Equity Guardrails for an Emerging California Hydrogen Market

06/26/2024

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CALIFORNIA ENVIRONMENTAL JUSTICE ALLIANCE

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Physicians for Social Responsibility Los Angeles

COMMUNITIES FOR A BETTER ENVIRONMENT
established 1978

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Agenda

- Introduction to hydrogen
- Hydrogen policy landscape
- Costs of green hydrogen in a drought prone region
- Local hydrogen projects: Angeles Link, Scattergood, Orange Cove
- Equity principles for hydrogen
- Q&A

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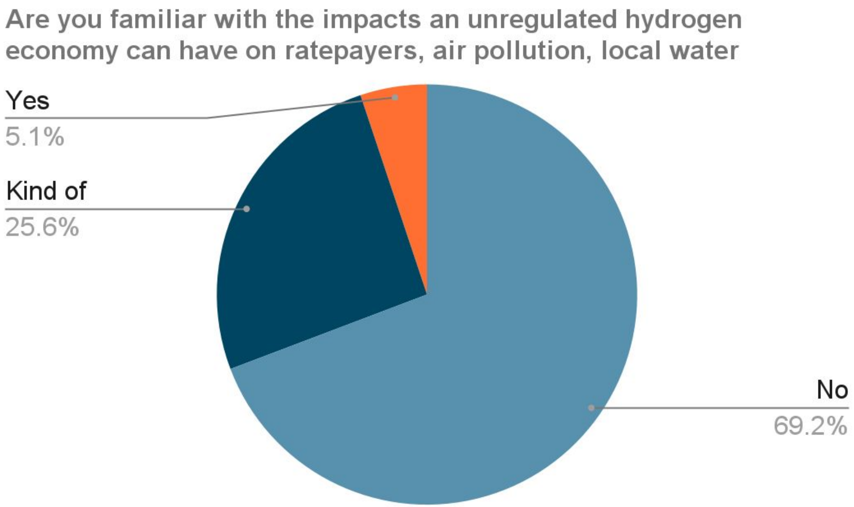
Poll Results

On a scale of 1-5 from no knowledge to expert, how do you rank your familiarity with hydrogen production and end uses?

Audience Response: 1.8 / 5

Poll Results

Are you familiar with the impacts an unregulated hydrogen economy can have on ratepayers, air pollution, local water sources, and the state's climate goals?



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Introduction to Hydrogen - What it is

Hydrogen is an energy carrier

Currently used in:

- Oil refining (~33%)
- Ammonia production (~27%)
- Methanol production (~27%)
- Steel production (~3%)

IEA (2019), The Future of Hydrogen, IEA, Paris https://www.iea.org/reports/the-future-of-hydrogen,

Introduction to Hydrogen - How it's produced

- **Steam-methane reforming (SMR)**
  - Fuel source: Natural gas
  - Percent of global production: *~75%*
- **Coal gasification**
  - Fuel source: Coal
  - Percent of global production: *~23%*
- **Electrolysis**
  - Fuel source: Water + electricity
    - Electricity fuel source: Solar + wind, biomass, digester gas, nuclear energy
  - Percent of global production: *< 0.1%*
- Other methods of production:
  - **SMR with carbon capture**
  - **Methane pyrolysis**
  - **Biomass gasification**

Table 1. Classification of Hydrogen Based on Energy Source and Carbon Intensity

Classification Based on Energy Source	Energy Source for Hydrogen Production	Classification Based on Carbon Intensity
Black Hydrogen	Bituminous coal	High Carbon Hydrogen
Gray Hydrogen	Natural Gas or Methane	
Brown Hydrogen	Lignite (brown coal)	
Blue Hydrogen	Natural Gas or Methane with CCUS	Lower Carbon Hydrogen
Green Hydrogen	Electrolysis powered by renewable energy	
Pink Hydrogen	Electrolysis powered by nuclear energy	

Source: Hydrogen 101: Frequently Asked Questions About Hydrogen for Decarbonization, Mohit, J. et al. NREL. July 2022.

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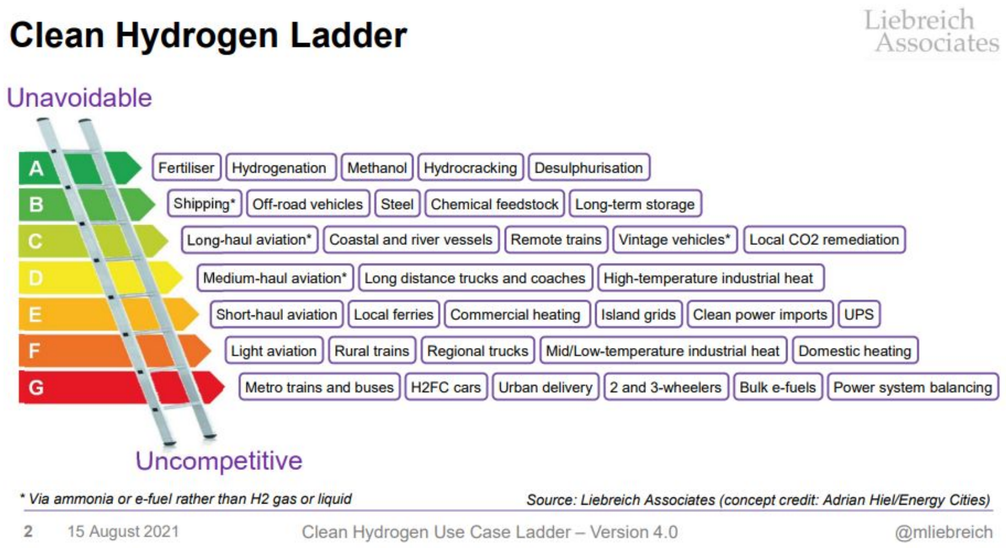
Introduction to Hydrogen - Definitions Matter

We oppose all hydrogen production that is not green hydrogen production, and we agree that green hydrogen is produced by means of electrolysis using surplus water and additional renewable electricity

- APEN Asian Pacific Environmental Network
- California Environmental Justice Alliance
- CCAEJ
- CRPE Center on Race, Poverty & the Environment
- CCAC Central California Asthma Collaborative
- CVAQ Central Valley Air Quality Coalition
- Communities for a Better Environment established 1978
- Environmental Health Coalition Empowering People. Organizing Communities. Achieving Justice.
- Leadership Counsel for Justice & Accountability
- Pacoima Beautiful
- PSR LA Physicians for Social Responsibility Los Angeles

