Sustainable Energy Hawai`i

The Rationale to Establish Pacific Islands Regional H_2 Hub™ Under the US-DOE's Clean H_2 Hubs Program

Sustainable Energy Hawai'i
Hilo, Hawai'i
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Introduction

Within the pages that follow you will find Sustainable Energy Hawai`i's (SEH) assessment of the perfect ecological, economic, and socio-political storm our planet faces today while also offering a powerful opportunity to expedite Hawai`i's transition toward a more sustainable, self-sufficient, renewable energy future.

Project Goal

SEH seeks to establish 'The Pacific Island Regional Hydrogen Hub' within the DOE's Energy Earthshots Initiative. Our first goal is to obtain the financial support needed to submit a winning application under: *'Funding Opportunity Announcement No.: DE-FOA-0002779 - Bipartisan Infrastructure Law: Additional Clean Hydrogen Programs (Section 40314): Regional Clean Hydrogen Hubs'.*

Should that milestone be met, SEH will also seek to obtain the matching funds' commitment needed to proceed through the next phases of the program[1].

Project Necessity – Limits to Growth

The perfect storm mentioned above goes beyond the widely discussed challenge of climate change and achieving net-zero carbon emissions. We factor in what is not discussed, considering each of the following to be of equal or greater import compared to decarbonization alone. Combined, they form a 'super-storm' as each affects the others and should not be viewed in isolation. They include:

- ***Resource Depletion*** - Many of the natural resources we've built our modern, complex society upon have already reached or are rapidly reaching the limits of their availability at the scale our 'system' demands. That demand includes both the energy and the critical raw materials needed to build and transport the renewable energy systems themselves.

- ***Overpopulation*** – Global human population was slated to cross the 8 billion count sometime next year. That has been revised to occur later this year. Each of those born into this world will find it one of seductive, excessive consumption.

- ***Global Economy Requiring Continuous Growth*** – The notion that adding 6 billion people to the human population in less than 100 years will not also bring about an abrupt change to civilization-as-we-know-it, involves faulty mathematics.

  Our global economic system requires continuous growth for its own survival. Unlimited, continuous growth on a finite planet is not possible despite what we've been told over the past 40+ years. There are Limits to Growth.[2]

Project Means – Geothermal Power for Hydrogen Production at Scale

Sustainable Energy Hawai`i is pursuing participation in the Clean Hydrogen Hubs program because it is big enough to make a meaningful difference within the timeframe global conditions demand while being achievable given the resources available on Hawai`i Island. If financed properly, this plan can provide a

[1] See "Hubs Implementation Phases" graphic on page 6

[2] https://www.clubofrome.org/publication/the-limits-to-growth/

mechanism to hedge against the inevitable impacts this perfect storm will have on The Big Island. Broadly, those impacts will be significantly different among island states than other places around the world.

We are convinced that Hawai`i can, with a long-term, goal-oriented focus, adjust to the rapidly changing environmental and economic conditions in a manner that can be among the most successful in the world. That, however, will require approaching business in a different way, with different metrics for success and a renewed awareness of the connection between human life and the rest of the natural world.

We have the resources to achieve that success: Sun, Water, Soil, Good people, people with the historical knowledge of living in sync with their environment, and so importantly, abundant, accessible geothermal heat from which we can derive the energy we need to thrive during this time of change.

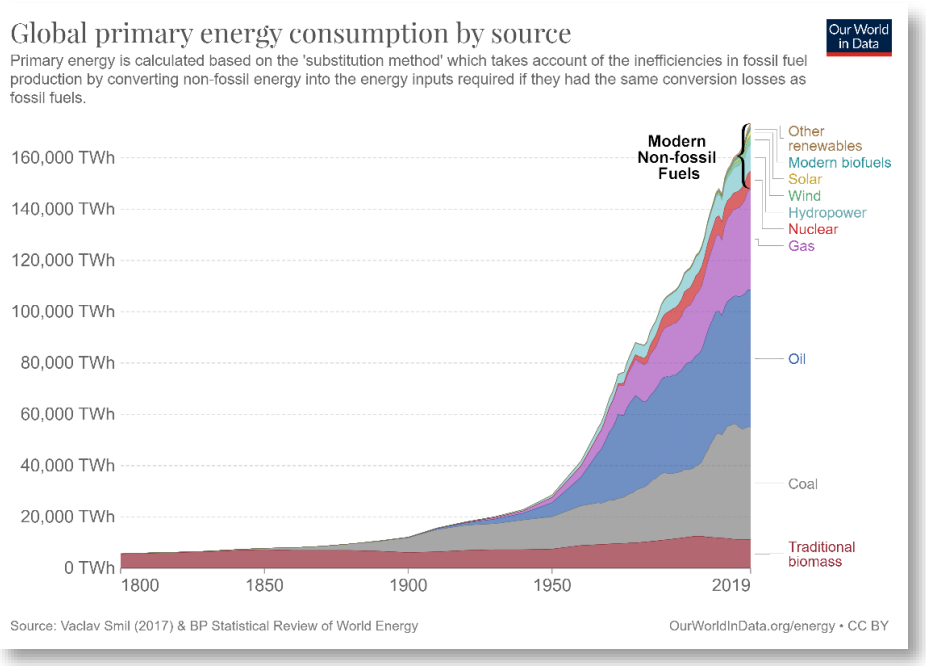
As you go through this White Paper, you will find many footnotes. They are an integral part of what's presented here. We encourage you to include them in your review process.

Mahalo,

The Board of Directors - Sustainable Energy Hawai`i

Executive Summary

Today, there is a global effort to decarbonize our energy production-consumption pipeline. The enormity of the challenge becomes more & more apparent every day. The most visible part of that effort has involved the global deployment of utility scale solar, wind, and hydro in combination with battery systems to replace electrical power generation from fossil fuels. Recent data shows, combined, they produced Just 21% of what was consumed in the US during 2021[3]. However, there is a long way to go before the job is done.



That's all well and fine. However, these systems do not address the concurrent need to replace liquid fossil fuels, the lifeblood of the global economy's transportation system. The overwhelming consensus among nations is that Hydrogen in its various transportable forms[4] will become the primary replacement.

History

In the United States, President Joseph Biden, Jr. signed the Bipartisan Infrastructure Law (BIL) into effect on November 15, 2021. The BIL[5] appropriates $62 billion+ for the US Department of Energy (DOE) to ensure a 'clean energy future' that delivers economic prosperity to the American people. Among the programs funded by the BIL is one to build multiple regional, clean hydrogen 'hubs' across the US.

Specific provisions define the term "regional clean hydrogen hub" (HUBS) as "a network of clean hydrogen producers, potential clean hydrogen consumers, and connective infrastructure located in close proximity." The HUBS program will also incorporate a range of social equity considerations including energy and environmental justice, labor and community engagement, consent-based siting, quality jobs, and inclusive workforce development.

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[3] https://www.eia.gov/todayinenergy/detail.php?id=52959

[4] Pure H_2 (compressed or liquid) & Ammonia (pressurized, liquified gas)

[5] https://www.energy.gov/bil/bipartisan-infrastructure-law-homepage

Investment capital to build out the hydrogen (H_2) economy is a significant portion of the BIL's funding at DOE. The BIL authorizes and appropriates $8.0 billion over the five-year period encompassing fiscal years 2022 through 2026 to support the private development of at least four and as many as eight H_2 production hubs. The DOE's goal is to jumpstart a national clean H_2 economy[6]. On September 21, 2022, The DOE published a Funding Opportunity Announcement (FOA)[7] starting the Regional H_2 Hubs funding application process.

SEH Intent

Today, we are experiencing a period that demands an expedited, foundational, systemic energy transition on a global basis. We have an opportunity to do something not just historic for our state, but something that can change the trajectory of Hawai`i 's future for generations to come. That opportunity is to trigger a scaled transformation from unsustainable fossil fuel importer to that of sustainable green-energy exporter[8]. Hawai`i Island has a robust energy resource that can be accessed, developed, and maintained over long periods of time: the geothermal heat concentrated below its surface. That heat, when properly harnessed, can facilitate the production of electricity which can then be used to produce abundant, green H_2. Green H_2 can be used to produce green ammonia, both of which have been determined to be among the clean, portable industrial transportation fuels of the future[9].

Sustainable Energy Hawai`i (SEH) intends to apply for inclusion in the DOE-FOA, Regional Clean H_2 Hubs program. This opportunity will select and fund (with a required minimum 50% non-federal cost-share) the number of H_2 Hubs the DOE determines appropriate at a future time. The overall funding allocation for this portion of the BIL is $8 billion. Our assessment is that Hawai`i must be chosen among those regions to be funded.

At this time, we are not aware of any other groups, public or private, intending to apply from this region. With the proper phased funding, SEH is uniquely positioned to satisfy the requirements set forth by the DOE in the following areas:

- Source renewable energy, land and water in sufficient quantities to produce green H_2 at the specified volume (min. 50-100 metric tons per day).
- Retain 3rd party experts to design, build and operate the 3 principal areas of production:[10]
    - Geothermal Power Production (250 mW – 500 mW)
    - Green Hydrogen Production (Industrial scale)
    - Green Ammonia Production (Industrial scale)
- Develop commercial offtake market sufficient to sustain post startup operations at the targeted scale and growth capabilities.
- Credibly demonstrate both the costs and benefits to local community members
- Implement local community engagement in support of:

[6] https://www.law.cornell.edu/uscode/text/42/16161a

[7] DE-FOA-0002779 https://oced-exchange.energy.gov/Default.aspx#FoaId4e674498-618c-4f1a-9013-1a1ce56e5bd3 (Download link found under documents)

[8] Today's solar, wind and battery systems are not sustainable when evaluated from a full system perspective. The Critical Raw Materials do not exist in sufficient quantities to maintain these systems at scale for more than 25-30 years. https://tupa.gtk.fi/raportti/arkisto/42_2021.pdf?fbclid=IwAR3CokP3Ic-wyFT4nggUuHYQH9YwPMioy-VCq5pq83hnJC2t-Av2AUsLTfQ p. 665-667

[9] https://www.seatrade-maritime.com/sustainability-green-technology/ammonia-fuel-gains-momentum-asia

[10] See "Scope of Project" Page 6

- Local workforce development with an eye toward participation among disadvantaged communities, labor unions and indigenous populations.
- Ensure the voice of local stakeholders is heard in decision making processes.
- Inclusion of private and public stakeholders have their input heard.
- Financially support local community needs especially local agriculture.
- Constantly strive for environmental and economic justice.

