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Final SoCalGas Comments on Clean Transportation Benefits Report Workshop 8.8.19

Additional submitted attachment is included below.

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Subject: Comments on the Staff Workshop on Clean Transportation Program (ARVFT) Benefits Report and Successes for 2019 IEPR, Docket # 19-IEPR-04

Southern California Gas Company (SoCalGas) appreciates the opportunity to comment on the California Energy Commission (CEC) staff workshop Clean Transportation Program Benefits Report and Successes held on July 18, 2019, conducted as part of the 2019 Integrated Energy Policy Report proceeding. SoCalGas strongly supports the state's climate goals: we are focused on becoming the cleanest natural gas utility in North America and are committed to 20% renewable gas being delivered in our system by 2030.

Given the challenge of projecting the pace and scale of innovation and economic trends, California must allow an "all of the above" approach to solutions with maximum flexibility and technology neutral policies to decarbonize California's economy as per the recommendation of The Energy Futures Initiative's recently released report, *Optionality, Flexibility and Innovation: Pathways for Deep Decarbonization in California*.[1] The authors analyzed the options (within the parameters of existing state policy) by sector for meeting California's near- (2030), mid- (2045) and long-term (2050) carbon emissions reduction goals and found that renewable gas and hydrogen are needed. By leveraging California's existing energy infrastructure, technological expertise, and skilled workforce, we can transition to a deeply decarbonized transportation sector. Additionally, innovative technology pathways and adoption frameworks along with sustained incentive mechanisms are critical to meet the above-mentioned goals.

[1] Energy Futures Initiative. *Optionality, Flexibility, & Innovation. Pathways for Deep Decarbonization in California.* May 2019. Available at: https://energyfuturesinitiative.org/s/EFI_CA_Decarbonization_Full-b3at.pdf

SoCalGas believes California should prioritize the development and use of hydrogen—produced from low- or zero-carbon feedstocks—to play a significant role to facilitate California's decarbonization of the transportation sector across multiple vehicle classes used across diverse economic sectors. To do this, hydrogen will need to be produced from steam reforming (SMR) using carbon capture, utilization, and storage; from renewable sources, like water electrolysis using carbon-free electricity; and by utilizing renewable gas from landfills and diary feedstocks. This low- or zero-carbon hydrogen can be used in several applications, but here we focus on the benefits for the transportation sector.

CEC should continue to support the growth of the hydrogen market to benefit the transportation sector in the following ways:

- Support the adoption of low- and zero-carbon hydrogen pathways: prioritize the production, use, and further development of renewable gas, such as biomethane and renewable hydrogen pathways, to provide immediate reductions in greenhouse gas (GHG) emissions.
- Ensure the longevity of the Low Carbon Fuel Standard
- Expand funding opportunities for pre-commercial carbon-capture and use demonstrations for hydrogen produced from low-carbon resources that can provide cross-sectoral benefits.
- Support the development of hydrogen-powered technologies for the transportation sector across all types of vehicle classes.
- Develop an implementation framework based on the results from CEC's strategic long-term roadmap for renewable hydrogen.[2]
- Follow the lead of science and hydrogen experts:
    - Embrace the finding in the recent study by Energy Futures Initiative that notes "[f]uels that are durable, storable, and easily transportable play a fundamental role in ensuring that all sectors can operate at the scale, timing, frequency, and levels of reliability that are required to meet social, economic, and stakeholder needs."[3]
    - Embrace the findings in the recent study by International Energy Agency, *The Future of Hydrogen: Seizing Today's Opportunities.*[4]
    - Embrace the recommendations in the recent study by Energy Independence Now, *Renewable Hydrogen Roadmap.*[5]
    - Consider the efforts of experts, governments, and innovative businesses around the world working to expand the hydrogen market. (See Appendix A)
- Utilize existing energy infrastructure to accelerate the adoption of low-carbon fuels.
- Continue to support low-nitrogen oxide (NOx) combustion technologies for immediate criteria and short-lived climate pollutant reductions.

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[2] CEC Docket 1 7-HYD-01: Renewable Hydrogen Transportation Fuel Production. Available at: https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=17-HYD-01

[3] Energy Futures Initiative. *Optionality, Flexibility, & Innovation. Pathways for Deep Decarbonization in California.* At p.xix. May 2019. Available at: https://energyfuturesinitiative.org/s/EFI_CA_Decarbonization_Full-b3at.pdf

[4] International Energy Agency Website. Available at: https://www.iea.org/hydrogen2019/

[5] Energy Independence Now Website. Available at: https://einow.org/rh2roadmap.

