Sustainable Energy Hawai`i

Making the Case for a Geothermal Based Hydrogen Economy on Hawai‘i Island

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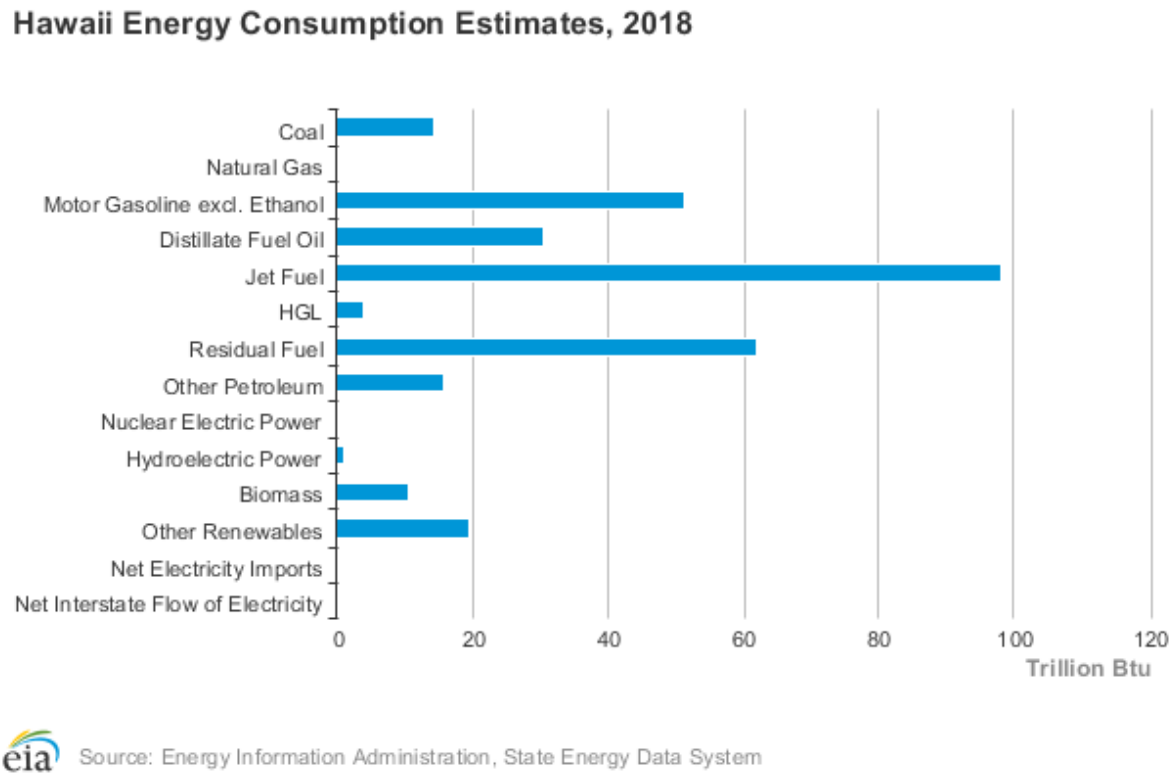
Hawai‘i’s Energy Landscape – 2021

The world is changing. Some of the energy resources we take for granted have now “peaked,” or reached their limit in terms of how much can be produced on a daily basis. [1]

The most significant of these is petroleum. While having hit the peak in petroleum production will stress the entire global economy, Hawai‘i is especially vulnerable. How it uniquely affects Hawai‘i will become increasingly clear in the coming years, as will Hawai‘i’s need to become as self-sufficient as possible (and not only when it comes to energy, but food, as well).

