U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

SUSTAINABLE TRANSPORTATION SUMMIT H2USA SESSION, TRACK 5 Meeting Proceedings

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Fuel Cell Technologies Office

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Session Overview

The U.S. Department of Energy (DOE)'s Fuel Cell Technologies Office (FCTO) hosted an H2USA session-- one of six parallel track sessions presented during Day Two of the first-ever Office of Energy Efficiency and Renewable Energy (EERE)'s Sustainable Transportation Summit in Washington DC. The other parallel track sessions focused on initiatives from EERE's Vehicle and Bioenergy Technologies Office, including EV Everywhere, Synthetic Biology Foundry, Workplace Charging Challenge, Clean Cities & Smart Mobility, and Co-optimization of Fuels and Vehicles. The tracks aimed to serve as a forum to share ideas and perspectives among key stakeholders from industry, academia, and government, regarding opportunities to accelerate the commercialization and deployment of advanced transportation technologies and smart mobility systems over the next decade and beyond.

The FCTO-led H2USA session featured three panels to discuss the H2USA partnership and the new DOE/National Lab "H2@Scale" initiative:

- The first panel titled "H2USA Overview and Working Group Chairs" provided an overview of H2USA, a public-private collaboration between DOE, industry, state agencies, and other key stakeholders to address key challenges in deploying hydrogen infrastructure.
- The second panel titled "The Hydrogen Supply Perspectives" covered hydrogen station and delivery activities, challenges, and opportunities from stakeholders in the hydrogen supply and infrastructure industry, as well as the state of California.
- The third panel titled "H2@Scale Concept Perspectives" followed an introduction to a new DOE lab initiative called H2@Scale, which offers the potential for renewable hydrogen as a flexible, clean energy carrier that can accelerate market penetration of renewables while also deeply decarbonizing our energy system. Participants discussed grid/utility and end use perspectives.

Session Participants

The H2USA track session was well attended with over 70 participants that included representatives from several DOE offices, including EERE, Nuclear Energy, and Electricity Delivery and Energy Reliability. Other attendees included stakeholders from the hydrogen and fuel cell industry, national labs, and local and state representatives.

Session Introduction

The H2USA track session was kicked off by an introductory presentation from FCTO Director, **Dr. Sunita Satyapal**, to set the stage for the following panel presentations and discussions. Dr. Satyapal's presentation also provided a high-level DOE perspective on the research and development, demonstration, and deployment progress achieved to date and the remaining infrastructure-related challenges FCTO is currently addressing. Dr. Satyapal concluded with the objectives and outcomes for the session.

Session Panels

H2USA Overview and Working Group Chairs Panel

Panel Overview

This panel provided an overview of the H2USA mission and purpose, which is to address key challenges in deploying hydrogen infrastructure. Speakers representing each working group provided updates on their activities and responded to questions from the audience at the end of the panel.

Panel Participants

Charlie Freese (GM) served as the moderator for the panel and provided an overview on the importance of H2USA in bringing together a key group of stakeholders to address a common goal. Mr. Freese highlighted the need for constancy of purpose as all stakeholders work towards a sustainable change in the transportation industry. His remarks set the stage for the H2USA working group chairs to discuss the activities, progress, and remaining challenges to be addressed in each working group area.

Bob Wimmer (Toyota) provided an update on the Market Support and Acceleration Working Group, describing specific outreach efforts achieved to date. These include working with the Council of Mayors and directly with New York City's mayor to create awareness around fuel cell electric vehicles (FCEVs) and hydrogen fueling stations in the NYC area. This working group has played a key role in developing activities for National Hydrogen and Fuel Cell Day (October 8th, for the atomic weight of hydrogen, 1.008), and they will continue to support the development of hydrogen safety codes and standards.

Steve Ellis (Honda) provided an update on the Locations Roadmap Working Group. The main focus for this working group has been on the Northeast, to support the development of a roadmap guiding how many, and where, stations are needed, and when they should be open for service. Efforts through this Working Group includes helping to determine the early market readiness and market locations for hydrogen stations in the Northeast.