Scope of Project

Consistent with SEH's stated intent above , this project will require the development of industrial export-scale production of green hydrogen and ammonia on Hawaii Island. There are 4 primary, dedicated production components needed to achieve this goal: Green power supply, water supply, hydrogen production, & ammonia production, each with their own onsite and remote location storage facilities. With respect to both the power and water supplies, these will need to operate outside the systems that provide services to municipal and agricultural consumers to maintain economic viability.

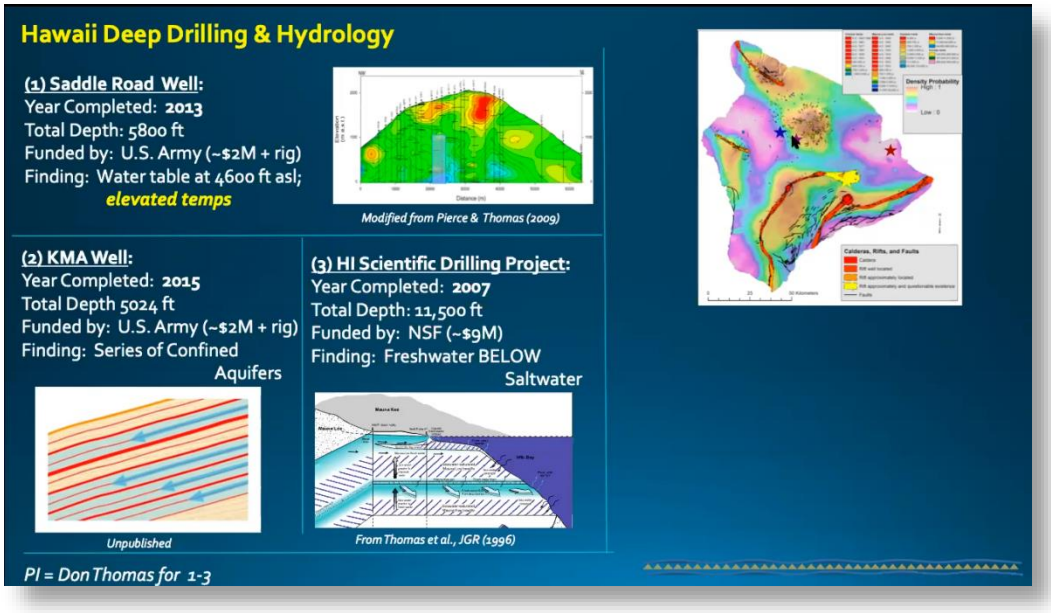
Additional support systems, some of which must be developed by 3rd party vendors, and include hydrogen and ammonia transport systems, appropriate bunkering operations for maritime needs, dedicated water transport infrastructure, land transport for both H_2 and ammonia.

Geothermal Power Generation Plant(s) (300 - 500 mW)

Green Hydrogen Production (50 – 100 mT/day)

Green Ammonia Production (300 - 550 mT/day)

Water Supply (Dedicated @ 300k – 500k gal/day)



Forward Looking Production Provisos

The estimates for daily production volumes are reflective of the range of production desired by the DOE under the provisions of the BIL. Actual production targets will be adjusted as the market sets demand over the next 5-7 years. It is anticipated that as the price of liquid fossil fuels increases, the demand will exceed these current targeted volumes. Provisions for scaling capacity up or down will be factored into all resource assessments and engineering designs. The volumes indicated can be achieved with known technology and reasonably anticipated natural resource availability.

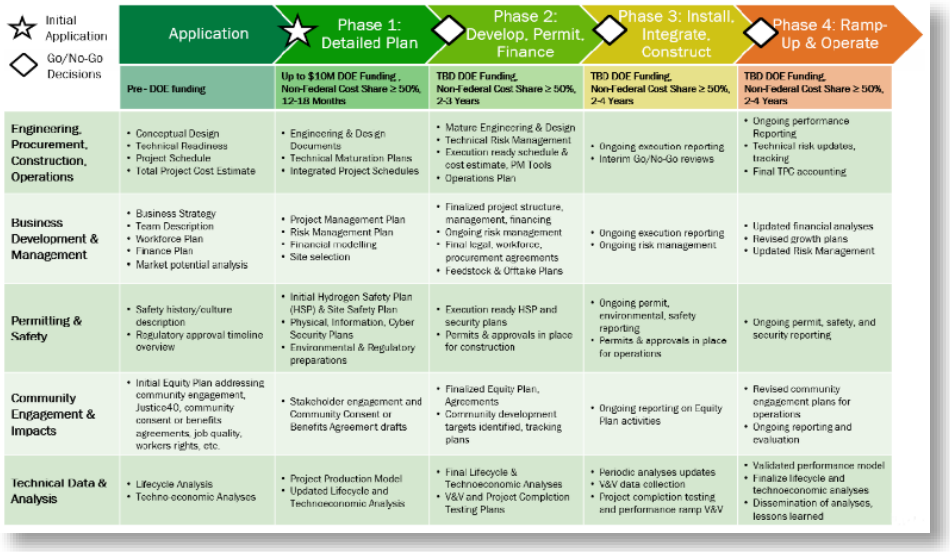
The site referenced in the 'Water Supply' slide (Pohakuloa Training Area (PTA)) is a prime candidate for all categories of production within a single, co-located site.

The future economics of this marketplace are being formed today. Hydrogen in its various forms[11] each have different applications of which only industrial uses[12] are commonplace today. We believe the market will develop quickly as global industries move to decarbonize and to prepare for a world where petroleum costs skyrocket.

What we do know is that producing hydrogen from geothermal heat offers a constant price for the heat producing feedstock over time. We know that the systems last much longer than their renewable system counterparts, solar, wind with battery backup. We know that geothermal systems are firm, 24-7-365 systems that are not subject to variations in the weather or time of day. We know that the component metals needed to manufacture intermittent renewable energy systems are finite resources which are already experiencing price increases affecting the price-performance benefits seen in recent years.

DOE Process

The DOE Regional H_2 Hubs Funding Opportunity consists of 5 functional phases[13] including the application phase, 2 planning phases, a construction phase, and an operational business phase.



☆ Initial Application ◇ Go/No-Go Decisions	Application	Phase 1: Detailed Plan	Phase 2: Develop, Permit, Finance	Phase 3: Install, Integrate, Construct	Phase 4: Ramp-Up & Operate
	Pre- DOE funding	Up to $10M DOE Funding, Non-Federal Cost Share ≥ 50%, 12-18 Months	TBD DOE Funding, Non-Federal Cost Share ≥ 50%, 2-3 Years	TBD DOE Funding, Non-Federal Cost Share ≥ 50%, 2-4 Years	TBD DOE Funding, Non-Federal Cost Share ≥ 50%, 2-4 Years
Engineering, Procurement, Construction, Operations	• Conceptual Design • Technical Readiness • Project Schedule • Total Project Cost Estimate	• Engineering & Design Documents • Technical Maturation Plans • Integrated Project Schedules	• Mature Engineering & Design • Technical Risk Management • Execution ready schedule & cost estimate, PM Tools • Operations Plan	• Ongoing execution reporting • Interim Go/No-Go reviews	• Ongoing performance Reporting • Technical risk updates, tracking • Final TPC accounting
Business Development & Management	• Business Strategy • Team Description • Workforce Plan • Finance Plan • Market potential analysis	• Project Management Plan • Risk Management Plan • Financial modelling • Site selection	• Finalized project structure, management, financing • Ongoing risk management • Final legal, workforce, procurement agreements • Feedstock & Offtake Plans	• Ongoing execution reporting • Ongoing risk management	• Updated financial analyses • Revised growth plans • Updated Risk Management
Permitting & Safety	• Safety history/culture description • Regulatory approval timeline overview	• Initial Hydrogen Safety Plan (HSP) & Site Safety Plan • Physical, Information, Cyber Security Plans • Environmental & Regulatory preparations	• Execution ready HSP and security plans • Permits & approvals in place for construction	• Ongoing permit, environmental, safety reporting • Permits & approvals in place for operations	• Ongoing permit, safety, and security reporting
Community Engagement & Impacts	• Initial Equity Plan addressing community engagement, Justice40, community consent or benefits agreements, job quality, workers rights, etc.	• Stakeholder engagement and Community Consent or Benefits Agreement drafts	• Finalized Equity Plan, Agreements • Community development targets identified, tracking plans	• Ongoing reporting on Equity Plan activities	• Revised community engagement plans for operations • Ongoing reporting and evaluation
Technical Data & Analysis	• Lifecycle Analysis • Techno-economic Analyses	• Project Production Model • Updated Lifecycle and Technoeconomic Analysis	• Final Lifecycle & Technoeconomic Analyses • V&V and Project Completion Testing Plans	• Periodic analyses updates • V&V data collection • Project completion testing and performance ramp V&V	• Validated performance model • Finalize lifecycle and technoeconomic analyses • Dissemination of analyses, lessons learned

SEH is currently in its pre-application phase. This is the period where, prior to the FOA's formal publication, SEH assembles the human and financial resources needed to submit a successful application. These resources include:

- Compiling the necessary organizational leadership to support a successful application.
- Recruiting a qualified, paid, project manager, someone with experience in leading the launch of a new products of this magnitude into a nascent marketplace.
- Selecting a qualified, paid, RFP/FOA consultant with a track record of successful submissions in seeking funding from US Government agencies, especially, the Department of Energy.
- Have a preliminary pro-forma prepared outlining project development cost
- Solidify a budget sufficient to achieve the previous goals and

[11] Three primary forms exist today … Compressed gas at varying pressures, liquid, & ammonia

[12] Petroleum refining, metal processing, fertilizer production, food processing

[13] https://oced-exchange.energy.gov/Default.aspx#FoaId4e674498-618c-4f1a-9013-1a1ce56e5bd3 (use link under "DOCUMENTS)

- Procure the financing needed to fund the above tasks.

