ITS-Davis Hydrogen Study: Modeling a complete H_2 System for California

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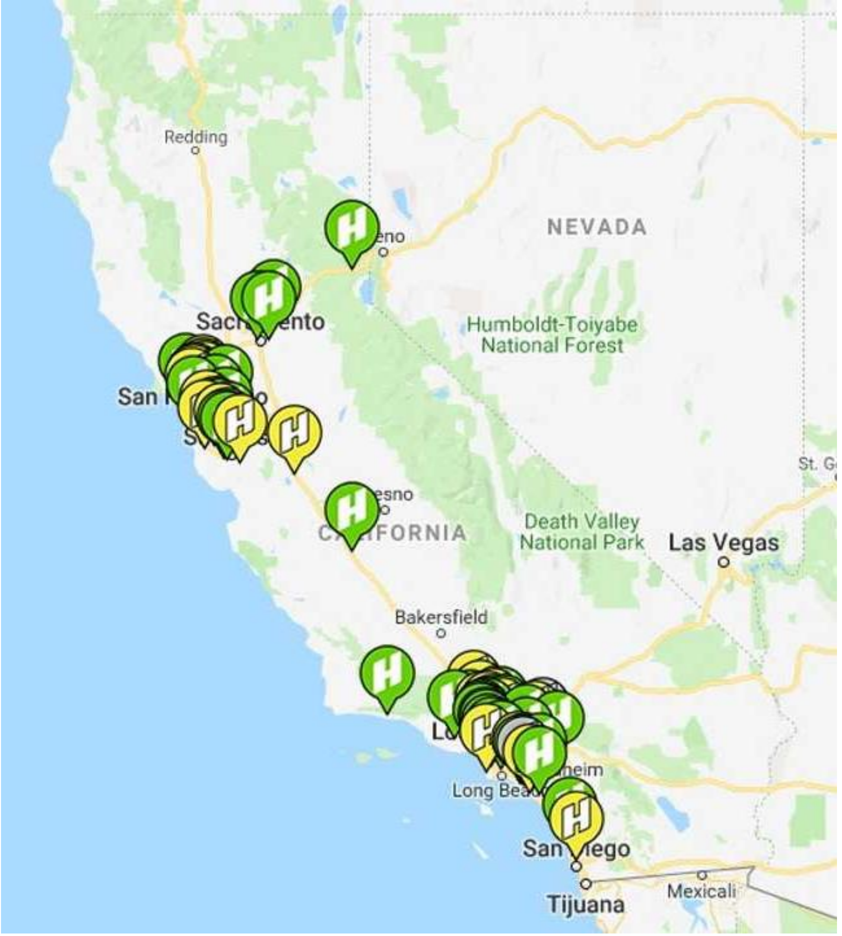
ITS-Davis Hydrogen Study

- Two-year study nearing end of year 1
- Separate sponsorship but has some STEPS co-funding
- Investigate and model the development of a large-scale hydrogen system for California, using linked models for transportation, electricity production/distribution, and hydrogen production/distribution
- Presenting some initial findings today, first report out during Q1 of 2022, and work will continue through the year.

California and Hydrogen

- In the United States, there are about 46 hydrogen vehicle fueling stations and nearly all are in California.
- Several vehicle manufacturers have begun making light-duty hydrogen fuel cell electric vehicles available in select regions such as Southern and Northern California where there is access to hydrogen fueling stations.
- The state is also home to most of North America's over 8,000 hydrogen-powered fuel cell electric vehicles.
- California's burgeoning hydrogen market has the potential to rapidly replace oil and gas at scale, helping the state to meet its carbon-neutrality goals by mid-century.