Introduction to Hydrogen - What it's used for

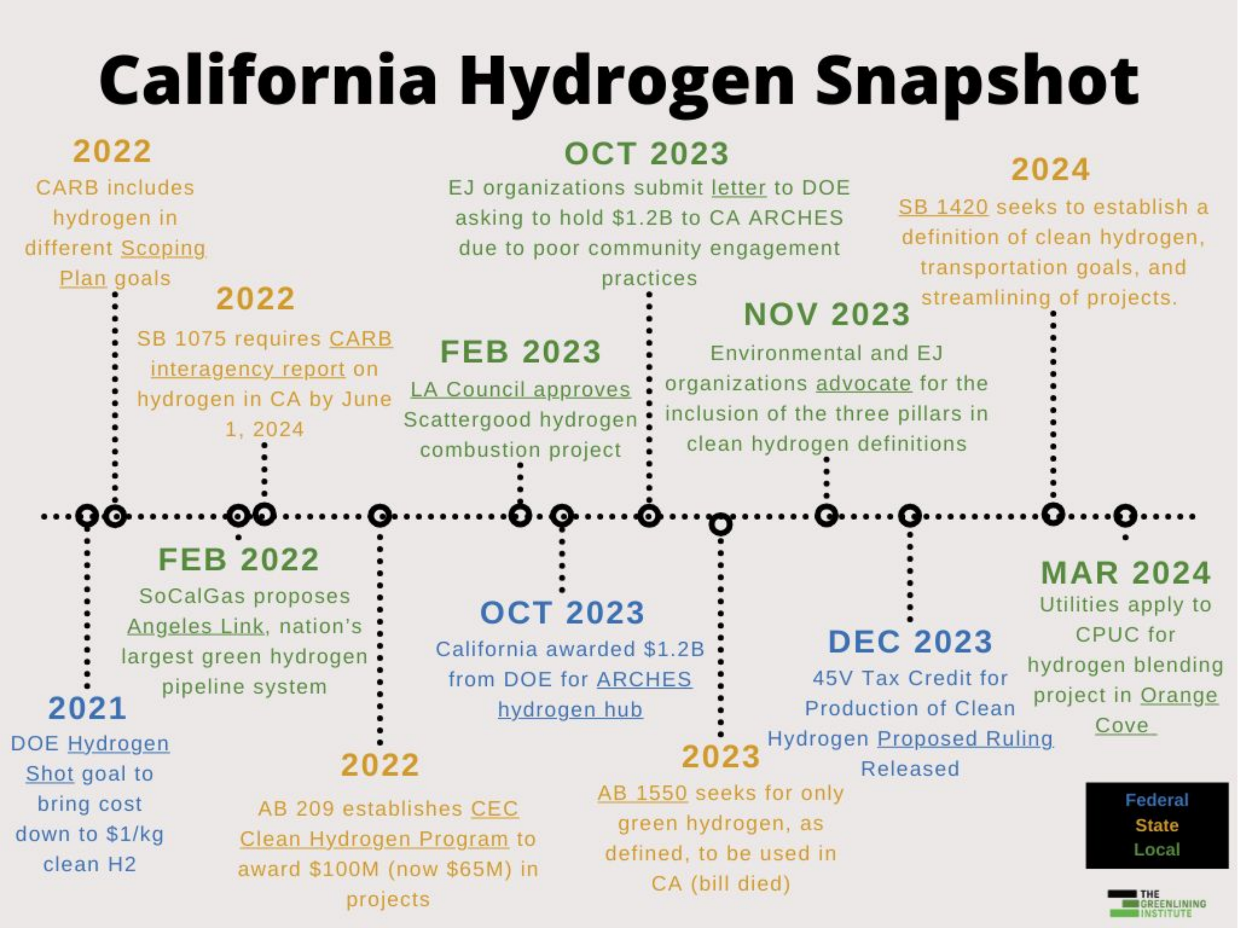


- **Shipping and aviation**
  - Ammonia and methanol as fuel
- **Agriculture**
  - Ammonia for fertilizer
- **Industrial processes**
  - Iron and steel production, oil refining, ammonia and methanol production
- **Fuel cell-based transport**
  - Cars, trucks rail, etc
- **Power**
  - Hydrogen blending, storage, fuel cell-based generation, etc
- **Buildings**
  - Blending hydrogen for heating

Federal

State

Local



California Environmental Justice Alliance

Nile Malloy, Climate Justice Director

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WHO IS THE CALIFORNIA ENVIRONMENTAL JUSTICE ALLIANCE?

Snap Shot of California's Hydrogen Landscape Context

1) **Moving decision-makers: legislative and administrative power** to address EJ production and hydrogen supply chain
2) **Educate and narrative at the federal, state and local level with data and research**

Hydrogen Lobby and Industry

1. **Big $$** Lobbyist access to millions, concern of further investment fossil fuels infrastructure
2. **Money in Politics:** Fossil Fuel Industry, Labor, Federal support, Elected officials
3. **Narrative:** $$Federal, State, and Local - marketing, a communications team in the world. Conferences without EJ or community participation

EJ/Enviros/Community

1. **Grassroots $$** EJ/Enviros/Community partners, Health, Climate justice solutions divest in state's fossil fuel infrastructure and support a manage decline of fossil fuels
2. **Money Not in Politics:** Climate, Legislators; Money vs Enviro/Safety
3. **Narrative:** NGO, Coalitions, manage decline, electrification, clean energy

Building Understanding to Address Hydrogen Projects

1. **Strengthening our partnerships** across state legislators, local government and across sectors
2. **Promote EJ and raise climate solutions that address hydrogen production, safety, health, and preventing CEQA streamlining**
3. **Work with state and local decision-makers on community health equity and climate solutions**
4. **Address EJ Hydrogen productions concerns, types of hydrogen, supply chain and end use.**

Federal Level - 45V Three Pillars

The Clean Hydrogen Production Tax Credit (Section 45V), established by the Inflation Reduction Act (IRA).

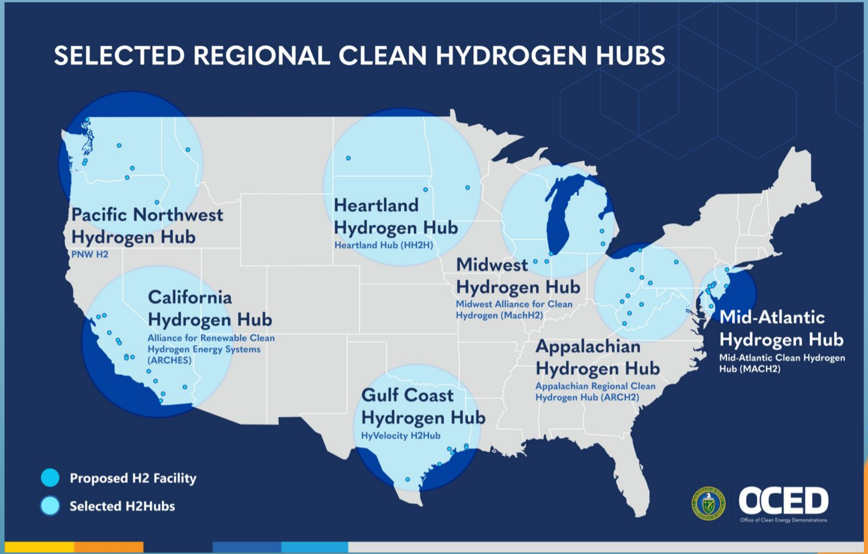
Urge DOE to require that all electrolytic hydrogen production seeking the 45V credit ensure that they do not drive increases in fossil electricity on the grid and comply with the three pillars:

1. **New clean supply** - qualified "clean" hydrogen that produced through a life cycle GHG analysis.
2. **Hourly matching** - hydrogen producers may only claim zero carbon power if clean electricity is generated in the same hour.
3. **Nearby/Deliverability** - power must come from same transmissions needs region - can physically reach production facilities

* The DOE has defined clean hydrogen as "hydrogen produced with a carbon intensity equal to or less than 2 kilograms of carbon dioxide-equivalent produced at the site of production per kilogram of hydrogen produced." In selecting projects for this specific funding opportunity, the DOE will evaluate life-cycle emissions for each project application and give preference to applications that reduce GHG emissions across the full project life cycle (Infrastructure Investment and Jobs Act P.L. 117-58).
** This represents one-third of the 2030 US clean hydrogen production goal.