If approved for participation in the next phase, Phase 1 in the graph above, will consist of drafting a detailed plan that will specify the following project features:

- Secure matching funding to develop a business and operating plan to implement:
    - Exploration & site acquisition
    - Local regulatory and legislative consulting to enhance our existing capabilities
- Define the SOW to develop at least one geothermal power production facility on the Big Island
- Define the SOW to develop least one industrial scale, green H_2 production facility
- Obtain commitments from 3rd party O & O partners to develop the support infrastructure and logistics systems required to service commercial offtake clients for both local and export markets
- Launch formalized community outreach and job development efforts enabling local support for the project within political and workforce development arenas.

Since its founding in January of 2020, SEH has focused on building the community, cultural, private business and public sector relationships necessary to pursue a project of this importance. Now it's time to focus on pursuing the project itself. With the proper support, This project can profoundly impact the future of Hawai`i Island and the State, as a whole.

SEH - Organization Readiness Status

Application Phase –

- **Engineering, Procurement, Construction & Operations**
    - Conceptual Design –
        - Millennium Reign Energy (Chris McWhinney-CEO)
        - HNEI – Mitch Ewan – Hydrogen Program Manager
        - Blue Planet Research – Paul Ponthieux – CTO
        - Manufacturers TBD
        - Ormat – Geothermal design, O & M post construction
    - Technical Readiness
        - Exploration – HGGRC – Nicole Lautze - Director
        - Connect with manufacturers re: supply chain factors and operations staffing leads
        - Connect with local transport and international companies re: distribution logistics
    - Project Schedule
        - TBD in coordination with Engineering Procurement, Construction & Operations
    - Project Cost Estimate
        - Source data from all of the above
        - Requires Project management and controller/CFO development to establish startup costs plus operations and market development periods in tandem with Finance Plan below

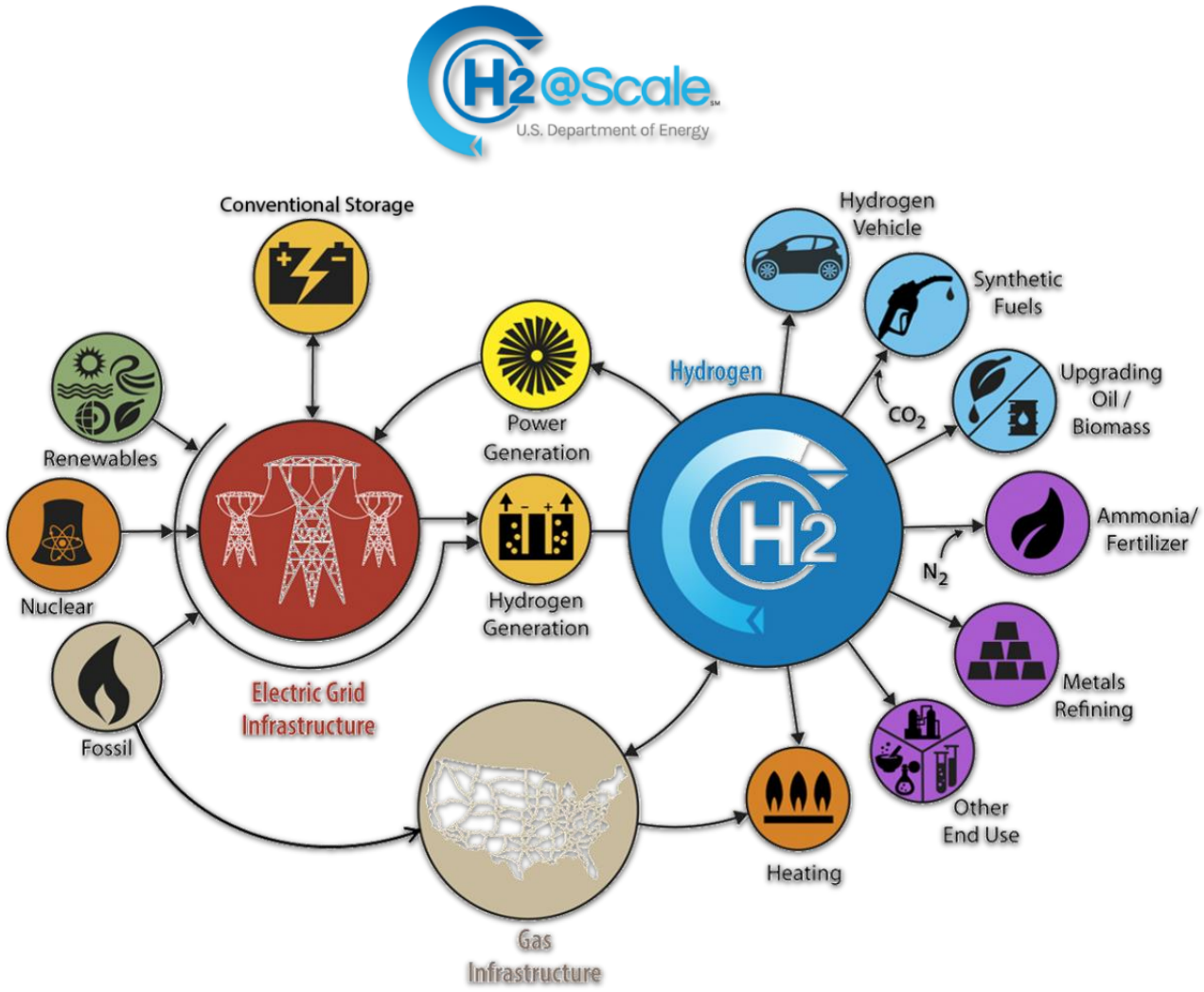
- **Business Development & Management**
    - Business Strategy – Internal concept with paid consultant's guidance as to form and necessary content
    - Team Description
        - Team development via existing internal advisory & collaborative resources plus outside experts in associated areas of development, operations and marketing.
            - SEH Board of Directors, advisors, and collaborative partners (APPENDIX A)
            - Mana Pacific Board, staff, and advisors (APPENDIX A)
    - Workforce Plan
        - Collaborate with local labor unions
        - Collaborate with State Power Utility as appropriate
        - Collaborate with Rachel Solemsass, HCC Chancellor, Workforce development expert
        - Collaborate with systems developers for workforce training resources & training programs
            - All engineering and design resources from above
        - Collaborate with local community organizations re: workforce recruitment
    - Finance Plan
        - Work with project management to detail the scope of the project
        - Present to local & state foundations
        - Present to traditional banking and capital investment resources
            - Will seek debt (preferred) or equity financing for DOE mandated cost share, if participating
                - Ormat has financed geothermal facilities in the past with 10-year buy-out structure
            - TBD further during the application period
    - Market Potential Analysis
        - Publicly available market evolution data
        - Secure, as possible, LOI's from offtake clients
            - Marine
            - Aviation
            - US Dept. of Defense
            - Ground transport
            - Grid backup for State Utility and IPP
            - Local and export market distributor LOI's
            - TBD
        - Summarize with professional RFP/FOA consultant
- **Permitting, Safety, Regulatory Approval**
    - Engage existing County and State regulatory relationships for process guidance and facilitation.
        - Potentially recruit additional project permitting expert/consultant
    - Engage with advisors from HGGRC, Blue Planet, HNEI
    - Engage with vendor and professional trade groups for specific safety guidance

- **Community Engagement**
    - Leverage community leadership relationships residing with our board of directors
    - Plan outreach events, media communications and communications strategies to establish:
        - Community benefit (investment/grant funding) intent, legal structure, workforce development plan, transparency plan
        - Native Hawaiian inclusion
        - Local Chamber of Commerce inclusion
        - Local community benefit, non-profit org inclusion
- **Technical Data and Analysis**
    - Engage needed analytical resources to produce a credible LCA and Technical/Economic analysis and projection(s) scenarios.

Why the DOE & H_2 Hubs?

The DOE's H_2 Hubs FOA is the inaugural step stimulating US involvement in an emerging, global Hydrogen production system to largely serve as a liquid fuel alternative, especially for the heavy-duty transportation sector where battery power simply cannot be a solution.

You can see from the graphic below that hydrogen, green hydrogen, in particular, will primarily come from emissions-free, renewable sources of electricity.



