation that are currently producing 1 kg/hr of hydrogen @ 28 kWhr/kg**.**

https://www.ecombustible.com/

Hysata

Hysata is a new Australian that claims its new capillary-fed electrolyzer, prototype, can produce 1 kg/hr hydrogen @ 41.5 kWhr.

https://newatlas.com/energy/hysata-efficient-hydrogen-electrolysis/

ACT Technology, as tested, produced 22.3 kg/hr of hydrogen @ 14.5 kWhr based on water consumption, which equates to .65 kWhr per 1 kg/hr of hydrogen. This is 4200% better than any currently existing commercial unit in operation. Put another way, 1 kWhr of energy produces 1.5 kg of hydrogen with the ACT unit.

However, if the ACT technology could only produce 1 kg of hydrogen an hour, this would equate to using 14.5 kW/hr. Even at this minimal production level, the ACT technology would produce 340% more hydrogen using the same amount of power as other existing commercial systems. This is also 100% better than the current eCombustible system that is currently in commercial operation.

Calpwr: 735 KW Cogeneration Plant – City of Oceanside San Luis Rey Wastewater Treatment Plant

The Calpwr Cogeneration plant provides power and hot water to the wastewater treatment plant under a 15-year contract that will be extended for an additional 3 years this upcoming December.

First and foremost, the overarching value of locating the pilot plant at this location is having access to an operating facility to install the ACT equipment. The facility gives us easy access, with a known entity that is in full support of the project. This test site will allow us do the required testing to gather all the required data to move the technology into the power generation sector. The Pilot Plant will allow ACT to prove the technology can operated safely, reliability and efficiency in an operating power generation facility. The value of the pilot plant testing is enormous for the technology, once the testing is complete the value of the technology will increase immeasurably.

This location was chosen by NAER Inc. for the following reasons:

- Secure Location
- Type of generation equipment. The engine is a Guascor low BTU engine that currently runs on digester methane gas supplied from the Anerobic Digesters located on site.
- The engine requires low pressure low BTU fuel and can run on hydrogen or syngas
- The wastewater plant cannot supply a sufficient about of fuel for the Cogen plant and the City is having to purchase natural gas to meet their contractual requirements.
- Ease of installation
- Location
- Relationship with the Owners of the facility
- NAER’s familiarity with the site
- Ability for Calpwr to obtain a follow-on contract with the City and upsize the plant to 2 MW’s which will allow ACT to sign a fuel supply agreement with Calpwr once the technology has proven to work reliably.

Calpwr Cogen Pilot Plant Economics

EPC Contractor: NAER Inc.

Plant design, construction and testing: $2,000,000 with contingency

735 KW Cogen Heat Rate: 10,000 BTU's kWhr
Annual MMBTU consumption at full output: 64,386
Annual MMBTU provided by Digester Gas: 30,660
Annual MMBTU provided by Hydrogen: 33,726
Annual equivalent hydrogen kg: 293,269
Hydrogen Tax Credits: $3.00 kg
Annual Tax Credit Revenue: $879,808 (Approximate)
Annual Fuel Sales: $0.0 (Note 1)
Total Gross Annual Revenue from Hydrogen Tax Credits: $879,808 (Approximate)

Note 1: The agreement with Calpwr to install the pilot plant was there would be no charge for the hydrogen fuel. Once their contract is extended and the system has proven itself to be reliable then Calpwr will enter into a fuel agreement with ACT at a negotiated price.
The hydrogen tax credits are ACT's.

