



Incorporating Resilience into Transportation Planning

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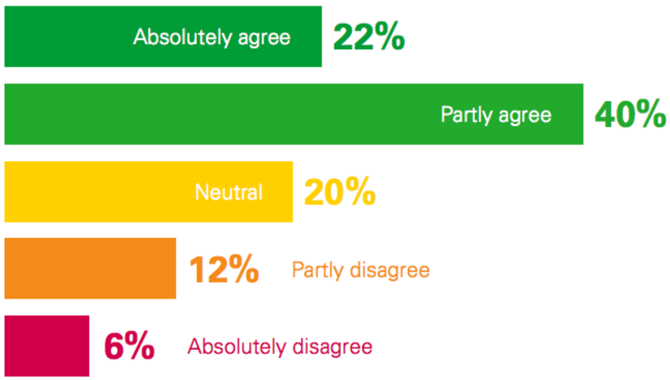
Motivation: 2017 Opinion Survey

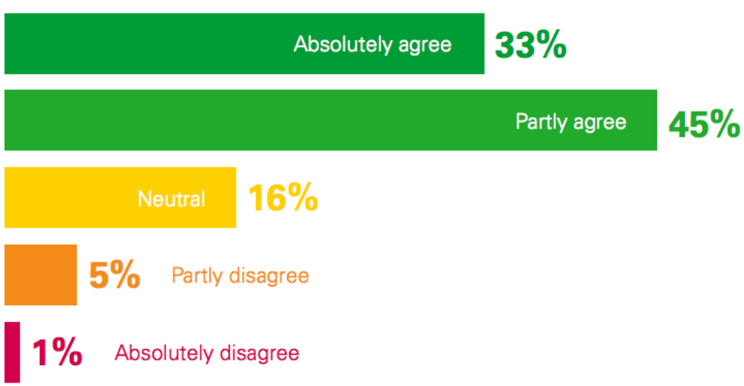
62% of executives absolutely or partly agree that **BEVs** will fail due to infrastructure challenges.

Executive opinion



78% of executives absolutely or partly agree that **FCEVs** will be the real breakthrough for electric mobility.

Executive opinion



From KPMG's Global Automotive Executive Survey 2017:

"Battery electric vehicles (BEVs) will fail due to infrastructure challenges while fuel cell electric vehicles (FCEVs) are seen are seen as the real breakthrough for electric mobility."

There is a need for tools to inform robust, resilient investment and policy decisions for transportation infrastructure

RESILIENCE

SUSTAINABILITY

RISK

For Priority-Setting	***Of*** Priority-Setting
Evaluating alternatives/investments with consideration given to system resilience <u>Suggested considerations:</u> Sustainability criteria for decision-making • Economic • Environmental • Social Regional needs/impacts	*Evaluating how priorities/preferences change due to future uncertainties* <u>Suggested considerations:</u> Scenarios of emergent conditions • Changes in mindsets/values • Technological advances • Introduction of laws and regulations