1. *Ensure the longevity of the Low Carbon Fuel Standard*

SoCalGas strongly believes the Low Carbon Fuel Standard (LCFS) program provides great opportunities and incentives for emerging low-carbon technology pathways in California to mature over the long-term and help achieve our aggressive climate goals. However, we need stronger policy and regulatory support mechanisms to ensure the longevity and continued success of the LCFS program. While recent increases in LCFS credit prices have in effect reduced the net cost of renewable hydrogen production to become more price competitive with other fossil fuels, long-term credit price risks have shunned private debt financing from investing in more renewable hydrogen projects. Mechanisms, such as loan guarantees and credit floor price mechanisms, can reduce investors' concerns and allow for continuous build-out of renewable hydrogen infrastructure which is needed to meet California's climate goals.

2. *Support the development of carbon capture, utilization, & storage to support transportation decarbonization*

Some California emissions will be challenging to eliminate. One option to mitigate these emissions is through carbon capture, utilization, and storage (CCUS) where CO_2 is efficiently captured, stored, and then converted into new products like carbon black, graphite, carbon nanotubes, etc. which contain the CO_2 for long periods of time. CCUS technology can provide cross-sectoral emission reduction opportunities including for the transportation sector. As described below, there are some entities that are starting to look into the opportunity for CCUS, including the U.S. Department of Energy (DOE), Energy Futures Initiative, and the European Commission.

CCUS is being studied by DOE to advance the safe, cost effective, capture and permanent geologic storage and/or use of CO_2. "The technologies developed and large-volume injection tests conducted through this program will be used to benefit the existing and future fleet of fossil fuel power generating facilities by creating tools to increase our understanding of geologic reservoirs appropriate for CO_2 storage and the behavior of CO_2 in the subsurface."[6]

Energy Futures Initiative presents *Natural Gas with CCUS* as one pathway to reduce emissions: estimating that there are 37 natural gas-fired power plants that could be potential candidates for CCUS in California.[7]

[6] Department of Energy, Office of Fossil Energy. Carbon Capture, Utilization and Storage Research. Available at: https://www.energy.gov/fe/science-innovation/office-clean-coal-and-carbon-management/carbon-capture-utilization-and-storage

[7] Energy Futures Initiative. *Optionality, Flexibility, & Innovation. Pathways for Deep Decarbonization in California.* 2019. At p.70. Available at: https://energyfuturesinitiative.org/s/EFI_CA_Decarbonization_Full-b3at.pdf

The European Commission's[8] study (2018)[9] in its "strategic long-term vision for a prosperous, modern and competitive climate neutral economy" evaluates the importance of hydrogen. The study states, carbon capture and sequestration (CCS) has not yet reached commercialization, hampered by lack of demonstration of the technology, economic viability, regulatory barriers, and limited public acceptance. They believe that to materialize CCS at scale more research, innovation, and demonstration is needed.[10]

Some universities are also working to sequester carbon in plant life. For example, the Salk Institute is exploring slight genetic modifications to plants to transform them into "superabsorbers" that absorb, two, four, or even 10 times as much CO_2 as they do today.[11] This is a way to use nature to absorb carbon from the atmosphere, while potentially improving the productivity of plants.

The cross-sector benefits of utilizing CCUS include grid resiliency, vehicle grid integration, zero-carbon fuel production for transportation, among others. SoCalGas asks CEC to consider the efforts highlighted above to assess CCUS as a solution to meet California's climate change goals. Specifically, please consider expanding funding opportunities for pre-commercial CCUS demonstrations.

3. *Support the development of Power-to-Gas technologies for the transportation sector*

SoCalGas was pleased to hear at the workshop that the CEC "is very interested in Power-to-Gas" and asked for feedback on the subject.[12] SoCalGas has submitted extensive comments[13,14] on the opportunity for Power-to-Gas (P2G) technology[15] to convert surplus renewable energy into hydrogen, which can be blended with natural gas or renewable gas and utilized in everything from home appliances to power plants to vehicles as a transportation "e-fuel."

