RHIA
RENEWABLE HYDROGEN ALLIANCE

Renewable Hydrogen Alliance

Taking Renewable Electricity Beyond the Grid

June 2018

Front Cover: Klondike 3 Wind Project, Oregon, courtesy Renewable Northwest.
Back Cover: 135 MW electrolyzer plant, Glomfjord, Norway, 1953-1991, coutesy Nel Hydrogen.

Renewable Hydrogen

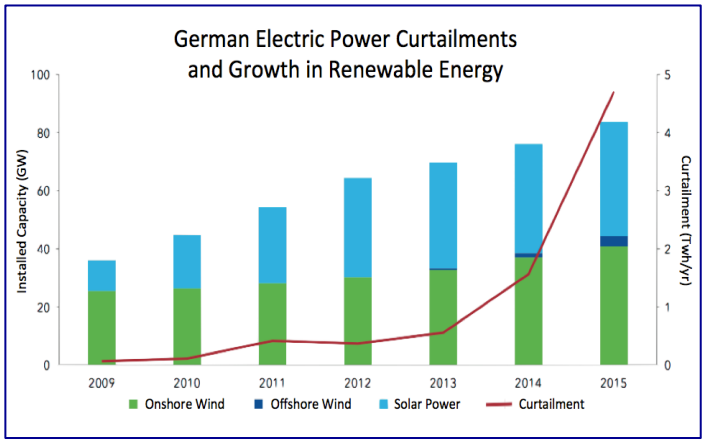
Passing an electric current through water splits it into component hydrogen and oxygen. The resulting hydrogen can be used as a fuel, or as a building block to make other energy-intensive products such as ammonia and methane. Using renewable electricity to make hydrogen and derivative climate-neutral fuels reduces dependence on fossil fuels and extends the reach of wind and solar power beyond the confines of the electric grid. Electrolyzers are the set of technologies for converting electricity and water into fuel. They can provide completely flexible electrical demand, helping to accommodate the variability of renewable resources, and reduce the amount of renewable energy lost when supply exceeds demand for power.

Renewable Hydrogen Alliance

The Renewable Hydrogen Alliance (RHA) is a new organization dedicated to promoting using surplus renewable electricity to produce climate-neutral fuels and other energy intensive products that would otherwise be created from fossil fuels.

Background

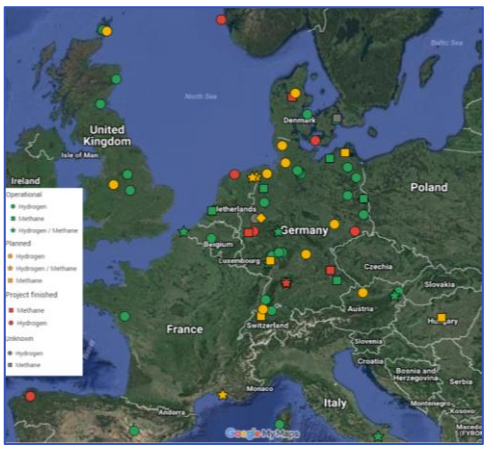
Wind and solar power have become the preeminent means of reducing carbon emissions from electricity production. Power from these sources is variable and not entirely predictable. Relying on them for significant fractions of power needs implies both periods of under-production when the resources are insufficient to meet demand and over-production when the available power exceeds demand.



Over-production conditions are already occurring in both North America and Europe. In the spring of 2017, both the Bonneville Power Administration (BPA) and the California Independent System Operator (CAISO) prevented the generation of hundreds of gigawatt hours of otherwise available renewable energy for lack of demand. Between 2013 and 2015, wind and solar resources in Germany increased just 20 percent, but the amount of "curtailed" energy from those resources quadrupled. Another effect of these surpluses is in reducing wholesale electric prices. For example, California experienced daily occurrences of negative market prices (i.e. producers paying wholesale "purchasers" to take power) around noon in the spring of 2017.

The urgency of making more efficient use of surplus renewable electricity

has been greater in Europe where the penetration of wind and solar is higher. Dozens of projects have cropped up designed to absorb renewable electricity and produce climate-neutral combustible fuels—often to supplant natural gas.



European PtG projects. Adapted from European Power to Gas Platform.

Electrolyzers split water into hydrogen (and oxygen) with electricity, a process ("electrolysis") that has been known for more than two centuries. It is getting far more attention now, with the advent of surplus renewable energy.

Increased deployments invited economies of scale, reducing the cost of the technology by about a factor of two in just a few years. Further reductions are expected as deployments continue to rise. The combination of decreasing cost of utility-scale, commercially available electrolyzers and increasing availability of low wholesale price can be expected to result in the potential to create cost-competitive climate-neutral fuels.

The many potential benefits of using surplus renewable electricity to produce hydrogen and other products:

1. Making better use of available renewable electricity.
2. Relieving downward pressure on wholesale electric prices.
3. Expanding the reach of wind and solar resources to decarbonize energy uses beyond the electric grid; including transportation, steel and fertilizer manufacturing, and refineries.
4. Providing renewable resources an additional market avenue, potentially one that is not dependent on "firm" transmission capacity.
5. Making climate-neutral fuels more available to existing and new markets for both hydrogen and natural gas.
6. Creating potential for the long-term storage of renewable electricity as hydrogen and hydrogen-derivatives– energy dense media for which considerable infrastructure already exists.

"Results indicate that [in an 80% renewable system] power-to-gas can reduce required wind and solar capacity by as much as 23% and curtailment by as much as 87%."