Resilience and Sustainability

Environment

Environmental Performance Index

UN Sustainable Development Goals

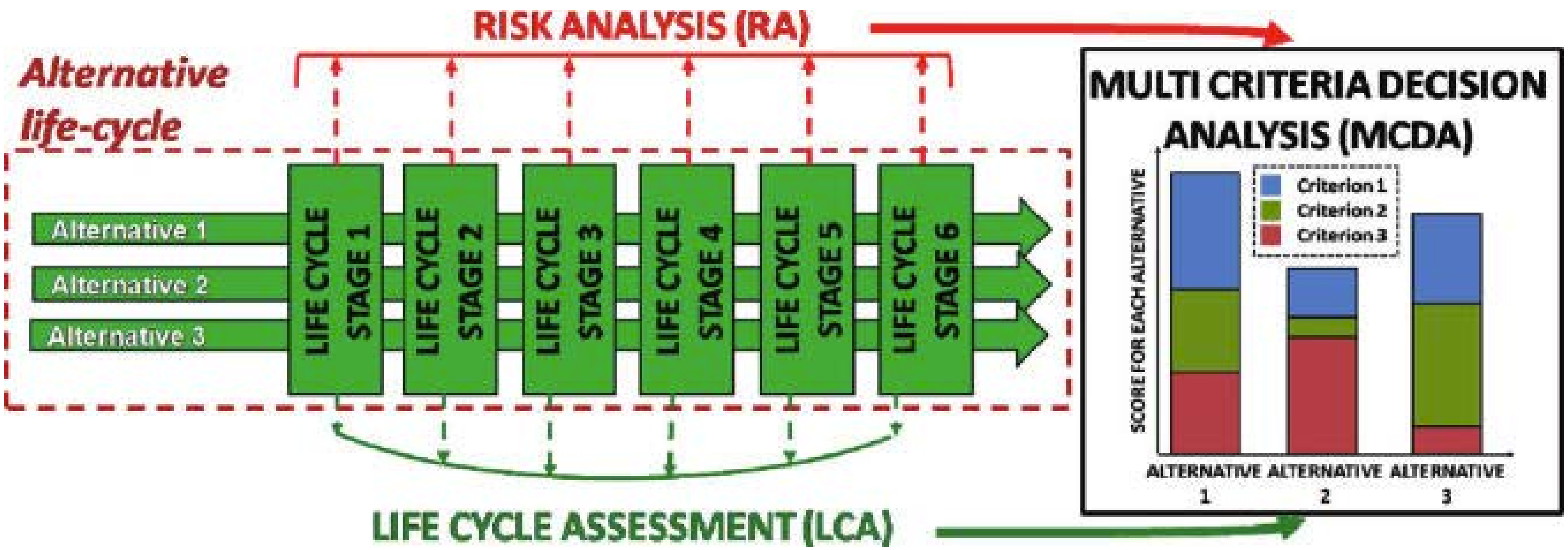
Resilience,
in the context of
policy making means
assessing alternatives with
respect to multi-dimensional,
interrelated **sustainability
criteria**