California ARCHES

- Needs improved Governance structure that **ensures community engagement process.** Current drafts has not prioritized environmental justice or public health and has not met even the most basic standards of transparency and meaningful community engagement.
- **NDA restrictions and lack of transparency** to disclose information about who has applied or how applicants plan to use the public money.
- Weak standards without the three pillars would **endanger the climate and public health**
- Without the three pillars, in most cases the **hydrogen production emissions limits set forth in 45V will be far exceeded by the induced grid emissions,** amounting to a cumulative increase of hundreds of millions of tons of carbon emissions and significantly increased air pollution.
- **Affordability of electricity** could increase the cost of new clean power that will fall on utility customers in the form of higher electricity and resource adequacy prices.



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State Legislation Climate Solutions

- **Work with legislature to develop clean and green hydrogen definition**
- **SB 1420 EJ/Enviros OPPOSE**
    - **This bill would codify a weak and harmful definition for hydrogen in California.** The proposed "qualified clean" definition for hydrogen lacks equity and health guardrails, is difficult to measure, and would support harmful projects.
    - **This bill would prioritize benefits to <u>existing</u> polluting facilities.**
    - **The bill has weak carbon intensity standard requirements.** The bill states in the added code section Health and Safety Code 43869.5 (a) that a fuel cell electric vehicle shall have the *same or better* carbon intensity as compared to an electric vehicle on a full well-to-wheel basis. However, the requirements then imposed in this bill do not achieve this; e.g. by 2045 only 60% of the hydrogen used must have a carbon intensity equivalent of the 2045 grid, as opposed to 100%.

State Legislation Climate Solutions

SB 1418 Hydrogen-fueling stations: expedited review. OPPOSE

- CEQA expediting and streamlining projects that introduce hydrogen, needs environmental review to address highly volatile and difficult-to-contain gas, into local communities is unequivocally dangerous.
- This bill will take away local control of land use and public health decisions by requiring ordinances that streamline the permitting of hydrogen fueling stations across the state regardless of how the hydrogen fuel was produced and without a full consideration of the guardrails in place to ensure safe delivery and storage.
- With regard to light-duty vehicles (passenger cars), it is now clear that BEVs are a far superior technology compared to fuel-cell electrics (FCEVs).
- Hydrogen on the other hand has never really caught on for good reasons; there are fewer than 15,000 passenger FCEVs on the road, and the trajectory in cost, affordability, and access – with regard to both vehicle and fueling – is trending in the wrong direction.

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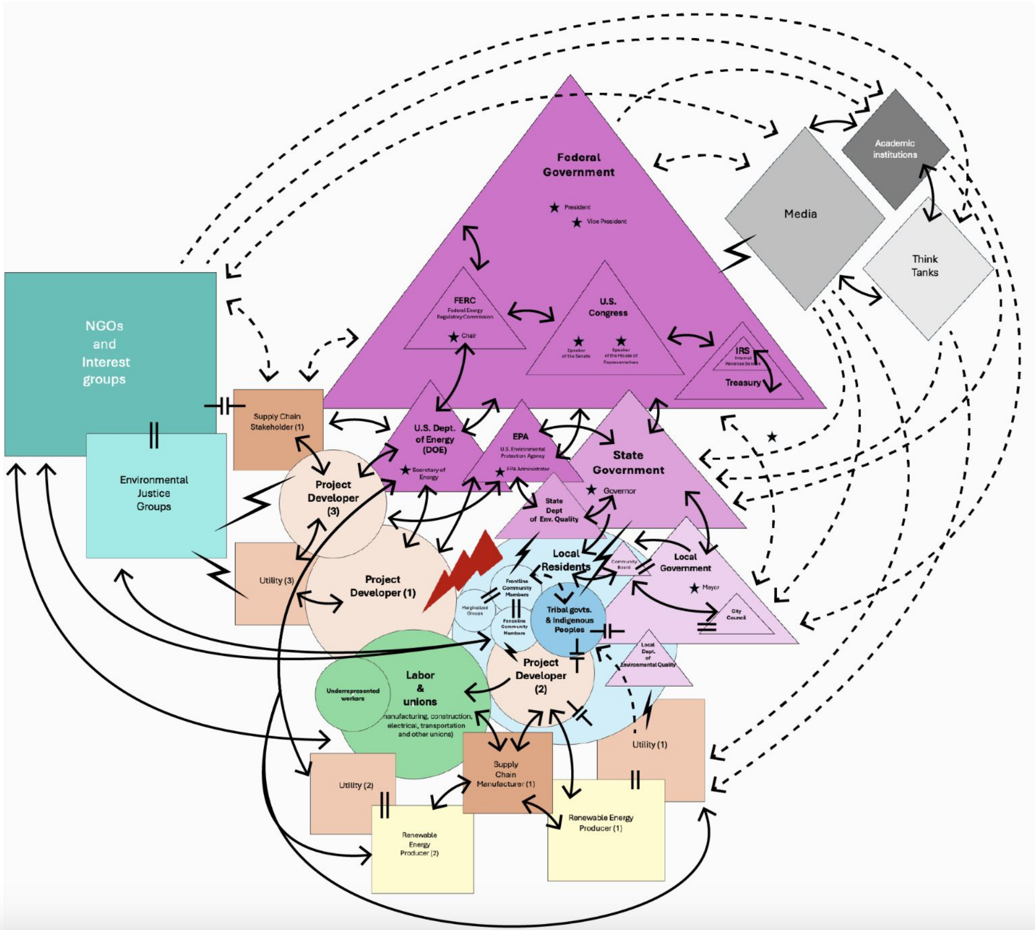
Local Projects Climate Solutions



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Legislation to Local Climate Solutions

- Local governments, many strapped for resources, should continue to spend their precious resources on improving the quality of life in their communities by focusing on making their cities walkable and bikeable, improving public transit options, investing in community-driven projects, and expanding electric vehicle charging infrastructure for those that must drive.

- Local projects success collaboration with local communities, labor groups, environmental justice (EJ) organizations, and tribal partners is necessary. Ensuring economic growth opportunities are coupled with true climate benefits and positive financial flows to communities with minimal impacts to environmental resources is a fundamental goal of the federal and state resources.

Understanding the water costs of Green Hydrogen in a drought prone region

How may large-scale hydrogen implementation affect California's water resources?

Prepared by:
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Outline

1. How will production of H_2 affect water costs?
2. How will use of H_2 affect water costs?

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How much water is needed truly?