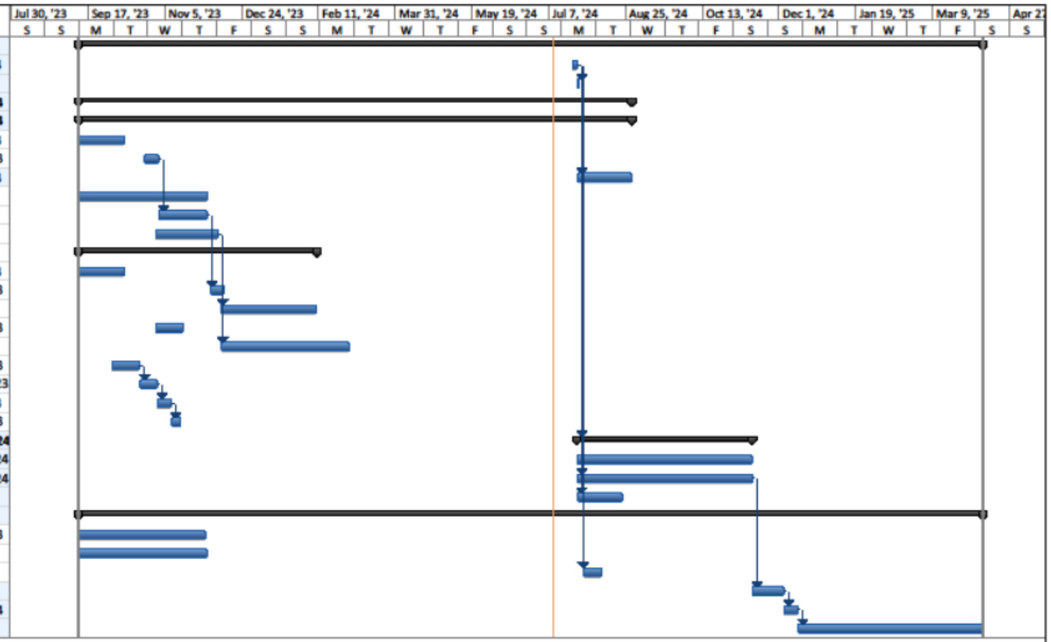
Calpwr Cogen Pilot Plant Status & Schedule

Pilot Plant Status:

- All engineering is complete
- All equipment, materials, and subcontract work has been priced and purchase orders are ready to be issued upon close of finance.
- The Guascor engine top end and end frame overhaul has been completed
- The notification to the San Diego County Air Quality Board has been submitted
- The authority to install agreement has been provided by Calpwr.
- Equipment Long lead items are approximately 12 weeks from issuance of purchase orders
- Construction schedule is 120 days this includes the delivery time for the long lead items
- Commissioning and startup will be 30 days
- Minimum of 120 days for testing, tuning and data collection
- Full Schedule from notice to proceed to startup will be 120 days

Calpwr Oceanside Hydrogen Pilot Plant Schedule

ID	Task Mode	Task Name	Duration	Start	Finish
1		**Hydrogen Production Integration & Field Testing**	**413 days**	**Mon 9/11/23**	**Wed 4/9/25**
2		Release of funds	3 days	Mon 7/22/24	Wed 7/24/24
3		Notice to Proceed	1 day	Thu 7/25/24	Thu 7/25/24
4		**Engineering and Design**	**253 days**	**Mon 9/11/23**	**Wed 8/28/24**
5		**Integration design**	**253 days**	**Mon 9/11/23**	**Wed 8/28/24**
6		P&ID development	21 days	Mon 9/11/23	Mon 10/9/23
7		Electrical One Lines	7 days	Mon 10/23/23	Tue 10/31/23
8		Controls I/O	25 days	Thu 7/25/24	Wed 8/28/24
9		Mechanical design and drawings	60 days	Mon 9/11/23	Fri 12/1/23
10		Electrical design and drawings	23 days	Wed 11/1/23	Fri 12/1/23
11		System Control & Operating Scenarios	30 days	Mon 10/30/23	Fri 12/8/23
12		**Integration engineering**	**110 days**	**Mon 9/11/23**	**Fri 2/9/24**
13		Mechancial	21 days	Mon 9/11/23	Mon 10/9/23
14		Electrical	7 days	Mon 12/4/23	Tue 12/12/23
15		Controls	45 days	Mon 12/11/23	Fri 2/9/24
16		Engineered drawings	14 days	Mon 10/30/23	Thu 11/16/23
17		Control System Preliminary Design	60 days	Mon 12/11/23	Fri 3/1/24
18		Equipment Specifications	14 days	Mon 10/2/23	Thu 10/19/23
19		Equipment RFQ	7 days	Fri 10/20/23	Mon 10/30/23
20		Receive Equipment Quotes	7 days	Tue 10/31/23	Wed 11/8/23
21		Equipment Quote Evaluation	4 days	Thu 11/9/23	Tue 11/14/23
22		**Equipment Purchase & Delievery**	**80 days**	**Thu 7/25/24**	**Wed 11/13/24**
23		HPU Power Supply	80 days	Thu 7/25/24	Wed 11/13/24
24		Control System Equipment	80 days	Thu 7/25/24	Wed 11/13/24
25		Fabrication	21 days	Thu 7/25/24	Thu 8/22/24
26		**Field Installation & Testing**	**413 days**	**Mon 9/11/23**	**Wed 4/9/25**
27		Field Site Evaluation	59 days	Mon 9/11/23	Thu 11/30/23
28		Design and engineering for field installation	60 days	Mon 9/11/23	Fri 12/1/23
29		Existing generation equipment modification	10 days	Mon 7/29/24	Fri 8/9/24
30		Hydrogen Production Installation	14 days	Thu 11/14/24	Tue 12/3/24
31		Field commissioning and statup	7 days	Wed 12/4/24	Thu 12/12/24
32		Field testing and modification	84 days	Fri 12/13/24	Wed 4/9/25