NATURAL CAPITAL COALITION

Economy

Society

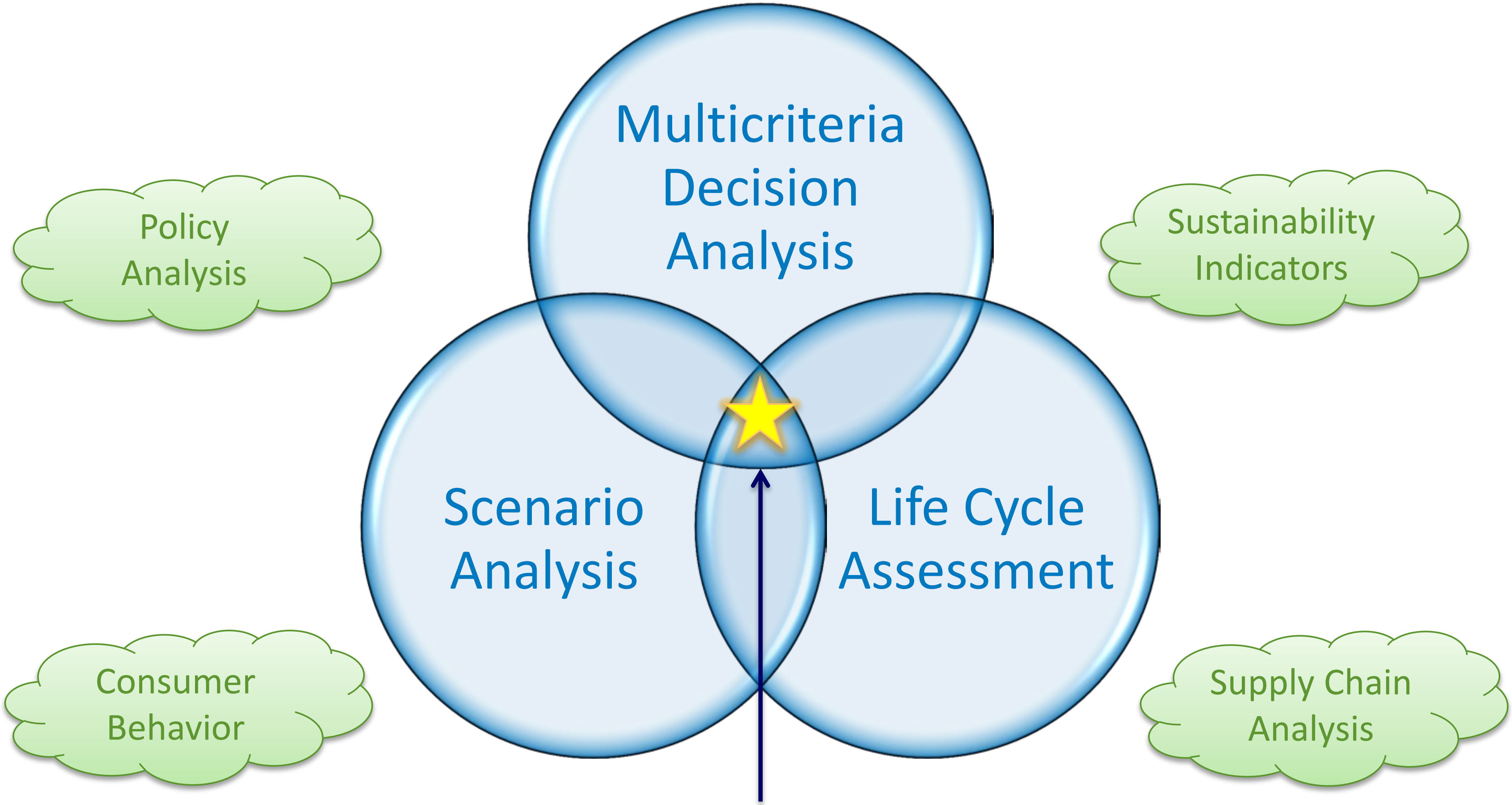
Risk and Sustainability



"It should be clear that developing appropriate risk- and life-cycle based decision frameworks that are operable in highly uncertain research domains should be a high policy priority."

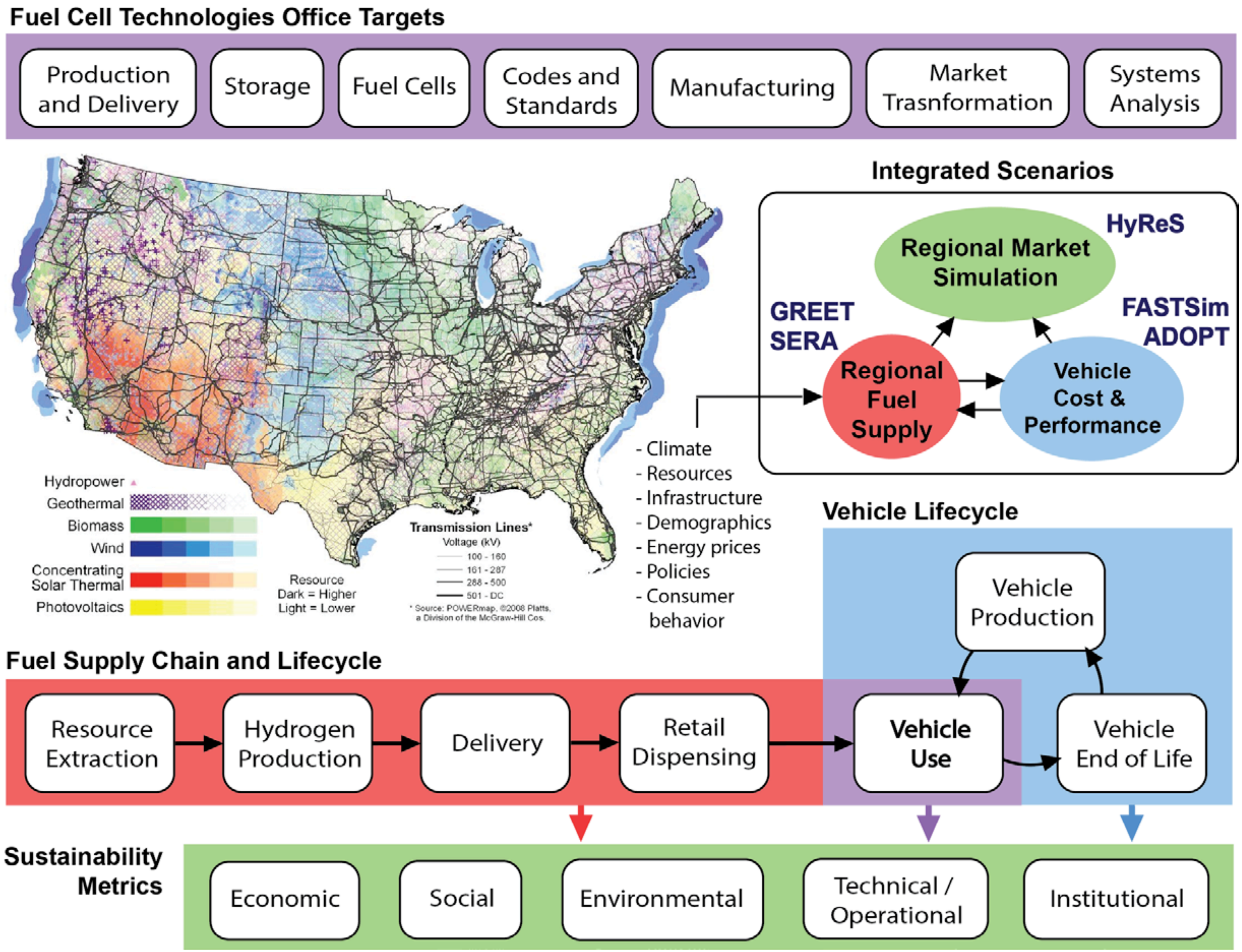
Source: Linkov and Seager (2011)