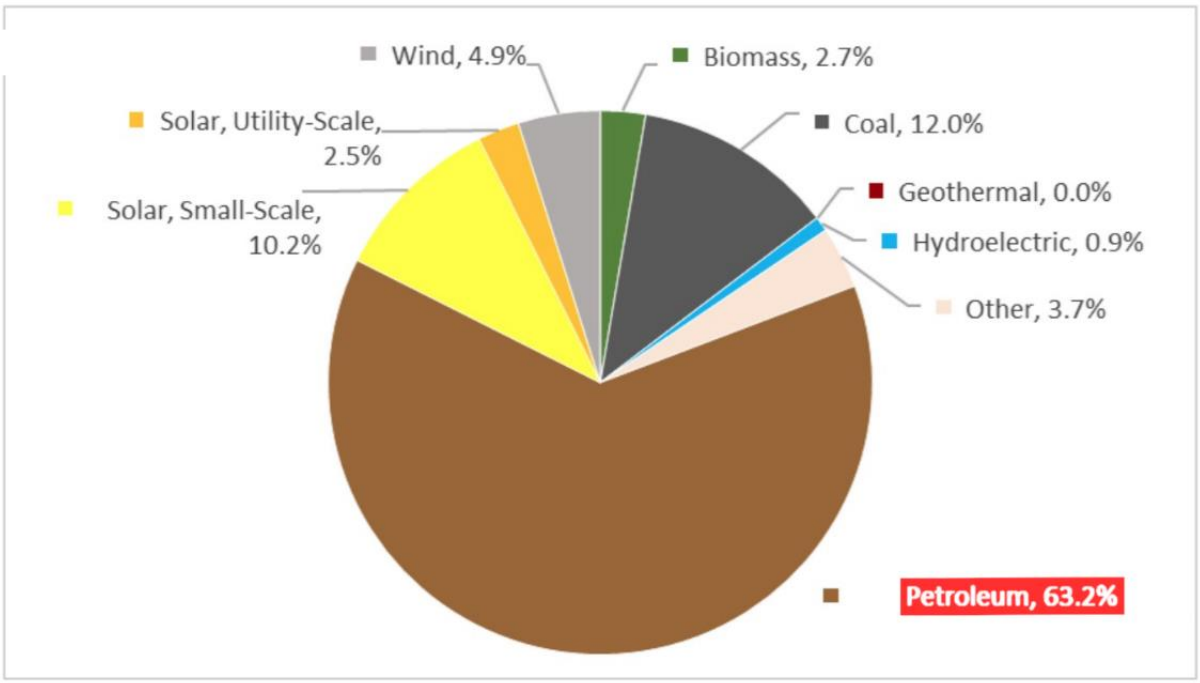
Peaking global petroleum supplies are especially worrisome here in Hawai‘i because 100% of our fossil fuel energy arrives by ocean freighter. While most of the world primarily uses petroleum for transportation and coal or natural gas to generate their electricity, here in Hawai‘i we are much more dependent on petroleum. We use it for both transportation and electricity production.

We find ourselves with not only the need but also the responsibility to plan much further into the future than we are accustomed to. We must rethink our relationship with the most essential element in our economy — energy, making it a top priority.



