CHBC SUMMER SUMMIT REPORT

Workshops on Renewable Hydrogen and Energy Storage

Abstract

The 2015 CHBC Summer Summit attracted 91 attendees from across California and beyond to discuss status, progress, barriers and next steps on renewable hydrogen and hydrogen energy storage.

The State of California is moving quickly to significantly reducing greenhouse gas emissions from stationary sources and transportation while simultaneously increasing the role of renewable energy as part of the state's energy portfolio. Key goals for California are reaching GHG emissions reduction to 1990 levels by 2020 and reduction of 80% of 1990 levels by 2050, while increasing renewable energy generation to 33% by 2020 and to 50% by 2030. Furthermore, Gov. Brown's accelerated that commitment in his 2012 Executive Order to bring 1.5 million zero emission vehicles on the road by 2025 and more recently, his goal to reduce oil reliance of transport sector by 50% by 2030 and reducing GHG emissions by 40% over 1990 levels by 2030. Among the vast number of technology options that can help achieve these goals are energy storage, distributed generation and renewable energy generation.

Hydrogen and fuel cell technology can provide an unprecedented portfolio of solutions to achieve these goals. Renewable hydrogen for transportation and stationary power generation is emission free, silent and provides consumer experience similar to existing technology. This CHBC Summer Summit will focus on renewable hydrogen generation and renewable energy storage in the form of hydrogen.

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CALIFORNIA HYDROGEN BUSINESS COUNCIL

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Note: The overview presented below is a combination of notable quotations, paraphrasing and notes taken during the Summit by CHBC staff and volunteers. This overview was not reviewed and approved by the individual speakers.

CHBC Summer Summit - Renewable Pathways to Hydrogen Workshop

Wednesday, July 29, 2015

Welcome, Introductions, Workshop Objectives

Jeff Serfass

The two workshops are part of the CHBC 2015 focus and are designed to identify the needs of industry, looking for outcomes, messages, and actions, as well as individuals and companies that will be leaders. The idea of this renewables workshop came out of a board meeting, it was clear that the auto manufacturers wanted this to happen. The OEMs well as many customers are expecting pathways that will be close to 100% renewable.

Keynote: Need and Opportunity

Tyson Eckerle - GoBiz:

Tyson outlined a world of a fully hydrogen based energy economy by discussing the story of "Henry the duck", a toy coming from China to his grandson in 2050, with hydrogen fueling every step of the logistics from renewable electricity in China, auxiliary systems of ship are fuel cell powered, fuel cells operate the shore power, fuel cell powered tug boats, containers that are transferred to an automated port system, using hydrogen fueling stations next to a biogas to hydrogen facility.

This scenario is entirely possible. CHBC members like Hydrogenics, Proton Onsite, Fuel Cell Energy, and Ballard Power Systems should ask themselves how they can fit into this picture.

State of California seeks to meet and expand upon the established emission reduction and renewable energy goals, very focused on California climate change AB 32 goals. It's important to note that emission reduction and renewable energy are not causing GDP reduction, actually gross domestic product continues to grow, having increased over 20% since 2000 while emissions have decreased by 20% since 2001. Decoupling growth from emission increase IS possible. Have doubled state renewable electricity output while transportation emissions are down 11% since 2007, in part due to having 140,000 electric cars on the road.

The State needs to continue to set targets and needs **CHBC members to provide input on defining and meeting those targets**, e.g. the recent executive order on sustainable freight due by July 2016. Need to direct and solicit broad stakeholder input.

Bill Elrick – California Fuel Cell Partnership:

Bill started by stating that we should "Make no small plans" by telling the story of Chicago World's Fair and a long term plan for the fair and the city. It was a huge success, by planning big and challenging everyone around. This fits the big picture for hydrogen: California has been a leader in renewable hydrogen from biogas, waste water, and solar and now power-to-gas storage projects.

Hydrogen can transcend the electricity and transportation sectors. It comes from central electrolysis, central SMR, onsite electrolysis and onsite SMR, renewables can be fed into electrolysis and central SMR, and Power-to-Gas. Renewable power can feed the grid and biogas & waste gas can feed into the gas network. The grid can feed and be fed by BEVs; CNGVs feed off the gas network. Biofuels can feed into liquid fuels. BEVs and FCEVs can

benefit each other through this system. Some of the pathways are existing and others need to be developed. We need to ensure compatibility and complementary nature of these sources and open every door for renewable hydrogen pathways.

The industry needs to develop a long term vision and systematic thinking. Real target is massive game changing renewable hydrogen plan with large scale production. There should not be any more "almost there" with small demonstrations, it's ready for integration. **A white paper or similar documentation is needed to get industry and stakeholders behind, perhaps led by a task force to start this process.**

Outreach and dissemination are needed, as well as champions to spread the word, vision, and keep the flame lit through the dark times by setting an unstoppable renewable wheel into action. Need to make big plans and inspire folks.

Henry Hogo – South Coast Air Quality Management District:

California South Coast Basin is the worst in air quality, but air quality over the last 14 years has improved. Every two years a new ozone quality standard comes out. In 2023, 2032, and about 2037 there will be increasingly stringent standards.

Top NOx emissions today are local sources primarily HD trucks from Class 4 and up. With regulations in place for 2032 the top NOx emissions sources will be shifted but still HD trucks are leading. Have to reduce NOx by 65% by 2023 then an additional decrease by 10% for 2032. Technology will allow us to attain these standards. Research and demonstration has to be done to lead to commercialization. There is high potential to reduce the NOx from HD trucks, locomotives, all vehicles, while ocean-going vessels, aircraft, and recreational boats have low reduction potential.

Beyond current technology SCAQMD is looking at BEV, FCEV, extended range catenary/wayside and alternative fuels that are 90% cleaner than 2010 emission standards. Key challenges include:

- Significant number of conventional on-road vehicles.
- Need for more commercial products, especially heavier vehicle applications.
- Enhance hydrogen infrastructure
- Incentive to purchase zero emission technology, currently there is a state program for low income persons.
- Need more hydrogen fueling stations, it's a delicate balance for the CHBC to work on.

SCAQMD R&D currently funds electric on-road and off-road trucks, and fuel cell trucks. Funding opportunities include:

- Clean Vehicle Rebate Program
- Hybrid Vehicle Incentive Program
- AB 118/Greenhouse Gas Reduction Funding Plan
- Enhanced Fleet Modernization Program
- California Energy Commission Programs

Home refueling is possible the way to go to kick start fueling infrastructure along with natural gas home refueling. The Hydrogen Education Foundation is managing the H2 Refuel H-Prize, a $1 million competition by DOE for companies to develop a home or community non-retail fueling system.

- Question: What is the White House's position regarding the emissions standards?
    - They want to see the EPA propose emission reduction similar to CA.
- Question: Is there any data on blends of fuel?
    - Up to 20% reduction on NOx.
- Question: Major commuter trains are a big deal in Europe, what about California?
    - SCAQMD is looking at some of the smaller locomotives for fuel cells.

Session I – Big Picture: Generating Market Drivers for Renewable Hydrogen

Chair/Moderator: Henry Hogo - SCAQMD

Delicate balance between hydrogen produced and the demand for it.