Approach



What scenarios are influential to the technology/infrastructure life cycle and disruptive to decision-maker priorities?

Application: Hydrogen Regional Sustainability Analysis (HyReS)



Data Sources and Models

ANL's **Greenhouse gases, Regulated Emissions, and Energy use in Transportation (GREET)** model describes emissions and resource use associated with hydrogen fuel and vehicle cycles.

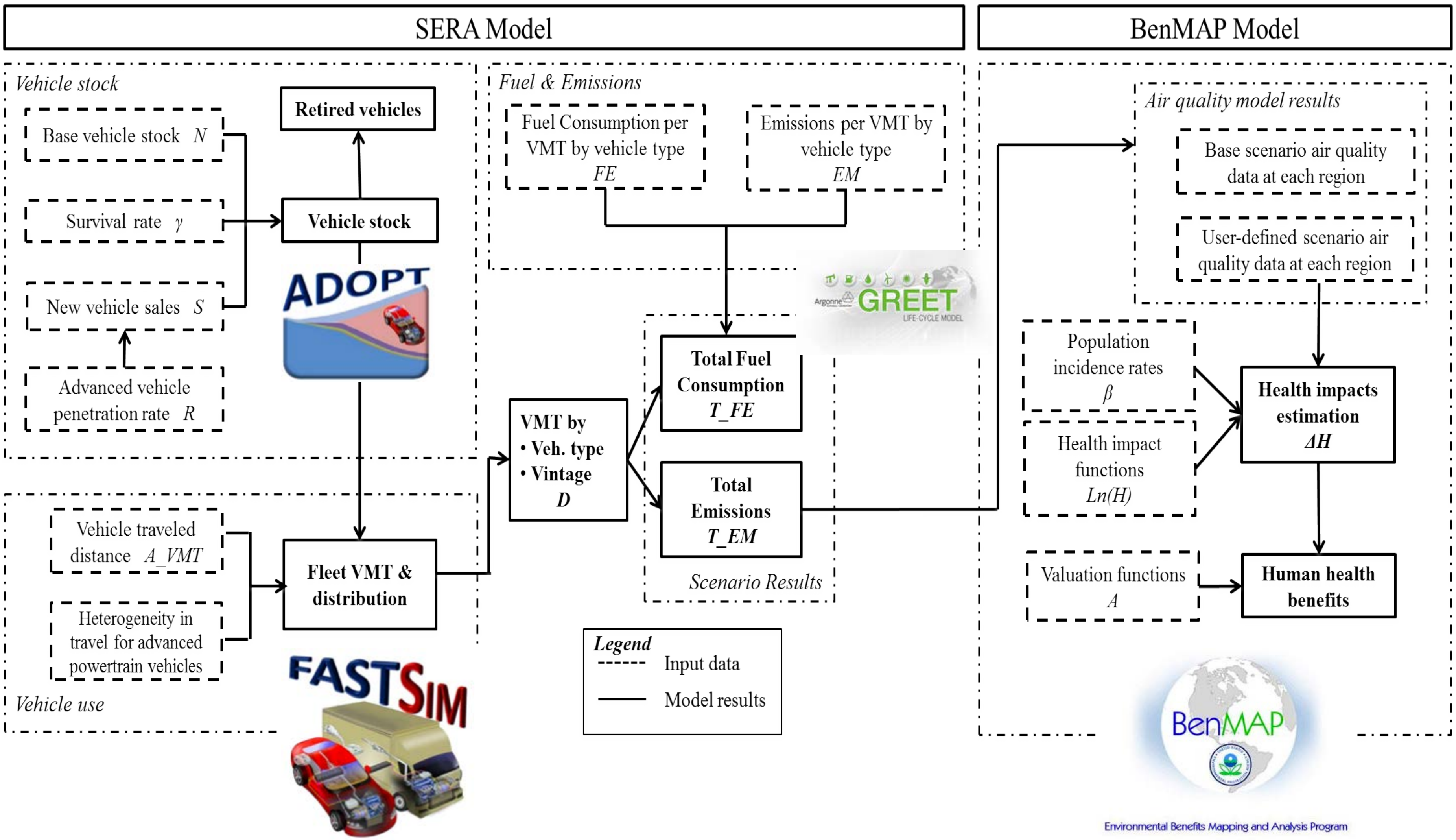
NREL's **Automotive Deployment Options Projection Tool (ADOPT)** estimated technology improvement impacts on future vehicle sales, petroleum use, and GHG emissions.