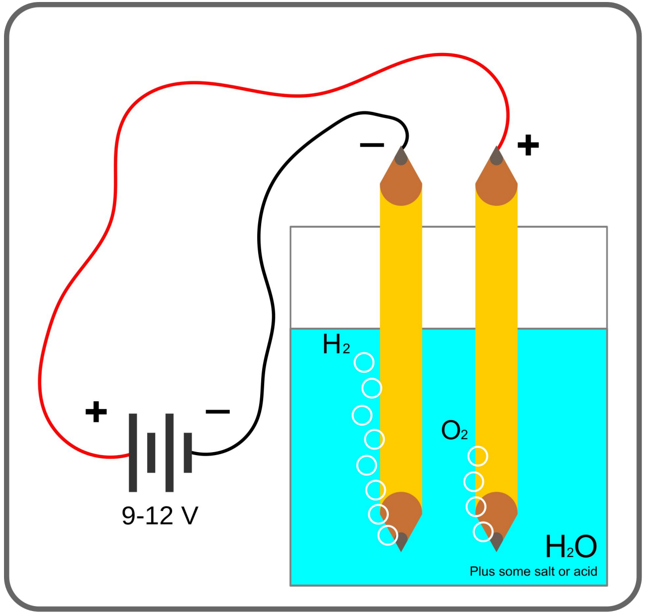
- 9L (or kg) of water to produce 1 kg of H_2 is the stoichiometric conversion factor (Lampert et al, 2015). This is not ideal for estimating true water costs.
- This assumes that the water quality is at ideal conditions, and that the electrolyzers are operating at 100% efficiency.
- This does not take into water loss elsewhere in the process.
- The challenge with calculating the true water costs of a H_2 project will depends on various factors.

Electrolysis Process

$2H_2O$ + Electricity $\rightarrow 2H_2 + O_2$

Stoichiometric Conversion Factor

9L of $H_2O \rightarrow$ 1kg H_2



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How do electrolyzers play a role?

Common Commercial Electrolyzer Types		
Type	**Estimated H2O L / kg H2**	**References**
Alkaline Water Electrolysis (AWE)	10	Arcos&Santos, 2023 Feng *et al*, 2017 Zuo *et al*, 2022
Proton-Exchange Membrane (PEM)	17	Newborough&Cooley, 2021 Feng *et al*, 2017 Arcos&Santos, 2023
Solid Oxide Electrolysis Cell (SOEC)	12.1	Min *et al*, 2022 Feng et al, 2017 Arcos&Santos, 2023
Anion-Exchange Membrane (AEM)	8.93 - 12.2 (Depending on alkalinity)	Miller et al, 2020 Arcos&Santos, 2023 Ng *et al*, 2023 Noor Azam *et al*, 2023

- Electrolyzers can range in size and type, and each requires ideal conditions to produce H_2 efficiently. Knowing which one is being used, and understanding it's components will help understand the water costs
    - Low-Temperature Electrolysis (LTE): commercially available, but available in low volumes, are costy, not durable.
    - High Temperature Electrolysis (HTE): less mature of a technology, high efficiency and has ability to be coupled with other energy sources.
- Commercially available electrolysis technology produces H_2 at a slightly larger water cost, opposed to the stoichiometric reaction, because you have to take into account electrolyzer efficiency and the quality of the water feedstock.

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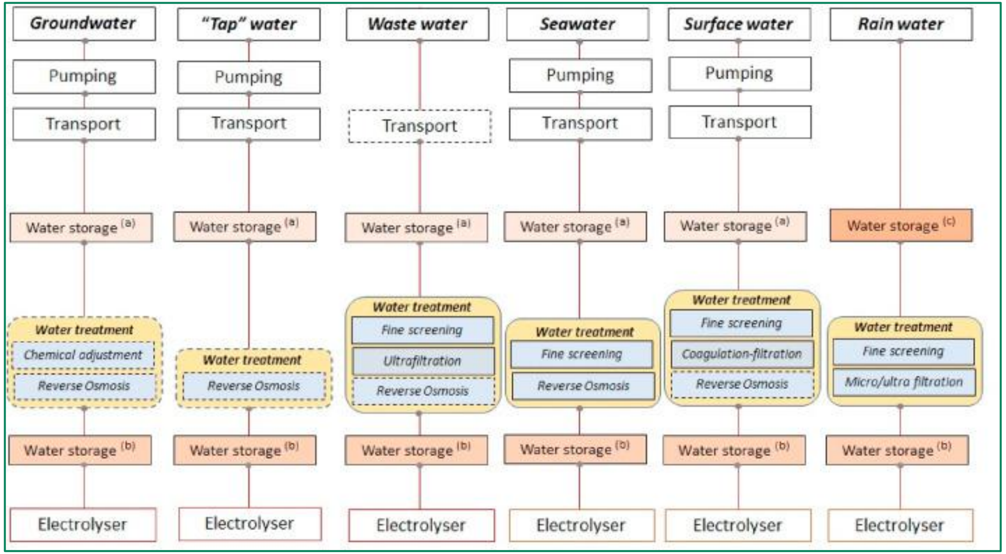
What kind of water is required? Why?

- High purity water ("Ultrapure") is essential for efficient hydrogen production, as contaminants reduce available water present in volume, increasing water demand.
- Commercial electrolyzers note they require ultrapure or deionized water to ensure efficiency and longevity (Saulnier *et al*, 2020; Lampert *et al*, 2015).
- Water treatment technologies like ion exchange and reverse osmosis may be needed to treat water supply source.
- The water source and treatment affects total water costs due to some being "rejected", energy demands, and impurity levels.

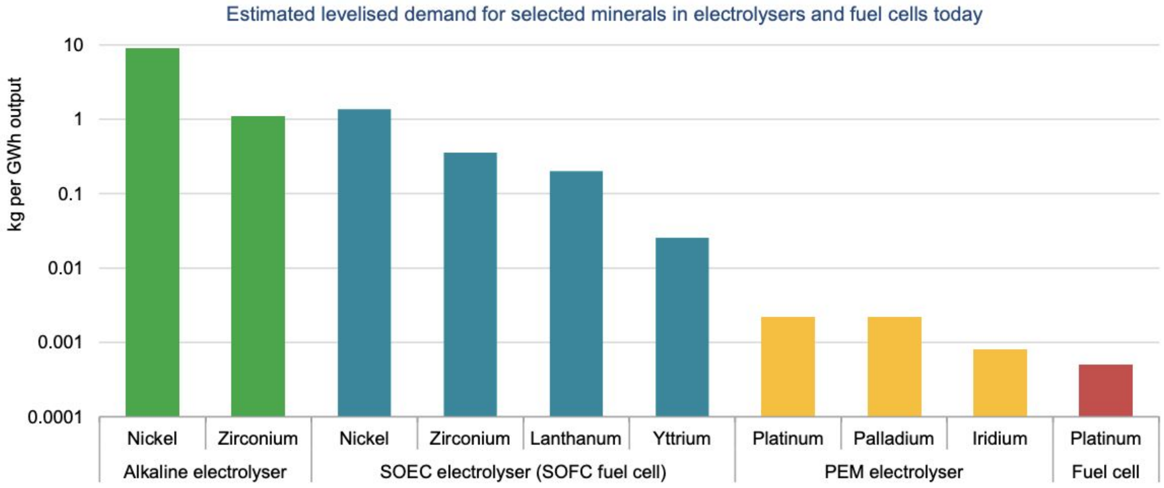


Simoes *et al*, 2021

External Water Cost: Mining Rare Minerals

- Water feedstock quality is crucial for the electrolyzer lifespan. Impurities can degrade membranes and components, leading to lower H_2 production and increase maintenance costs.
- Impurities (carbonates, chlorine, sulfates, organic compounds, and metal ions) can “poison” or clog electrolyte flows, degrading the catalysts.