The primary technological processes used today to produce hydrogen are electrolysis and reformation, including SMR and autothermal reformation (ATR) (there are two types of reformation technologies). Hydrogen is also produced when organic mass is gasified, but this

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[8] The European Commission is the executive of the European Union.
[9] European Commission. *Communication from the Commission to the European Parliament, the European Council, The Council, The European Economic and Social Committee, the Committee of the Regions and the European Investment Bank*. November 2018. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52018DC0773&from=EN, pg.13
[10] *Ibid*. at p.15.
[11] Salt Institute Website. Harnessing Plants Initiative. Overview. Available at: https://www.salk.edu/harnessing-plants-initiative/
[12] Tim Olsen's response to public comments made by a Nikola Motor representative who stated that they were thinking more about electrolyzing and asked CEC to consider this technology.
[13] SoCalGas. Comments in response to the 2015 IEPR Draft AB 1257 Report, the 2017 IEPR Increasing the Need for Flexibility in the Electricity System Workshop held on 5/12/17, and the Draft 2017 IEPR.
[14] SoCalGas Comments - E3's Article, Decarbonizing Pipeline Gas to Help Meet California's 2050 Greenhouse Gas Reduction Goal. Available at: https://efiling.energy.ca.gov/GetDocument.aspx?tn=220242&DocumentContentId=29876
[15] SoCalGas Website. Available at https://www.socalgas.com/smart-energy/presentations-webinars/decarbonizing-the-pipeline.

"syngas," consisting of mainly CO and hydrogen, is typically an intermediate product often used to generate methane or electricity. Reforming is a mature technology and is the most economical way to produce hydrogen, supplying 95% or more of the hydrogen used in the U.S. today. This process must be paired with CCS to produce clean hydrogen.

The P2G pathway uses the electrolytic process of using renewable electricity to split water into hydrogen and oxygen. Mature technologies, including polymer electrolyte membrane (PEM) and alkaline electrolysis (AE), already exists in the market and is being used widely in commercial applications. The hydrogen produced from the P2G pathway can either be stored directly and consumed, or methanated and injected into the natural gas grid to be stored and delivered for a variety of end uses, supplementing or displacing traditional natural gas. Storing hydrogen from electrolysis enables an energy storage pathway that can also provide significant scalability and versatility in helping to balance increasingly complex and variable electric grid.

Being modular in sizing and flexible in siting, P2G systems can be deployed efficiently for hydrogen production as a source of transportation fuel at the point of consumption (e.g. at or near a hydrogen refueling station, at warehouses for use in forklift operations, etc.).

According to the World Energy Council,[16] electrolysis is a solution to store energy as a fuel or combined with CO_2 and converted into methane or liquid fuels for use in the transportation sector. This green hydrogen could also help decarbonize processes that are difficult to electrify, like medium- and heavy-duty trucking. The Council expects the cost of electrolysis techniques to decrease as production increases. And it notes that hydrogen can also be stored in the form of ammonia or methanol. The stored hydrogen could also be converted back to electricity to support electric vehicle charging and vehicle grid integration.

Hydrogen produced from these renewable or low-carbon feedstocks can then contribute to the decarbonization of transportation. Utilizing P2G technologies offers numerous benefits including helping to support grid resiliency, to integrate electric vehicles to the grid, to utilize the existing gas grid as storage mechanism, and to meet California's aggressive climate goals.

CEC should consider the research conducted by Enea Consulting on *The Potential of Power-to-Gas* (2016). They found "power-to-gas technologies have the most potential when applied to green mobility markets. As such, their fate will be strongly correlated to policies and incentives implemented in the much broader perspective of the transport sector decarbonization."[17]

The International Energy Agency maintains a list of all projects worldwide since 2000 (including those in planning and construction stages) to produce hydrogen for energy or climate change mitigation purposes. There are currently 319 projects underway; categorised by hydrogen

[16] World Energy Council. Bringing North Sea Energy Ashore Efficiently. 2018. Available at: https://www.worldenergy.org/wp-content/uploads/2018/01/WEC-brochure_Online-offshore.pdf

[17] Enea Consulting. The Potential of Power-to-Gas. January 2016. At p.6. Available at: http://www.enea-consulting.com/wp-content/uploads/2016/01/ENEA-Consulting-The-potential-of-power-to-gas.pdf

production technology (electrolysis or fossil fuels with CCUS; the use of the hydrogen, and the form in which it is used).[18]

CEC should expand funding opportunities for the commercialization of P2G technologies to help reduce emissions from the transportation sector.

4. *Develop an implementation framework based on the results of CEC's Strategic Long-term Roadmap for Renewable Hydrogen*

SoCalGas appreciates the CEC's development of a Strategic Long-term Roadmap for Renewable Hydrogen.[19] Additionally, we support the University of California, Irvine's efforts to help CEC develop an implementation framework for renewable hydrogen production and usage in the transportation sector. SoCalGas looks forward to engaging further with the CEC on this effort.