NREL's **Future Automotive Systems Technology Simulator (FASTSim)** estimates the impact of technology improvements on vehicle efficiency, performance, cost, and battery life.

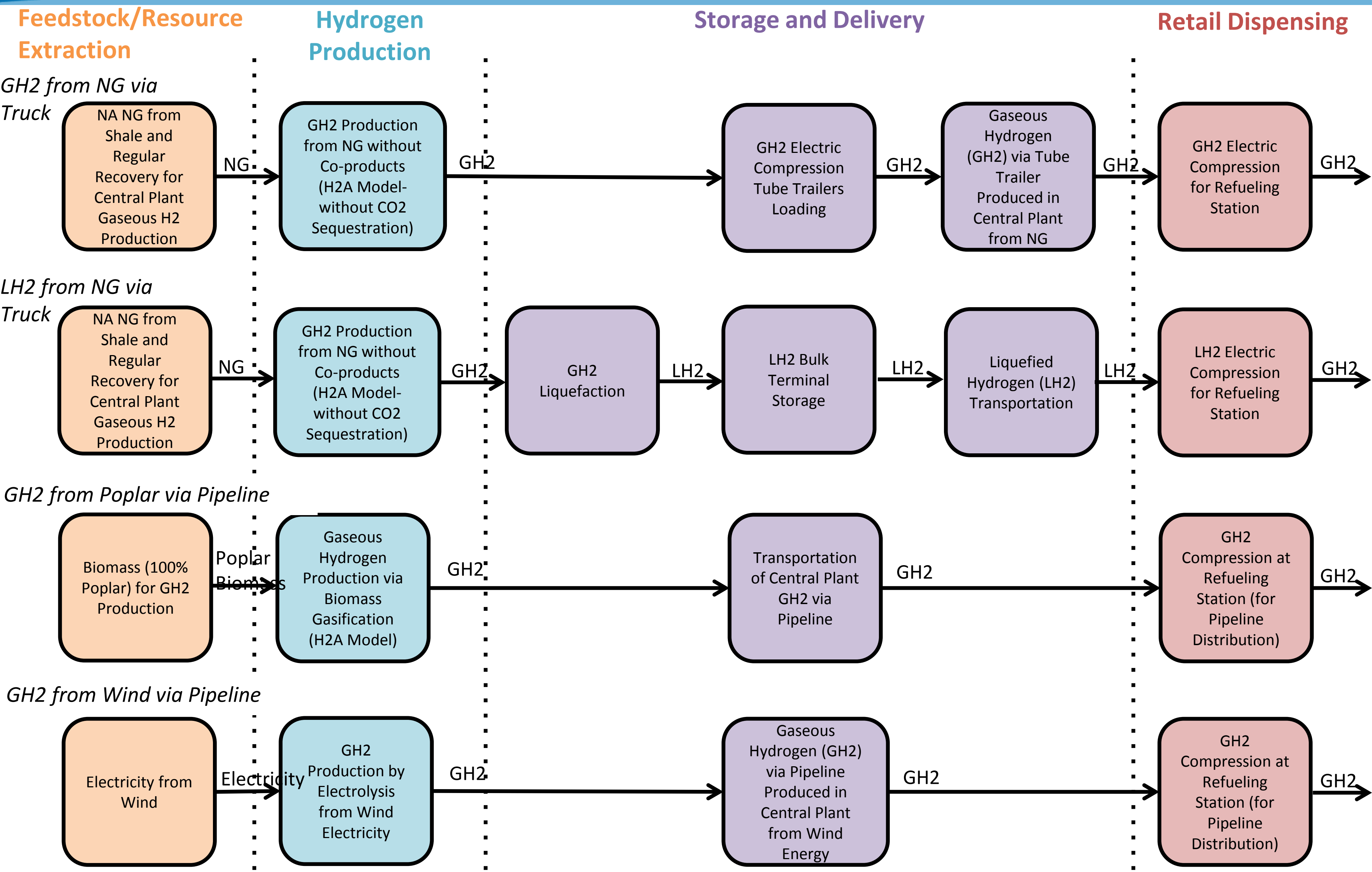
NREL's **Scenario Evaluation, Regionalization and Analysis (SERA)** model is a geospatially and temporally oriented model that determines optimal production and delivery scenarios for hydrogen, given resource availability and cost.