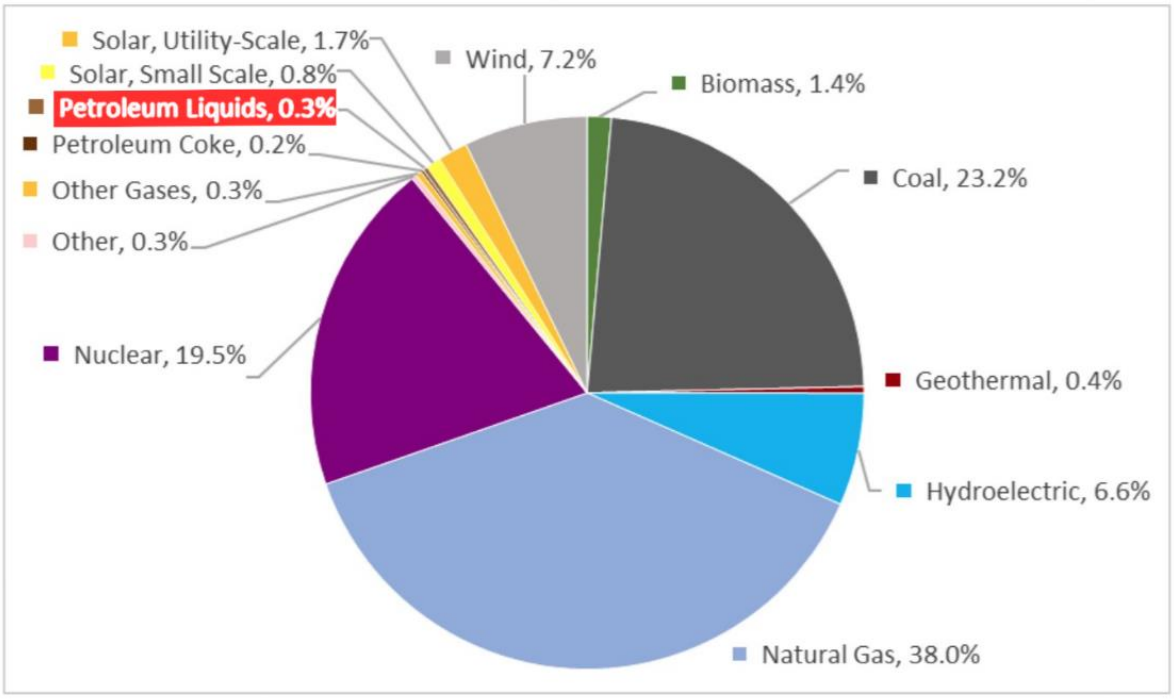
[1] https://www.cnn.com/2021/02/11/business/shell-oil-production-peak/index.html

Hawai'i's Electricity Production by Source (2019)



While we do use coal and some renewables here in Hawai'i,
petroleum is still the principal generation source for our electricity production.
Compare Hawaii's 63.4% electrical generation from petroleum to the US, in general, at 0.3%.

United States Electricity Production by Source (2019)



It’s the Law

The State of Hawai‘i passed legislation mandating a transition from our current energy mix of petroleum, coal, and renewables. It requires us to produce all our energy from renewable sources by 2045. A similar mandate will be needed for transportation.

In order to meet this requirement, each island will need to build new, grid-scale electrical systems that are fundamentally different from today’s norm.

It’s critical to understand that renewable energy systems:

- Can only produce electricity.
- None, including biofuels, can replace liquid transportation fuels at the scale needed.
- With the exception of geothermal, hydroelectric, tidal or wave, renewables are largely intermittent due to weather conditions or cannot produce energy both day and night.

Those realities define our future renewable energy conundrum. The amount of electricity Hawai‘i needs to generate will increase across all islands to accommodate increasing traditional use as well as the added demand of electric transportation.

As we plan new electrical systems, we must consider many factors, including:

- The status of the global energy landscape
- How current options for a multi-solution “renewable” energy mix will evolve over time
- The durability, future availability, and cost of renewable system components
- How each system will integrate with others
- The types of support infrastructure needed to combine these sources
- The relationship between public and private entities for finance and regulation
- The recruiting of experienced operations management

Every system we consider must have a *sustainability roadmap*. We must know what it takes to keep the system working over the long term.

Defining Energy

Before we make any decisions about the form of our energy future, it’s important we understand what energy is, where it comes from, and how we use it.

Science defines energy as “the ability to do work.” At its most basic, all energy comes from the sun. The energy in sunlight is transformed by plants and then “stored” in and around the Earth, much like a battery stores electricity for future use. Some energy is from ancient sunlight that has been concentrated and stored for millions of years, such as oil and coal. Even the molten core of our planet is concentrated energy, virtually the same as the sun itself.

Some energy, in the form of current sunlight, is more recent and is stored in the foods we eat. Since humans discovered fire and unleashed the sun's stored energy in wood, all peoples have transformed the sun's energy, old and new, to help them do their work.

Today, the energy we use primarily falls into two categories:

1. Transportation energy (this is principally petroleum)
2. Infrastructure energy or electricity (this is principally coal and natural gas)

An important distinction: Electrical energy consumption within island populations, such as here in Hawai‘i, has limitations that don’t exist on larger, interconnected land masses such as North America, Europe, or Asia.