5. *Continue to support low-NOx vehicles, with renewable gas as the feedstock*

Recently, the Disadvantaged Communities Advisory Group recommended the CEC not fund natural gas or biofuel technologies.[20] SoCalGas opposes this recommendation as decarbonized natural gas is an important strategy in reducing criteria pollutant and GHG emissions today. Additionally, the overall natural gas system and multiple renewable gas feedstocks, including blended hydrogen, will continue to be an important part of California's future energy infrastructure. Low-NOx vehicles with renewable gas as the feedback is an important solution for hard-to-decarbonize sectors, such as medium- and heavy-duty trucking. Reducing these emissions and delivering renewable gas via the existing natural gas distribution system will help achieve critical climate change and air quality objectives. Furthermore, maintaining a diverse portfolio of energy resources provides greater resiliency of our overall energy delivery system.

Conclusion

Meeting California's goal to reduce emissions from the transportation sector will require business leaders, non-governmental organizations, and policy makers to work together to reimagine how California's energy infrastructure can operate as an integrated system that maximizes emissions reductions and minimizes waste. SoCalGas provides these comments to help move California towards meeting our aggressive climate goals in a thoughtful, reasoned, studied, and cost-effective way.

We ask that CEC support the growth of the hydrogen market for use in the transportation sector; develop an implementation framework based on the results of the Strategic Long-term Roadmap for Renewable Hydrogen; embrace the finding in the recent study by Energy Futures Initiative; utilize existing energy infrastructure to accelerate the adoption of low-carbon fuels; and continue

[18] IEA. Hydrogen Project Database. Available at: https://www.iea.org/media/publications/hydrogen/IEA-Hydrogen-Project-Database.xlsx

[19] CEC Docket 1 7-HYD-01: Renewable Hydrogen Transportation Fuel Production. Available at: https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=17-HYD-01

[20] Disadvantaged Communities Advisory Group Comments on the *2019-2020 Investment Plan Update for the Alternative and Renewable Fuel and Vehicle Technology Program*. Available at: https://efiling.energy.ca.gov/GetDocument.aspx?tn=228878&DocumentContentId=60238

to support low-NOx combustion technologies for immediate criteria and short-lived climate pollutant reductions. Additionally, we ask CEC to look at the research and projects conducted by the entities mentioned in Appendix A as well as all the available and emerging technologies and innovative and sustainable pathways to support the growth of the hydrogen market.

We strongly believe that a diverse energy portfolio that includes multiple fuels and technologies is necessary to meet California's energy needs and environmental policies in a cost-effective and feasible manner.

Sincerely,

/s/ Tim Carmichael

Tim Carmichael
Agency Relations Manager

Encl.

SoCalGas Comments in Response to the CEC Staff Workshop on Clean Transportation Program (ARVFT) Benefits Report and Successes for 2019 IEPR held on July 18, Docket # 19-IEPR-04

Appendix A:
Follow the Lead of Hydrogen Experts

Follow the Lead of Hydrogen Experts

This appendix includes information on experts, countries, and businesses expanding the hydrogen market to reduce emissions from the transportation sector. SoCalGas asks the CEC to look at the research and projects conducted by the entities mentioned below as well as all the available and emerging technologies and innovative and sustainable pathways to support the growth of the hydrogen market and decarbonize the transportation sector.

A. Follow the lead of hydrogen experts to reduce emissions from the transportation sector

Expanding the hydrogen market to reduce emissions from the transportation sector are supported by several forward-looking entities, including the following:

- Intergovernmental Panel on Climate Change- believes there is an essential role for hydrogen in meeting climate change goals. Their report, *Renewable Energy Sources and Climate Change Mitigation*, found that hydrogen fuel cell vehicles are expected to compete strongly with other low- or zero-emission options, such as biofuels and electric vehicles.[21]
- International Energy Agency (EIA)- believes hydrogen offers ways to decarbonize long-haul transport and can also help to improve air quality and strengthen energy security. IEA's new report, *The Future of Hydrogen: Seizing Today's Opportunities,* offers seven recommendations to help governments, companies, and others to scale up hydrogen projects around the world. The researchers recommend "[b]uilding on existing infrastructure, such as natural gas pipelines" and "[e]xpanding the use of hydrogen in transport by using it to power cars, trucks and buses that run on key routes."[22]
- Energy Independent Now[23]- recently released a *Renewable Hydrogen Roadmap* which provides "a framework to help guide the priorities and investments of policymakers, regulators, consumers and business leaders" to expand the hydrogen market. They recommend:
    1. Begin the Journey to 100% Renewable Hydrogen Now
    2. Fund Scalable Projects for 100% Renewable Hydrogen Production
    3. Improve LCFS Incentives
    4. Promote Tools to Lower the Cost of Electricity for Renewable Hydrogen Producers
    5. Address Hydrogen Distribution and Storage Challenges
    6. Expand the U.S. EPA's Renewable Fuel Standard Program
    7. Incentivize Consumers and Stakeholders
    8. Broaden the Hydrogen Community Through Education & Outreach