Hydrogen electrolysers and fuel cells could drive up demand for nickel, platinum and other minerals, but the market effects will depend on the shares of the different electrolyser types



Notes: PEM = proton exchange membrane; SOEC = solid oxide electrolysis cells; SOFC = solid oxide fuel cell. Normalisation by output accounts for varying efficiencies of different electrolysis technologies. Full load hours of electrolysers assumed to be 5 000 hours per year.

Sources: Bareiß et al.(2019); Fuel Cells and Hydrogen Joint Undertaking (2018); James et al. (2018); Kiemel et al. (2021); Koj et al. (2017); Lundberg (2019); NEDO (2008); Smolinka et al. (2018); US Department of Energy (2014; 2015).

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External Water Cost: Energy Sources

Electrolysis Energy Costs		
Energy Source	**Estimated Water Costs (L H_2O / kg H_2)**	**Reference**
Gas (CCGS)	17-18	Newborough&Cooley, 2021
Nuclear	51 - 127	Newborough&Cooley, 2021 Makhijani&Hersbach, 2024
Petroleum-based Fuels	2.7 - 11.7	Newborough&Cooley, 2021
Biofuels (ethanol)	1800	Newborough&Cooley, 2021
Biofuels (biodiesel)	12,600	Newborough&Cooley, 2021
Coal	50	Olaitan *et al*, 2024
Solar	3.7 - 20	Makhijani&Hersbach, 2024
Wind	0-0.2	Makhijani&Hersbach, 2024
Steam Methane Reformation (SMR)	22	Olaitan *et al*, 2024
Biomass (Wood chips)	7450	Olaitan *et al*, 2024

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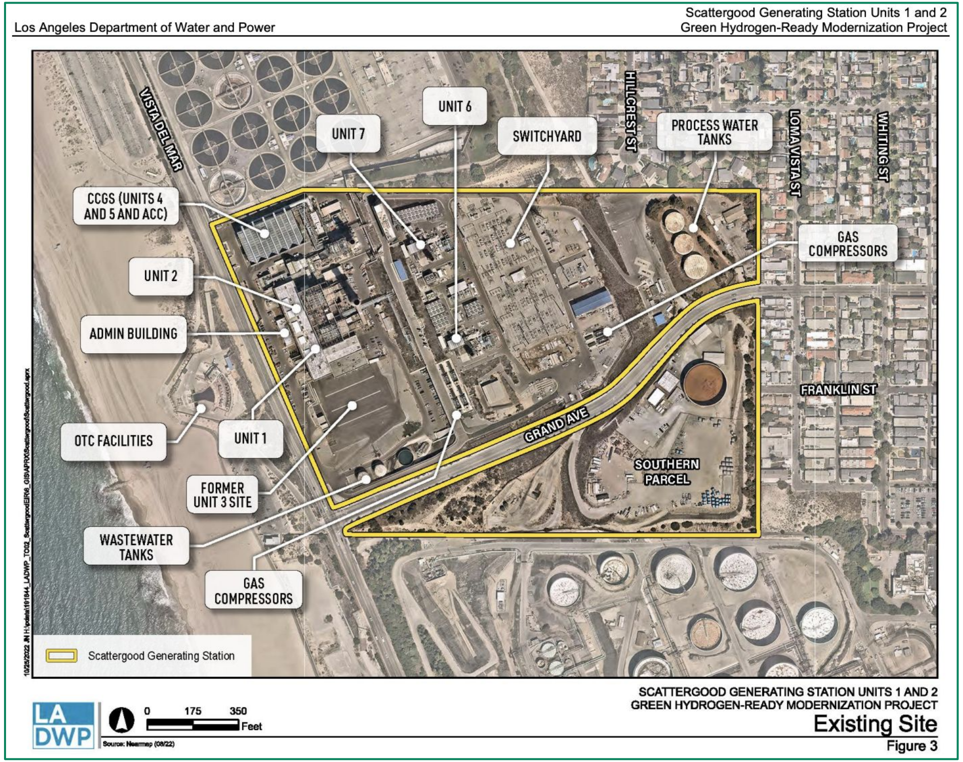
Using H_2: LADWP's Scattergood



Los Angeles Times

CALIFORNIA

L.A.'s ambitious goal: Recycle all of the city's sewage into drinkable water

Los Angeles officials have set a 2035 goal of recycling all the treated wastewater produced by the Hyperion Water Reclamation Plant, which processes most of the city's sewage. (Christina House / For the Times)

By Bettina Boxall

Feb. 22, 2019 9:30 AM PT

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So knowing this, where you going to get the water from? :D

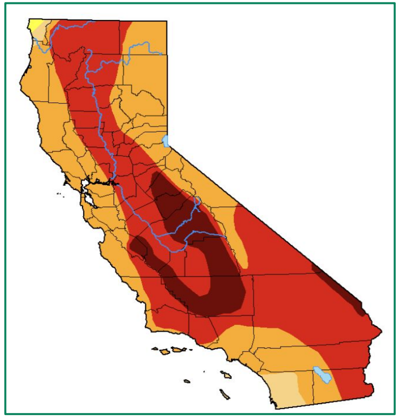
Because…

California is both prone and vulnerable to drought

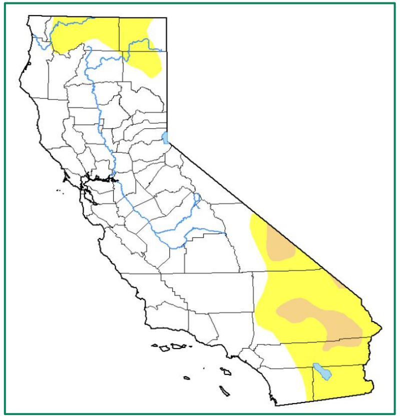
"Droughts are projected to increase in intensity, duration, and frequency, especially in the Southwest….Human and natural systems are threatened by rapid shifts between wet and dry periods that make water resources difficult to predict and manage"

-Fifth National Climate Assessment, 2023

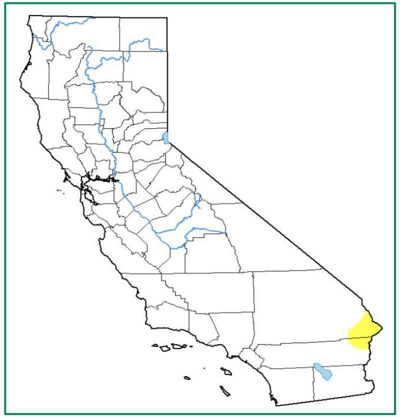
June 21st, 2022



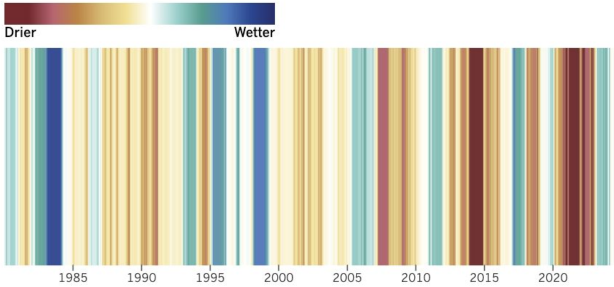
June 20th, 2023



June 20th, 2024



California's drought stripes



Stripes are colored based on the "one-year standardized precipitation evapotranspiration index," or the one-year standard deviation of water balance from the average. Each stripe represents five days. Data as of June 3.