Brent Koski - United Hydrogen

UH has built a hydrogen filling station at JFK.
On any day there are 250 tons/Day (t/Day) of production in the hydrogen market, it would take 2-3 years to increase that number to 300t/Day, all of Plug Power solutions use 10t/Day as of last fall. The goal for United Hydrogen is 33% renewable component while keeping the price of hydrogen below $10/kg sustainably. Best way to get hydrogen is a Chlor-Alkali process with excess vented to atmosphere, and is a green pathway since it is using waste components.

UH has gaseous hydrogen stations in which electricity is 30% of cost, for liquid hydrogen stations electricity amounts to 65% of cost. Hydrogen price go up 20% with a renewable component. Solutions are on the technology side:

- Low cost renewable energy
- Supply capacity added from renewable sources
- Eliminate need of compression or liquefaction.

In the mean-time a subsidy is needed to catch up without negative financial impact.

Mike Beckman - Linde

Linde is involved in a lot of activity in Germany, Japan, and California. Linde has stations across California with the newest coming to San Juan Capistrano. The first retail station is in West Sacramento. There is conventional and renewable hydrogen production and they overlap.

- Renewable pathways are:
    - Electrolysis from wind/water/solar
    - Biological metabolism (algae)
    - Biomass gasification (wood)
    - Bioliquid reforming (glycerol)
    - SMR (landfill, sewage)

The public needs to make it a goal for all. Linde has a 15t/Day plant in Quebec takes brine water and extracts hydrogen using electrolysis. Meeting the 30% green requirement will add some cost to the short term. Solutions could be like Mainz, Germany where Linde has a Power-to-Gas pilot plant, which uses large scale electrolysis from wind energy. Hydrogen fills tube trailers, insert into natural gas grid, and dispenses onsite.

Sam Wade - ARB

California has adopted the Low Carbon Fuel Standard in 2009, goal is to reduce transportation fuel pool by at least 10% by 2020. Hydrogen is an eligible fuel, station owner or person who produces the station fuel receives the credit.
Looking for opportunities to increase hydrogen production

- Proposed rule what make H2 forklifts eligible for generate credits
- Enhance collaboration with CEC grants.

Discussion of a renewable hydrogen refinery credit:

- Credits can be awarded for using renewable hydrogen to make conventional fuels. This encourages refineries to use renewable hydrogen.
- It must be at least 1% fossil hydrogen replacement.

- Cannot be sold or transferred.

Discussion

- Fuel pricing:
  - Mike Beckman: From the industrial gas supplier standpoint, the discussion should move from the cost per gallon to cost per fill up and cost to drive 350 miles. The premium difference is not that different. Current numbers would show $500-700 cost increase per year versus current price of gasoline. He believes the cost of the car needs to come down.
  - Sam Wade: From ARB, the cap and trade program and increasing price of fossil fuels, there is LCFS to reduce cost of fuels and there are incentive programs to reduce the cost of the vehicle.
- Thoughts on what the State of California could be doing:
  - Brent Koski: Not a lot the state can do besides incentivize home refueling. Need to perform bulk hydrogen, perhaps from biogas. Right now California is relatively aggressive.
  - Mike Beckman: State can help to develop demand, like guarantee a payback for a hydrogen producer. Maybe the state would guarantee a minimum level of fueling, a level of return for a station. 20,000 cars by 2020 would require 14T of hydrogen, which requires a large plant. No one is going to make a big investment into a plant without such guarantee.
- What about long term heavy duty vehicles?
  - Sam Wade: The necessary fueling needs to be developed.
  - Mike Beckman: When a demand can be planned, an economic model can be planned and sold to investors. Technology is being developed for stations to back heavy duty vehicles.
  - Brent Koski: A lot easier to achieve with the bigger stations. Liquid pumping is a lot more reliable. Compression is very expensive, while pumping liquid is not expensive at all. State could help with the liquid setbacks. Liquid is the way to go with stations once there is volume. Would be helpful to see movements with San Dias efforts.
- What is the purity of the Chloralkali and what is the scrubbing cost?
  - Brent Koski: Hydrogen is pretty pure at 99.9999%, they went to mercury membrane system. The cost of the byproduct hydrogen is a fraction for the overall cost of the plant. Majority of costs come from electricity, labor, and maintenance of plant.
  - Mike Beckman: Purity is not an issue, it competes very well against SMR hydrogen.
- Is the refinery credit assigned to the hydrogen producer and refinery itself?
  - Sam Wade: The refiner applies for the credit.
- What are the opportunities for LCFS and the process for pursuing the electrolysis pathway?
  - Sam Wade: ARB needs an applicant to come forward with information on an electrolysis project. For some technologies ARB has a value and others need a value defined.
- Regarding the JFK station, what are the visions to saturate the East Coast market?
  - Mike Beckman: They would love to build 1,000 stations tomorrow, but won't because the cars aren't there. It is a real chicken and egg situation. Stations are $1.5M to build which needs demand in place. Government could continue to offset the initial and operating costs that are a way to move forward now.
  - Brent Koski: JFK was a support station for GM. They realize the stations need to go up first. There needs to be a minimum number of stations. Northeast would be a second tier to build out with an initial 10 stations as a base, much more stations will come online when critical mass is met.
- Diversity of renewable sources, what is the magnitude of renewable hydrogen that could be created.
  - Mike Beckman: They are working on algae products, there are a lot of pathways, which Linde actively reviews.

Session II – Meeting California's Renewable Hydrogen Targets

Sam Wade - ARB

AB 8 was signed in 2013 which allocates $20M to the CEC for annual hydrogen infrastructure investment. SB 1505 was signed in 2006 set the renewable requirement to 33.3%, 30% reduction of GHG, 50% reduction in NOx and ROG, and no increase in toxic air contaminants. 3,500 T/Year threshold before private-funded stations impacted.

- Concluded initial pre-rulemaking work in 2010.
- Considering future implementation by 2018.

1/5 would be electrolysers and 4/5 of renewable hydrogen from renewable natural gas.

Johannes Escudero - Coalition for Renewable Natural Gas

CRNG is a 501(c)(6) trade association with 70 members to provide an advocacy platform on natural gas and focused on public policy for renewable natural gas.
Members collectively produce 90% of the renewable natural gas available. Sources:

- Water treatment facilities - Only 1,200 of 17,000 have been developed
- Landfills - only 636 of 1,750 have been developed
- Agricultural digesters - only 239 of 8,000 have been developed

California has opportunity to lead rest of nation, there is huge potential. RNG from biogas as a feed stock is a real viable option. Goals are to expand existing markets, create new markets, and improve project financing.

Graham Noyes - Keyes, Fox & Wiedman

Government agencies are not aligned on hydrogen policies. KFW is a clean fuels regulatory law firm. Represents much of the solar and renewables space, represent Sierra Energy, a future hydrogen producer.
SB 1505 is two stages for a hydrogen highway. Currently there are no regulations in place, which are 5 years late than originally scheduled.

- Stage one is state funded stations with 1/3 produced from renewables.
- Stage two is triggered by 3,500T of hydrogen California transportation.

Current policy is focused on reducing GHGs, NOx, and the impact on disadvantaged communities. Current pathways are:

- Centralized reformation from NG
- Onsite reforming of NG
- Onsite reforming from renewable feedstocks
- Liquid H2 from centralized reforming of NG

California's annual 30.4 million tons of waste can be converted to 1.6 billion kg of low carbon H2.