[21] Special Report of the Intergovernmental Panel on Climate Change. *Renewable Energy Sources and Climate Change Mitigation.* Available at: srren.ipcc-wg3.de/report/IPCC_SRREN_Full_Report.pdf
[22] IEA. International action can scale up hydrogen to make it a key part of a clean and secure energy future, according to new IEA report. June 2019. Available at: https://www.iea.org/newsroom/news/2019/june/international-action-can-scale-up-hydrogen-to-make-it-a-key-part-of-a-clean-and-s.html
[23] Energy Independence Now. Renewable Hydrogen Roadmap. At p.30. 2018. Available at: https://einow.org/rh2roadmap

- University of California, Davis, Institute of Transportation Studies- Its 2017 report, *The Potential to Build Current Natural Gas Infrastructure to Accommodate the Future Conversion to Near-Zero Transportation Technology,* found that current transportation applications for hydrogen include light-duty vehicles, buses, mediumz-duty trucks, and heavy-duty trucks. Proposed applications include rail, marine, and aviation applications. They recommend the state "[c]onduct a California-specific assessment of the costs, benefits and emissions reductions of a methanation or e-gas strategy, and its role in a future energy system with increasing use of intermittent renewables. Examine the costs and benefits of producing renewable methane via methanation of CO_2 by electrolytic hydrogen produced from curtailed renewables like wind and solar, and "storing" this excess renewable power as methane injected into natural gas pipelines."[24]
- California Fuel Cell Partnership- provides a plethora of information on hydrogen vehicles, infrastructure, and policy.[25]
- California Hydrogen Business Council- said "[r]enewable hydrogen and its derivatives stored in the existing gas system network can provide the only known long-duration seasonal storage at the terawatt-hour scale."[26]

B. Follow the lead of countries working to expand the use of hydrogen as a transportation fuel

There are significant international efforts to expand the use of hydrogen as a transportation fuel, including in China, Japan, Germany, and Australia as described below.

- *China*[27]- The father of China's electric vehicle revolution, Wan Gang (formerly China's Science-and-Technology Minister), now says hydrogen is the next "game-changing moment." By 2030, Beijing plans to have one million fuel-cell vehicles on the road. According to Bloomberg New Energy Finance, more than $17 billion (US) worth of announced investments will flow into the industry in China through 2023. The country also has a goal to construct over 1,000 refueling stations by 2030.[28]

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[24] UC Davis, Institute of Transportation Studies. The Potential to Build Current Natural Gas Infrastructure to Accommodate the Future Conversion to Near-Zero Transportation Technology. At p. 62. March 2017. Available at: https://steps.ucdavis.edu/wp-content/uploads/2017/05/2017-UCD-ITS-RR-17-04-1.pdf

[25] California Fuel Cell partnership (CAFCP) has a lot of resources and data specific to the current hydrogen stations in California. Available at: https://cafcp.org/resources

[26] NGI's Daily Gas Price Index. California Hydrogen Sector Supports SoCalGas Decarbonization Effort. March 2019. Available at: https://www.naturalgasintel.com/articles/117747-california-hydrogen-sector-supports-socalgas-decarbonization-effort

[27] Flanders-China chamber of Commerce. Hydrogen vehicles becoming a new focus in renewable energy vehicles. July 2019. Available at: https://news.flanders-china.be/hydrogen-vehicles-becoming-a-new-focus-in-renewable-energy-vehicles

[28] Bloomberg. Air Liquide and Houpu Create a Joint Venture to Develop the Hydrogen Distribution Infrastructure in China. April 2019. Available at: https://www.bloomberg.com/press-releases/2019-04-25/air-liquide-and-houpu-create-a-joint-venture-to-develop-the-hydrogen-distribution-infrastructure-in-china