Charlie Myers (Massachusetts Hydrogen Coalition) provided an overview on the Financing Infrastructure Working Group. This working group is working towards increasing collaboration among auto manufacturers, to enable them to determine how to mitigate financial risk for stations and how to increase early station utilization. Other activities through this working group include tools and scenario planning to support station developers, creation of support materials, and hosting investor meetings.

Karen Quackenbush (Fuel Cell and Hydrogen Energy Association) provided an overview of the Hydrogen Fueling Station Working Group. This group is supporting activities to enable economical hydrogen stations across the U.S. with the safety, reliability, and performance that consumers expect. The hydrogen station modeling activities, including DOE's Hydrogen Refueling Stations Analysis Model (HRSAM), have provided a foundation for the near-term station economic modeling activities in this group.

The Hydrogen Supply Perspectives Panel

Panel Overview

This panel convened hydrogen supply companies, as well as the state of California, to discuss the current opportunities in the hydrogen production market and challenges in delivery of hydrogen to existing stations.

Panel Participants

Pete Devlin (DOE FCTO) served as the moderator for the panel, and to set the stage for the panel speakers, provided an overview of hydrogen supply and market challenges.

Bill Elrick (California Fuel Cell Partnership) discussed the progress and challenges in California's commercial rollout of hydrogen stations, as well as future plans to address an increased number of FCEVs in the short-term. One of the biggest accomplishments for the state of California has been obtaining certification for hydrogen stations and transitioning them from operational to open for service. California is currently evaluating next steps and future priorities to ensure the market continues to grow, and that state funding is dedicated to address the appropriate barriers.

Eileen Brown (Linde) reviewed Linde's challenges and accomplishments as a supplier of hydrogen. Linde has focused on working with station developers and maximizing the use of stations through different approaches (i.e., hydrogen stations paired with convenience stores). In the future, Linde envisions selling many types of fuel at one station.

Dave Edwards (Air Liquide) reviewed Air Liquide's plans in the Northeast states. Air Liquide is focused on a hub approach in two areas, around Boston and New York City. Air Liquide believes that fleets of FCEVs are a good option for the early market, and that the industry needs to focus on renewable hydrogen production.

Jeff Pallito (United Hydrogen) discussed the industrial gas market and its challenges. Some of the challenges are related to the fact industrial gas is a mature market with stagnant demand. United Hydrogen believes vertical integration is an option to improve the market, and they are working with Noble Gas on a joint venture for Northeast infrastructure activities. United Hydrogen is looking for new applications for industrial gas, including reducing nitrous oxide emissions through land-based gas turbine fuel blending, as well as power-to-gas storage through liquid organic hydrogen carriers.

The H2@Scale Concept Presentation and Perspectives Panel

Panel Overview

This panel was kicked off by a presentation from **Bryan Pivovar** (National Renewable Energy Laboratory, NREL) on the H2@Scale concept, its requirements, and its potential to deeply decarbonize the U.S.'s energy system. The panel following included presentations from government and industry speakers discussing grid/utility and end-use perspectives for the H2@Scale concept. After the presentations there was discussion with the audience, and participants had the opportunity to submit any comments and/or remaining unanswered questions at the end of the session for future follow-up.

Panel Participants

Bryan Pivovar (NREL) presented the H2@Scale concept. Below are details on the concept:

Society is facing a multisectoral energy challenge in needing to decarbonize transportation, industry, and the grid. As more intermittent renewable energy sources, such as solar and wind, are integrated onto the grid, the price of renewable energy has plummeted. This drop in prices has facilitated such a rapid increase in renewable energy penetration in certain locations that it has outpaced the ability of the existing grid to integrate these new resources, and has done little to impact the transportation or industrial sectors. In Germany, it has been hard to specifically plan a pathway for transition to 80% renewables by 2050 due to the challenges of integrating intermittent energy on the grid alone. This creates an overall need for a means to store energy and/or convert to fuels and products to facilitate increased integration of renewable energy with the existing grid.