- Equivalent to avoiding 56 million tons of CO2
- Removing 36% from CA autos
- Potentially provides 6,000 jobs
- Estimated $8.8 billion in new revenue.

Something needs to drive consensus, like a whitepaper. A carrot for the industry can be from greenhouse gas reduction funds. Next fiscal year will be at $2.5billion, it is on a steep incline.

Discussion

- Will the EER stay constant for heavy duty vehicles?
  - Sam Wade: Yes, they look at if the technology has progressed enough.
- Are there any rules and regulations progressing and are they on the transportation side or on the stationary side?
  - Sam Wade: Currently no renewable requirements for stationary fuel cells. The grid has to reach a 30% RPS by 2023.

    - Graham Noyes: There is a consensus that a lot of attention has to be paid to the transportation sector. Policy rules are divided between transportation and power. EVs and FCEVs end up in the middle. LCFS program is great with the renewable fuels program.
    - Johannes Escudero: Public policy drives demand that shapes markets and drives the value of the product. Historically RNG has been produced for utilities. There is an environmental and economic benefit from using RNG for transportation. There is a slight premium for RNG. Federally RNG can now be considered as D3, the highest of its category.
- What are the current efforts for a renewable hydrogen task force?
    - Sam Wade: There is currently not one.
- Would it make sense to offer credits for RNG?
    - Johannes Escudero: The best use for RNG is transportation.
    - Sam Wade: ARB views end use of RNG in transportation as attractive. However, there is more potential from converting RNG to hydrogen.
- For SB105 does it include transit buses?
    - Sam Wade: Yes.
- Using RNG to fuel heavy duty trucks a comparison should be made to hydrogen heavy duty trucks.
    - Johannes Escudero: Absolutely, I would happily provide the comparison in electronic form. The industry needs to band together and speak with clarity with one voice from Sacramento to Washington D.C.

Session III – Modeling and Experiences from Real Projects around the Globe

Wouter Vanhoudt - CertiHy

FCH JU is providing financial support with funding from the EU. The steps of the project are generic market outlook for green hydrogen are to:

- Define green hydrogen
- Review of existing platforms for GoO (guarantee of origin)
- Develop a road map.

Green hydrogen demand will be triggered by policy barriers. There is a clear need for a dual purpose system: reduce greenhouse gases and increase renewable input. Green hydrogen has been defined as being from renewable sources with an associated GHG intensity below a specified threshold. That threshold needs to be defined. Feedstock can come from biowaste, corn, and landfill gas. Green hydrogen can be produced from high emission production.

Brian Goldstein - Energy Independence Now

EIN is a NGO dedicated to developing innovating, action-oriented solutions to catalyze a rapid transition to a clean, renewable energy and transportation economy in the California. They did a project three years ago to review the impact of renewable energy credits on the renewable market. LCFS and RIN credits are good but not enough to spur renewable hydrogen investment and mostly focused on transportation. There need to be renewable mandates on stations. Renewable hydrogen needs to be expanded beyond transportation's view of it, by focusing on the intersection between hydrogen, power grid, and natural gas.

They need to continue to support ARB and EPA in getting H2 credits and pathways up and running. Pathways from renewable power to hydrogen need to be explored, it has yet to be done in the US. Most valuable use of renewable hydrogen is transportation. Outreach and education campaign has been introduced through reporters, bloggers and other alt fuel through leaders about the emerging H2 marketplace. Objective is to answer questions consumers have.

Prabhu Rao - McPhy

Founded in 2008, a spinoff from National Labs in France, they work on electrolysers and metal hydride storage. A lot of work has been done by McPhy in Europe to show the roadmap to renewable pathways to hydrogen. With low price of NG in US it is hard for industrial gases to compete. This is not the case in the Middle East, Africa, China, and others.
Operation site is in Italy with system development, product development, and they have a large electrolyser product/project development in Berlin. Customer base is international, 1,000 clients using 3,000 electrolysers. Mostly in Europe, Asia, and the Middle East. They have 5kg/day to 250kg/day electrolysers. They also have a 250kg/day unit installed at the new Berlin airport with a single stack, and a 100kg/day metal hydride storage. In California, McPhy is partnered with HTEC to provide hydrogen in Woodside, CA and have the most cost effective electrolyser for 100kg/day+ demand.

They have performed various P2G and energy storage projects. Audi project called e-Gas provides 2800kg/day with methanization. It has been certified for grid management, up to 6MW can be supplied to the grid in less than 5 minutes. Exclusive supplier to ThyssenKrupp. Contracted with China to provide electrolysers to be hooked up with wind.

Mike Levin - FuelCell Energy

Distributed hydrogen production can be performed using Tri-generation which provides heat, power, and hydrogen. Essentially a fuel cell/electric power plant. There are 110 power plants in 9 countries, 20 of which are in California. They have 350kW fuel cell stacks which combines to form four stack 1.4MW modules and a 59MW plant in Korea.

Distributed hydrogen can be done with industrial hydrogen, large scale electrolysis and SMR are more complicated than tri-generation. Tri-generation is claimed to be renewable, clean, affordable, local, and uses the least amount of water. Demonstration is in the Fountain Valley facility that takes biogas to produce heat, power, and hydrogen. Hydrogen is then used to fuel vehicles.

10% of all the wastewater treatment plants in LA and SF would provide enough fuel for four 2.3MW tri-generation systems. Each system can provide enough hydrogen for 300 cars a day. Each system can create two revenue streams: power and hydrogen. California RPS sources must be in the state of California.

Discussion

- In the EIN work, has anything been found for reducing electricity rates in California?
  - Brian Goldstein: The analysis in the EIN paper might shed some light in that.
- Question about electrolysis for McPhy, do they have small and large stacks?
  - Prabhu Rao: Yes
- What are the economics of steam reformation?
  - Mike Levin: To be cost competitive with gasoline hydrogen needs to be around $8. The tri-generation provides two revenue streams so selling power may offset the cost of hydrogen.
- What are the prospects on continuing the Fountain Valley projects?
  - Mike Levin: There needs to be a power and fuel contract to keep it going. They have to beat the economics of the engines that Fountain Valley has recently installed.
- How to heat big cities with hydrogen?
  - Mike: It can be done by inserting hydrogen into the natural gas pipeline.

Facilitated Discussion of Barriers to Adoption

Chair: Catherine Dunwoody

- This session is the business case for hydrogen.

Steve Jones - ITM Power

Based out of the UK with subsidiaries in Germany and California, the Riverside station has 33% renewable hydrogen supplied. Currently it will be up to 100% renewable as demand starts slow, it is a combined site for CNG refueling and electric vehicle charging. Current barriers are:

- LCFS and RINs are not currently supported with electrolysis unlike biogas based H2 generation.
- Small amount of funds for 100% renewable stations.
- Lack of vehicles

Solutions are:

- Link fuel with energy storage
- Have LCFS and RINs support electrolysis
- Increase funding levels for 100% renewable stations

Michel Archambault - Hydrogenics

They provide stations to areas where industrial gases are too far away. The CapEx for an electrolyzer is high. It is challenging to put an electrolyser station in California, though an electrolyser can easily respond to the fluctuations in the grid. Hydrogenics has been providing electrolysers for 35 years.