System-level power-to-gas energy storage for high penetrations of variable renewables, Lyseng, et al, International Journal of Hydrogen Energy, December 2017

These multiple value propositions are potentially attractive to multiple entities:

1. Electric utilities:
   a. Higher market prices for surplus energy sales.
   b. Fewer curtailments of owned renewable resources.
   c. Lower cost in meeting renewable portfolio or climate goals.
   d. Flexible load that can contribute to balancing grids.

2. Renewable developers:
   a. Greater value for the power generated.
   b. Potential to double the market for renewable electricity.
   c. Potential to develop projects where power transmission is congested.
3. Gas utilities:
   a. New source of fuel to reduce carbon footprint of their product.
   b. Potential to apply expertise to promoting climate neutral fuels (e.g., hydrogen).
4. Environmental stakeholders, climate activists, ratepayers.
   a. Expands reach of low-cost solar and wind energy to reduce carbon beyond electric grid (e.g., transportation, fertilizer production, refineries, steel manufacturing).
   b. Reduces the cost of meeting carbon emission goals.
5. Electrolyzer manufacturers, and other manufacturers of hydrogen-related equipment (fuel cells, ammonia production, transportation).
   a. Expands the availability of climate-neutral hydrogen.
   b. Reduces cost of climate-neutral hydrogen.

> "Using this gas with existing gas infrastructure, smartly combined with renewable electricity in sectors where it adds most value, can lead to €138 billion societal cost savings annually compared to decarbonisation without a role for renewable gas [in Europe]."
>
> Gas for Climate: How gas can help to achieve the Paris Agreement target in an affordable way, Ecofys, 2018

Despite multiple benefits to multiple important industries and stakeholders, the value and importance of creating climate-neutral fuels from renewable electricity is not widely recognized by most of the affected parties. In addition to limited recognition of the value of this resource, a way needs to be cleared to pursue projects. For example, electric tariffs were largely predicated on utility obligation to serve load and not utility option to serve load. The lack of appropriate tariffs, and relative obscurity of commercial contract terms for this type of electrical load, need to be addressed. Similarly, practices and terms for injecting hydrogen and climate-neutral methane into transmission and distribution pipelines may need to be developed.

Why This, Why Now

As the West moves to increase its reliance on renewable energy, surpluses of renewable energy will also rise. Incidence of curtailed renewable generation and negative wholesale market prices will also increase. At the same time, deployments of European projects are causing the cost of electrolyzer technologies to drop. In short, the need for this technology is rising at the same time that the costs are dropping. An advocacy organization can help pave the way for these technologies, hastening cost-effective deployments that will reduce the cost of meeting climate goals.

Mission, Vision, Values

The Renewable Hydrogen Alliance mission is to:

Promote using renewable electricity to produce climate-neutral hydrogen and other energy-intensive products that reduce dependence on fossil fuels.

RHA's vision is:

A decarbonized energy economy where climate-neutral fuel production complements renewable generation to optimize the value of renewable sources and minimize carbon emissions.

RHA's values are:

- **Equity and respect for the community and the environment.**
- **Working innovatively and collaboratively diverse stakeholders to realize mutual benefits for its members and society at large.**
- **Independence and veracity.**

"Air Liquide is committing to increasing by 2020 the percentage of hydrogen produced for these applications from carbon-free processes, i.e. sources that emit no CO_2. The Group's objective is to produce at least 50% of the hydrogen required by hydrogen energy applications from carbon-free energy sources..."

Air Liquide Blue Hydrogen Initiative, web posting, 2018.

Objectives and Functions

RHA's objectives are to foster the development of flexible electrical loads to create climate-neutral fuels from renewable energy. Its five-year objectives are:

1. Creation of a viable advocacy organization that serves its membership.
2. Organize and fund an annual conference.
3. Identify needed policies, regulations, and legislation to overcome barriers to electrolyzer deployments.
4. Educate all stakeholders on the multiple values and roles of electrically produced hydrogen in establishing decarbonization.
5. Foster at least 500 megawatts of flexible electrolyzer demand in the US in five years.
6. Create a scholarship fund to assist at least one student per year in pursuing an educational program in science, technology, or engineering at with a focus on producing clean fuels from renewable electricity.

"Hydrogen production in the United states is currently [2004] about 9 billion kg, or the energy equivalent of 8 billion gallons of gasoline [about 10% of US gasoline consumption]."

The Hype About Hydrogen, Joseph Romm, Island Press, 2004.

The proposed functions of the organization are:

1. Educate stakeholders, public, legislators and regulators on the vital role of electrically produced hydrogen in maximizing the value of renewable electricity, and hastening decarbonization.
2. Facilitate member meetings in which challenges are identified and solutions developed.
3. Conduct annual conferences to facilitate the exchange of ideas, news, policy proposals and best practices.
4. Provide members a clearinghouse for information relating to the costs, benefits, and opportunities relating to electrically produced hydrogen and its derivatives.

"As the pressure to reduce carbon emissions increases, and the cost of the technology improves with scale, there will be increasing opportunities for cost-effective PtG applications."

Power to Gas: Opportunities for Greening the Natural Gas System, Flink Energy Consulting, 2018.

By forging the interests of diverse stakeholders into a focused effort, Renewable Hydrogen Alliance will facilitate a new gigawatt-scale billion dollar industry that will reduce costs, increase values and lessen pressure on climate change for all participants.

For More Information

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RHA Founding Committee

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Resources

Power to Gas: Opportunities for Greening the Natural Gas System, Flink Energy Consulting for NW Natural, February 2018.

Gas for Climate: How gas can help to achieve the Paris Agreement target in an affordable way, Ecofys, February 22, 2018.

The Coming of Electrofuels, David White, March 27, 2018.

Renewable Hydrogen, Fuels, & Chemicals, Gerry Snow, October 13, 2017.

Power System Flexibility Strategic Roadmap, Ecofys for European Copper Institute, 2015.

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