DOCKETED

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Description:	N/A
Filer:	Tami Haas
Organization:	True Zero
Submitter Role:	Public
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Renewable Hydrogen Analysis

FirstElement Fuel

January 30, 2017

The Value of Renewable Hydrogen

Sustainability Analysis

	Hydrogen at this station - Fuel Cell EV	Future Hydrogen - Fuel Cell EV*	Gasoline - Internal Combustion Engine	Battery EV Today (California Grid)
Energy Sources				
Petroleum	1.2%	0.1%	79.6%	0.4%
Natural Gas	64.1%	9.7%	13.5%	66.3%
Coal	1.1%	1.1%	0.4%	7.6%
Renewable	33.6%	89.1%	6.5%	25.7%
GHGs	158 grams/mile	28 grams/mile	412 grams/mile	117 grams/mile
Tailpipe Emissions	Pure Water	Pure Water	VOC, CO, NOx, PM10, PM2.5, Sox, CH4, N2O	None

*True Zero's target is to sell 100% renewable hydrogen in 5 years. However, we expect to still need to utilize a small percentage of non-renewable energy for delivery and on-site processing.

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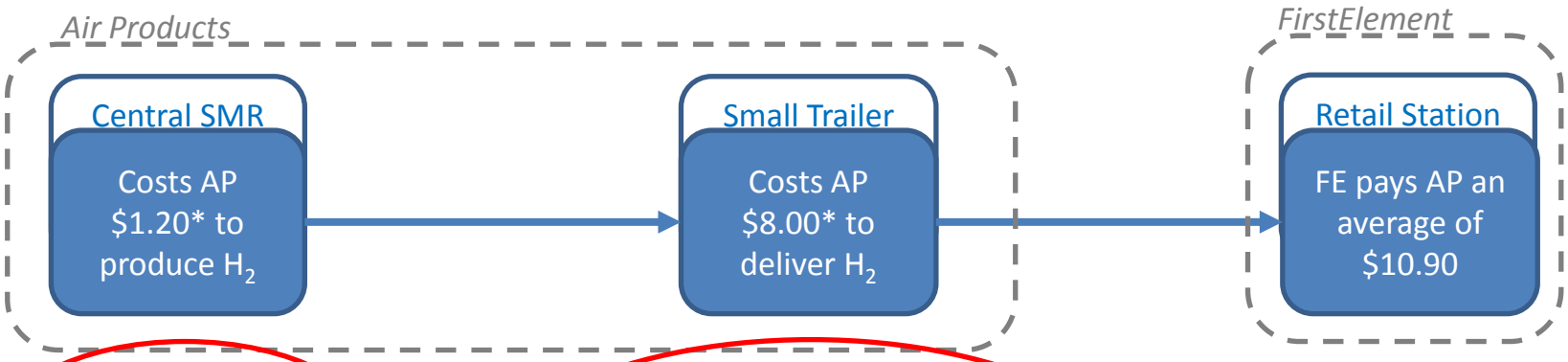
FE's Current Situation



Only 1 SMR in CA with high pressure capability

FE Stations regularly run low on H_2 supply

Average only 83 kg per delivery

* FE Estimates

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Average Day, 1/29/17

Sun 1/29/2017 1:17 PM
voiceforward@firstelementfuel.com
Compressor Alarm Event Reported from FE1007 Long Beach at 01/29/201713:17:10
To alarm.forward@firstelementfuel.com; ghassan.sleiman@fefuel.com

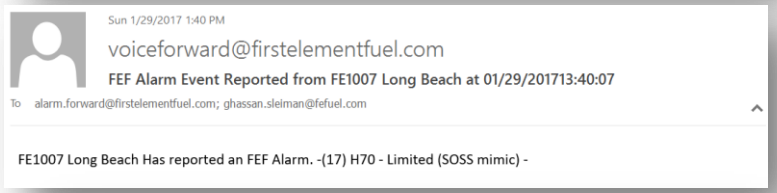
FE1007 Long Beach Has reported a Compressor Alarm. -(53) S700 - H2 Supply is Low-

1:17 PM H_2 Supply is Low

Sun 1/29/2017 1:38 PM
voiceforward@firstelementfuel.com
Dispenser Shutdown Alarm Event Reported from FE1007 Long Beach at 01/29/201713:37:41
To alarm.forward@firstelementfuel.com; ghassan.sleiman@fefuel.com