Keith Ropchock - Golden State EPC

Engineering Procurement Construction for Hydrogen & Fuel Cells, they do not own any stations. EPC is contracted to build and perform maintenance on the stations. To improve H2 business case:

- Solar to hydrogen incentive credits.
- Electrolyser and SMR should have incentives to SGIP.
- PEM electrolysers can be used for off peak.
- Direct photosynthesis to hydrogen with cyanobacteria has tremendous promise as to other emerging technologies.

Jonathan Palacios-Avila - StratosFuel

They are on the infrastructure side and want to establish the renewable infrastructure side. Electricity costs are high for peak demand. Looking into the future of centralized electrolysis stations is a viable option: where renewable hydrogen is purchased by the stations.

Dan Poppe - H2 Frontier Inc.

Customer needs to accept premium price. Policies need to change. OEM needs to commit to building cars. Right now the business model does not exist to operate fueling stations. Hydrogen costs $7 to produce via SMR.

Discussion

Key points:

- Steve Jones - Don't have a pathway under LCFS and nothing at the federal level.
- Michel Archambault - Concerned about the cost of power.
- Keith Ropchock - New and innovative ideas for R&D for the investment side.
- Jonathan Palacios - Challenges with using electrolysis and electricity.
- Dan Poppe - Price of feedstock/biogas is high. The hydrogen producers will have a hard time competition with that resource.

- How much are people willing to pay? Is the government pushing for renewables?
    - Steve Jones: For the public there are various issues and they are reluctant to pay for things they don't have to.
    - Jonathan Palacios: With economies of scale renewable sources of hydrogen can compete with non-renewables. Production of hydrogen can drop to $2-3 per kilogram.
- Concerns about supply, what about volume?
    - Michel Archambault: Hydrogenics has recently scaled up largely. Refer to what the policies are to produce hydrogen.
    - Dan Poppe: They need United Hydrogen to come to California to increase the suppliers of hydrogen. There are more problems to overcome right now than getting renewable hydrogen.
    - Steve Jones: Market for electrolysers will start to increase and come on board for power-to-gas plants. The pathways for biogas and electrolyzer hydrogen are there for renewables.
- Comment: $0.08 power can be used to produce hydrogen cheaply through electrolysis.
- Comment: Maybe the RECs can be revamped and restructured to help keep station costs down.
- Comment: Aggregation of facilities together as a single load in a grid balancing market to drive the price of electricity down. If these facilities could be pooled to buy RECs it would help lower the price of hydrogen.
- Question: Who takes the initiative to produce hydrogen in large volumes? Also what about capacity of stations?
    - Michel Archambault: Station capacity is not an issue at this time.
    - Steve Jones: There needs to be a large scale purchase agreement. A bus fleet is not a large enough demand but using an electrolyzer for grid leveling is an attractive case.
- Takeaways:
    - Demand needs to be known.
    - Find renewables at a reasonable price.
    - Utilities are going to play an important role.
    - More funding for production technologies, CARB has not put that much thought into that.
    - ARB has quite a bit of funding from the cap-and-trade program. There will be a series of workshops to discuss the investment plan for the next three years.

Session V – Workshop Conclusions - Next Steps to Project Development - Panel Discussion

Chair: Matt McClory - Toyota

Main points made this morning:

- The point of "If you build it they will come." Has been validated.
- 1/3 renewable is a good pathway but it can't stop there.
- Toyota is going to sell the vehicles, not lease them.
- Consumers will expect a known retail experience. They need to be up and functional 100% of the time and exist in perpetuity.

Mark Abramowitz - Session I:

- It takes 2-3 years to increase capacity. The demand from Plug Power is putting a constraint on their capacity.
- ITM Power really needs byproduct H2 as a pathway. They would like to see technology advances to bring down the price of electricity. Looking for ways to add to supply capacity. Suggested interim subsidies and listing byproduct hydrogen as renewable. They are being asked to compete with an infrastructure that has been in place for many decades and do it immediately. Ways to compete better would be a cost on carbon, maybe a higher cost of gasoline. Don't look at hydrogen as a low cost solution in the short term. They are pursuing different ways to produce hydrogen.

- Sam Wade has seen limited participation from the hydrogen community. The range of $0.25-$0.65 per kg of impact. There is an ability to create credits for hydrogen.
- Linde is not thinking much about the price, they are thinking about it more in terms of other vehicles. They would like to see more guarantees on investment.
- United Hydrogen suggested the state can help the Sandy efforts on setbacks to liquid hydrogen.
- Further discussion on the government stepping in until there are enough cars to support the infrastructure.
- There needs to be pursuit of many different ways to produce green hydrogen.

James Provenzano- Session II:

- Johannes Escudero stated there is vast capacity existing for renewable hydrogen. There are 371 landfill sites alone available for renewable natural gas. Heavy duty diesel trucks are the enemy. 70% of air pollution is from heavy duty trucks. RNG can be inserted into the existing natural gas grid. Linde and others are investigated RNG from biogas and other sources.
- Graham Noyes stated policy views are not aligned. SB1505 is a key driver to push forward to the hydrogen highway. SB350 calls for 50% reduction in petroleum use. SB 32 calls for 40% cut in green house gases from 1990 levels by 2030. The SIP calls for 90% reduction in NOx by 2031. Focus needs to go to the disadvantaged communities. The hydrogen step is going from renewable natural gas to hydrogen. A white paper needs to be put together for all to get behind.
- Economics are favoring transportation fuels.
- It makes more sense to reform natural gas and use it in a fuel cell vehicle than to combust natural gas.
- Hydrogen community does not see BEVs as competitors, they need to work together.
- Public policy drives demand.

Josh Eichman - Session III:

- Hydrogen can be used in a lot of different ways. In the transportation sector, power, etc.
- Idea of breaking the silos that exist on the regulatory side and technical side will allow for improving competitiveness.
- Wouter Vanhoudt asked about dealing with green hydrogen. It was a good discussion on what the definition of green hydrogen is, and important it can be to regulatory agencies like ARB.
- EIN talked about the work they had done on the value of credits. It provides an incremental benefit but will it spur that larger investment. Need to pick the pathway and make sure they treat it appropriately. If $2 of credits can be provided for renewable hydrogen that would put it with parity with nonrenewable hydrogen.
- McPhy is focused on electrolysis and metal hydride storage. Market is focused on industrial, energy, and mobility sectors/markets. They have projects with varying scales.
- FuelCell Energy has a 59MW fuel cell plant in S. Korea; the utility would be interested to hear about that. Tri-generation provides heat, power, and hydrogen.
- Overall there needs to be a push for regulatory changes as well as developmental changes. Also need for pushes in the technology sector.

Geoff Bud - Session IV:

- The question was posed to the panel to what station developers need to develop a better business case.
- Catharine Dunwoody also posed the following questions to the panelist:
    - How do your stations plans meet renewable hydrogen requirements today?
    - What is the biggest challenge with renewable hydrogen?
    - How does it impact your costs?
    - Do you expect renewable hydrogen to help cost?
- Barriers are:

- Cost of electricity and biogas too high.
  - Solution: lower electricity prices, negotiate with utilities, no peak purchase agreements, aggregate electricity purchases, large electrolysis plants.
- LCFS and RINs do not support renewable hydrogen to the extent required.
  - Additional CEC funding for 100% renewable hydrogen stations.
- Lack of FCEVs on the road. Station utilization?
  - Electrolysis providing energy storage and grid balancing revenue streams.
- CEC funding not adequate for renewable stations.
  - Incentivizing renewable biogas and electrolysis hydrogen supply with similar funding mechanism as offered by SGIP.
- Consumers' acceptance of high prices.
  - Incentivize design and manufacturing development.