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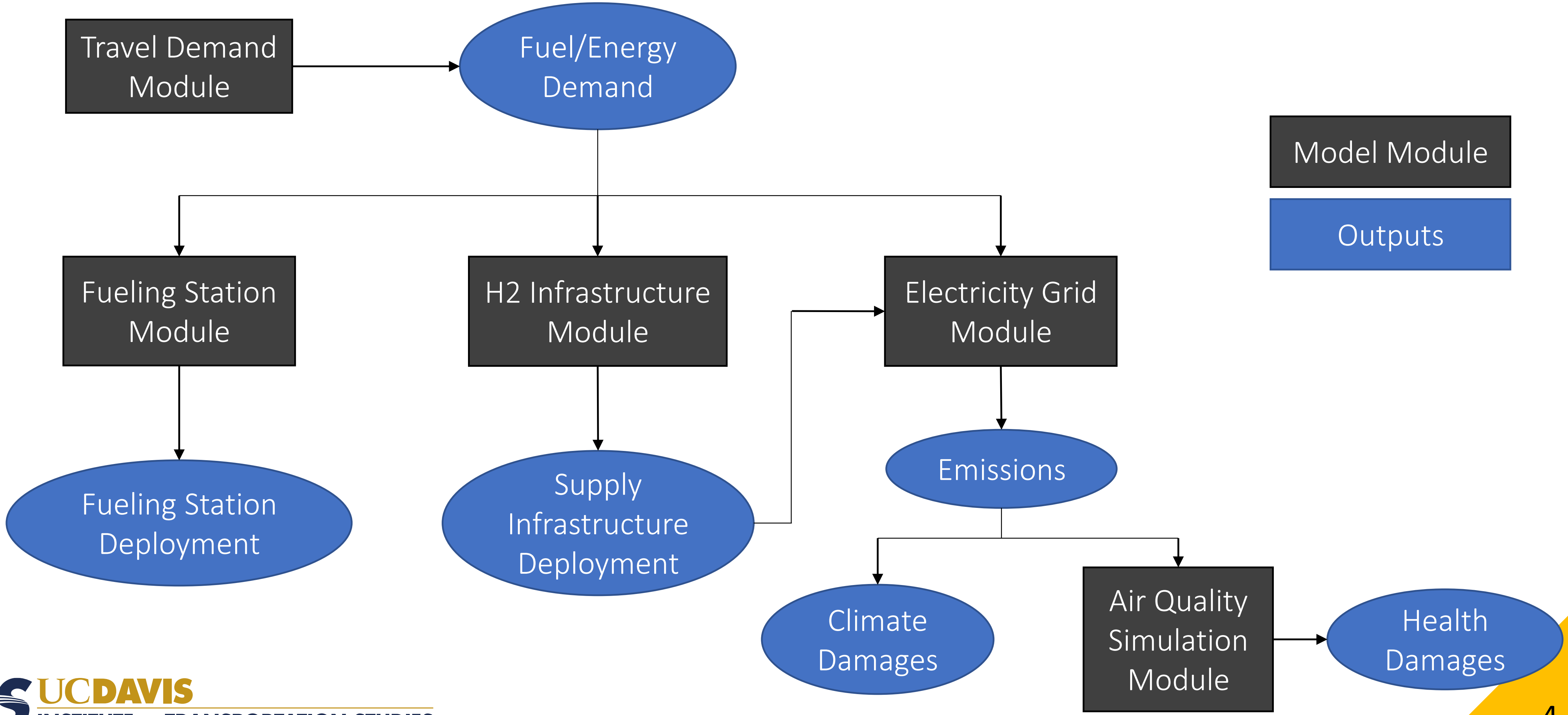
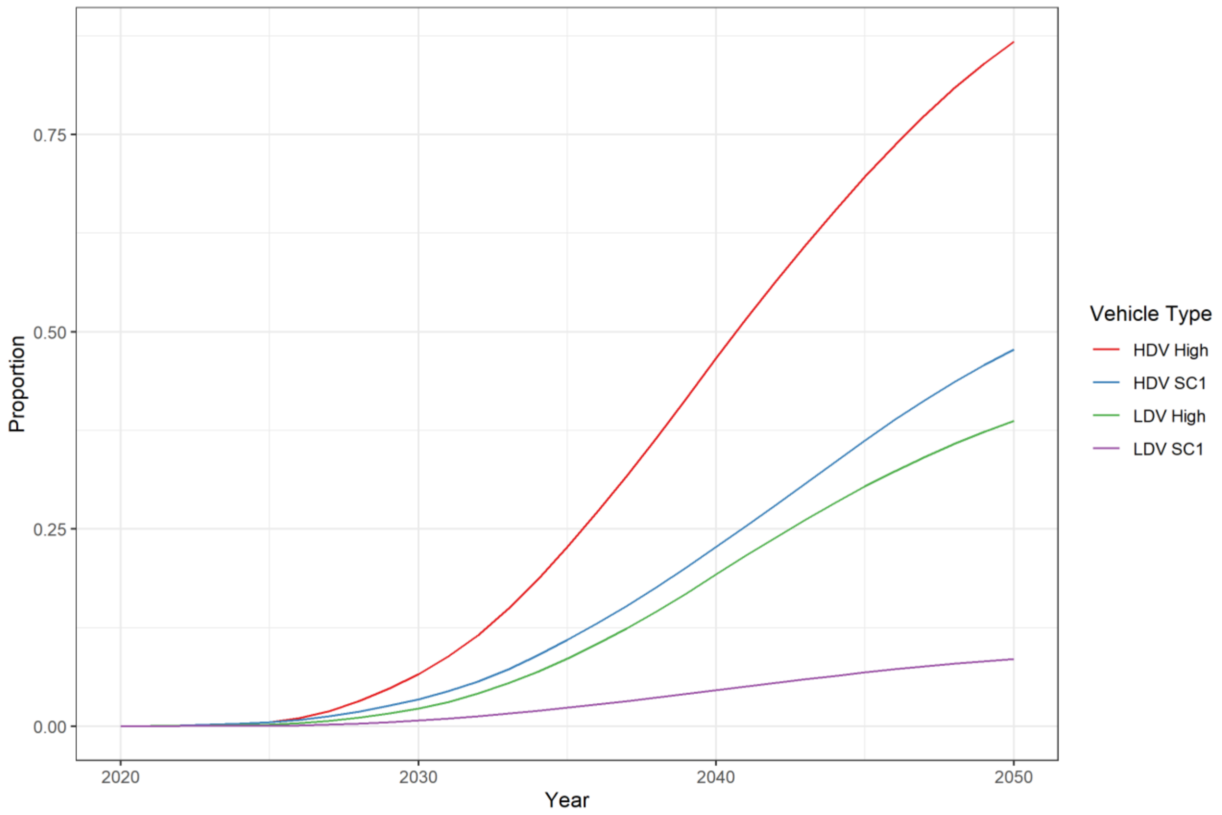
H_2 System Model



H_2 Station Deployment

Two scenarios of H_2 vehicle adoption

- We consider two scenarios for vehicle adoption (SC1 [low] and high cases) derived from the Technology Transition Model (TTM)
- These values are used as input proportions for sampling daily trips specified by CSTDM
- By 2050:
  - Low: LDVs ~2.8m, HDVs ~260k
  - High: LDVs ~12.5m, HDVs ~1m



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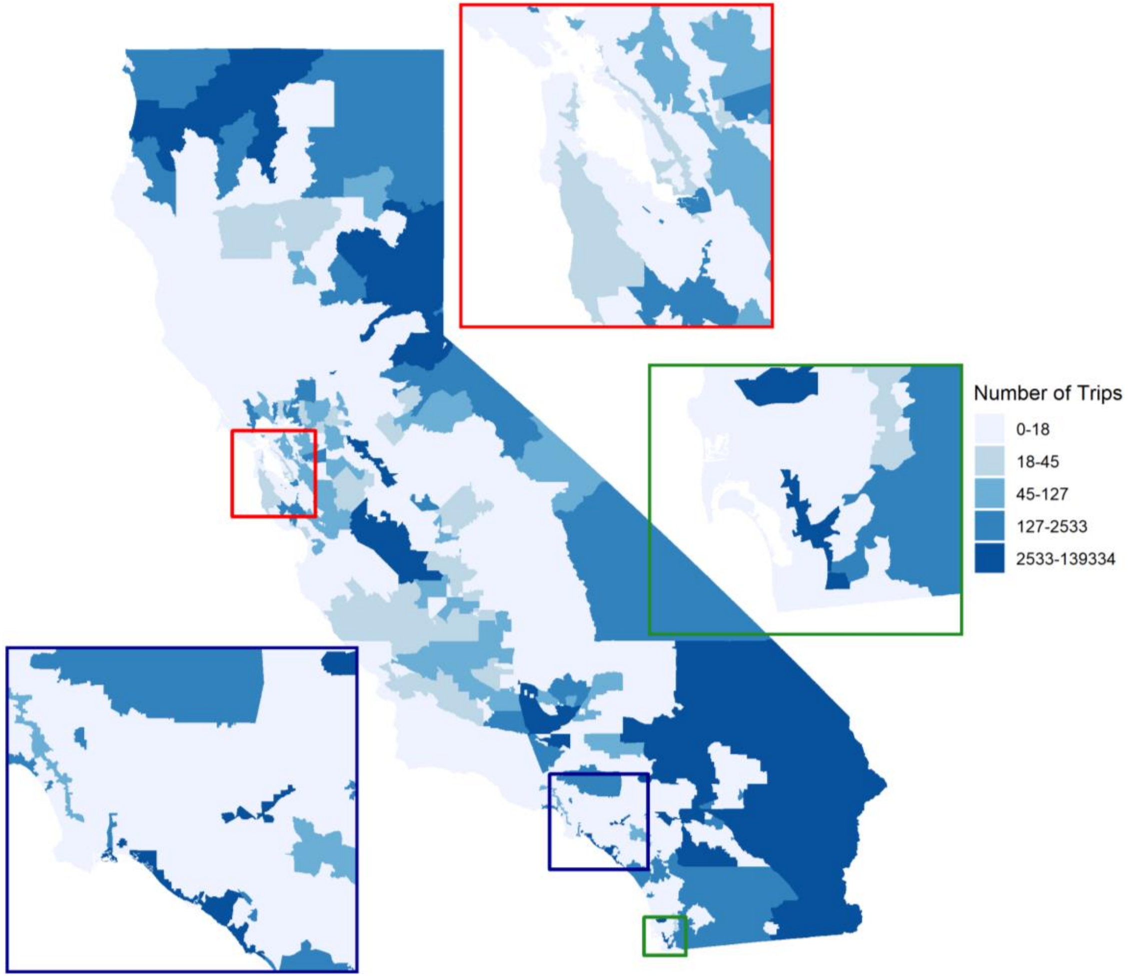
Simulating trip demand