Katherine Hegewisch and John Abatzoglou, Historical Drought Stripes, Climate Toolbox

(Top) https://droughtmonitor.unl.edu/

(Left) https://www.latimes.com/projects/california-drought-status-maps-water-usage/

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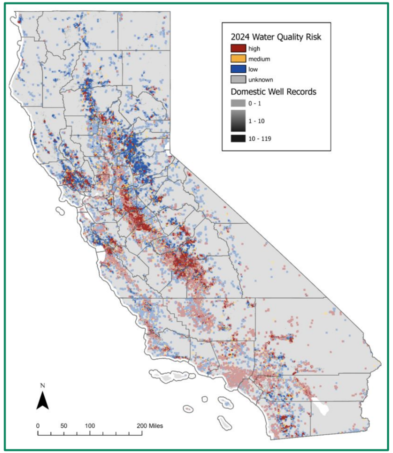
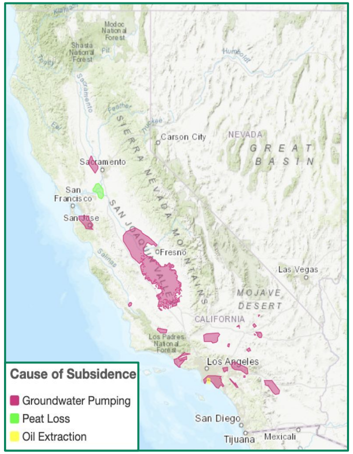
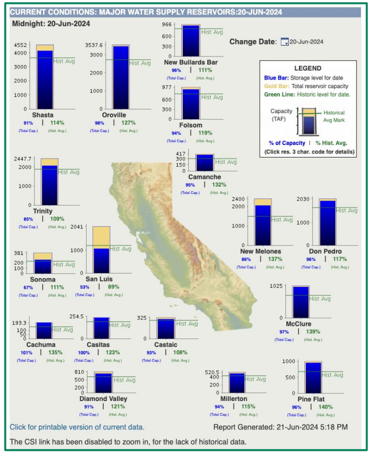
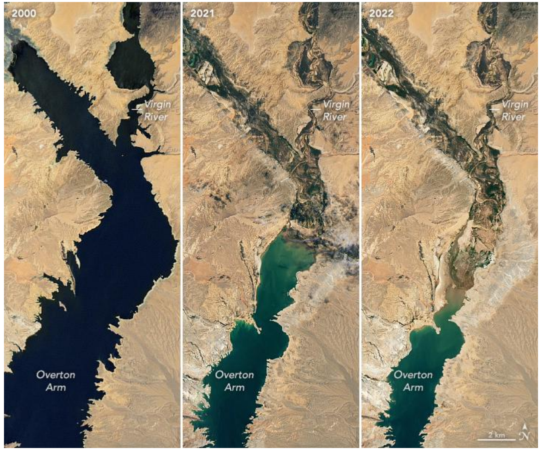
California's Water Resources Vulnerable





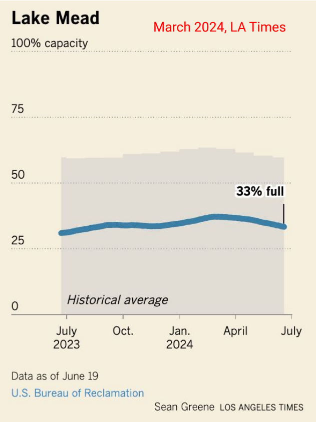


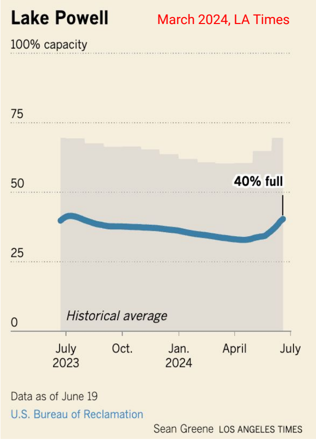


L.A.'s water supplies are in good shape. But is the city ready for the next drought?

"While our reservoirs are full following two wet winters, we are still seeing the impacts of climate whiplash across the state," read a statement from Martin Adams, the DWP's general manager and chief engineer. "We know we have to stay focused on our investments in local water supply projects as LADWP continues to evolve and balance the needs of our customers with the challenges associated with extreme weather patterns. More than anything else, we encourage our customers to stay vigilant in their water-wise practices, which have helped keep water conservation citywide near record highs."

November 2023, LA Times





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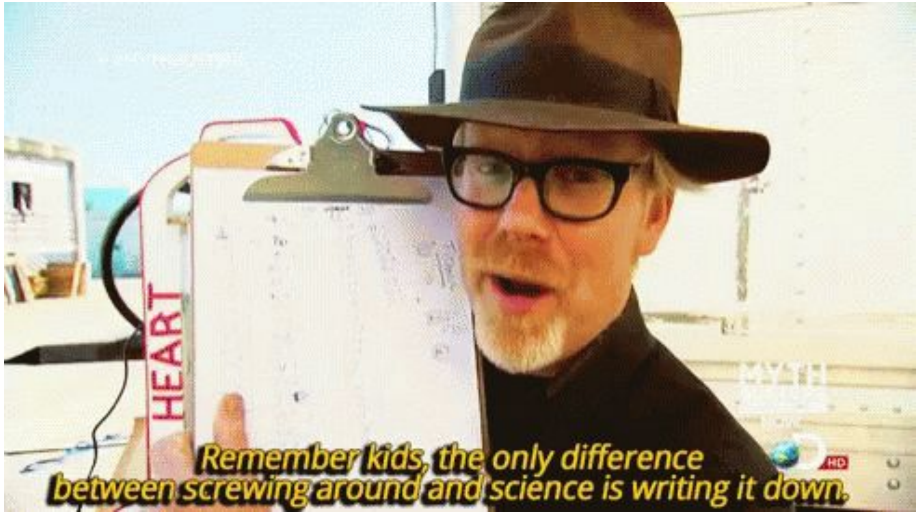

Questions?

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Summary

1. The challenge with calculating the true water costs of H_2 production and use is the lack of transparency and data.
2. Literature on these topics do not use consistent factors (e.g. using energy units when talking about water; kwh/ kgH2)
3. Water consumption estimated will be influenced by the water quality of the feedstock, the water source, electrolyzers used and energy source.