Discussion

- How would they start the White Paper activity?
  - James Provenzano: SCAQMD asked for a list of projects and the CHBC provided that.
- Would you see NREL and universities starting to collaborate?
  - Josh Eichman: There are many ongoing projects looking at the business case for renewable hydrogen, power to gas, and electrolysis. Industry Canada and DOE is helping. NREL is working with DOE and CARB on these issues. Those are good proxies to start that work. Using all the information they have to start a white paper.
- With the passage of AB 1900 what would be necessary to start to begin the program of doing inserting the natural gas into the pipeline?
  - Josh Eichman: First step would be for it to become a bill and the second step would be the support for natural gas systems.
- What would be the pathway to electrolysis?
  - Mark Abramowitz: Technology is there, companies with real products who are able to accomplish things. A certainty would really help in calculating that pay back. Need to get away from ones and twos and get into larger projects. The agencies are in a position to help with a lot of that. It provides a real cost effective way of meeting air quality standards.
  - Geoff Bud: The European integration is easier since they are all under one roof. In the US the grid is segmented. UK and Germany are looking at these solutions.
  - James Provenzano: CPUC needs to get involved to incentivize the use of renewables, since the utilities run the transmission lines.
- Comment: Major impediment is the cost of power; need to get to $0.07-$0.08 per kW. A major action of this meeting needs to be a roadmap. $0.17 kW is not feasible. Over the next 24 months there needs to be a pathway formed.
  - Josh Eichman: No one has asked the utility for their own rate; meanwhile BEVs get their own rate. A different rate structure needs to exist. ACTION ITEM: Ask your utility for a different electricity rate.
- Comment: Regulations on the books not designed for where they are right now. Legislators can't deal with ambiguity. It shouldn't just be an electrolysis base; RNG can also play a role.
- Comment: There are real benefits to the technologies we're talking about that they can give to their respective markets without an incentive. They are actually valuable. Electrolysers provide a real value back to the utility right now. There is not another technology out there that can provide that service to the utility.
  - Electrolysers need to be monetized.
- Comment: More biogas facilities need to be implemented to dispense hydrogen.

- Comment: Renewable methane being converted to hydrogen is a cool idea. Tri-generation makes the penalties of doing that as small as they can be. Really great feature taking digester gas to produce hydrogen, power, and heat. They need batteries, fuel cells, electrolysers all together.
- Question: Why are the utilities not a member of CHBC yet?
  - Audience: Most of the utilities are run by lawyers who have no idea what the technology is.
  - Mark Abramowitz: CHBC has tried to engage the other utilities, SMUD is ahead of the other utilities and is a leader.
- Comment: SMUD has the lowest rates in California and installed an electrolyzer there.
- Question: What value will you provide the utility?
  - Audience: there is an inherent value to buffering the grid.
  - Josh Eichman: When the demand comes in, the grid will pick up these technologies.
  - Mark Abramowitz: It would be a public service towards an emission reduction.
  - Audience: There is a double dip in the losses of transmission by not using electricity onsite.

Renewable Hydrogen Workshop Results and Messages to Stakeholders

Jeff Serfass:

- They got recognition of the role of government in the highest level in Tyson Eckerle. With the governors aggressive roles.
- Bill Elrick said they need to create a big plan, a big white paper.
- There was a good discussion at the end with SMUD probing the question of "What value does an electrolyzer supply?" The notion then of public good is very important.
- There are a number of audiences for the work that they produce out of this. There are a number of policy leaders that can talk about the outcome of this.
- Industry is enhanced by the number of non-industry players in attendance.
- Car buyers expect to know more about the source of hydrogen for their vehicles.
- California is the leader in the US and the world. There are a lot of groups in other parts of the US that are interested in the outcomes of this workshop.
- In summary, there needs to be a few products, a whitepaper or at least a draft of a whitepaper; a factsheet for different audiences. In the process need to identify project ideas.
- Hopefully some of the attendees will step forward to offer to help this effort and guide the CHBC to capture this workshop in a white paper.

CHBC Summer Summit – Hydrogen Energy Storage and Grid Services Workshop

Thursday, July 30, 2015

Day 2 Orientation and Workshop Objectives

Jeff Serfass

A takeaway from yesterday was a whitepaper to policy makers to deal with policy and economics of dealing with hydrogen. HES began in 2013 with the CHBC; it is an important topic to take on. California is a leader in hydrogen production.

Keynote: Need and Opportunity

Daryl Wilson - Hydrogenics

California is a special place for hydrogen. There is a long history and heritage of focus on hydrogen. Nowhere else in the world is there as large a number of agencies discussing hydrogen. More than $100M at stake for hydrogen projects. Climate change is an important conversation with leaders around the world. This will accelerate progress in renewables.

The $2.1B from California's cap and trade puts $100M from DOE in the shade. They don't attract thousands to our programs and events, but they need to say thank you to each other. Looking forward, we have to keep our safety record excellent with meaningful action to ensure. Along with safety needs to come a high level of quality. Scale and cost reduction has to come next. Fact is, fuel cells are much too expensive and are not widely used. Cost falls away dramatically with scale. Policy is much more important than funding. The right decisions need to show the value that fuel cells bring.

CHBC is important to create meaningful discussion, to focus on what matters and move things in policy. Let's focus on the horizon and talk to each other. VUCA: Term born in Vietnam war. Volatility, Uncertainty, Complexity, Ambiguity.

Vision corrects volatility. No one can state the vision for hydrogen in California. A clear, concise, repeatable mission statement needs to be made. Understanding is the solution to uncertainty. Focus on clear understanding. Hydrogenics formed a joint venture with Kolon to deliver continuous power generation at a refinery from surplus hydrogen using PEM fuel cells. It took 10 years from the seed planted. Solution to complexity is clarity. Bring the discussion down to clear focus points. Hydrogen is a complex subject. Need to bring simplicity into the discussion. The white paper discussion item will help bring clarity to power-to-gas. It will help the utilities understand how power-to-gas can help the utilities now.

Following factors matter to utilities:

- Safety
- Scalability
- Reliability

To survive in the hydrogen economy it take special people with three traits:

- Stress resilient with diet, health and sleep
- Ability to embrace change, industry needs to constantly change
- Seek consensus with agile leadership – this is not easy.

CHBC is critical in moving the discussion ahead with critical parameters.

- High penetration of renewables is needed.
- A need must be felt
- Policy has to be moved
- Wholesale price of electricity is a door opener.
- Renewable fuel standard
- Value needs to be realized
- Champions are arising, Jeff Reed is one of them.

Power-to-Gas discussion has been going on for a number of years. A vision is deeply needed and needs to be told to policy makers. A teaming and a consensus is required and meaningful progress needs to be made, like the whitepaper.