- We randomly sample a proportion of trips from CSTDM based on the percentage of adoption
- Example figure (right) shows simulated number of trips by H_2 vehicles in 2030



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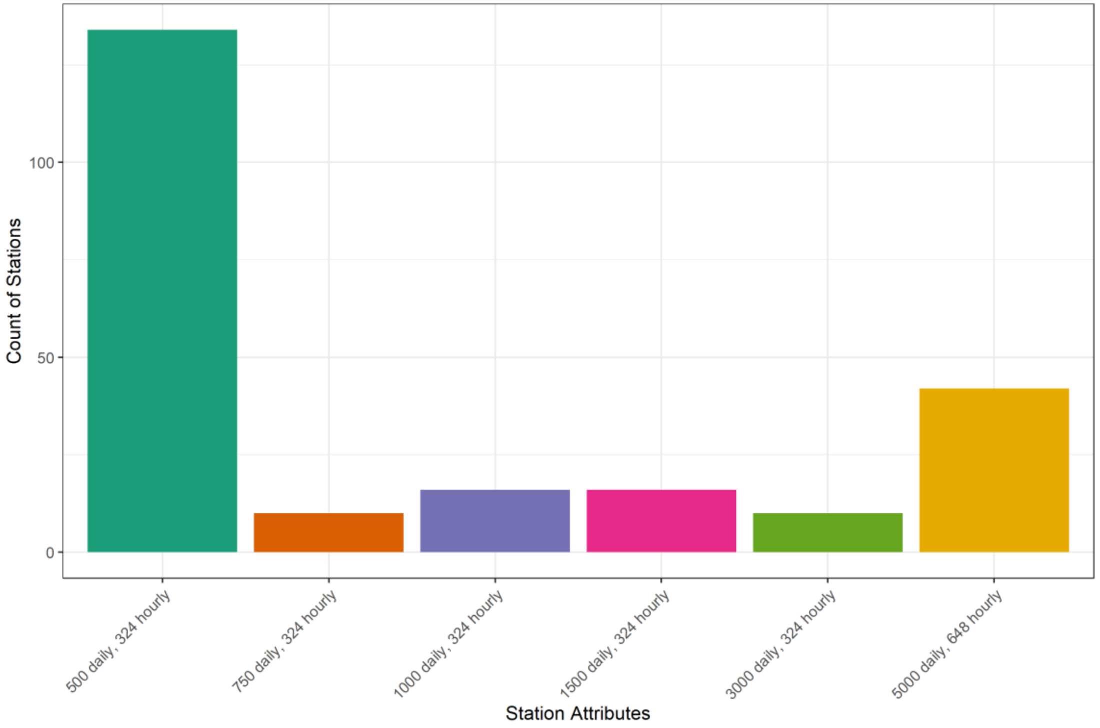
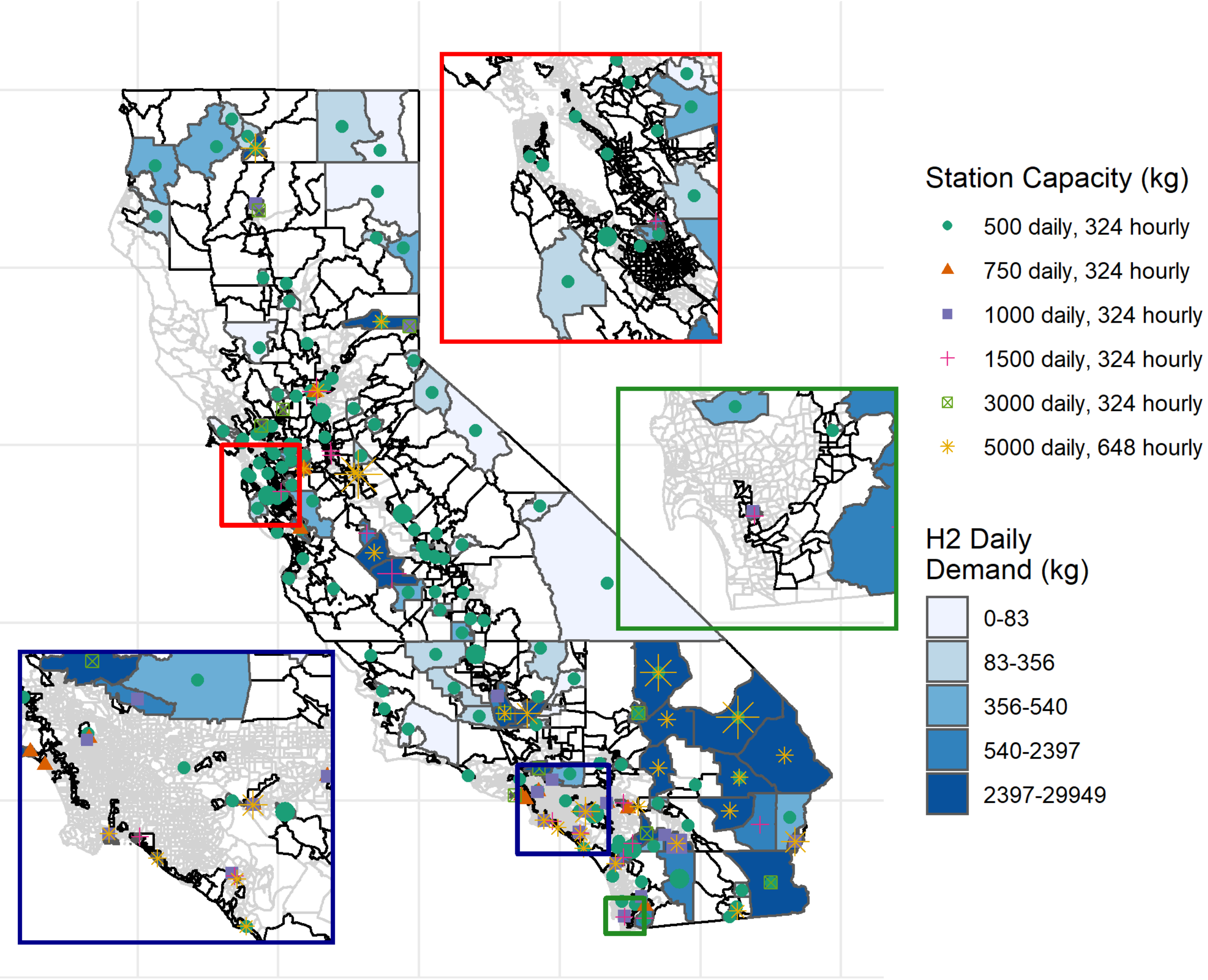
Station deployment in 2030 (SC1 scenario)