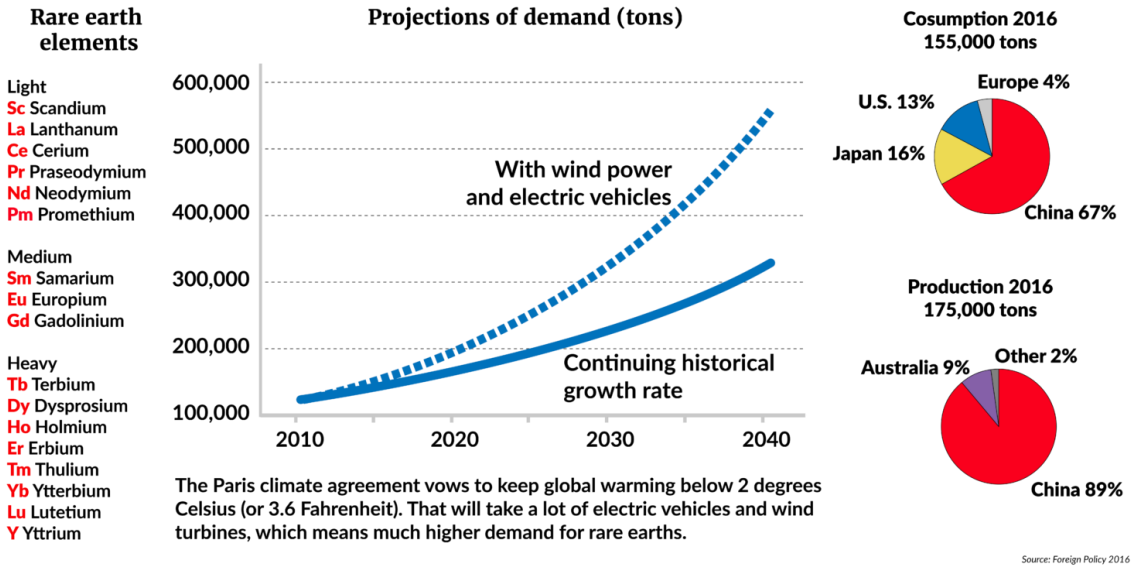
This comes at a time when private sector financing is not prepared to make a market-driven commitment to transition away from fossil fuel energy within the time frame needed absent a corresponding public sector incentive. It's always about the money. This is the reality of our economic condition. This remains a time where corporate governance and the shareholders it serves can't accept that continuous growth on a finite planet is not. Modern economic theory, via its economists, has told the world that growth is the only valid sign of economic health.

They were wrong.

The Global Energy Landscape – 2022

The world is changing and it's changing quickly. Some of the natural resources we've taken for granted have now "peaked," or reached their limit in terms of how much can be extracted on a daily basis.[14] At the same time, resource demand continues to grow. The logistics of industry today requires many of these resources be delivered on a just-in-time basis exposing supply chains to increasing disruption.

The most significant of these comes in the form of petroleum; the fuel used to transport the output of our finely tuned global economy. However, that now has grown to include mined, raw materials … and especially the Rare Earth Metals and other Critical Raw Materials (together, CRM) required by today's renewable energy systems. All have increasing geopolitical and national security implications.



Rystad Energy[15], one of the premier energy analytics firms in the world, publishes a distillation of the three major global energy reports[16] published each year. At the end of June 2022, Rystad stated the following with regard to the status of globally recoverable and proven petroleum reserves:

> *All OPEC countries have proven reserves that are expected to last over 10 years, ranging from Iraq with just over 10 years to more than 14 years in Saudi Arabia. In non-OPEC member countries, Mexico ranks last among individual countries with fewer than five years of proven reserves, whereas Canada's reserves are projected to last almost 20 years.*[17]

In the oil and gas sector, 'proven reserves' have a reasonable certainty of being recovered, while 'unproven reserves' have a decreased level of certainty in being recovered. Recoverable oil reserves are the amount of oil that can reasonably be recovered given current technical and economic conditions.[18]

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

15 https://www.rystadenergy.com/aboutus/

16 IEA, EIA & BP Statistical Review

17 https://www.rystadenergy.com/newsevents/news/press-releases/total-recoverable-oil-worldwide-is-now-9-lower-than-last-year-threatening-global-energy-security/?amp;amp;amp

18 https://www.investopedia.com/ask/answers/060115/what-difference-between-proven-and-probable-reserves-oil-and-gas-sector.asp#:~:text=In%20the%20oil%20and%20gas,current%20technical%20and%20economic%20conditions

That estimate is alarming. It means that having hit the peak in petroleum production we're looking at a situation where there will be an increasing gap between supply[19] and demand. Currently, there is no alternative to industrial grade, liquid transportation fuels. Logically, this will increasingly stress our economic models as 100% of economic output needs to be transported from one place to another. Everything will become more expensive. Supply chains for raw materials will be impacted. Affordability of consumer goods will be impacted. The steady growth expected in GDP will likely contract vs. grow. Our economic mindset does not know how to deal with continuous contraction.

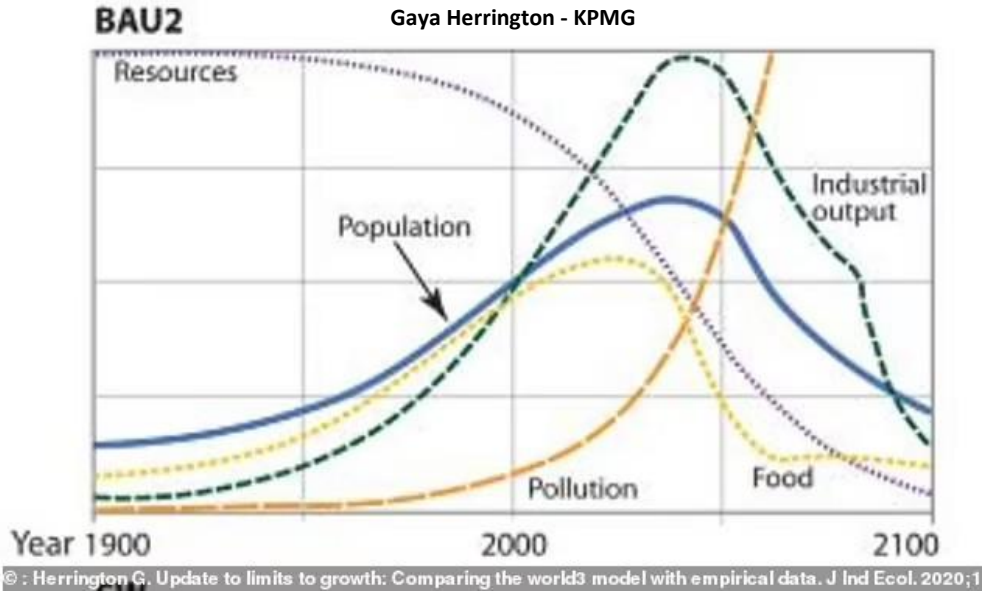
What does this mean in 'real-world' terms?

It means that the energy used to transport the output of the global economy is entering a phase of continuous, irreversible, contraction. Many factors will contribute to this situation, however, one that is not controlled by human decision making is reaching the inevitable *Limits to Growth*[20] (LtG). It means the price for oil and oil products will trend higher over time. It means the cost-of-goods & services will follow suit since everything the economy produces/consumes has the price of oil baked in. It means as prices rise, people's disposable income will shrink as their spending will need to prioritize basic necessities over discretionary purchases. Interest rates will tend to rise to combat the resulting inflation.

If this assessment is accurate, and many credible analysts show that it is, these conditions will result in varying degrees of economic recession or in a worst-case scenario, economic depression in the years to come.[21, 22]

***Limits to Growth* '50'-year Update - 2020**

Gaya Herrington - KPMG



© : Herrington G. Update to limits to growth: Comparing the world3 model with empirical data. J Ind Ecol. 2020;1

It also means, consistent with LtG analyses, that without a replacement for liquid transportation fuels at the scale, the global economy in its present form is likely to irreversibly contract, and that contraction will likely accelerate over time, tending to take an inflationary or hyper-inflationary toll on the value of our fiat currencies over time.

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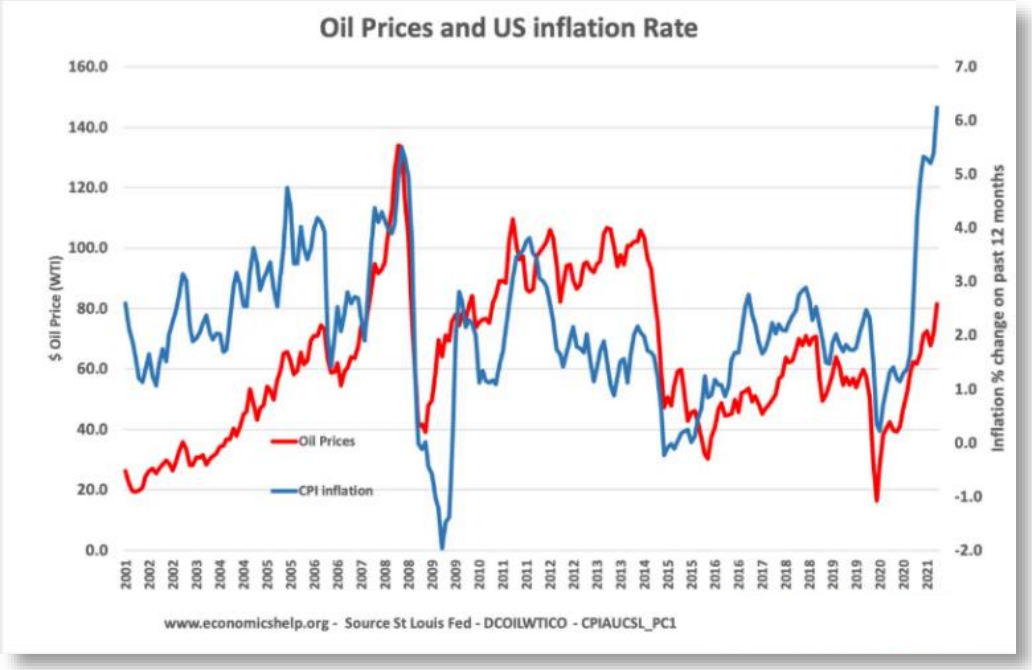
19 https://www.eia.gov/outlooks/steo/