Project: Oceanside Cogen Hydrog Date: Wed 7/10/24	Task	Summary	External Milestone	Inactive Summary	Manual Summary Rollup	Finish-only
	Split	Project Summary	Inactive Task	Manual Task	Manual Summary	Deadline
	Milestone	External Tasks	Inactive Milestone	Duration-only	Start-only	Progress

Example: 100 MW Gas Turbine conversion from Natural Gas to Hydrogen

Currently there are 658 GW (658,000 MW's) of natural gas fired power plants in the US.

Converting one 100 MW gas turbine power plant from natural gas would yield the following economic benefit to ACT.

100 MW power plant heat rate: 9,300 BTU's kWhr
Annual MMBTU consumption: 8,961,000 MMBTU
Annual equivalent hydrogen kg: 77,921,739
Hydrogen Tax Credits: $3.00 kg
Annual Tax Credit Revenue: $233,783,217
Hydrogen Fuel Price: $3.50 MMBTU
Annual Fuel Sales: $31,363,500
Total Gross Annual Revenue: $265,146,717

Hydrogen Production Costs - ACT Technology

Quick Reference

Assumptions

LHV 1 kg Hydrogen BTU's	113,745
Gallons of water to produce 1 kg H2	2.376
Electrical Power Required kW **(includes BOP parasitic load)**	35.000
Electrical Power Required kW (HPU only)	14.700
Cost of Electrical Power $/kwr	$ 0.015
Cost of Demenerilized Water $ gallon	$ 0.0300
Annual O&M Costs **Note 1**	$ 18,000
kG's/MMBTU	8.79
Heat Rate for generation equipment btu/kwhr	9,000
Annual Hours of Operation	8760

Kg of Hydrogen Produced per Hr	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Cost of Demineralized Water $/kg	$ 0.07128	$ 0.07128	$ 0.07128	$ 0.07128	$ 0.07128	$ 0.07128	$ 0.07128
O&M Costs $/kG	$ 2.05479	$ 1.02740	$ 0.68493	$ 0.51370	$ 0.41096	$ 0.34247	$ 0.29354
Power Produced by H2 kWs	12.64	25.28	37.91	50.55	63.19	75.83	88.47
Electrical Power Required kW (HPU only)	14.70	14.70	14.70	14.70	14.70	14.70	14.70
Power required to produce H2 kw/hr**(including parasitic load)**	35.00	35.00	35.00	35.00	35.00	35.00	35.00
Total Delta power used vs generated in kWs	**-22.362**	-9.723	2.915	15.553	28.192	40.830	53.468
Total Power Purchased kWs	22.362	9.723	0.000	0.000	0.000	0.000	0.000
Total Cost of Purchased Power $ **NOTE 2**	$ 0.3354	$ 0.1459	$ -	$ -	$ -	$ -	$ -
Cost of hydrogen produced	$ 2.4615	$ 2.4891	$ 2.2686	$ 2.3399	$ 2.4112	$ 2.4825	$ 2.5538
Cost $/kg Hydrogen	**$ 2.4615**	**$ 1.2445**	**$ 0.7562**	**$ 0.5850**	**$ 0.4822**	**$ 0.4137**	**$ 0.3648**
Total MMBTU produced	0.11	0.23	0.34	0.45	0.57	0.68	0.80
Cost per MMBTU H2 $	$ 21.641	$ 10.941	$ 6.648	$ 5.143	$ 4.240	$ 3.637	$ 3.207