- Most stations are relatively smaller in size with 150 500kg per day stations
- Several 5 ton per day stations strategically placed throughout the California





Electricity Grid Impacts

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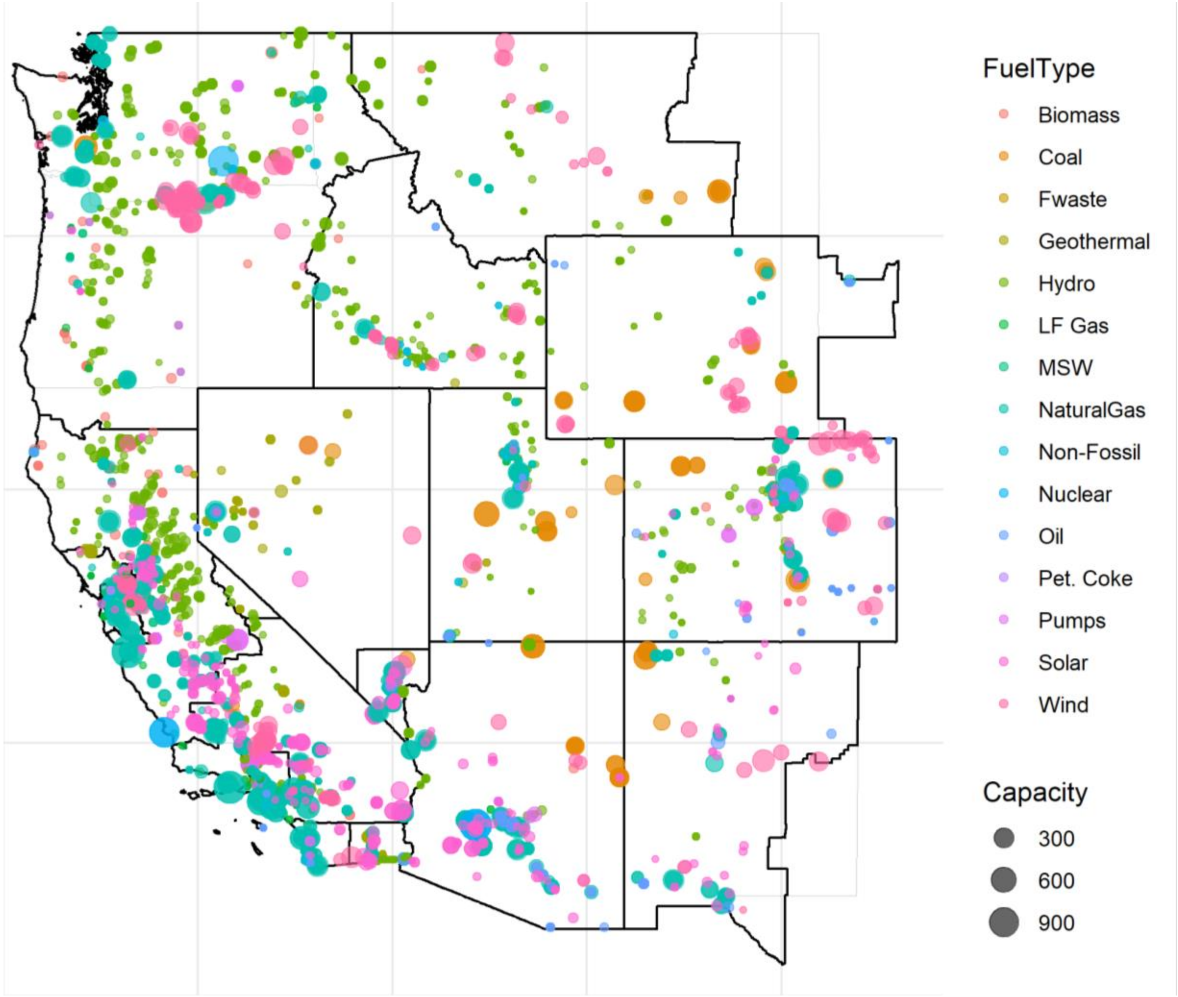
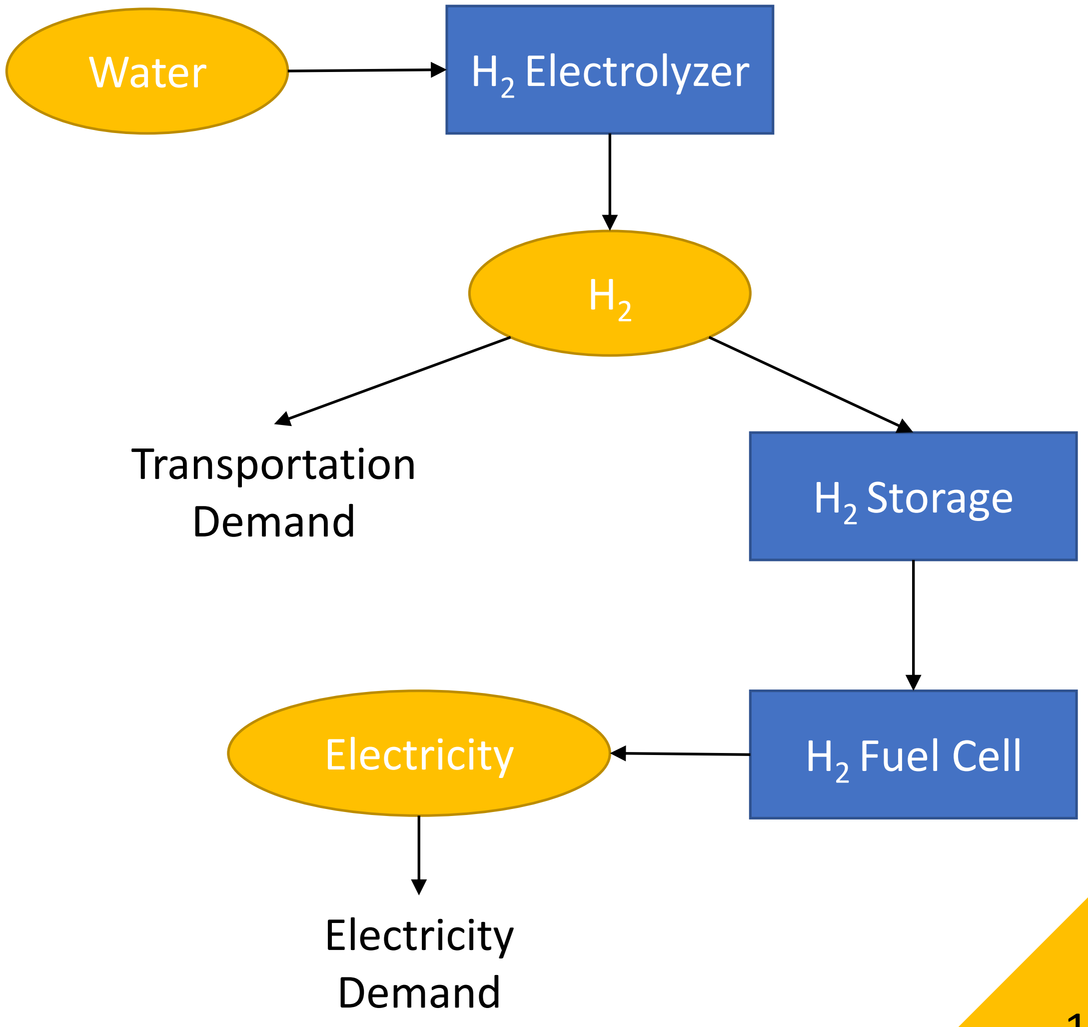
CA GOOD model scope