Currently, there is a sizeable demand for hydrogen in the U.S. economy. Roughly as much energy goes into hydrogen production today as is currently produced by wind and solar in the U.S. This is also comparable to the amount of energy produced in the U.S. by hydroelectric plants. The demand for hydrogen is primarily fueled by the ammonia fertilizer production and oil refining sectors. NREL has determined that this existing hydrogen demand, as well as some of the demand for hydrocarbons, could be replaced with low carbon hydrogen. Using projections for very large-scale systems and current methane prices, hydrogen production costs of $1.75-$2/kg can be achieved using steam methane reforming (SMR). Conversely, NREL's modeling projects that hydrogen production costs from electrolysis is on the order of $4.20/kg, assuming gigawatt-sized electrolyzers, electricity prices at $0.066/kWh, a 97% capacity factor, 66% conversion efficiency, and a capital cost of $400/kW for electrolyzers. This is too high, and thus it is critical to figure out how to make low-carbon, cost-competitive hydrogen.

The path toward lower cost renewable hydrogen involves the use of curtailed energy from renewables. If one retained a $400/kW capital cost for electrolyzers and 66% conversion efficiency, but instead operated the electrolyzers at 40% capacity factor, and utilized $0.01/kWh electricity (an arbitrary average price for curtailed renewables to illustrate the impact of low cost electrons), one would get hydrogen at $2.24/kg. To further reduce prices, one needs to reduce electrolyzer capital costs, which, while likely compromising efficiency, could conceivably get hydrogen production costs to $1.14/kg, assuming capital costs of $100/kW, 60% electrolyzer efficiency, and a $0.01/kWh curtailed electricity price. This analysis assumes that the operating life of the electrolyzer is reduced by cycling to an equivalent calendar lifetime. Due to the current economics of electrolyzers and the low level of R&D investment, a great opportunity exists to lower the price of electrolyzers.

The general principle of H2@Scale follows on the framework of the Renewable Energy Futures Study (REF).[1] The point of the REF was to see whether or not an 80% renewable energy-powered grid could be enabled for the entire U.S. by 2050, through the use of various grid-balancing mechanisms such as increased transmission capacity, flexible biofuel-powered electricity generation, electrical energy storage, and dispatchable solar thermal generation. The REF found that no insurmountable technical barriers existed that would bar this transition.

In the H2@Scale concept, the grid envisioned by the REF was modified such that the compressed air energy storage (CAES) was removed, and biofuels were used only to make transportation fuels. Then, to regain the 80% renewable energy-powered grid that was lost when flexible, renewable electricity generation from biofuels was removed, more wind and solar were added. However, given the high levels of renewable penetration, approximately 89% of this new generation had to be curtailed. This curtailed energy, along with the energy previously destined for CAES, was instead turned into hydrogen via the low cost, 60% efficient electrolysis units described above. This renewable hydrogen was used to displace transportation energy use via the use of FCEVs, to displace coking coal use for steel refining, and to displace the existing, SMR-derived hydrogen for petroleum refining and ammonia production. Given the assumptions above, the H2@Scale study showed that a roughly 44% reduction in GHG emissions was possible in the U.S. economy by 2050. This analysis could be greatly refined, and increased in scope to, for instance, tackle emissions from the residential and commercial end-use sectors.

Michael Pesin (DOE-OE) served as the moderator and provided the perspective from DOE's Office of Electricity Delivery & Energy Reliability on the challenges facing the modern grid (also articulated in the Quadrennial Technology Review Report[2]).

The electricity grid is facing changes brought on by a variety of factors. From a supply side there is a general shift taking place from centralized, dispatchable generation towards a more decentralized grid, with many intermittent renewable energy sources coming online that cannot be dispatched. There is an increase in the number of threats to grid reliability, posed by cyber-attacks and other entities. Furthermore, the equipment that makes up the transmission, distribution, and utilization infrastructure of the grid is aging, posing more reliability issues. Finally, the traditional, vertically integrated utility is under pressure from deregulation (in regions that have not yet deregulated their utilities), as well as by greater consumer choice in how to purchase and generate electricity, for instance through residential solar photovoltaic installations. In order to adapt and evolve the grid, the above challenges must be faced so that the country can develop a more sustainable grid, while also ensuring that energy costs to the consumer are affordable. Generally, there is a consensus that energy storage will play an increasing role in managing the changes to the grid, while maintaining its existing use for the end-user.