Session I – Energy Storage as a Grid Asset

Chair: Jeff Reed

There is no need felt for hydrogen by the utilities. There is a mixed view of level of that need today. It's on the components manufactures and abilities to convince the utilities that these solutions work. Power to gas is complex in the form of tariffs; however, as a dispatchable resource it has a real value. The Duck Curve is real. In 2015 there is already sizeable over-generation and requirements for increased ramping at the end of the day. In California there are large underground storage fields for natural gas.

Val Tiangco - SMUD

SMUD serves 1.4 million popular with a 3300MW peak power. SMUD has a very aggressive RPS, more so than the state. Biomass is the majority of the renewable sources of power. SMUD has a grand vision for the future in responding to the customer challenges with a high level of satisfaction using renewables.

SMUD will need bulk and distributed storage in the long run. SMUD is pursuing a multi-pronged research approach. Energy storage will benefit SMUD in a variety of ways. However, the storage challenges remain. Some of them being capital cost, performance not being fully proven as business cases are still being developed. Intermittent renewables are challenging to handle for utility companies. Utilities need to know the value of hydrogen. It needs to be clearly defined as a storage or source of electricity to meet customer needs. Present values are:

- Transportable storage to defer distribution investments.
- Community energy storage installed adjacent to distributed transformers.
- Commercial customer sited storage to reduce energy costs and demand charges.
- Residential and commercial customer sited storage aggregated by a 3rd party and value sole to utility.

Cost needs to be considered to convert hydrogen into renewable natural gas. SMUD performed a study on the different forms of energy storage, besides hydrogen. This includes lifecycle cost comparisons.
SMUD is looking at:

- an attractive use of lithium ion for energy storage. Other advanced battery technologies were also being considered and researched.
- Thermal Energy Storage is a real potential for SMUD.
- Compressed air energy storage is being considered. Natural gas fields in the area can also be used.

Storage will be an integral part of the future of SMUD. SMUD has a large storage R&D portfolio and is demonstrating a smart residential energy system. SMUD has learned a large amount from research pilots. It needs to continue its analysis on the value of hydrogen.

Steve Jones - ITM Power

The message of hydrogen needs to get out to the utilities. Focused primarily on electrolysis equipment. ITM Power has HGAS and HFUEL divisions.

Wind curtailment is a big issue in the UK, cannot export surplus electricity to other states/countries. Large amounts of money are being paid in Europe for grid balancing services. The trend of payments made in that market is increasing. Frequency control is a major part of power-to-gas. Load of an electrolyzer can balance the frequency. Frequency Controlled by Demand Management has to be performed in 2 seconds to qualify for revenue streams.

Future operating needs due to the duck curve are: load following, regulation and continuous ramping. There is a growing trend in the US with multiple states for energy storage; policy is the real driver. P2G Elements add value to the power grid, the gas grid and the economy.

Energy storage versatility is like a smart phone, is has a variety of applications. Both batteries and P2G will play a role in the future. However, when comparing a 32MWh battery system versus a 32MWh P2G system, the P2G system is more cost effective. Europe has embraced energy storage using P2G. Germany estimates 46GW of electrolysis usage in 2030.

Josh Eichman - NREL

There is a seasonal cycle of natural gas usage that creates opportunities to fill the voids with hydrogen inserted into the NG network. There is an expected 0.23% curtailment in 2024 with 33% renewables and a 3.42% in 2024 with 40% renewables. Market values change depending on use:

- Energy
- Ancillary Services
- Capacity

NREL has worked to quantify the value of energy storage with a variety of different technologies. Energy storage can do a lot of things but they are all not necessarily needed now. Fuel cell and electrolyzer costs are prohibitive compared to pumped hydro and lithium-ion. However if the hydrogen produced from electrolysis can be sold, it can help offset the cost of equipment and increase the technology's competitiveness. More storage is not necessarily more competitive in current energy and ancillary service markets. Impacts for variable generation:

- Energy
  - Reduce locational marginal prices (LMP)
  - Greater need for flexible resources
- Ancillary Services
  - Increase requirements for normal balancing curve, which can increase prices for those services.
- Capacity-
  - Increases in resources providing capacity

NREL is active in various projects relating to hydrogen and P2G.

Dr. Jack Brouwer – UC Irvine

The duck curve shows a problem in three regards:

- The belly shows problems with generators that can't be turned off.
- The peak is a problem with delivering enough power after the sun has gone down.
- The dynamic problem is coupled with increasing demand and the sun going down.

It is not clear that P2G is the alone solution for the duck curve. At peak times wind power is not available so generators must be dispatched to meet the load. Therefore the existing infrastructure must remain. Extreme dynamics of powering on and off can't be handled by existing generators. This is where a P2G can play a vital role. Spatial and temporal emissions are different with higher renewables. This causes air quality to get worse even though there is a net reduction in ppm. Wind power from the winter can be stored and used in the summer when it is more needed through hydrogen storage. Using the existing NG grid is an amazing benefit for

P2G. Hydrogen energy storage is fundamentally different from battery storage for the long term. It is more comparable to pumped hydro.

Discussion

- Question: Comparing daily the balance of the power needs and the seasons, analysis is usually focused on daily needs. For the long term how much advantage is there?
  - Josh Eichman: The entire system can be modeled.
  - Jack Brouwer: Long term energy storage technologies will get paid. It will be more valuable for short term energy storage. The longer the duration goes the better P2G and HES looks in comparison to technologies that doesn't scale in the same way. HES will have a very strong competitive advantage in years to come.
  - Jeff Reed: The old model of incumbent utility needs to be moved away from through policy and tariffs. There is a need for new modeling to show these potentials.
- Question: Should there be a convergence on terminology between HES and P2G.
  - Jeff Reed: P2G is a subset of HES.
- Comment: The smart phone analogy is great and exposes the real communication challenge. Communication to the policy makers needs to be in a language they can hear. They need to know the value.
- Question: When looking at electrolyser value in energy only, can enough hydrogen be made to sell 400kg/day?
  - Josh Eichman: Yes, it can be shifted to anytime during that day. The model matches the fueling profiles of transportation. The electrolyzer is sized accordingly. There is variability in sizes of electrolysers that can be taken into account to afford for price spikes.
- Comment: The full cost of dispensing hydrogen doesn't need to be included in the model.
  - Josh Eichman: Correct, it's not now but it will be in the future.
- Question: What is the water use and is it factored into the cost data?
  - Jack Brouwer: The water use is surprisingly low, less than 1% of the household water can be converted into enough hydrogen to power the whole house.
- Question: NERC standards are not seen in the model, why?
  - Steve Jones: The audience depends on if those standards and tariffs are relevant. There needs to be a focus through the weeds on the demand for the customer on what it does for a particular customer.
  - Jeff Reed: There has been an effort to communicate information on the technology. Once the electric utilities get involved, then those standards will be included once procurement is closer.

Session II – Practical Examples

Steve Szymanski - Proton Onsite

PEM Electrolyzer company based in Connecticut. Connected with the innovators of PEM. Proton Onsight has a project on UCI. Jack Brouwer and his team have learned some very interesting things. Serving markets that exist today. Doesn't P2G make sense in the US? Market issues do not currently exist, grid issues, policy issues, and unclear value proposition are all barriers. Large barrier is lack of analysis. There is a list of questions on P2G R&D that are being addressed at the UCI National Fuel Cell Research Center.