Electricity is most often produced through a simple process: water is heated to create steam, which spins a turbine across magnets, and the net result is electricity. Even nuclear power plants use this same process of heating water to spin a turbine and make electricity.

Virtually all the raw materials used today to heat water and make electricity come from fossil fuel resources: coal, natural gas, and petroleum.

There are many questions:

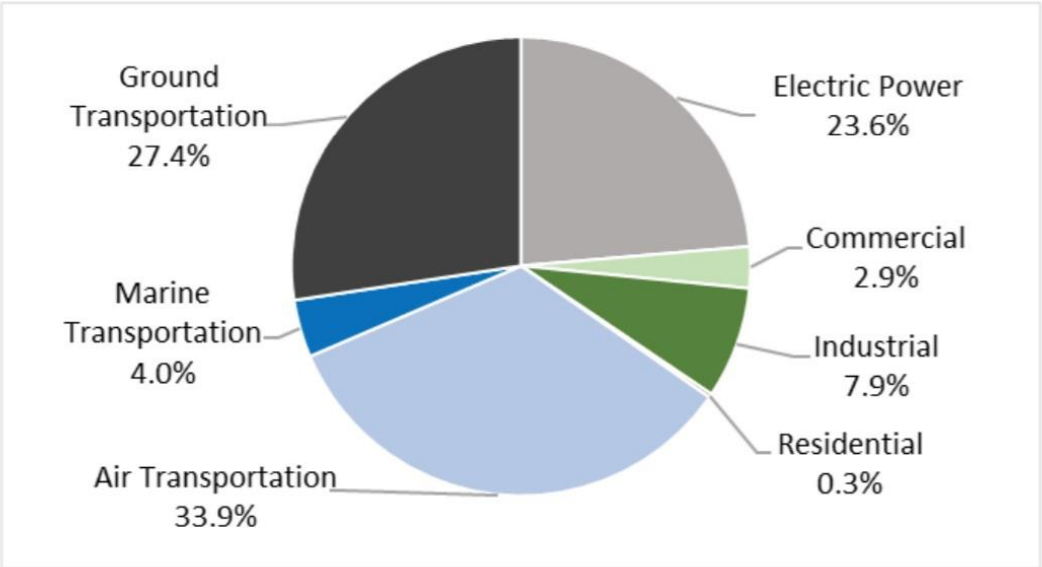
- How do you generate enough electricity without fossil fuels? With solar? Wind? Waves?
- Can those systems guarantee on-demand electricity, at scale, 24/7/365?
- How long will those systems last?
- How expensive are they in comparison to what we have now?

The answers are much more complex than we have been led to believe.