- CA GOOD covers the Western Interconnect (WECC)
- Simulates the operation of each generator in the region from 2020 to 2050 in 5-year increments
- Each model year run consists of 8760 hours in each year



Hydrogen storage in GOOD

- Hydrogen must be used to meet transport demand but can also be re-converted back to electricity
- Storage can assist in integration with renewables (decrease curtailment, decreasing overall capacity needed to meet RPS)



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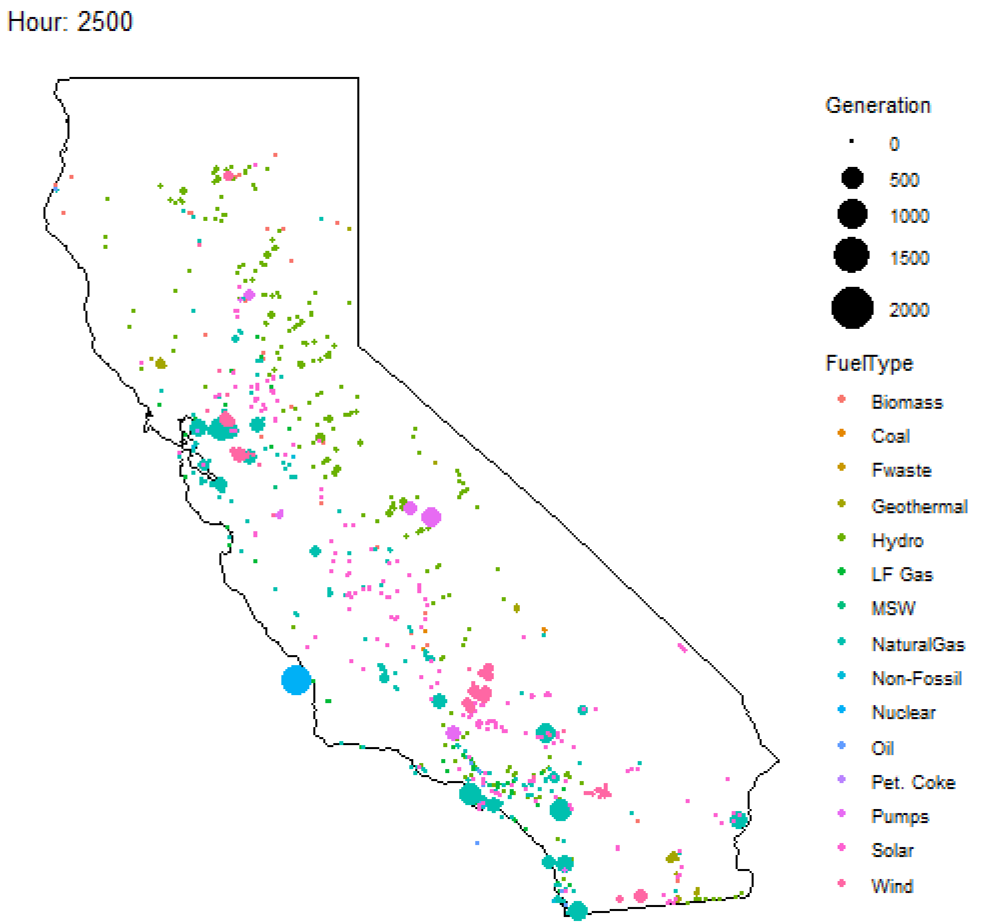
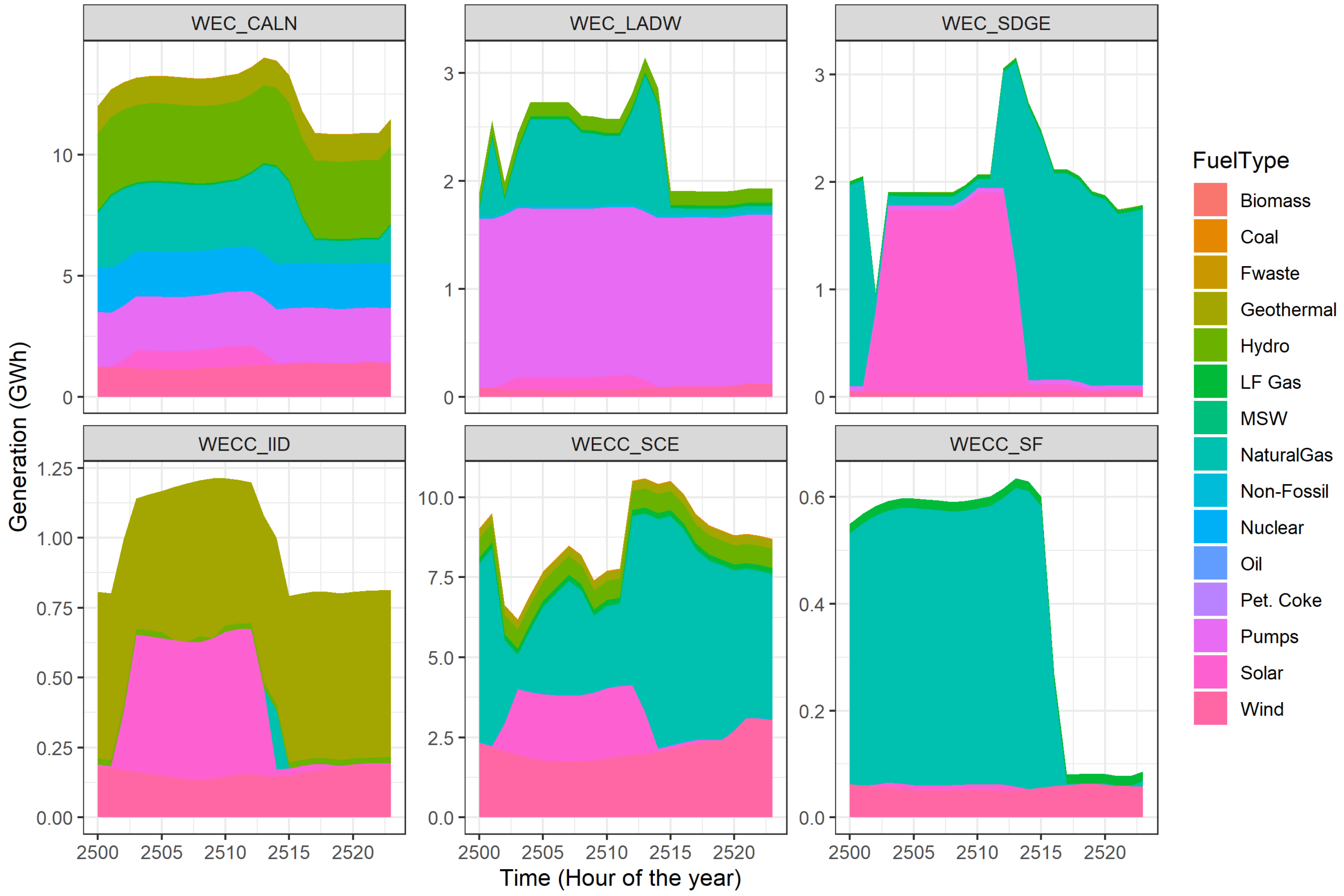
Simulating operation of power plants