Cost of Demineralized Water $/kg	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
O&M Costs $/kG								
Power Produced by H2 kWs	$ 0.07128	$ 0.07128	$ 0.07128	$ 0.07128	$ 0.07128	$ 0.07128	$ 0.07128	$ 0.07128
Electrical Power Required kW (HPU only)	$ 0.25685	$ 0.22831	$ 0.20548	$ 0.18680	$ 0.17123	$ 0.15806	$ 0.14677	$ 0.13699
Power required to produce H2 kw/hr**(including parasitic load)**	101.11	113.74	126.38	139.02	151.66	164.30	176.94	189.57
Total Delta power used vs generated in kWs	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70
Total Power Purchased kWs	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00
Total Cost of Purchased Power $ **NOTE 2**	66.107	78.745	91.383	104.022	116.660	129.298	141.937	154.575
Cost of hydrogen produced	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cost $/kg Hydrogen	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total MMBTU produced	$ 2.6250	$ 2.6963	$ 2.7676	$ 2.8389	$ 2.9102	$ 2.9814	$ 3.0527	$ 3.1240
Cost per MMBTU H2 $	**$ 0.3281**	**$ 0.2996**	**$ 0.2768**	**$ 0.2581**	**$ 0.2425**	**$ 0.2293**	**$ 0.2181**	**$ 0.2083**
	0.91	1.02	1.14	1.25	1.36	1.48	1.59	1.71
	$ 2.885	$ 2.634	$ 2.433	$ 2.269	$ 2.132	$ 2.016	$ 1.917	$ 1.831

Kg of Hydrogen Produced per Hr	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
Cost of Demineralized Water $/kg	$ 0.07128	$ 0.07128	$ 0.07128	$ 0.07128	$ 0.07128	$ 0.07128	$ 0.07128	$ 0.07128
O&M Costs $/kG	$ 0.12842	$ 0.12087	$ 0.11416	$ 0.10815	$ 0.10274	$ 0.09785	$ 0.09340	$ 0.08934
Power Produced by H2 kWs	202.21	214.85	227.49	240.13	252.77	265.40	278.04	290.68
Electrical Power Required kW (HPU only)	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70
Power required to produce H2 kw/hr**(including parasitic load)**	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
Total Delta power used vs generated in kWs	167.213	179.852	192.490	205.128	217.767	230.405	243.043	255.681
Total Power Purchased kWs	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total Cost of Purchased Power $ **NOTE 2**	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Cost of hydrogen produced	$ 3.1953	$ 3.2666	$ 3.3378	$ 3.4091	$ 3.4804	$ 3.5517	$ 3.6230	$ 3.6942
Cost $/kg Hydrogen	**$ 0.1997**	**$ 0.1922**	**$ 0.1854**	**$ 0.1794**	**$ 0.1740**	**$ 0.1691**	**$ 0.1647**	**$ 0.1606**
Total MMBTU produced	1.82	1.93	2.05	2.16	2.27	2.39	2.50	2.62
Cost per MMBTU H2 $	$ 1.756	$ 1.689	$ 1.630	$ 1.577	$ 1.530	$ 1.487	$ 1.448	$ 1.412