- *Japan*- In Japan, hydrogen is also "taking center stage"[29] with an effort to have 40,000 fuel cell vehicles on its roads by 2020.[30] Additionally, at the invitation of Japan's Ministry of Economy, Trade and Industry, the Hydrogen Council participated in 2019 G20 Summit events "to elevate the benefits of a hydrogen economy and to chart a path forward for those at the highest levels of government." They showcased flagship hydrogen projects and discussed ways to overcome the bottlenecks that prevent the investment needed for large-scale hydrogen deployment.[31]
- *Germany*- Germany is building one of the world's most advanced hydrogen infrastructure for a future mass market. They are building 100 hydrogen refueling stations now with the eventual goal of 400 stations around the country. They believe that "[t]he future reputation of hydrogen will increasingly depend on a solid pathway and credible progress towards green hydrogen."[32]
- *Australia*- Australia developed a *National Hydrogen Roadmap* as a blueprint for further research and development as well as to "activate" the market for the development of a robust hydrogen industry. The roadmap explains that government support is need to "kick-start the industry" and market barriers can be overcome with strategic investments along the value chain. The road map states, "[t]he opportunity for hydrogen to compete favourably on a cost basis in local applications such as transport and remote area power systems is within reach based on potential cost reductions to 2025."[33]

C. *Consider expanding supporting hydrogen opportunities for trains, planes, and ferries*

There are also companies now utilizing hydrogen for trains, planes, and ferries as described below.

- *Trains*[34]- In June, the U.K.'s first full-sized hydrogen train opened at the Quinton Rail Technology Centre. The HydroFlex prototype is a joint initiative of the University of Birmingham's Centre for Railway Research and Education and Porterbrook, the British railway company. The team demonstrated the four-car train and plan to test it further on

[29] Hydrogen Council. **G20 in Japan: Hydrogen Takes Centre Stage.** June 2019. Available at: http://hydrogencouncil.com/g20-in-japan-hydrogen-takes-centre-stage/
[30] South China Morning Post. Wan Gang, China's father of electric cars, thinks hydrogen is the future. June 2019. Available at: https://www.scmp.com/news/china/article/3014275/wan-gang-chinas-father-electric-cars-thinks-hydrogen-future
[31] Hydrogen Council. **G20 in Japan: Hydrogen Takes Centre Stage.** June 2019. Available at: http://hydrogencouncil.com/g20-in-japan-hydrogen-takes-centre-stage/
[32] Medium. Germany: building one of the world's most advanced hydrogen infrastructure. May 2019. Available at: https://medium.com/@cH2ange/germany-building-one-of-the-worlds-most-advanced-hydrogen-infrastructure-f6062683bbf0
[33] CSIRO. National Hydrogen Roadmap: Pathways to an economically sustainable hydrogen industry in Australia. 2018. Available at: https://www.csiro.au/en/Do-business/Futures/Reports/Hydrogen-Roadmap
[34] IEEE Spectrum. All Aboard the U.K.'s First Hydrogen Train. June 2019. Available at: https://spectrum.ieee.org/energywise/transportation/alternative-transportation/all-aboard-uk-first-hydrogen-train

the main U.K. railway network later this year. Germany already has two such trains. Japan and South Korea are also planning to develop hydrogen trains.

- *Planes*[35]- SkyNRG, KLM Royal Dutch Airlines, SHV Energy, and Amsterdam Airport Schiphol plan to build Europe's first dedicated production facility for sustainable aviation fuel at Delfzijl. They explain that green hydrogen would be combined with waste and residue streams such to produce 100,000 tons of sustainable aviation fuel and 15,000 tons of bioLPG per year.
- *Ferries*[36]- SW/TCH, a New York-based investment company, announced in June that they would be the first to test a zero-emission hydrogen vessel in commercial commuter service, beginning as early as 2020 in San Francisco Bay. The Water-Go-Round boat has capacity for 84 people and will be demonstrated for three months. However, it was developed with the intent to provide long-term commercial service.

[35] Nouryon. Nouryon and Gasunie study scale-up of green hydrogen project to meet aviation fuels demand. May 2019. Available at: https://www.nouryon.com/news-and-events/news-overview/2019/nouryon-and-gasunie-study-scale-up-of-green-hydrogen-project-to-meet-aviation-fuels-demand/

[36] The Mercury News. Nation's first hydrogen fuel cell ferry to transport commuters across San Francisco Bay in early 2020. June 2019. Available at: https://www.mercurynews.com/2019/06/12/nations-first-hydrogen-fuel-cell-ferry-to-cart-commuters-across-san-francisco-bay-in-early-2020/