- How to best blend and inject hydrogen into a pipeline.
- What the dynamics are on putting hydrogen into the pipeline.

A focus area for the electrolyser is understanding the dynamics of operation. Commercially AC power is provided that is rectified to DC power. Currently the electrolysers offered Proton OnSite take DC to AC to DC. The UCI project is a 7kW electrolyzer with a coupled AC/DC converter. Proton has built 20 of these systems over the years. It's on loan from Excel Energy, an electrical utility in CO. 10 years ago they were funding research on

electricity to hydrogen. Next phase is a 60kW electrolyzer designed as a load follower. It is a combinable scalable system with a change of stack, leaving the balance of plant.

A load following electrolyzer in Kona, HI is taking utility signal, 4 -20mA, to drive and affect the frequency on a simulated grid. Hydrogen will be used to fill busses. Primary purpose of the project to demonstrate the different services provided by an electrolyzer. Looking at electro-chemical cycles including ammonia. That device can do the same functions but without water. Moving forward there needs to be a learned adjustment, document uses cases, scale up of projects to MW, and there needs to be real customers with commercial terms. Third party analysis is needed. The transportation network needs to be leveraged. Work with policy makers.

Kevin Harrison - NREL

Used the wind–technology Center in Boulder, CO. Synthetic natural gas can be made from deep sea enzymes and insects. Traditionally wind turbines run at constant speed; an electrolyzer varies stack power and output hydrogen depending on incoming wind power. NREL put a power converter between the solar/wind and electrolyzer to maintain a constant output to the electrolyzer. In frequency regulation time matters. The benefit of an electrolyzer is it can respond very quickly. The entire system response in 200ms. Meets utilities test to perform frequency regulation. Alkaline batteries response was slightly faster than PEM. A lot of energy (hydrogen) can be stored at different pressures in caverns around CA. SCG test is to scale up bio-methanation and looking at the full round trip stats of efficiencies. All renewable electrolyzers are possible with a balance of plant. Electrolysers can be sized to handle variable wind

Geoff Budd - ITM Power

The PEM electrolyzer is a disruptive technology with many applications. Germany has specific targets to reach in renewable energy. Ultimate goal is to reduce GHG by 80% of 1990 levels by 2050. FCH JU performed research on how hydrogen can be a solution to energy storage as it pertains to Europe. Thuga performed an analysis of the German natural gas network storage potential. They found it to be enormous at 250TWh. European P2G website shows all the sites of P2G projects going on in Europe. ITM Power has a P2G plant just outside Frankfurt. It was the first PEM electrolyzer in Germany. It has been running for the last 18 months. Cooperation is crucial to achieve success in the industry.

Discussion

- Question: What are the examples of what to do with the oxygen?
  - Geoff Bud: The opportunity to use the oxygen is to employ biomethanation at waste water treatment plants. Increase the efficiency of the anaerobic digester by using the oxygen.
  - Steve Jones: A differential pressure safe is the oxygen is at ambient pressure, therefore it is not compressed. Compression would add cost.
- Question: What about absorbing the reactive power?
  - Kevin Harrison: Modulating stack power and absorbing reactive power switching IGBTs need control. It has not been done but it would be nice to show next year.
- Question: For the 100kW companies and 70% efficiencies what would be the price range per kW?
  - Steve Szymanski: For the specific efficiency level it can be designed to be less efficient with less capital cost. Efficiency is a driver of cost. 80% of the cost per kg comes from the net cost of the electricity.
  - Steve Jones: Economics are dominated by the opex.

Session III – California Market Opportunities and Regulatory Issues

Rich Myhre - BKi

BKi staffs and operates the CaFCP. AB 2514 gave the CPUC to set targets on the investor owned utilities to buy or build energy storage in three "grid domains". There is a cost effectiveness hurdle. By 2020 they are trying to get 1325MW of energy storage. The three storage grid domains are: transmission connected, distribution connected, and behind-the-market. The Energy Storage roadmap was a joint effort by CAISO, CPUP and CEC. Published in 2014, prepared with hundreds of stakeholders. The roadmap was broken down into sections: planning, procurement, implementation, interconnection, market participation.
CAISO is looking at opening an area for the energy storage. There will be a series of public workshops on AB 2514 on use cases. The round trip efficiencies will be low for power generation ancillary services. There are a lot of large hydrogen users in the state for industrial products. The CEC needs help in framing the use case.

Steve Jones - ITM Power

There are areas in Europe that are more advanced on their thinking than the US. Especially Germany. Localized evidence is needed for the value proposition of power to gas. The loads are different for different areas. No one will believe it until they see the potential application their areas. Education comes first in explaining the concept of P2G. Second, local modeling needs to be done for the areas envisioned for P2G implementation. There have been large European P2G research projects, something similar needs to be done in California. Third, demonstration pilots need to be funded that are utility sized in the MW range using federal and state funding. Fourth, policy influence needs to increase and compliance requirements made. Fifth, straight forward commercialization. P2G fits with renewable grids and solves real problems.

Dr. Susan Schoenung - Longitude 122 West, Inc.

P2G can be power-to-gas or power-to-gas-to-power. Referring to the duck curve, the high dollar benefit comes from:

- Renewable firming
- Capacity

The present value of a system with a 15 year life has a higher cost than benefit. Although the future cost will be slightly less than the benefit. The power-to-fuel future costs are higher than the benefit. Same with transmission deferral. For power-to-gas use case in using the hydrogen infused natural gas to power a turbine. The future cost is less than the benefit. There can be another use case scenario with bio-gas. It was not done in the white paper.

Discussion

- Question: What could the community do to get the information to the CPUC?
  - Rich Myhre: Find the sweet spots in the use cases, assemble it, and send it to the CEC guys. It should not be terribly detailed – it should contain mostly pictures with some analysis.
- Comment: They kind of missed the boat on energy storage, what didn't we do? If there is another change, what do we do this time?
  - Steve Jones: They definitely missed the boat on the public policy talks on energy storage. California has been focused on transportation. The industry put itself in a silo for a while until demonstrations in Europe complete. Looking forward they need to follow what the Europeans have already done. Education on P2G is starting to pay off and show in public charts. People like Rich Myhre need to be supported with facts and figures.
  - Susan Schoenung: Thank Jeff Reed for the new interest at the CEC, SoCalGas has been a leader.
- Comment: When the bids were solicited for energy storage, hydrogen was unintentionally excluded.

- Comment: SoCalGas has a large interest in hydrogen. The CHBC HES Committee was formed once the public storage solicitation was already underway. They all have to make sure to communicate on public legislation.
- Comment: There is a lot going on at the CPUC and staying informed is half the battle.
- Comment: In three days in the energy storage conference in Dallas there was only two mentions of hydrogen P2G. There is a clear value that they bring to the table and they have been unable to monetize it. A commercial relationship between utilities and companies needs to be made.
- Comment: In the 1300MW energy storage workshop at CEC it was asked that hydrogen electrolysers not be presented as an option. They were publicly saying that the round trip efficiency was too low.
- Comment: Our community needs to make sure that one parameter is not the argument against us. We cannot end the argument there; we need to bring up the fact that it is cheaper to store than lithium ion batteries.
- Comment: It's the same argument as to why they need BEVs and FCEVs.
- Comment: Solar cells are 12% efficient, which needs to be remembered.
- Comment: In Europe, Siemens started producing electrolysers and brought attention to the public, maybe a large multinational company can help in the US.
- Comment: They need short sound bites like what Jack said to give public a perception.
- Comment: They need to work on a two sentence mission statement like Darryl brought up in the morning to rally behind and convince the public and policy makers with.