Suna Taymaz (PG&E) discussed how PG&E believes hydrogen can fit into its business model. PG&E is a leader in sustainability within the utility space, with their portfolio currently made up of 58% greenhouse gas (GHG)-free wholesale electric power, seven of the ten largest solar plants in the U.S., and 25% of all rooftop solar in the country. However, as mandated by California's SB 350, by 2050, 50% of the energy utilized by California's public utilities must come from renewable energy sources other than large-scale hydroelectric plants and municipal waste-fired generators.[3] This renewable portfolio standard (RPS) creates unique challenges for PG&E and other California utilities. Using grid and renewable energy production forecasting modeling techniques, it is projected that up to 8.9% of the total energy acquired by California utilities to satisfy the RPS will be curtailed under scenarios involving high penetrations of large-scale solar photovoltaic plants.[4] The curtailment events will be particularly acute during the spring, when low electricity demand coupled with near-maximum solar generation will create a large surplus of power on the grid during the daytime. Unless new means of storing electricity or transmitting electricity out of California are developed, curtailment will be required during more than 2000 hours per year (23% of the time), and the curtailment need will exceed 20 GW during a worst case scenario.

1 http://www.nrel.gov/analysis/re_futures/

2 http://energy.gov/under-secretary-science-and-energy/quadrennial-technology-review-2015

3 http://www.leginfo.ca.gov/pub/15-16/bill/sen/sb_0301-0350/sb_350_bill_20150224_introduced.htm

4 https://ethree.com/documents/E3_Final_RPS_Report_2014_01_06_with_appendices.pdf

A suite of energy storage technologies could alleviate the problems with grid stability identified in the scenario above. While batteries can help to balance small deviations between supply and demand on the grid over shorter time scales, technologies such as hydrogen are necessary for greater supply-demand production-demand mismatches, and to store energy over longer time periods. Hydrogen could be used for a variety of end uses including electricity generation, and it can also integrate into PG&E's existing support of alternative fuel vehicles. Beyond the issue of intermittent renewable energy curtailment, another potential means to generate low-carbon gaseous fuel would be to utilize trees and biomass that are dying across the state due to California's ongoing droughts. This could be used to displace existing methane use, as well as to generate low-carbon hydrogen for transportation and other end-uses.

Jeff Reed (Southern California Gas Company) focused his presentation on renewable gaseous fuels. SoCalGas's primary business is distributing natural gas to its Southern California service area, but in the future, SoCalGas can envision hydrogen-blending and being involved with hydrogen infrastructure as business opportunities. Currently SoCalGas is investigating many pathways for renewable natural gas, including organic conversions, electrolysis, methanation, hydrogen blending, and artificial photosynthesis. There are numerous challenges with utilizing power-to-gas (PTG) methods for generating renewable fuels from a utility perspective. First, the technology is still expensive, as there is limited market penetration. Greater market pull, generated by policy, as well as greater funding for R&D efforts would help to reduce costs. From a policy standpoint, there is a lack of framework for gas utilities because using PTG technology would require serving multiple markets (the electricity grid and transportation fuel sectors). The Investment and Production Tax Credits are also not well suited for PTG devices. Finally, it is difficult to capture the value of reduced carbon emissions over the life of a project. This is due to the fact that, per the low carbon fuel standard[5] regulations, average carbon emissions (not marginal) are used to determine the carbon intensity of electricity that would be input to PTG infrastructure. This makes it difficult to get subsidies that actually reflect the low carbon intensity of curtailed renewables.