FE1007 Long Beach Has reported a Dispenser Shutdown Alarm. -(1408) Dispenser H70 does not have enough gas.-

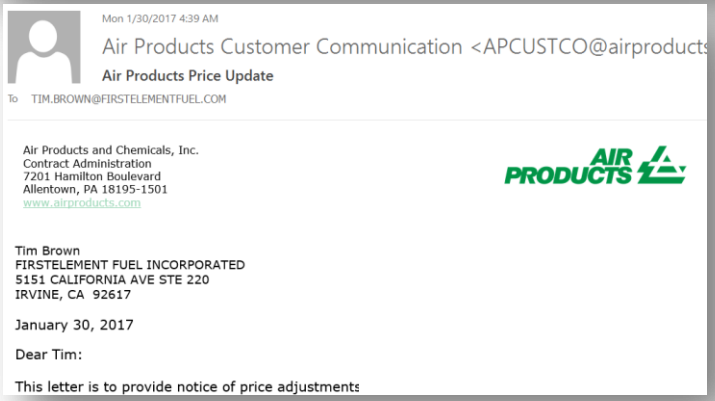
1:37 PM H70 does not have enough gas



Sun 1/29/2017 1:40 PM
voiceforward@firstelementfuel.com
FEF Alarm Event Reported from FE1007 Long Beach at 01/29/201713:40:07
To alarm.forward@firstelementfuel.com; ghassan.sleiman@fefuel.com

FE1007 Long Beach Has reported an FEF Alarm. -(17) H70 - Limited (SOSS mimic) -

1:40 PM SOSS Offline



Mon 1/30/2017 4:39 AM
Air Products Customer Communication <APCUSTCO@airproducts
Air Products Price Update
To TIM.BROWN@FIRSTELEMENTFUEL.COM

Air Products and Chemicals, Inc.
Contract Administration
7201 Hamilton Boulevard
Allentown, PA 18195-1501
www.airproducts.com

Tim Brown
FIRSTELEMENT FUEL INCORPORATED
5151 CALIFORNIA AVE STE 220
IRVINE, CA 92617

January 30, 2017

Dear Tim:

This letter is to provide notice of price adjustments

Ticky tacky price increase this morning

Meeting Retail H_2 Demand in California

The challenge is two-fold:

1. Scaling to meet rapidly growing retail H_2 demand in time
2. Providing customers with retail H_2 at a cost that accelerates, rather than stifles the adoption of fuel cell electric vehicles

Year	**2017**	**2018**	**2019**	**2020**	**2021**
Total Potential H_2 Demand by Year (kg of H_2 per day)	1,770	6,074	7,398	7,758	13,158

Consider that if a hydrogen production plant is started TODAY …

2 years to open is a very aggressive timeline

3 years to open is probably more realistic

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FirstElement's Goal - $10.00 per kg at Dispenser

General cost Breakdown:

Hydrogen Production • Land • Feedstock • Equipment • Maintenance	$5.00	
Hydrogen Delivery • Equipment • Fuel • Labor	$3.00	
Retail Operations • Land • Maintenance • Equipment • Cost of goods sold	$5.00	
Credits • LCFS • RINS?	($3.00)	

Electrolyzer Costs

Capital Costs

- 2.5 MW electrolyzer installed (including engineering, permitting, construction)
  - 1,000 kg/day at 24/7 operation
  - $3.5 MM
    - Financing at 7 years and 7% interest
      - $1,700 per day debt service
  - When operated 24/7
    - $1.70/kg in capital cost
  - When operated on PV with 25% capacity factor
    - $6.80/kg in capital cost

Energy Costs

- 60 kWh/kg
  - Josh Eichman renewable H_2 report
    - $0.09/kWh
    - $5.40/kg
  - Cheapest wind in U.S. (Great Plains)
    - $0.025/kWh
    - $1.50/kg
    - But, H_2 transport from Texas is troublesome
  - If 24/7 renewable is available at $0.06/kWh…
    - $3.60/kg
    - + $1.70/kg capital
    - =$5.30/kg → in the ballpark