- The figure shows how individual power plants respond to electricity demand over a period of time
- Large changes in generation is visible for renewable sources due to intermittency and for natural gas which ramp up and down to meet demand



Example dispatch results (1 day)

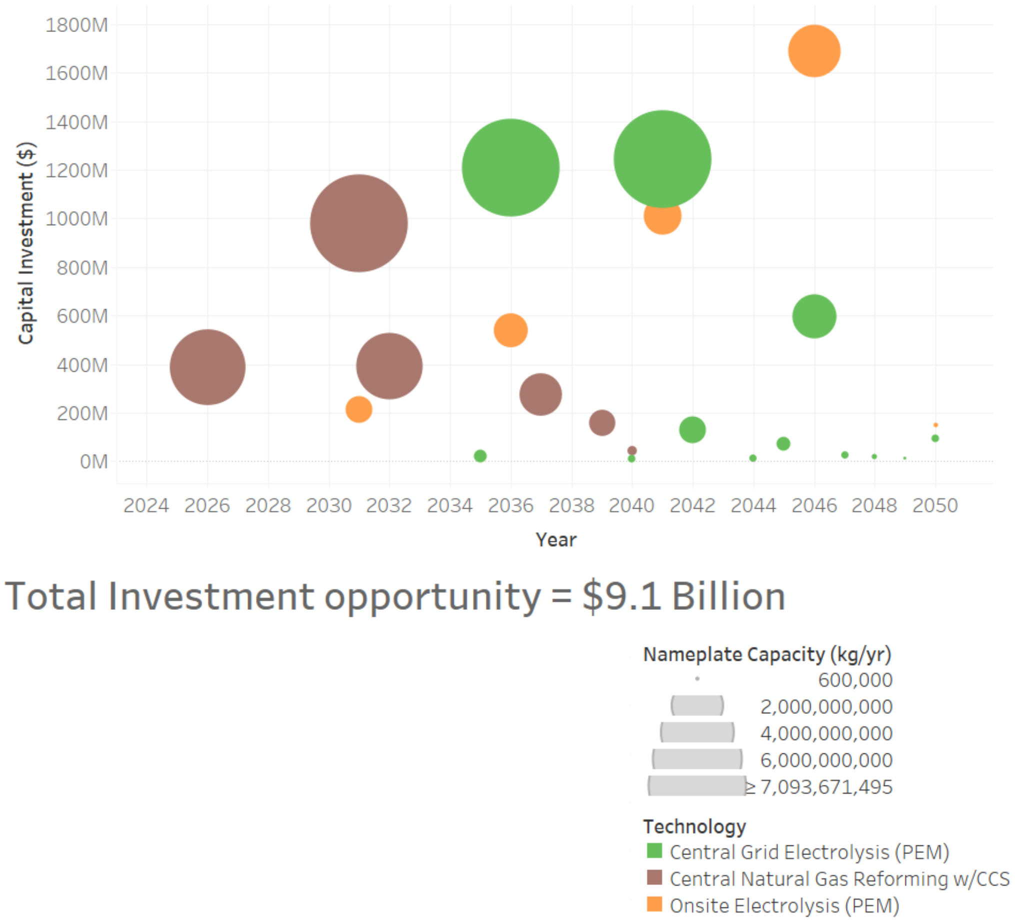
- Daily fluctuation due to cycle of increased demand during the day and decreasing demand at night
- Shape doesn't exactly match load shape due to imports of electricity
- Majority of generation from natural gas and solar (note different axes)