Mitch Ewan (Hawaii Natural Energy Institute) covered Hawaii's perspective on their hydrogen programs. Hawaii is at the start of implementing hydrogen at scale within the state, and the state wants to deploy cost-effective infrastructure to produce, distribute, and dispense hydrogen. Their strategy is to focus on fleet vehicles (at the Honolulu Airport), looking at central fueling for large vehicles (e.g., buses at Hawaii Volcanoes National Park), while also providing public benefit. Public benefit is of key importance because, initially, tax dollars will have to support public transportation needs. Hawaii is focused on supporting the early heavy users of hydrogen to develop a hydrogen market, before industry steps in to continue to move the market forward. In order to do this, Hawaii has pursued progressive energy policies, including a tax per barrel of oil imported and a 100% renewable energy RPS standard that comes into effect in 2045. Overall, Hawaii has been able to achieve significant progress by generating political will, developing policies and plans, funding strategic market transformation projects, building community support, and working with strategic partners.

[5] http://www.arb.ca.gov/fuels/lcfs/lcfs.htm

Panels Q&A/Discussion

The main points raised during the H2USA Working Group Chair Panel Q&A session included issues pertaining to hydrogen delivery methods, which were generally described as being truck-based for existing stations, with a potential to shift to pipelines if demand increases. Additionally, H2USA representatives stated that there needs to be further efforts undertaken to increase collaboration between the working groups in the future. By working on shared issues and concerns together, the working groups will better be able to address hydrogen infrastructure challenges and achieve the mission of H2USA.

The Hydrogen Supply Perspectives Panel Q&A session included discussions on how the use of fleet vehicles could accelerate the FCEV and hydrogen market, leading ultimately to subsidy-free deployment of hydrogen vehicles and fueling networks, and how industrial applications for renewable hydrogen must be leveraged in the near-term to build a supply chain for renewable hydrogen.

For the H2@Scale Perspectives Panel, the major points for discussion included how one could increase fuel cell efficiency as well as how methanation of hydrogen, the implementation of policy and outreach efforts could be short term goals on the longer pathway towards the full scale deployment of H2@Scale. Additionally, issues pertaining to how transportation as well as power to gas could serve as the best economic opportunities for hydrogen produced from curtailed renewables, and how further policy work is needed to allow for pipeline injection of hydrogen. At the end of this Q&A session, participants were asked to submit any questions and feedback on H2@Scale. These questions and comments have been compiled in Appendix 1.

Appendix 1: H2@Scale Questions and Comments

Questionnaire cards were circulated at the end of the meeting to directly solicit feedback from those in attendance. Questions were also asked to the speakers during the breakout session (as noted below). The appendix includes a categorized list of questions and feedback received from those in attendance.

1. Enlarge/change scope of H2@Scale analysis/effort to include other research efforts/stakeholders

    a. Consider deployment, technology, etc. for transportation across fuel types. For instance, do not de-aggregate based on fuel (hydrogen, electricity, biofuels, etc.) but rather on operational function.

    b. How will H2USA coordinate with the SMART mobility pillar—vehicles and infrastructure, which include analysis of opportunities to enable economic viability of hydrogen stations?

    c. How can U.S. Department of Transportation-affiliated university transportation center research activities be leveraged to benefit H2@Scale projects?

    d. Consider adding a policy cross-cut with H2@Scale, because interfacing with the diversity of regulators is a challenge.

    e. How will other federal agencies be involved?

    f. What are the funding sources for pilots to produce renewable hydrogen from biomass?

    g. How can we get utilities, energy storage industries, and regulators to put hydrogen energy storage in the mainstream?

    h. After electrolyzing water, is there a market for the oxygen?

    i. RFI to demo H2@Scale components needs to demonstrate all parts of system (e.g. controls at grid level to manage overgeneration).

    j. Certain end-use demands, such as steel production, probably are not in high demand in the U.S. Is it appropriate to export hydrogen and reduce emissions abroad where hydrogen is used in greater quantities for other applications, like steel refining? How could one "claim" or report emissions reductions in this case?

    k. Why are electric utilities not actively involved?

    l. There should be a focus on wasted resources as a pathway to hydrogen:

        i. Agricultural waste (USDA)

        ii. Industrial waste heat to syngas or electrolysis

        iii. US Department of Energy Bioenergy Technologies Office – waste from biomass from biofuels production

        iv. Geothermal heat or nuclear heat

    m. How can H2USA and H2@Scale be coordinated in such a way that the hydrogen ecosystem deployment is accelerated?