20 https://www.clubofrome.org/publication/the-limits-to-growth/

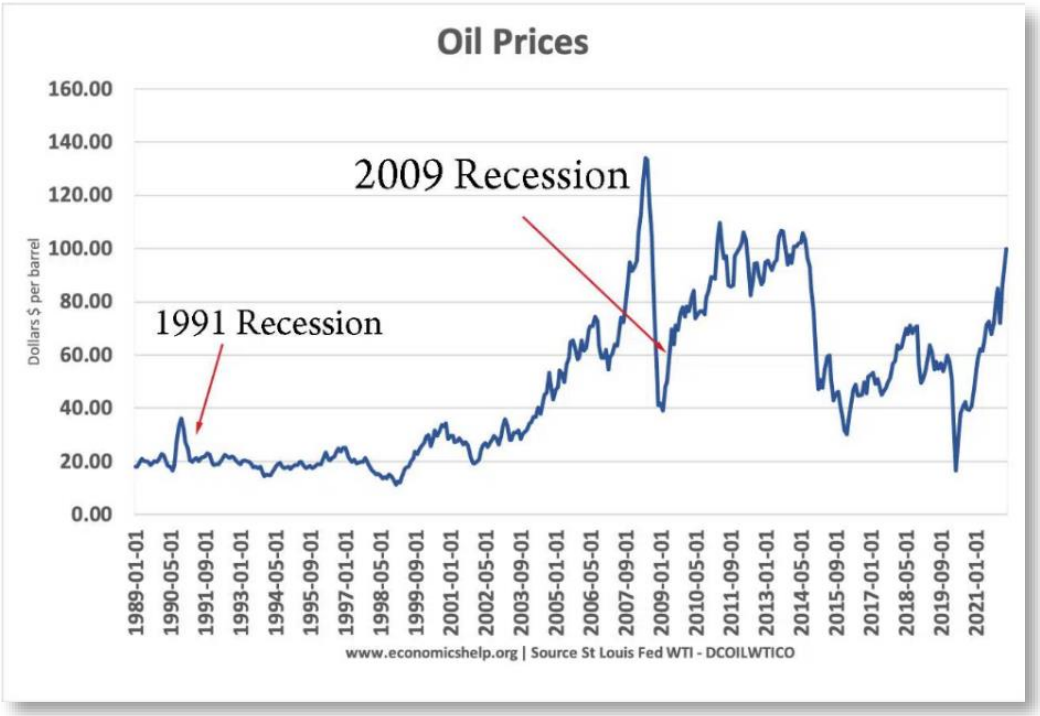
21 https://www.economicshelp.org/blog/167932/economics/do-rising-oil-prices-cause-recession/

22 https://www.dailymail.co.uk/sciencetech/article-9788957/MITs-1972-prediction-collapse-society-track-happen-2040-study-reveals.html



A preemptive focus on resiliency and self-sufficiency starting with local, sustainable energy and food production is a more than a reasonable mitigation strategy. Time is of the essence. H_2 is the transportation energy fuel every developed economy around the globe is focused on producing. These systems take time to finance, permit and construct. Shifting gears 10 years from now is not a viable option.

Successfully competing to establish a 'Pacific Island Regional H_2 Hub' can be a game-changer for our state. It reasonably could offset the expected impacts both a contracting economy and the intensifying resource depletion will have worldwide.

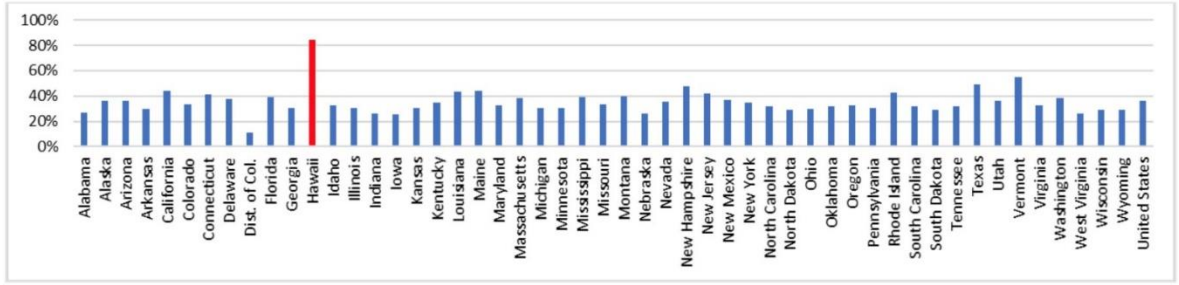


What does this mean for Hawai`i?

How this developing condition affects Hawai‘i is already becoming apparent. Hawai‘i could & should prioritize becoming as self-sufficient as possible, as quickly as possible, as the trends we are experiencing today are, more likely than not, to intensify over the coming years.

Peaking global petroleum supplies are especially worrisome here in Hawai‘i because our reliance on oil for our energy needs is the highest in the nation. While most of the world primarily uses petroleum for transportation and coal or natural gas to generate their electricity, here in Hawai‘i we have been much more dependent on petroleum for both transportation and power generation.

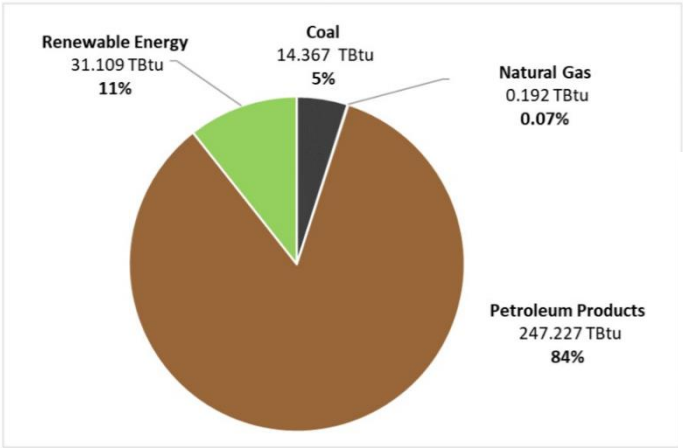
Figure 4 - Dependence of States on Petroleum for their Energy Needs, 2018



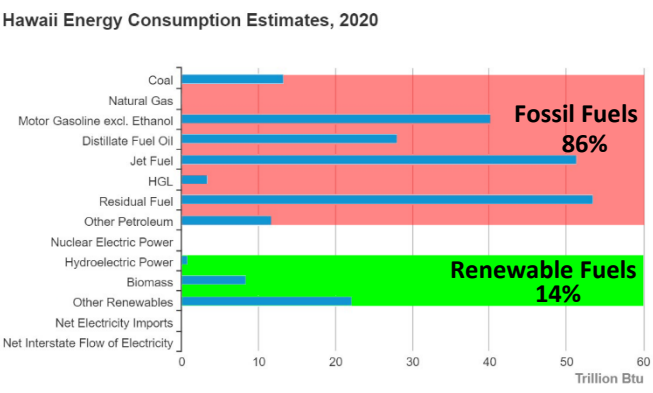
HSEO Facts & Figures 2020 **(most recent published data)**
https://energy.Hawai`i .gov/wp-content/uploads/2020/11/HSEO_FactsAndFigures-2020.pdf

Combine current needs with the risk of future supply shortages, and it begs the questions, “How do we responsibly plan for our future?” Can we muster the political will to look further into the future than we are accustomed to? Can we rethink our relationship with the most essential element in our economy – **energy** - and make sustainable, affordable, local access to clean energy at scale a time-critical priority? The DOE’s Regional H_2 Hubs project can provide a means to address those questions with resolve.

Hawai‘i’s Energy, By Source, 2018;
Trillion Btu (TBtu) and Percent of Total



Renewables Grew 3%
over 2 years
(Most recent EIA Data)



RPS 2045 - Are We on Track?

In 2015, the State of Hawai'i passed legislation known as "RPS 2045" mandating all electricity generated statewide be produced with 100% 'renewable'[23] energy sources by 2045. The purpose of this legislation was to aggressively pursue the reduction in greenhouse gas (GHG) emissions within our State, beginning with the decarbonization of our electrical generation system(s) and then to pursue the same end with transportation.

The answer to the question, "Are we on track?" depends on the factor(s) we're considering when defining 'Track'. Is it the 'Carbon Track' or the 'Sustainability Track'? Is it the 'Time Track' or the 'GDP Track'? We need to examine what the differences are between them and determine where their goals coincide and where they don't. Over time, we can add or modify tracks as we find outcomes our current strategy doesn't adequately anticipate[24]? Regardless of today's status in meeting RPS 2045 goals, we should confirm or deny whether 2045 is, in fact, soon enough to head off significant negative climate and/or economic impacts? What is clear is that this plan didn't consider systems' sustainability as a determining factor. It only considered the input energy source. Adjusting as we learn more must always be an option.