1. Lampert *et al*, 2015. https://publications.anl.gov/anlpubs/2015/10/121551.pdf
2. H2NEW, 2024. https://h2new.energy.gov/#:~:text=Hydrogen%20from%20Next%2Dgeneration%20Electrolyzers%20of%20Water%20(H2NEW)%20is,durable%2C%20efficient%2C%20and%20affordable.
3. Arcos&Santos, 2023. https://www.mdpi.com/2673-5628/3/1/2#
4. Feng *et al*, 2017 https://www.sciencedirect.com/science/article/pii/S0378775317311631?via%3Dihub
5. Zuo et al, 2022. https://www.nature.com/articles/s41467-023-40319-5#MOESM1
6. Newborough&Cooley, 2021. https://itm-power-assets.s3.eu-west-2.amazonaws.com/Green_Hydrogen_Water_Use_56b96f577d.pdf
7. Min et al, 2022. https://www.sciencedirect.com/science/article/pii/S0306261922014027#da1
8. Miller *et al*, 2020 https://pubs.rsc.org/en/content/articlelanding/2020/se/c9se01240k
9. Ng *et al*, 2023. https://www.mdpi.com/2297-8739/10/8/424#
10. Noor Azam *et al*, 2023. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10006946/
11. Saulnier *et al*, 2020. https://watersmartsolutions.ca/wp-content/uploads/2020/12/Water-for-the-Hydrogen-Economy_WaterSMART-Whitepaper_November-2020.pdf
12. Mahhijani&Hersbach, 2024. https://justsolutionscollective.org/wp-content/uploads/2024/01/IEER-Water-Report-r2.pdf
13. Olaitan *et al*, 2024. https://www.sciencedirect.com/science/article/pii/S0048969724025300?via%3Dihub
14. USGS 2024. https://ca.water.usgs.gov/land_subsidence/california-subsidence-areas.html
15. LA Times, 2024 https://www.latimes.com/environment/story/2024-03-06/risks-ease-for-colorado-river-reservoirs-after-wet-winter

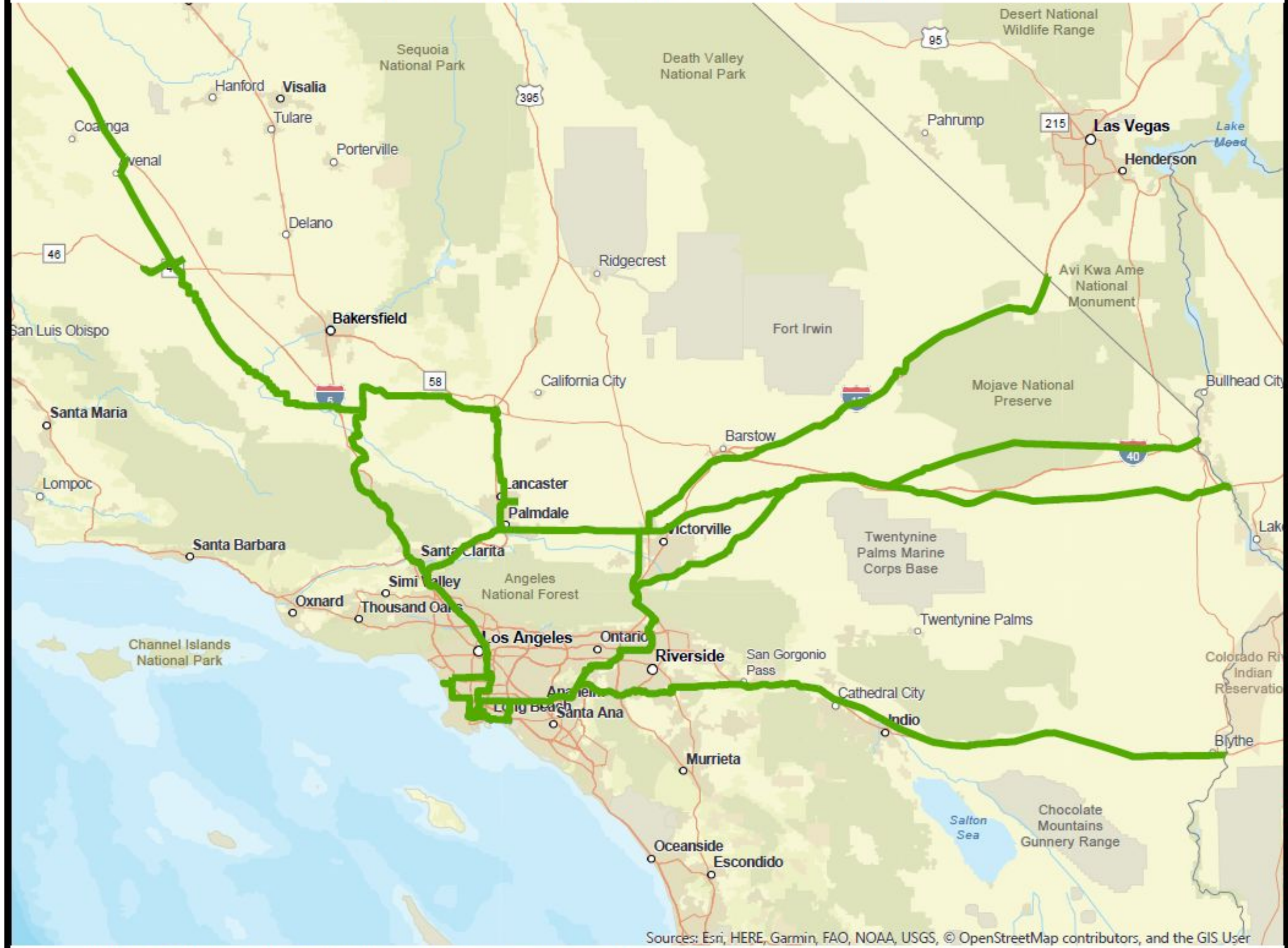
Case Studies of Hydrogen Projects: Angeles Link, Scattergood, Orange Cove

Jay Parepally

Potential (Very Preliminary) Routes of Angeles Link

- Generally tracks I-5 in the Central Valley through the Grapevine into the San Fernando Valley, downtown LA, Southeast LA
  - Possible links to Lancaster and Palmdale
- From Nevada state line along the I-15 corridor near Barstow and Victorville before passing through the Inland Empire (between Ontario and Riverside) into eastern Orange County and south LA County
- From Blythe through the Coachella Valley through San Bernardino County and points to the west
- Within LA area: prongs reach as far west as the coast

Conceptual Pipeline Corridors Under Evaluation*



Map Name:
Map Type:
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*These renderings show conceptual corridors (or initial concepts) for the Angeles Link project. Potential Angeles Link routes are still to be determined and analyzed for feasibility including hydraulics, engineering, etc. During Phase Two, corridors will be further evaluated to produce refined proposals.