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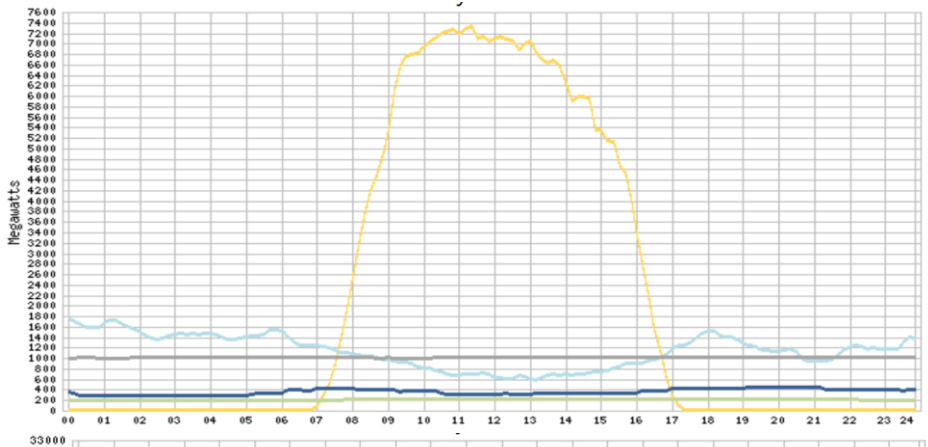
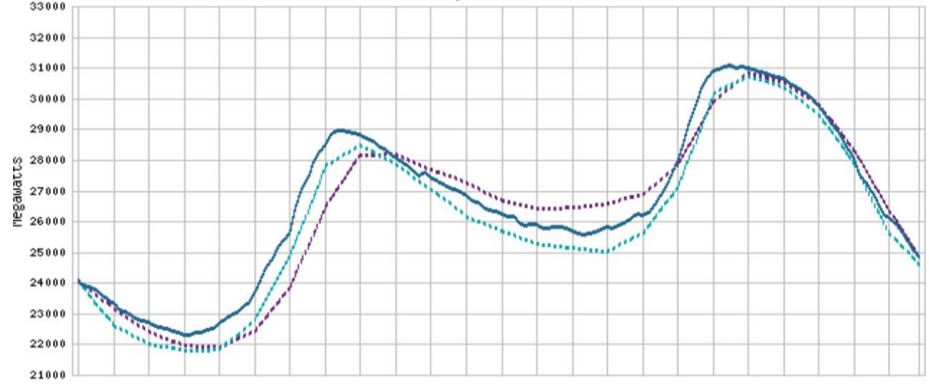
Need to be Economical at Scale

Small-scale “tricks” do not help us - California’s retail hydrogen demand projected at 13,000 kgpd by 2021

California Renewable Profile (1/24/17)



California Demand Profile (1/24/17)



- Allows net-metering for PV installations under 1 MW
- Essentially uses the electric grid as a free, perfect battery
- 1 MW PV installation
  - 25% capacity factor results in 6,000 kWh/day
- Net metering allows those kWhs to be used at anytime during the 24 hours
  - E.g., continuous power of 250 kW
- Electrolyzer operating at 250 kW produces roughly 100 kg/day
- **NOT SCALABLE!**

Bio-Hydrogen Costs

Capital Costs

- 3,500 kg/day SMR installed (including engineering, permitting, construction)
  - $8.2 MM
    - Financing at 7 years and 7% interest
      - $4,100 per day debt service
    - $1.20/kg in capital cost

Energy Costs

- 0.15 MMBTU/kg
  - Industrial NG cost
    - $5.75/MMBTU
    - $0.86/kg → Bingo!
  - Biogas cost
    - $5.75/MMBTU for NG
    - Plus $30.00/MMBTU biogas credit
    - $5.40/kg → too high

Things that could help

Enable easier injection of biogas into the California pipeline system to increase supply

Revise Federal Renewable Fuels Standard to appropriately value FCV efficiency (as LCFS correctly does)

- This would provide sufficient RIN value to allow H_2 to compete with CNG/LNG for biogas

Build hydrogen pipelines from low-cost renewable areas

Increase intermittent wind and solar penetration on the California grid such that grid instability allows inherent electrolysis attributes (high dispatchability, fast start-up/turn-down) to be monetized

Develop electricity rate structures for electrolysis; need $0.04-$0.06 renewable electricity

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