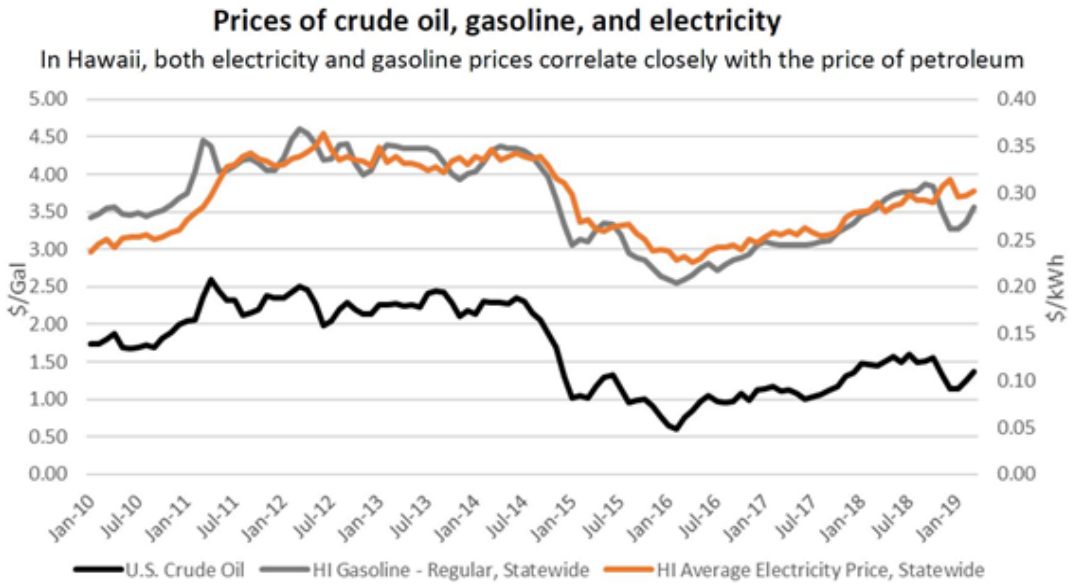
Hawai‘i’s Challenges

Hawai‘i’s energy mix has been similar to elsewhere in the world. We use electricity for infrastructure and petroleum for transportation. As it is elsewhere around the world, petroleum is shipped to Hawai‘i. However, there are a few differences that make electricity production in Hawai‘i more challenging.

Hawai‘i’s Petroleum Use by Sector, 2018



First, Hawai‘i primarily uses petroleum to generate its electricity, while most of the rest of the world has phased that out and now uses coal and natural gas. In recent years, the price of petroleum has fluctuated significantly from year to year. To have a stable electricity cost, you must be able to anticipate petroleum price fluctuations. Miscalculating the market has costly results.



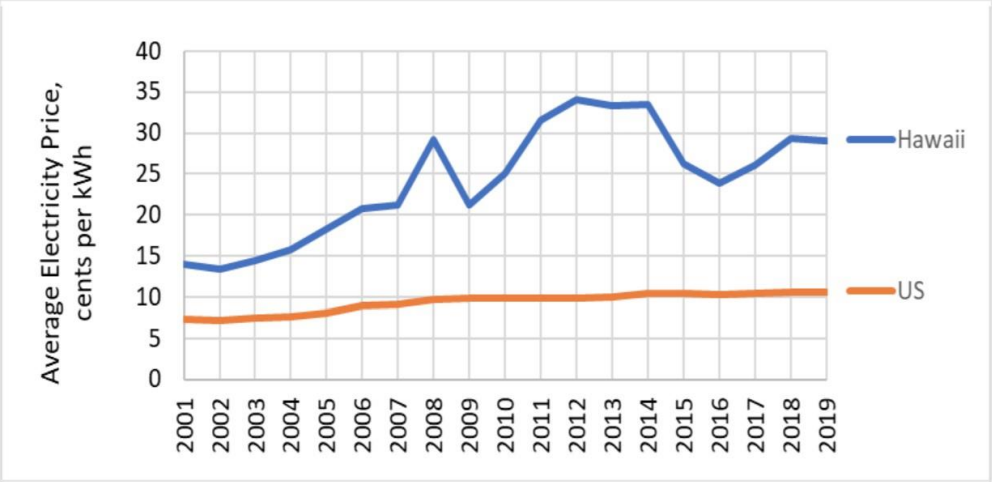
Another challenge in Hawai‘i, albeit one we share with the rest of the world, is that all fossil fuels are finite resources. That Hawai‘i uses petroleum for both electricity and transportation makes this even more problematic. As mentioned above, the global supply of petroleum has hit its peak—the maximum amount that can be produced on a daily basis. We are not guaranteed its availability at affordable prices in the future.

Islands, of course, are self-contained and tend to be relatively small in area, and that creates another challenge. Elsewhere, electricity can be consumed thousands of miles from where it is generated and serve millions of people. Electricity used on the east coast of the U.S. mainland or in the country’s “heartland” can be produced almost anywhere in the nation. A source of electricity may combine or switch between different locations many times a day. This “load sharing” allows for greater efficiency and flexibility when balancing supply and demand throughout the day and across broad areas.

Because the Hawaiian Islands are physically isolated from each other, they cannot load share. They cannot interconnect production facilities on neighbor islands. Each island must produce enough electricity to meet its smaller, local, consumer demand, whatever that is, day and night.