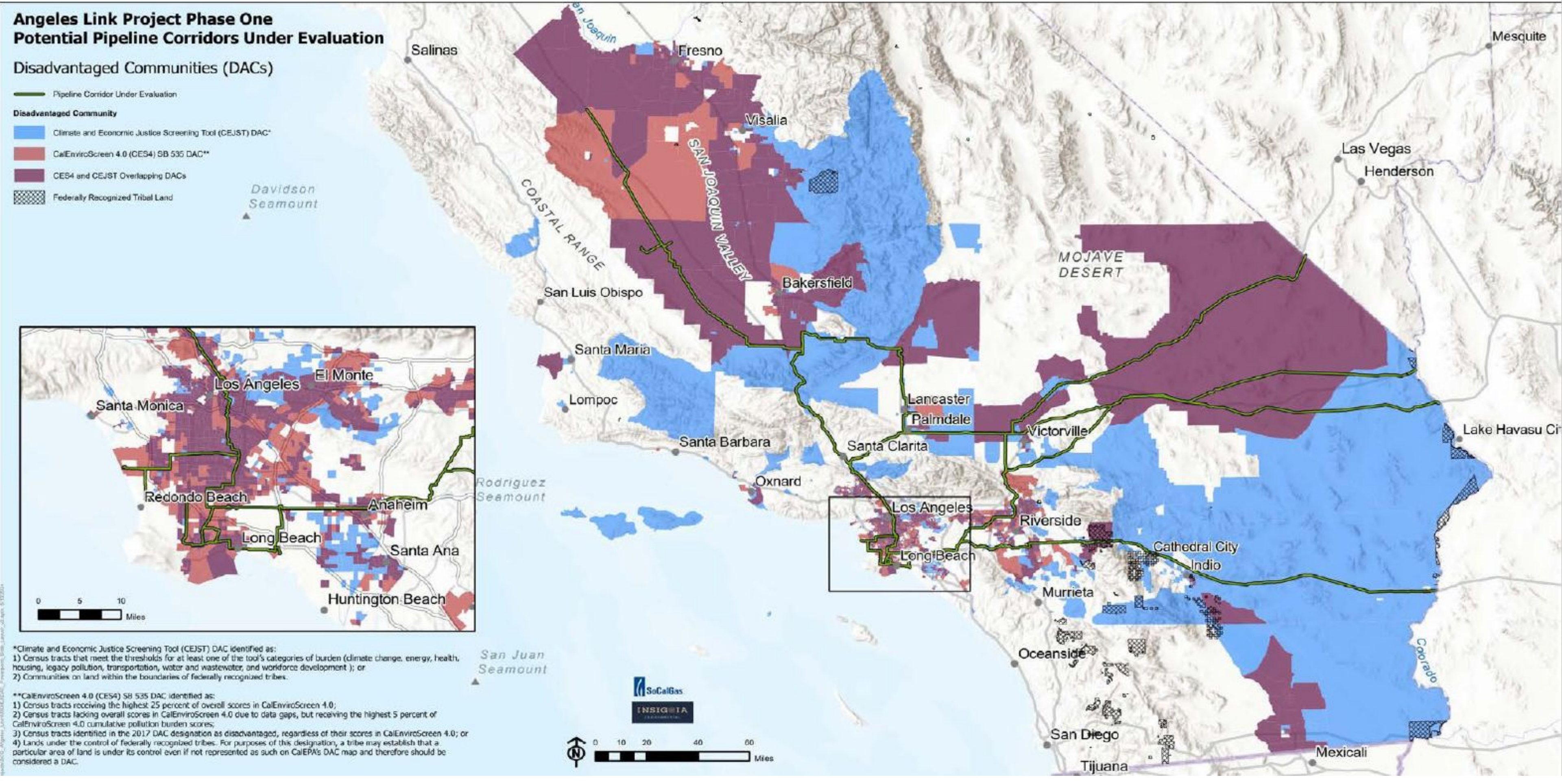
Angeles Link: Preliminary GHG Emissions Potential

- SCG projects between 17 and 36 million metric tons of CO2e per year will be removed by end users by 2045
  - Source: GHG Emissions Preliminary Data and Findings (Feb. 2024)
- In general, we have criticized SCG for making assumptions that overstate demand from hydrogen and underestimate GHG emissions from Angeles Link
  - Although AL does not produce hydrogen (third party production, storage, and end use), most of the common ways to produce hydrogen do result in heightened GHG emissions
- GHG study excluded the known climate impacts of hydrogen leakage in AL emissions estimates

Early Evaluation of EJ Community Impacts

- SCG recently released preliminary EJ maps with CalEnviroScreen data of Disadvantaged Communities (DACs) in Central and Southern California
- For 4 of the preferred pipeline route options, DAC mileage ranges from 54% to 67% of total mileage
  - "Hydrogen production and demand centers are concentrated in DACs. Most of the preferred pipeline routes in the San Joaquin Valley and the Los Angeles Basin that would connect them are also designated as DACs or ESJ communities."
- Yet, these early reports are light on meaningful data and heavy on SCG marketing: "Angeles Link has the potential to reduce greenhouse gas emissions, improve air quality, create union jobs, grow small and diverse businesses, and generate millions of dollars in community benefits."
  - Source: Environmental & Environmental Social Justice Analysis - Preliminary Data and Findings

ALL POTENTIAL PIPELINE ROUTE OPTIONS COMBINED WITH DACs



LADWP Scattergood: Hydrogen Blending for Power Generation

- Transition from natural gas-fired boilers to generation system that burns a mixture of natural gas and a minimum of 30 percent hydrogen
- By law, Scattergood (a once-through cooling plant) was scheduled to close; but this proposal could extend its life until or beyond 2035
- EJ concerns
  - NOx emissions
  - GHG emissions of continuing life of Scattergood generating facility (continued combustion of natural gas/methane)
  - Indirect GHG effects of hydrogen (including from leakage)
  - Cumulative impacts of continued fossil fuel reliance

PUC Related H2 Blending Demonstration + EJ Impact: Orange Cove

- Hydrogen blending: gradual increase from 0.1% up to 5% in existing natural gas distribution system
- Community of fewer than 10,000 residents
- City manager reached out to SoCalGas when UC Irvine blending proposal faced opposition and was largely scrapped
- Community engagement and literacy about the project is low
    - Source: Fast Company (June 2024)

Equity Principles for Hydrogen: Production

1. We oppose all hydrogen production that is not green hydrogen production, and we agree that green hydrogen is produced by means of electrolysis using surplus water and additional renewable electricity.
2. We agree that green hydrogen production projects should consider the impacts of electrolysis and be tightly regulated.
3. We agree that hydrogen production projects must center Tribal consultation and consent for projects considered on or near ceded and unceded Tribal territories.
4. We agree that hydrogen production projects should center community consent and engagement.

Equity Principles for Hydrogen: Production (contd.)

5. We oppose hydrogen production that includes dirty hydrogen production methods

6. We agree that hydrogen production projects should result in net-reduction of energy pollution.

7. We agree that hydrogen production projects should only be considered if they are limited in scale and scope.

Equity Principles for Hydrogen: Storage & Delivery

1. We agree that any hydrogen pipelines and storage infrastructure project should be equipped with safety and leak detection technologies and strictly monitored.
2. We agree that any hydrogen delivery project should minimize risk by limiting size and scope and by focusing on environmental impact from development through operations and decommissioning.
3. We agree that existing methane infrastructure is not equipped to deliver hydrogen safely.
4. We agree that data gaps should be addressed before hydrogen delivery projects are permitted.
5. We agree that community impacts should determine where hydrogen pipelines are placed.
6. We agree that the cost of infrastructure to deliver hydrogen should be clear and transparent to ratepayers and consumers.

Equity Principles for Hydrogen: End Uses

1. We agree to principles of supporting electrification, minimizing harm, and centering community voice and environmental impacts in our consideration of any end-uses that could use green hydrogen as a resource or feedstock.
2. We prioritize equitable direct electrification with renewable energy, and we agree that green hydrogen should only be used when that is not an option.
3. We agree that additional research is needed regarding the use of green hydrogen in maritime transport, port infrastructure, long-haul trucking, aviation, fertilizer production, and hard-to-electrify industrial manufacturing.