Session IV – Next Steps to Project Development

Moderator: Rob Friedland

What projects can come out of this and what can the CHBC do to move P2G along?

Susan Schoenung - Session I

- HES and P2G can many potential opportunities and applications like a smart phone.
- In order to reach out to potential customers and stakeholders we need better educational materials.
- HES and P2G doesn't fit the battery type storage model and does not have to be at a single location.
- The incremental cost of the storage provides opportunities for seasonal storage. However, the market doesn't have a way to value that.
- They don't have a way to monetize the reduction of pollution and green house gases.
- The duck curve tells a story but may not be the best or first market.
- Need to look further into the future with transformation, modernization, and diversification.
- A lot of analysis has been done but there is still a lot of work to do.

Jay Keller - Session II

- Think about ICE cars industry. There is still very fundamental aggressive work in that region. We've crossed the line from fundamental development research.
- Looking at Germany pushing forward with a large number of demonstration plants with MW sizes it is very encouraging. The US is behind, but things are happening here too on a smaller scale. European policy is ahead with climate change – that is a real driver.
- Need to tell the customer the value added clearly.
- Learning by demonstration is "racing to train".
- There's a lot to learn and a lot to grow but we have crossed a threshold.

Michel - Session III

- CPUC targets of 1325MW of energy storage is encouraging. They need to attend workshops and give a clear vision of value.
- P2G fits into the other use cases besides electrons to electrons.
- Steve's presentation about gaps in funding is important.
- Need to ask utilities for wholesale prices.

Discussion of next steps

Chair:

- Looking backward on missing the boat of energy storage, they just weren't ready.
- We need to quantify the value and where, why, and how it fits into the state's energy storage plan.
- We have to be less harsh on ourselves.
- The MW electrolyzer is still in the prototype phase.
- What specific policy attributes do we need to start to discuss?
- The farmers in Germany look at wind like a crop. When the wind turbine is spinning they make money. When the wind is curtailed they have crops they can't sell. They need to enable that farmer to use that crop to power electrolysers. Think about how to structure the contracts around this.
- Projects can't just be found they also need to find you with drivers.
- What are the policy drivers? Do they want to mimic Europe? What about the federal level who has really punched out.
- CHBC needs to spread the word to the states that do not have companies attending this event.
- Need to put together our collective influence to change the mind of EPRI. The utilities need to tell us on how to make money.

Audience:

- Comment: It's not clear that they missed the boat on HES. The GHG discussion is just starting to take off in California.
- Comment: They need to be attentive to the transportation and non- transportation policy.
- Comment: The big challenge is if big power comes from $0.15 or $0.20 a kW it will be difficult to sell the hydrogen. A pathway for low cost power needs to be found and a strategy made.
- Comment: The CAISO offers cheap electricity for surplus renewables.
- Comment: There isn't a renewable standard for gas, they need more of those.
- Comment: Legislation is proposing RNG standards as recently as this year.
- Comment: EPRI received a $1M contract from the CEC but hydrogen has not been included. This is an additional door for HES by telling EPRI and the state that hydrogen belongs at the table of energy storage.
- Question: Is the duck curve real?
    - Jack Brouwer: Yes it is real and can be shown on the CAISO phone app.
- Comment: We need to sell the technology abilities and capabilities that we have. We need to demonstrate an economic renewable station to show to utilities the value P2G has. There is already a renewable LCFS credit for giving renewable hydrogen to the refineries; there could be some push back but they might be interested in renewable hydrogen.
- Comment: Need to find the large scale hydrogen users.
- Comment: In Europe it will not change their current assets of onsite SMR, but they might be willing to purchase green certificates for renewable hydrogen. Could sell the renewable hydrogen virtually to refineries.

- Comment: A rec program can work.
- Comment: Visibility now is with transportation fuel, that's what's getting public attention. If a project or two to supply renewable hydrogen for visibly placed hydrogen fueling stations it would attract a lot of public attention.
- Chair: How do we increase projects and what would the feds say?
- Comment: Currently we don't have the right incentives to do it because renewable electricity is more expensive. The people making the policies on the grid need to include hydrogen. If we can get $0.10 kWh then $5/kg hydrogen can be sold.
- Comment: In Europe people will take a risk on the capex on a demo projects, they are very afraid to risk the opex. If the opex cost could be reduced by dropping electricity prices and keeps it under control then they will take a risk in doing implementation.
- Comment: The CA cap-and-trade auction proceeds are being put into an investment plan that is going to be discussed at upcoming workshops at ARB in Sacramento.

Energy Storage Workshop Results and Messages to Stakeholders

Jeff Reed - CHBC

- The themes that came out are correct. A continuing good analysis has to be done to give a fact base to the policy makers.
- One thing for CHBC to think about is that the HES industry is where solar was at the early 2000s. A lot of collaboration among competitors, cost performance data has to be done with cost forecasts of the future. DOE and other agencies are helpful with target, but are those targets going to be met? The rest of the companies need to bottom up accounting.
- They need to better manage our engagement with policy and regulator processes. We need to outline tactics of what we need to do. Need to put up a calendar on the website with dates of workshops.

Summit Results and Messages to Stakeholders

Jeff Serfass

- Thanks to sponsors, attendees, staff, and volunteers.
- We are really looking for feedback on doing workshops. We are doing something different and need to know if this is a good idea.
- There are a lot of things CHBC can do:
    - Manage the organization
    - Put on events
    - Listen to the board
    - There is a certain presence we have with the state agencies.
- This is not an expensive organization, we need funding to do what can to help in the policy halls.
- There will be upcoming VIP lunches.
- The members need to be more active in supporting the CHBC if the CHBC is going to be more successful.
- How can the organization identify policy issues early enough to mobilize sector action groups to help the staff to draft and review statements. Need to let staff know if something is going on, like a hearing or deadline for comments it needs to be known well in advance.
- They also need members to lead things like the HES white paper. Need to figure out the output from yesterday's workshop.
- They need more members.
- Fall Summit is in two months at Cal EPA. We will deliver the results of these two days. We need to make an agenda to address the circumstances. They want input for the agenda.

- We are planning with sponsorship from Toyota to create a Financing the 101st Station workshop.
- We are planning a meeting in Silicon Valley to brief influence leaders, companies and investors. The board wants to do this to counter the “Elon Musk” factor and negative perception of fuel cells.
- We are planning a Supply Chain Briefing to expand the supply chain. There are some shortages and lack of capacity. The state would like to have more of these products manufactured within the state. What could warrant more manufacturing in the state.
- We are working informally with POLB to create a handbook for hydrogen and fuel cells. We need to be brought up to date with an analysis of facts to be put on the table and initiative for a hydrogen terminal.
- We need to get the results of this workshop out.
- CAISO is having a symposium in October, members should exhibit or attend to spread information about hydrogen energy storage.