Kg of Hydrogen Produced per Hr	**24**	**25**	**26**	**27**	**28**	**29**	**30**
Cost of Demineralized Water $/kg	$ 0.07128	$ 0.07128	$ 0.07128	$ 0.07128	$ 0.07128	$ 0.07128	$ 0.07128
O&M Costs $/kG	$ 0.08562	$ 0.08219	$ 0.07903	$ 0.07610	$ 0.07339	$ 0.07085	$ 0.06849
Power Produced by H2 kWs	303.32	315.96	328.60	341.23	353.87	366.51	379.15
Electrical Power Required kW (HPU only)	14.70	14.70	14.70	14.70	14.70	14.70	14.70
Power required to produce H2 kw/hr**(including parasitic load)**	35.0	35.0	35.0	35.0	35.0	35.0	35.0
Total Delta power used vs generated in kWs	268.320	280.958	293.596	306.235	318.873	331.511	344.150
Total Power Purchased kWs	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total Cost of Purchased Power $ **NOTE 2**	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Cost of hydrogen produced	$ 3.7655	$ 3.8368	$ 3.9081	$ 3.9794	$ 4.0506	$ 4.1219	$ 4.1932
Cost $/kg Hydrogen	**$ 0.1569**	**$ 0.1535**	**$ 0.1503**	**$ 0.1474**	**$ 0.1447**	**$ 0.1421**	**$ 0.1398**
Total MMBTU produced	2.73	2.84	2.96	3.07	3.18	3.30	3.41
Cost per MMBTU H2 $	$ 1.379	$ 1.349	$ 1.321	$ 1.296	$ 1.272	$ 1.250	$ 1.229

Note 1:

Due to the passive nature of the HPU no on site O&M personnel would be required for units up to several MW's the $18,000 for O&M used in the above evaluation would cover operational and maintenance costs for units being monitored remotely
For larger systems the O&M costs **may go up** by 10% depending on the application and the requirements of the client. Also would depend on the legnth of the contract and the maintenance reserve that we may want to carry for longer term contracts.

Note 2:

60-75% of the overall cost for green hydrogen is the cost of the power to produce the hydrogen
Power to startup the HPU would be grid supplied or with a black start individual generation unit.
Once the HPU is producing hydrogen the power to run the unit is a parasitic load provided by the generation unit.

Technology

ACT FAQ's

- Is ACT Fuel the same as the current hydrogen fuel in the marketplace generated by electrolysis? **Yes** – it can be delivered as pure hydrogen or blended with a hydrocarbon like CO to make a syngas
- Is ACT Fuel Safe? **Yes** – It has the same characteristics as natural gas, no more flammable or explosive than natural gas, less explosive as it is much harder to reach an explosive limit as it dissipates much faster than natural gas.
- Is ACT Fuel High Pressure? **No** - It is produced at atmospheric pressure, then the pressure is increased via compression to the needs of the equipment it will be supplying.
- Is the equipment to produce ACT Fuel Reliable? **Should be** – The ACT system is Passive system, simplicity are the key advantages, the ACT fuel units are modular with each module producing a specific amount of fuel. Additional individual modules are added to achieve the needed output of fuel for the project. Each individual module consists of many fuel production cells. The design of the system is intrinsically redundant with no single point of failure that could shut down all fuel production. One of the purposes of the field test is to determine what changes if any may be needed to ensure the system is extremely reliable.

Emissions and Safety

EMISSIONS

Emission Factors-lb/MMBTU			
	ACT	NaturalGas[2]	Propane[2]
CO_2	0	123	148
CO	0	0.022 - 0.037	0.023 - 0.039

Monthly Issues for 18,000 MMBTU/monthModule(lb)			
	ACT	Natural Gas	Propane
CO_2	0	2,207,000	2,672,000
CO	0	399 - 665	406 - 684

Safety - NAER design

ACT Fuels will meet the following applied Standards

- NFPA 2 - Hydrogen Technologies Code
- CGA 5 - Hydrogen
- CGA G 5.3 - Specification of basic products for hydrogen
- NEC - Class I Div 1
- CGA G 5.6 - Hydrogen pipeline systems
- OSHA 1910.103 - Hydrogen System Distances
- ISO 1"6&%-1:1999 - Hydrogen fuel applications
- ABNT ISO/TR 15916:2015 - Hydrogen System Safety