The Carbon Track

Today, the RPS 2045 mandate is already encountering planning and execution delays, most notably on the island of Oahu. The AES[25] coal-fired power plant on Oahu is slated to close in September of 2022. The plan was to replace AES' power production with multiple, utility-scale solar and battery storage systems. However, that plan has encountered numerous supply-chain problems and price increases[26]. It's not unreasonable to conclude Hawai`i's legislature anticipated different biophysical/economic conditions when crafting RPS 2045 and that both will likely continue evolving well into the future.

Other renewable energy projects that were already under PUC approved contract and scheduled for construction have been cancelled by their developers for similar reasons. With the writing on the wall, can we meet expectations, the letter of the law, and under these kinds of volatile economic conditions? Can we expect developers to be able to meet their system maintenance costs or expansion commitments over time? Are renewable energy systems 'sustainable' in a market that is already under pressure for raw materials when systems such as batteries for EV's need to expand 10-fold[27] in coming years?

If a full Lifecycle Analysis (LCA) were employed, we could reasonably anticipate outcomes closer to those we're now experiencing. Current policy trends seems to assume that fossil fuels, especially those used for transportation, will always be a fallback, plan "B" or that upstream supply-chains will continue to provide raw materials at the scale and price demand dictates. How well positioned are we to build and maintain these renewable energy systems, while the rest of the planet is competing for the very same systems? Maybe reevaluating our strengths and weaknesses is an exercise best exercised sooner rather than later?

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[23] https://www.eia.gov/energyexplained/renewable-sources/

[24] For example, the inability to replace the production at AES' Oahu coal fired power plant.

[25] AES is a Virginia based power generation company that owns and operates the AES Hawai`i Generation Plant

[26] https://www.Hawai`i anelectric.com/Hawai`i -ends-use-of-coal-for-power-generation-as-30-year-contract-with-oahu-plant-winds-down

[27] IEA report 'Global Supply-chains of EV Batteries' https://iea.blob.core.windows.net/assets/4eb8c252-76b1-4710-8f5e-867e751c8dda/GlobalSupplyChainsofEVBatteries.pdf

The Sustainability Track is the Time Track

It should be apparent that projecting future outcomes based on past performance is not a reasonable method to plan the mitigation of an existential crisis. Traditional market forces (invest, work, profit, grow, grow more & more) may be ill-equipped to offer future success, since year-over-year growth has been the sole metric upon which success has been evaluated. Taking a sober, data-driven look at resource depletion, ongoing population growth, and entrenched social expectations, we don't believe traditional economics can effectively or sustainably transition a global energy system within the time or at the scale required. In fact, changing the energy system appears to also mean changing the economic system, too.

'Sustainability' ... What does that word mean in practice?

> *Sustainability is a means of configuring civilization[28] and human activity so that society, its members, and its economies are able to meet their needs and express their greatest potential in the present, while preserving biodiversity[29] and natural ecosystems[30], planning and acting for the ability to maintain these ideals for future generations.*

Geothermal and hydroelectric power generation are the two most sustainable methods for producing electricity today. Both use a majority of base metals in their systems' design. Their life cycles can be many decades. Examples of hydro are many. Examples for geothermal can be seen in Iceland, New Zealand and with the oldest set of power plants found in Larderello, Italy, clocking in at more than 100 years. Both hydro and geothermal systems can function in low-tech forms, minimizing the need for Rare Earth Metals.

The GDP Track - What Goes Up …

Quoted in a recent New York Times interview[31], 'Pioneering Economist" and former senior-economist at the World Bank, Herman Daly[s] said:

> *"Growth is an idol of our present system … But I think it's an elementary question to ask: Does growth ever become uneconomic?".*

If we accept the logical premise that 'continuous growth on a finite planet' is not possible long-term, then the answer is clearly, "YES". As resource demand outstrips supply, the resulting economics should be obvious.

Business-As-Usual (BAU) demands continuous growth. Continuous growth demands a limitless supply of affordable energy. GDP and energy consumption have historically varied in lockstep. Energy is what enables all productivity including the acquisition of the raw materials needed to produce … well, everything including our food.

How then do we shift gears toward a sustainable economy, one that maintains itself without continuous growth? Will our global economy begin to fragment, becoming more localized as supply chains reach the limitations of centralized production? Can fiat currencies retain their value over time, as the energy they are exchanged for (incl. labor and the goods it produces), demanding higher and higher prices? Will BAU deliver what's needed when it's needed if profits aren't increasing YoY?

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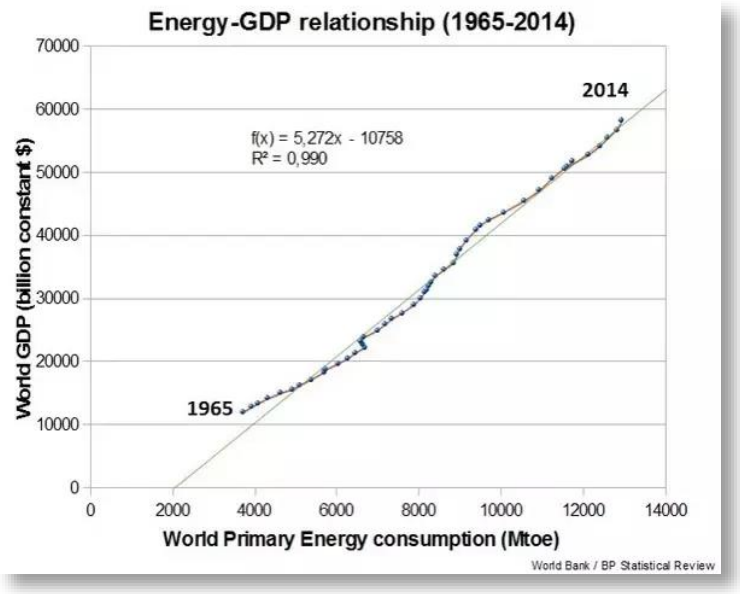
[28] https://www.wordnik.com/words/civilization

[29] https://www.wordnik.com/words/biodiversity

[30] https://www.wordnik.com/words/ecosystems

[31] July 17, 2022 https://www.nytimes.com/interactive/2022/07/18/magazine/herman-daly-interview.html?smid=fb-nytimes&smtyp=cur&fbclid=IwAR14balwWGdnddq5eiM1Wdfk020p8DwKKeeyh32NngXIqWFfhrNrP_PRrSM



Source: World Bank 2014 (GDP), BP Statistical Review 2014 (Energy)

Over a 50-year timeline, the chart above illustrates that global GDP gain, when plotted against global energy consumption gain tracks within 1% of one another. If we consider this data to be credible, is it reasonable to conclude that energy consumption is a fair indicator of GDP, and visa versa? Is it also fair to conclude that if total energy consumption were to contract, GDP would contract accordingly? There's an old axiom. 'What goes up must come down. … especially when conditions such as the availability of affordable energy supplies change. Energy is economic oxygen.

What's Missing From Hawai`i 's Current Strategy?

In our view, what's missing from Hawai`i's current energy strategy is a long-term, systems analysis, detailing the likely supply chain economics of the systems we've chosen to employ, while factoring in the reality that we are competing with the rest of the world to renewably electrify our communities.

Right now, our strategy requires us to meet emissions requirements set by the legislation discussed above, 'RPS 2045'. This means each island will need to build new, grid-scale electrical systems that are fundamentally different from today's norm. The current implementation strategy involves developing both large scale solar and wind operations with each being supplemented by grid-scale, battery storage.

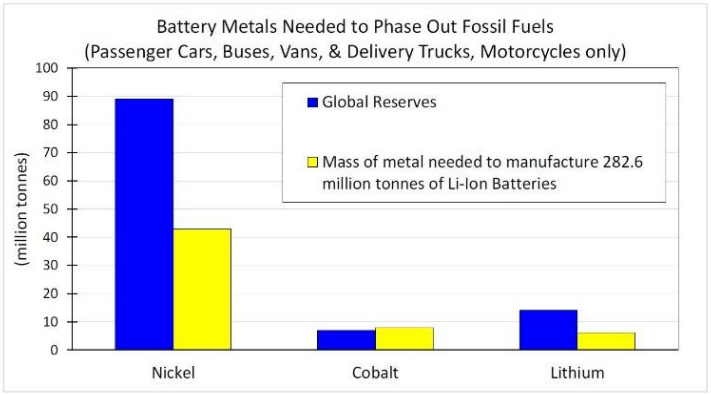
It's critical to understand that today's renewable energy systems:

- Only produce electricity.
- None, including biofuels, can replace liquid transportation fuels at the scale needed.
- With the exception of geothermal & hydroelectric, renewables are largely intermittent due to weather conditions &/or cannot produce energy both day and night.
    - None of these systems, including battery backup, are economically or biophysically sustainable beyond the first-cycle deployment expected to last 15 -25 years.

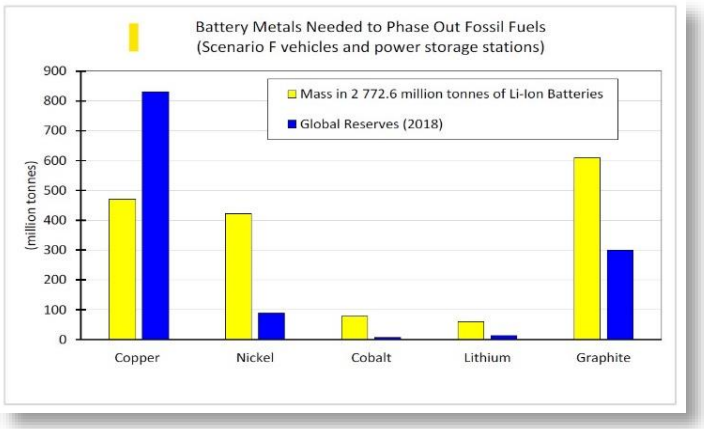
- These renewable energy systems do use 'renewable' energy inputs, but are built using non-renewable resources, many of which are considered Critical Raw Materials (CRM)[32] [33]
    - What are CRM's
        - *Any substance used in technology that is subject to supply risks, and for which there are no easy, economically viable substitutes*.