2. Potential economic pitfalls/solutions possible for the H2@Scale effort

    a. What if all the hydrogen produced from renewables/nuclear is used for FCEVs due to economics, and never goes to other uses (refining, ammonia, etc.)…would H2@Scale still achieve the scale needed to trigger deep decarbonization and lower the hydrogen cost to enable FCEVs to flourish?

    b. Most hydrogen produced is for refineries. How do we get them to participate in a renewable hydrogen market? Most refineries currently produce their own hydrogen at low cost (through steam methane reforming).

    c. What is the cost reduction projection of retailed hydrogen per kg by pathway (natural gas, electrolysis, etc.)?

    d. How do we leverage nuclear assets for electrolysis given that the hydrogen produced would need to be stored and delivered, and that it is less economic than decentralized on-site production?

    e. How soon can the production/delivery and storage cost be brought down to gasoline costs?

    f. The biggest question is how to overcome cost of low utilization of electrolyzer capital when the renewable penetration results in small scale overgeneration (how to overcome the transition period towards large scale renewable penetration). Major policies need to be created to overcome the transition challenge.

    g. H2@Scale relies heavily on the availability of low cost electrons. What is the strategy for addressing market and regulatory barriers to making low cost electricity available for hydrogen production?

    h. How do we create sufficient value streams to make H2@Scale happen? It is much larger than transportation.

    i. How do we get the larger fleets (buses, trucks) to convert to hydrogen? For cars to work, need one needs less expensive hydrogen, which requires increasing both supply and demand for hydrogen.

    j. Coal and nuclear plants are shutting down. What's the cost of hydrogen production when these run at a constant rate, producing electricity at 1.5-3 cent/kWh? Coal would require CCS (existing plants only). This would create economies of scale to reduce hydrogen production costs. What would be the cost of hydrogen under this approach? What would be the amount of hydrogen produced? Low vs. high temperature electrolysis.

    k. H2@Scale needs to quantify and reduce the technology risk of advanced hydrogen production, storage and distribution technologies to enable industry adoption and policy issues.

    l. What do you see as the biggest value proposition from a hydrogen economy?

        i. Transportation – hydrogen is a feedstock for multiple applications, but the largest market potential is in transportation. Also in power generation.

        ii. A combination of the right policy environment, incentives, favorable policies and the involvement of other commercial entities are necessary for H2@Scale to be viable from a utility perspective. Specific applications that offer good value include power to gas and generating hydrogen from electrolysis.