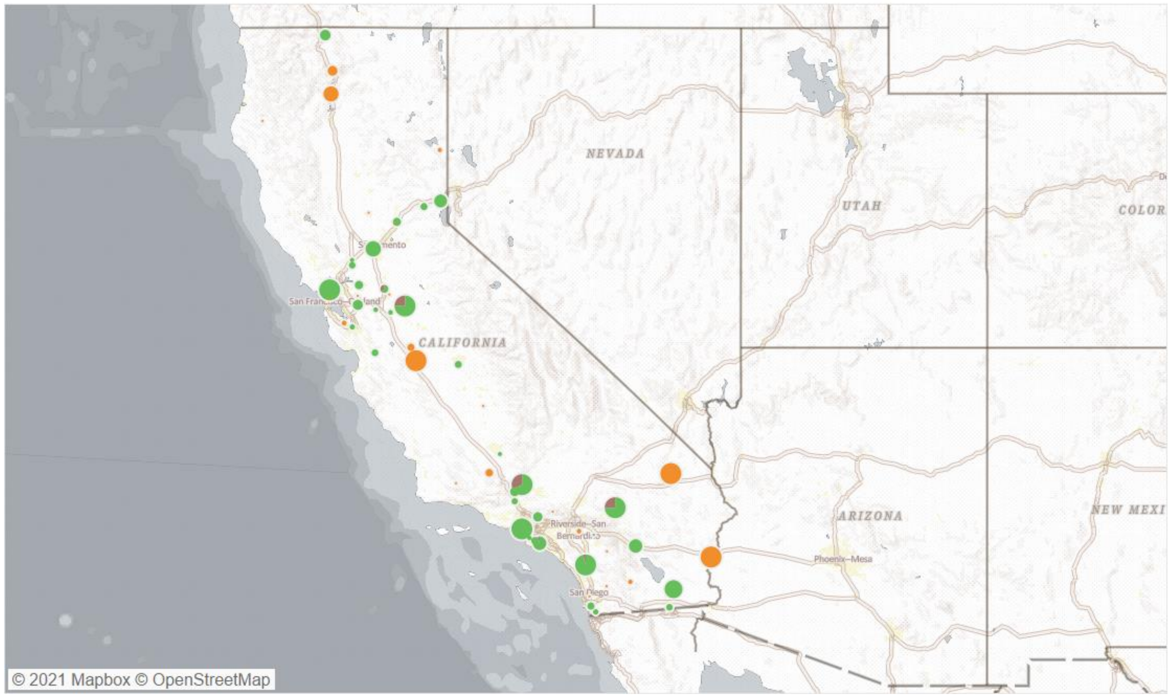
Hydrogen Supply Infrastructure

How will H_2 be produced?

Not final integrated results



Total Investment opportunity = $9.1 Billion



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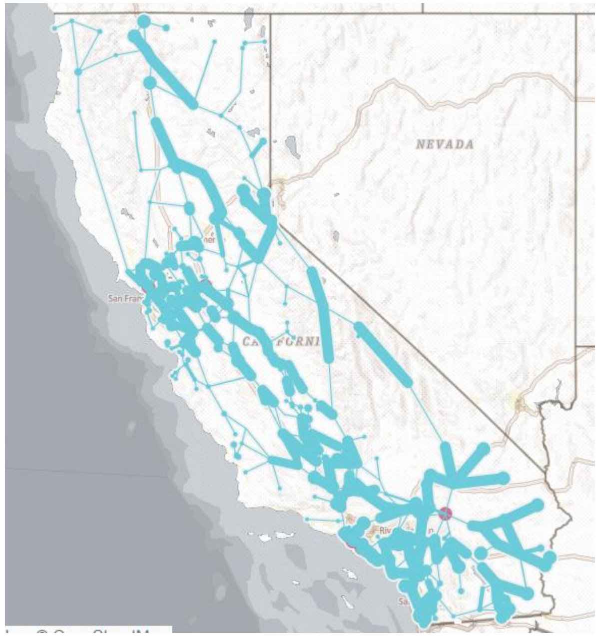
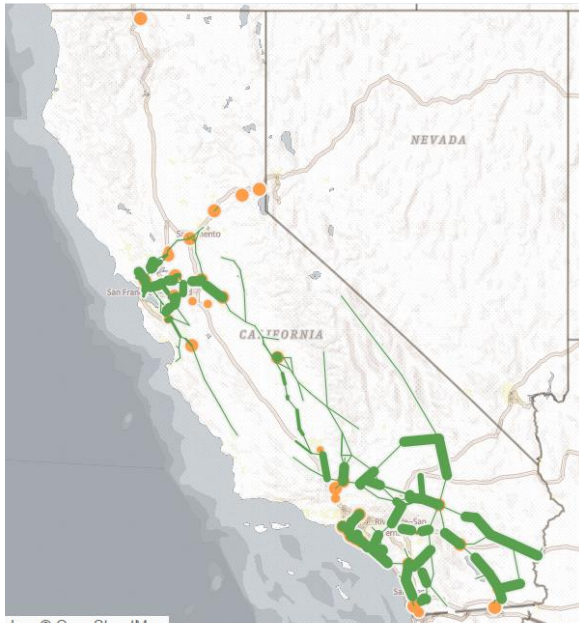
How will H_2 be delivered?