These graphs illustrate the volumes of CRM needed for one cycle of battery production for:

Light Duty Vehicles Only



Light Duty Vehicles plus Grid Storage



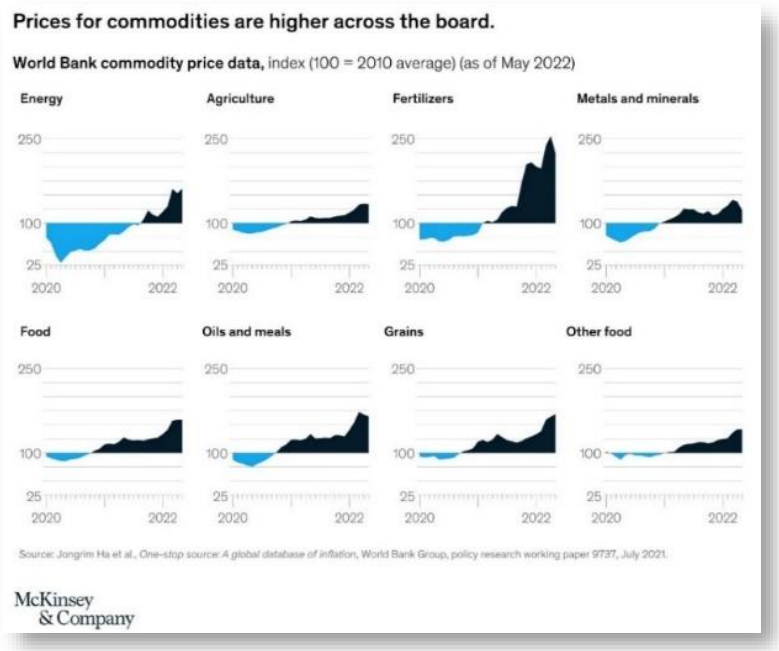
Simon Michaux, PhD, Geological Survey of Finland

Assessment of the Extra Capacity Required of Alternative Energy Electrical Power Systems to Completely Replace Fossil Fuels

08/2021; p. 665-667

https://tupa.gtk.fi/raportti/arkisto/42_2021.pdf?fbclid=IwAR3CokP3Ic-wyFT4nggUuHYQH9YwPMioy-VCq5pq83hnJC2t-Av2AUsLTfQ

Current "Supply-chain Problems"



[32] https://www.sgu.se/en/mineral-resources/critical-raw-materials/

[33] https://www.usgs.gov/news/national-news-release/us-geological-survey-releases-2022-list-critical-minerals#:~:text=The%20Energy%20Act%20of%202020%20defines%20a%20%E2%80%9Ccritical%20mineral%E2%80%9D%20as,supply%20chain%20vulnerable%20to%20disruption

How likely is it that the path we're on will be able to satisfy the energy needs of our children or their children within the timeframe we've constructed for ourselves? Is it possible to achieve the goal on a scale that's smaller than '*global*'? Many researchers analyzing future economic paradigms, in fact, see the world of trade becoming smaller and more regionally isolated in nature.

Realities such as these now define our future energy conundrum. The amount of electricity Hawai'i needs to generate as transportation becomes electrified could easily double or triple. It's not just Hawai`i that will be increasing its reliance on electrical power. We will be competing with the entire planet for renewable energy systems, systems we know cannot be produced in sync with demand.

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

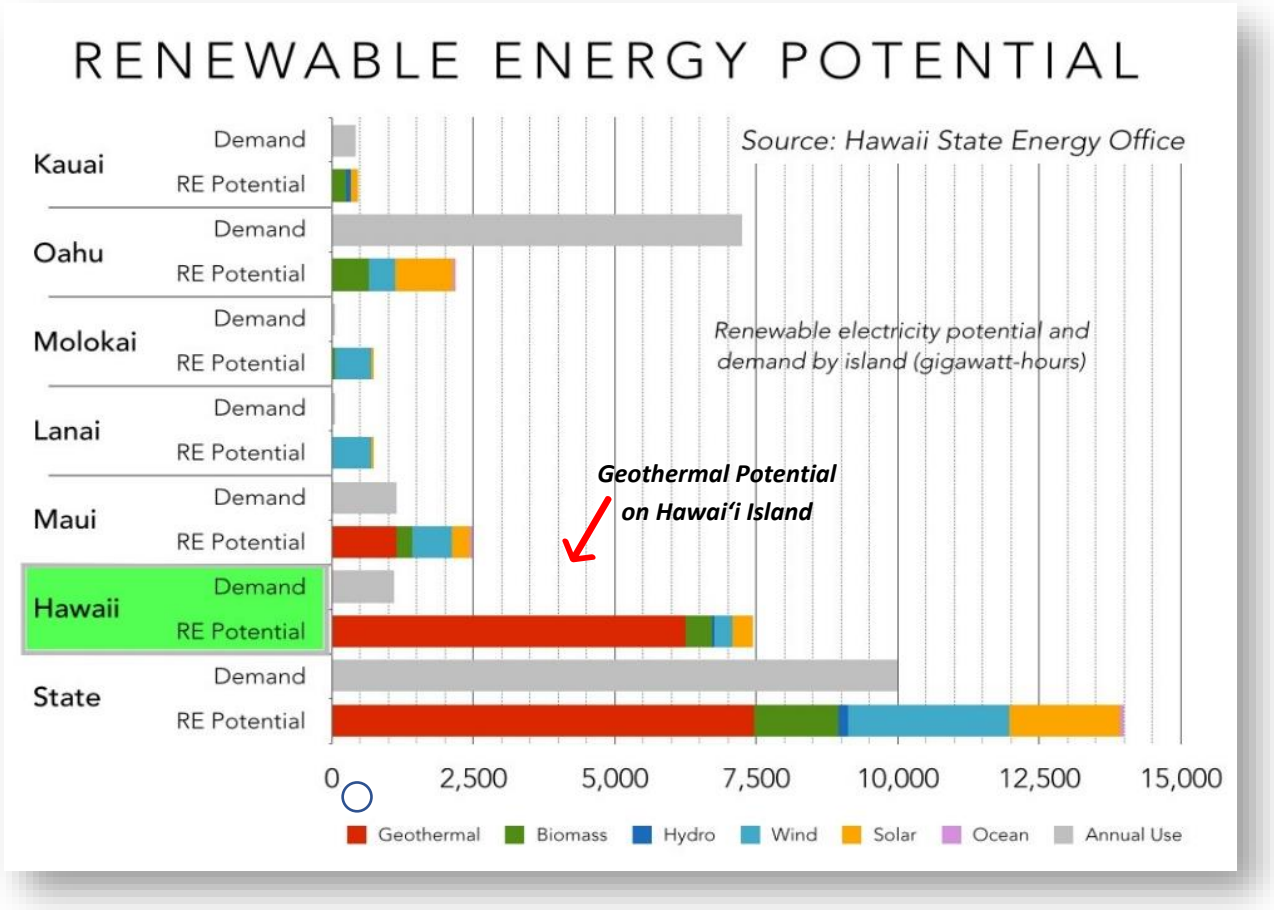
- The status of the global energy landscape – supply vs. demand vs. economically recoverable reserves
- How current options for a multi-solution "renewable" energy mix can be expected to evolve over the next 10, 20, 40, 50 years. Are they reliable long-term solutions?
- The durability, future availability, and cost of renewable system components.
- How each system will integrate with the existing grid? Does the grid have the capacity to transmit and deliver additional needed supplies?
- 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.
- And critically … Time to market.

Every system we consider must be evaluated within the context of a ***sustainability roadmap***. We must know what it takes to keep the system working over the long term. Unfortunately, that process is not part of today's decision-making protocols.

SEH Mitigation Strategy
Local Focus – Global Reach

Hawai‘i Island’s Gifts - Geothermal Heat & Water

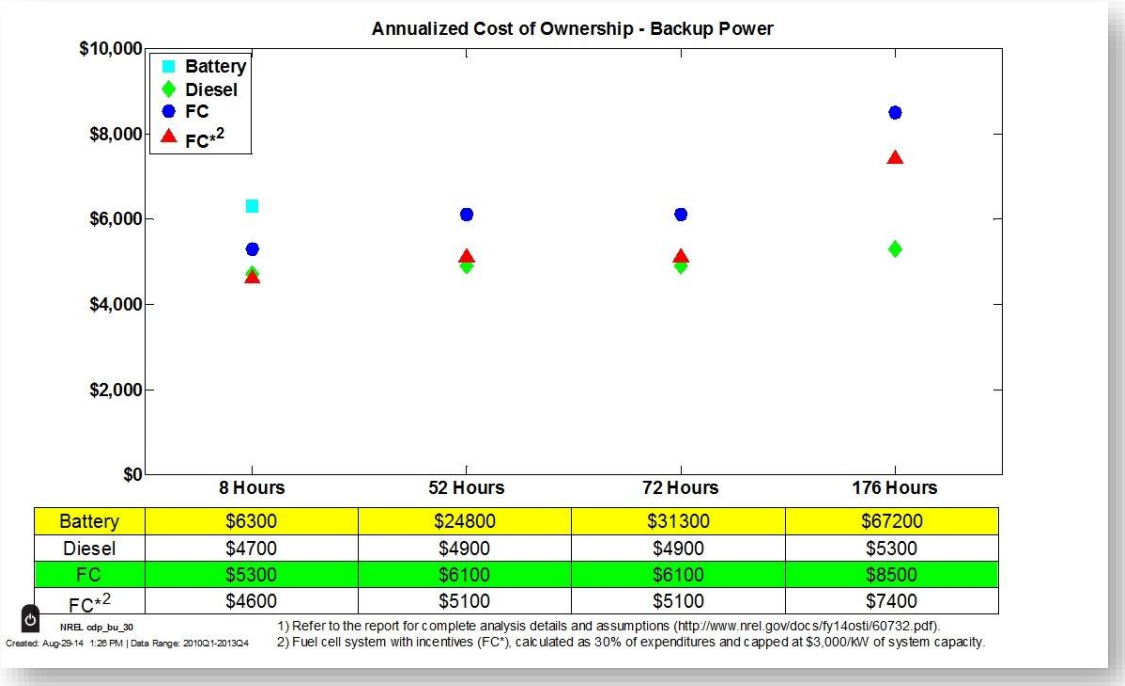
Here on Hawai‘i Island, we have access to the energy we need to generate electricity that doesn’t use fossil fuels or any non-renewable feedstock[34], for that matter. This energy is present in the form of geothermal heat, the essential energy used to generate electricity around the world. This eliminates the need to import an energy source, making The Big Island much more self-sufficient.