That also means each island’s generation facilities must be designed with a load capability that can deliver a clearly defined “peak” in demand, even though, in a year, that peak might only occur 5% of the time. The islands’ differences in geography, population size, fuel mix, and facility peak capacity are among the factors that contribute to Hawai‘i’s high cost of electricity.

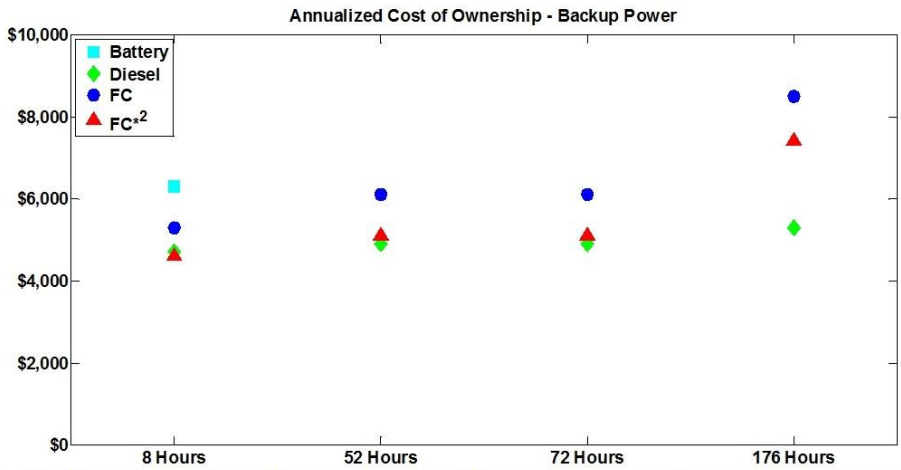
Hawai'i's electricity prices are more than double the U.S. average



As we redesign our supply and distribution infrastructure, we'll have the opportunity to become more efficient, which, in turn, should lower energy costs for all of us.

There are ways to ensure we meet peak demand while also building an overall production capacity that is lower. That should reduce the initial investment required to construct future facilities and also contribute to lower prices.

One way to cut down on the engineered peak load capacity is to store excess production when demand is lower. Storing electricity is also the key to making the output of intermittent renewables, such as solar and wind, more stable and reliable. Recent cost comparisons between conventional, high-efficiency batteries and hydrogen fuel cells show that hydrogen fuel cell operation cost for utility-grade backup can be nearly one-eighth as expensive than conventional batteries for the same storage capacity.[2]



	8 Hours	52 Hours	72 Hours	176 Hours
Battery	$6300	$24800	$31300	$67200
Diesel	$4700	$4900	$4900	$5300
FC	$5300	$6100	$6100	$8500
FC*2	$4600	$5100	$5100	$7400

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1) Refer to the report for complete analysis details and assumptions (http://www.nrel.gov/docs/fy14osti/60732.pdf).
2) Fuel cell system with incentives (FC*), calculated as 30% of expenditures and capped at $3,000/kW of system capacity.

[2] https://www.nrel.gov/docs/fy14osti/60732.pdf

If we decide that hydrogen fuel cells are our best option for an energy storage system, where will we get the hydrogen? Can we supply that locally?

Yes, we can.