3. Is H2@Scale novel or advantageous when compared to other energy storage means? How can it be differentiated from other efforts?
    a. Deep decarbonization opportunities to determine limits and costs for electrification vs. H2@Scale vs. pipeline gas vs. other scenarios should be investigated.
    b. How is H2@Scale different from the "hydrogen economy" presented and discussed in the USA + internationally circa the year 2000?
    c. The current market conditions for H2@Scale to work are economically unfavorable. There is very limited curtailment of renewable energy, the overall demand for hydrogen is low, and natural gas prices are very low. How can one overcome these challenges?
    d. Is hydrogen at scale just another energy storage plan? How will you differentiate that?
    e. It would be good to show the value of hydrogen generation from the grid (or potential value with increased renewable penetration) for applications including long term/seasonal grid storage and other high value applications.
4. The need to address public awareness of hydrogen
    a. Are the existing public hydrogen fueling stations being properly leveraged to increase public awareness? Can the design/location of planned stations be improved to further public awareness?
    b. How to improve public awareness of the opportunity from hydrogen?
    c. How do we provide the public up-to-date facts on the hydrogen technology and dispel the many misconceptions? Even many educated people and people in energy are unaware of how far the technology has come for FCEVs and refueling.
    d. How will H2USA coordinate with the clean cities coordinators to educate consumers on FCEVs?
5. The need for temporal planning in the H2@Scale rollout
    a. We need a pathway for getting from today to the H2@Scale vision of the future. How is the renewable aspect of hydrogen valued? Can there be a demo project that overcomes regulatory barriers?
    b. What are the steps that form a roadmap for deployment of hydrogen as a viable power source for utilities? Can we use hydrogen generators for dispatchable power sources?
    c. In the future, understanding how the grid will evolve is a key question for H2@Scale. Policy can shift us off natural gas and petroleum, but may be necessary to enable renewable hydrogen and other fuels.
    d. H2@Scale is a compelling vision, and an exciting idea, but it is going to take time. What do you see as a short term opportunity before the "at scale" part can be achieved?
        i. Need to concentrate on fleet users to build up basic infrastructure and demand for hydrogen.
        ii. Need to pursue opportunities in methane.
        iii. Need policies like those in California. The opportunities provided by H2@Scale, as well as the emerging issue of renewable energy curtailment are generally poorly understood by the various stakeholders whose engagement is critically important to H2@Scale's success (natural gas utilities, electric utilities, transportation planners, etc.). This must be addressed.

6. Organizational/funding questions for the DOE
    a. Who will primarily drive H2@Scale? DOE or industry?
    b. This is a big opportunity and task—what and how will DOE prioritize what?
    c. How can DOE help to turn H2@Scale and H2USA into a national energy policy?
    d. What could convince the DOE to not divide the program funds for different FOAs into small funding amounts? The small funding amounts make it more difficult to achieve success without critical mass of H2 and vehicle deployment.
    e. How will DOE promote H2@Scale deployment without taking away from the R&D activities that are still needed to reduce cost?
    f. How can we really set up the H2@Scale proposal for success including collecting key info on the top problems in each technology?
    g. How can we ramp up the FCTO budget to make the at scale investments needed to achieve H2@Scale? This is so important to the nation's energy and environmental security.
    h. Can DOE leverage other agencies to promote hydrogen fleets? Federal, state and local government fleets, airports, mass transit, trains…all are opportunities for hydrogen but may require influence beyond DOE.
    i. Is it possible to coordinate efforts and redirect some of the code based carbon capture and underground sequestration technology to steam methane reforming production of hydrogen?
    j. What can H2USA and DOE do to promote fleets to invest in fuel cells and hydrogen?
    k. Why does the US Government not financially support the development of hydrogen infrastructure, as is done in other countries?
    l. Funding R&D to reduce the cost of hydrogen and fuel cells is not enough to accelerate the market. Moving some of this funding at the federal and state should be directly used to help build hydrogen stations to jumpstart demand. More stations would enable the purchase of more cars, which in turn would increase hydrogen demand. This would create a business case. Increased demand of the hydrogen will enable private sector and industry to be more involved, which in turn will also enable H2@Scale.
7. Changing the role for electric utilities as PTG scenarios are introduced
    a. Why can't power distributors become station owners since they could effectively produce hydrogen as a result of bleeding off the extra energy during peak generation times?
    b. Is there a new initiative at the California-level for direct injection of biomethane into pipeline system of utilities?
        i. Not presently, but perhaps the factors that have previously prevented biomethane injection have changed so that this is now a viable idea.
8. Bookending efforts for H2@Scale
    a. At what rate will hydrogen need to be produced at a given facility? At what rate will hydrogen need to be delivered at a given rate? What are the regional/requirement differences?
    b. We need more clear understanding of hydrogen demands now and in the future.

9. OEM and private industry role in H2@Scale
    a. What is OEM role within H2@Scale? H2@Scale must "fit into" current hydrogen and fuel cell electric vehicle commercialization activity.
    b. Are OEMs and states actively working on replicating the CA hydrogen rollout in other locations?
    c. How does industry involvement impact the progress of H2@Scale?

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