Geothermal heat can consistently, safely, and reliably generate electricity for decades or even centuries if we properly manage our systems and their components. Our targeted use for this electricity is principally to produce industrial-scale volumes of hydrogen for sale to a global export market. Local needs would also be supported where commercial distributors would service transportation and power backup applications.

[34] A feedstock is any raw material that can be used directly as a fuel or converted to another form of energy. i.e.: Natural gas, coal, nuclear materials, wind, sunlight, wave energy are examples of energy generation feedstocks.

The last item in the preceding list offers an alternative to battery storage. Data suggests that hydrogen fuel cell & storage systems are a less costly means to provide supplemental power and grid scale load balancing for local solar and wind facilities.



	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

NREL cdp_bu_30
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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.

There are generally two methods for producing hydrogen. One involves extracting hydrogen from the fossil fuel methane (natural gas). This method emits carbon into the atmosphere. The other involves splitting water molecules into hydrogen & oxygen. The latter is preferable since its only outputs are hydrogen and oxygen. There is no carbon present in the production cycle.

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

Sustainable Energy Hawai`i's strategy to leverage these gifts for the benefit of all who live on the Big Island is pretty straightforward.

- Go big. Leverage our strategic economic and national security location to garner the public funding needed to seed a project of this scale.
- Go quickly & effectively. Time is not on our side. We don’t have the luxury of experimenting until the market develops on its own. This is what is needed today. The funding is available. The terms are appropriate. Our future is on the line.
- Hire the best people to do the job. Hire local, train local, serve local.

Constructing additional geothermal facilities and developing industrial-scale hydrogen production represents a viable new industry for Hawai`i Island. This industry could benefit all our people, not only with potentially stable energy costs for their homes and businesses but also by creating new employment opportunities plus a means to capitalize a community benefit fund to financially strengthen all aspects of shared life during this time of transition.

The goal is to facilitate on-island production of life essentials such as food, fertilizer, transportation energy, basaltic construction materials, and other goods that are suited for local manufacture, thereby minimizing our dependence on imported necessities. Hydrogen can also serve as a feedstock to repurpose existing power plants by replacing fossil fuel powered generation with H_2 powered generation.[35]

The scale sought by the DOE H_2 Hubs program would be large enough to allow us to participate in an emerging international export marketplace serving the needs of transoceanic shipping, supplemental power storage for neighboring islands' solar and wind projects, heavy-duty transport fuel, and more.

Sustainable Energy Hawai'i is working toward the goal of **local** ownership and management of this operation. 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.

We need to decide, as a community how we want to live? … Do we want to insure access to affordable locally generated electricity? transportation fuel? Do we want to leverage Pele's gift to support those who live here? What we do in response to that question today will determine Hawai'i's future tomorrow.

SEH being chosen to participate in the DOE's Regional H2 Hubs program is a direct path to enable this potential.

[35] Efficiency might be questioned in terms of using hydrogen produced from electricity to produce electricity, however, need and real cost of reusing stranded generation assets should be factored into the equation. Keep in mind that the feedstock that generates the electricity in the first place is naturally occurring and plentiful as is the water from which it is extracted. Oxygen is also a byproduct of H_2 production, impacting efficiency and presenting an economic offset.

Near-term DOE Strategy

1. *Application Phase*,
    a. Organize, fund, and execute a suitable application to establish the Pacific Island Regional Hydrogen Hub in accordance with the DOE guidelines
    b. Continue to recruit the necessary staff, advisors (including legal), suppliers, 3rd party partners, and viable matching funds sources in preparation for Phase 1
    c. Ramp up community outreach operations
    d. Explore options for siting geothermal and H2 production facilities
        i. Engage geothermal production viability exploration resources
    e. Expand the ongoing process of securing lawmakers and regulators for political and expedited implementation support.
        i. This will likely involve crafting updated regulations that currently make development unreasonably difficult.
2. If selected by the US Dept. of Energy to move on to 'Phase 1' (FOA publication slated for the early October 2022 timeframe):
    a. Adjust to updated DOE goals and guidelines
    b. Seek Phase 2 matching funds
    c. Engage qualified developers for:
        i. Geothermal facility design
        ii. Electrolysis facility design
        iii. Water supply
        iv. Interconnect with HELCO as needed
        v. Engage with the County, State, and PUC for environmental & regulatory guidance.
            1. Write and advocate for updates where needed.
3. If we make it this far, any plan listed here will be outdated, having been updated along the way. First things first.

Community Outreach Strategy

Our ability to achieve success depends on overwhelming support from our community. There are community obstacles to overcome in pursuit of our goal. There are two general community groups that have presented objections to the development of geothermal energy in Hawaii - the Native Hawaiian Community and Social/Environmental Justice groups.

We take an inclusive approach and seek to include our various communities in the discussions and the development of our solutions. By having stakeholders at the table, we're better able to build trust and navigate avoidable pitfalls.

Native Hawaiian Community Considerations

From the beginning, SEH has worked to establish trust and credibility within our Native Hawaiian communities. Our board of directors includes several Native Hawaiian leaders who also hold respected positions within their communities. They have been instrumental in guiding our discussions and framing our strategies.

To raise awareness of the Native Hawaiian perspectives on indigenous resources, the environment, and geothermal energy, we create the opportunity for public discussions, including webinars and open meetings, where local leaders and community members can share their perspectives and concerns.

Critically, our Native Hawaiian community is not homogeneous. It is comprised of several groups with varying views on development. We acknowledge and embrace this diversity and recognize that building mutual trust is critical to our success.

Social Justice Considerations

Social justice groups, including environmental justice, are vocal and influential in Hawaii. Their motivations focus on protecting the natural environment, ensuring that the environmental impacts of development (negative and positive) are shared or considered, and environmental injustices (undesired social impacts) are avoided.

Vocal opposition to geothermal development in the Puna region of Hawaii Island has largely been due to local community environmental injustice claims – complaints regarding air and sound pollution, concerns about chemicals used in the geothermal plant, and speculation about the relationship between the geothermal operation and volcanic activity in the region. (The plant and adjacent communities are on or close to a volcanically active rift zone.)

SEH also offers the opportunity for social justice groups to engage in dialogue. Prominent members have been invited to speak at our webinars, and we've participated in cordial discussions with local leaders who have actively opposed the geothermal operation in Puna.

Our approach of inviting social justice groups and members into our discussions allows us to pursue solutions that consider their concerns and allow us to clarify misconceptions and mitigate undesired consequences.

By making a tangible commitment to equitably shared economic benefits, we create a win for all stakeholders involved. These benefits can take the form of community benefit dividends, food security, and an improved cost of living for all sectors of our community. This approach will go far in addressing the social justice concerns that have historically plagued Hawaii and have been fodder for groups opposing any development.

Conclusion

Given the climate of the climate, there is one question that serves as the foundation for all that follows within every aspect of modern life …

How do we want to live? Do we have the luxury of letting the market decide for us over time or do we agree that's no longer an option? It's time to make a choice. The economics supporting this type of effort must look at 'profit' from a different perspective, one that is not only calculated in financial terms.

Today's conventional wisdom is 'just' stop using fossil fuels and go all in on solar, wind and batteries.

Based on recent credible reporting, that can not be achieved, even through one deployment cycle. Many on our Hawai`i Island advocate for other unsustainable systems to provide our power or that all decisions regarding land and resources be made according to Hawaiian tradition.

What would that look like? Do we want to ensure our grandchildren have the benefits of electricity and hydrogen, or are we ok to live, as we did for millennia, on available sunlight?

In our view, we no longer have the luxury of spending years arguing over what system is better, wind or solar or batteries or fuel cells, capitalism or socialism, solitary tribes or integrated communities, whether to live as a part of nature or apart from nature.

The modern energy/economic system status quo has an expiration date. To say there is a storm coming is not hyperbole. However, by knowing it's coming and treating it as such, we can, to a greater or lesser degree, mitigate our position, or we can let outside forces decide for us. It's our choice. But, it's one that we must make together.

Mitigation via geothermal power and hydrogen production will realistically take a decade or more just to launch, We hope that choice gets made from a well-informed position that considers more than technology or spirituality as existing in isolation. We need to find a balance between the two. We can do this!

Mahalo nui loa,
Sustainable Energy Hawai'i, LLC
www.sustainableenergyHawai`i .org