Not final integrated results

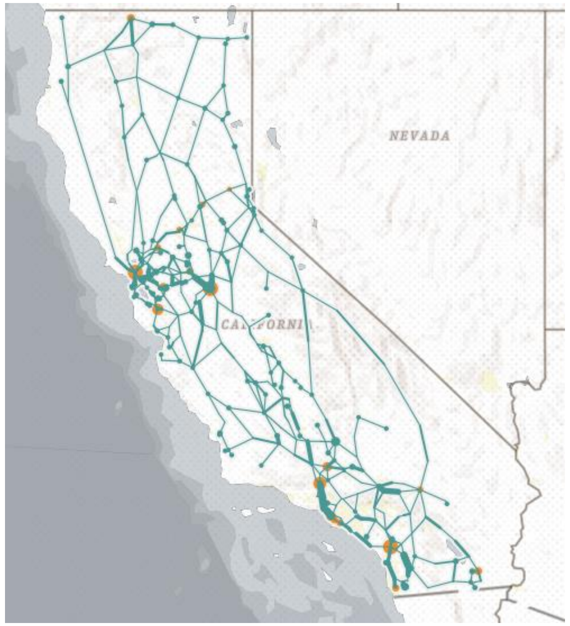
Liquid Tanker Network



Pipeline Network

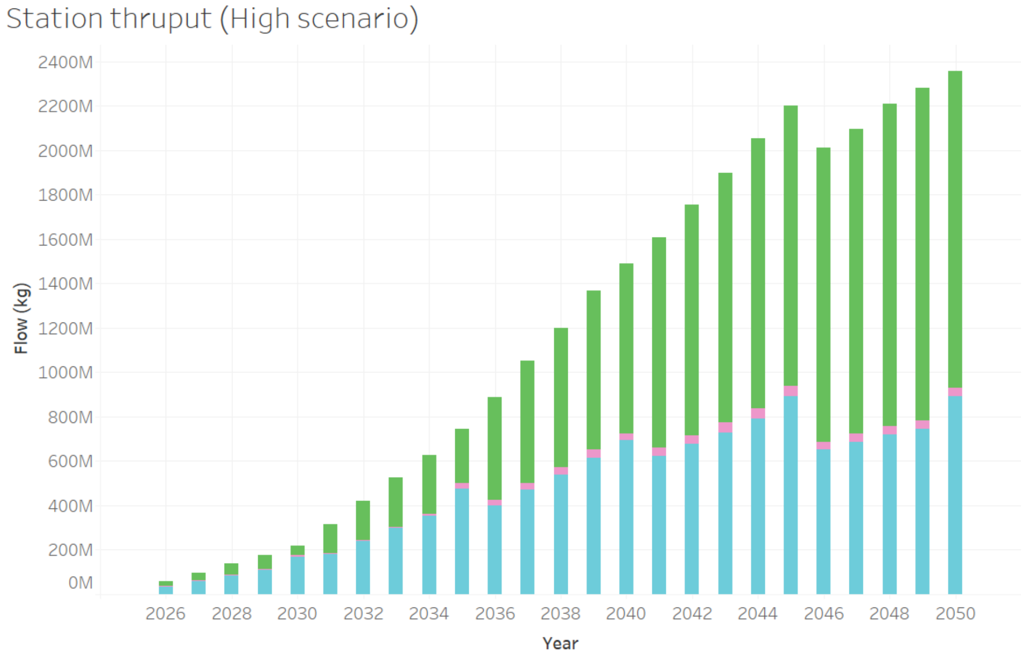


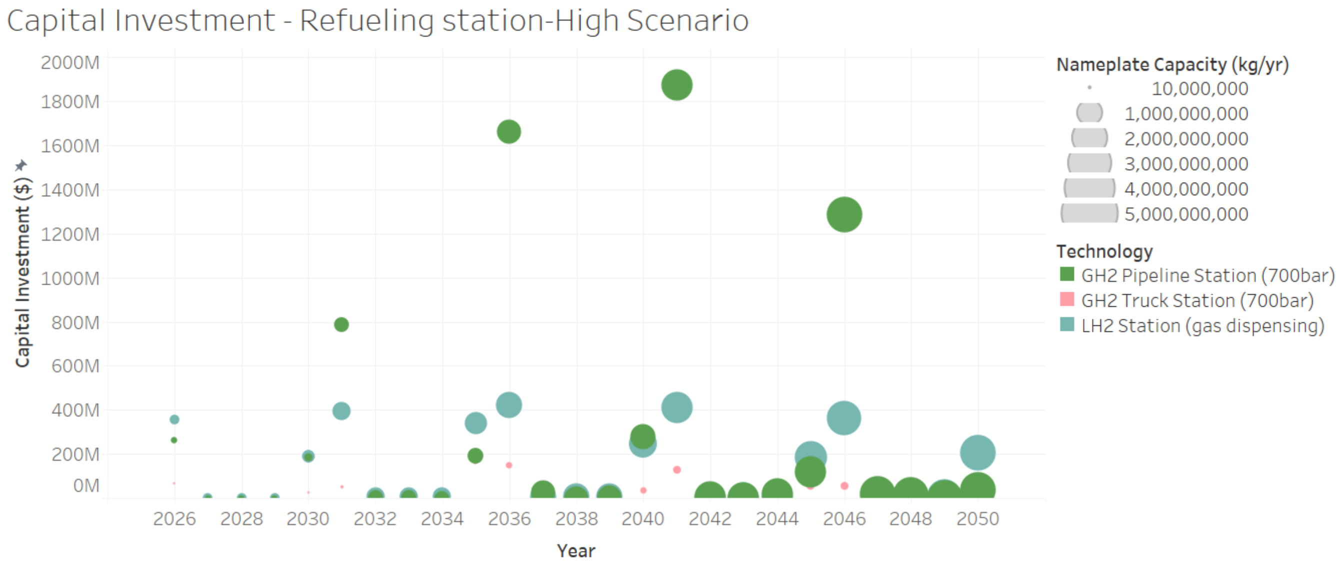
Gas Tube Trailer Network



H_2 Delivery and System Costs

Not final integrated results





Total Investment opportunity = $10.7 Billion

Big picture: scenarios and sensitivity cases

- There are many ways that these can be developed, combinations, etc.
- We will explore most/all of the ones listed but will make some decisions on major ones to report. Comments welcome.

Scenarios

- Low vs high H2 demand from transportation (and industry, in various combinations)
- Limits to non-renewable H2 (from within/outside the state, even if CCS)
- Availability of large-scale hydrogen storage (coupled with cost of pipelines, vs electricity transmission into CA and H2 production much closer to end-use)
- Heavy early build out of key H2 supply/transmission/storage infrastructure with supported investments vs more market oriented (do we get stuck from chicken-egg issues)

Sensitivity cases

- SERA model foresight: 1 vs 5 vs 10 years
- Different H2 storage availability and cost assumptions
- Renewable (especially wind) energy production costs
- Percentage of electricity/H2 from within California or outside
- Pipeline types and costs
- Electrolyzer costs, (and vs SMR with CCS)

Timeline of modeling efforts

- 2021 Q4
  - Complete this phase of modeling
    - SERA modeling—final runs with “legacy” SERA
    - GOOD modeling—Complete scenario exploration
    - Connect and align all modeling results
    - Complete some sensitivity cases/scenarios
  - Start creating draft report of H_2 modeling integration
- 2022 Q1
  - Emissions modeling for air quality
  - Integration with EVs in system
  - SERA modeling in SERA 2.0
  - Complete first report

Thank you!

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