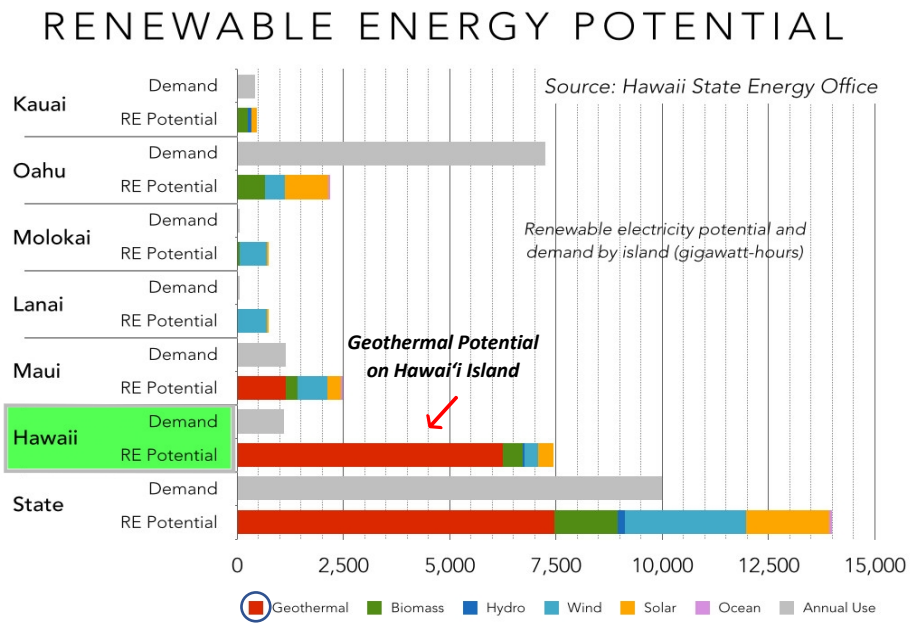
Hawai‘i Island’s Gifts - Geothermal and Hydrogen

Here on Hawai‘i Island, we have access to the heat we need to generate electricity that doesn’t use fossil fuels or any feedstock, for that matter. This is present in the form of geothermal energy. This eliminates the need to import a fuel source from off-island.

Geothermal energy can provide this heat consistently, safely, reliably, and for thousands of years. Since geothermal energy is present 24/7/365, there is always the capacity for excess electrical production. This is excess electricity would be used to produce hydrogen. The hydrogen produced would then be used in fuel cell systems to serve as load balancing, supplemental power for local solar, wind facilities. This hydrogen would also be available for fuel-cell powered transportation.

There are generally two methods for producing hydrogen. One involves extracting hydrogen from the fossil fuel methane (natural gas) and contains carbon. The other involves separating oxygen and hydrogen from water molecules. Clearly, the latter is preferable since its only outputs are hydrogen and oxygen. There is no carbon present in the source materials.[3]

Geothermal can be engineered to operate with a lower ecological impact than our current fossil fuel power plants while also providing portable energy that minimizes our dependence on imported resources.



The potential for Geothermal Renewable Energy on Hawai‘i Island is nearly 6 times its annual demand. The difference between the potential and the demand can go directly toward commercial hydrogen production.

[3] Hawai‘i County has plans to produce hydrogen for their FC buses using naturally occurring methane from our landfills. Methane is a hydrocarbon molecule. Carbon Capture can mitigate this exception while curtailing the uncontrolled release of methane into our atmosphere.

A New Industry – By Hawai‘i - For Hawai‘i

Developing additional geothermal facilities and hydrogen production represents a viable new industry for Hawaii Island. This industry could benefit all our people, not only with lower energy costs for their homes and businesses but also by creating new employment opportunities.

Expanded hydrogen production on Hawai‘i Island could be scaled to the point where it provides a reliable source of low-cost supplemental power for neighboring islands' solar and wind projects, as well.

It could also drive the demand for ground and ocean fuel-cell vehicles, along with the new construction jobs needed to build out the necessary support infrastructure. This could truly become a growth industry for Hawai‘i Island.

Sustainable Energy Hawai‘i is working toward the goal of seeing **local** ownership of this industry. If successful, money would stay here and cycle through our economy instead of leaving to benefit economies in faraway lands.

Considering all the changes coming our way, the technical aspects may be the easiest to achieve. The harder part may involve imagining our future differently.

- Can we change how we look at what surrounds us?
- Can we include everyone in our community and see "us" instead of "them"?
- Are we all in this together, or are we not?

One thing is for sure: Ten or 15 years from now, our options will not be what they are today.
How do we want to live? … What we do in response to that question today will determine Hawai‘i's future tomorrow.

Mahalo nui loa,
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