The EPA's **Benefits Mapping and Analysis Program (BenMAP)** assesses the health impacts resulting from changes in air pollution concentrations.

Model Framework



Case Study Pathways



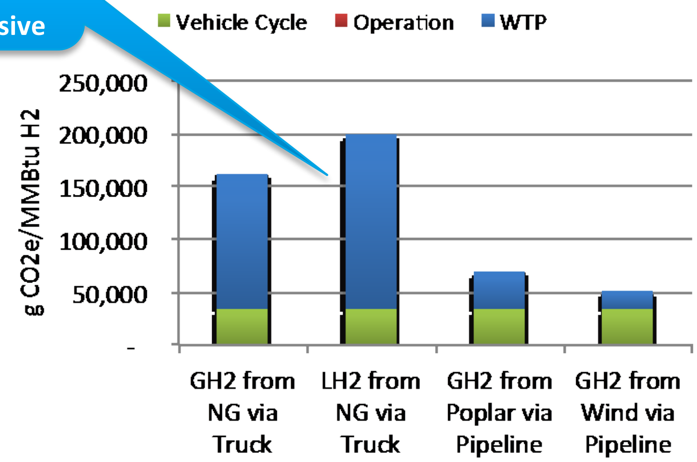
Emissions and Water Demand Case Study Results

LC Impacts (g/mi)	GH2 from NG via Truck	LH2 from NG via Truck	GH2 from Poplar via Pipeline	GH2 from Wind via Pipeline
GHG-100	335.83	414.47	144.89	106.22
CO	0.28	0.29	0.24	0.19
NOx	0.26	0.27	0.21	0.09
PM10	0.07	0.09	0.05	0.05
PM2.5	0.04	0.05	0.02	0.02
SO2	0.00	0.00	0.00	0.00
CH4	0.91	1.07	0.35	0.27
SOx	0.38	0.55	0.41	0.34
N2O	0.003	0.004	0.016	0.002
VOC	0.25	0.25	0.23	0.22
Water Use	662.84	1,077.76	1,304.02	803.80

GREET defaults were varied so that transportation of hydrogen is consistent across modes (100 miles)

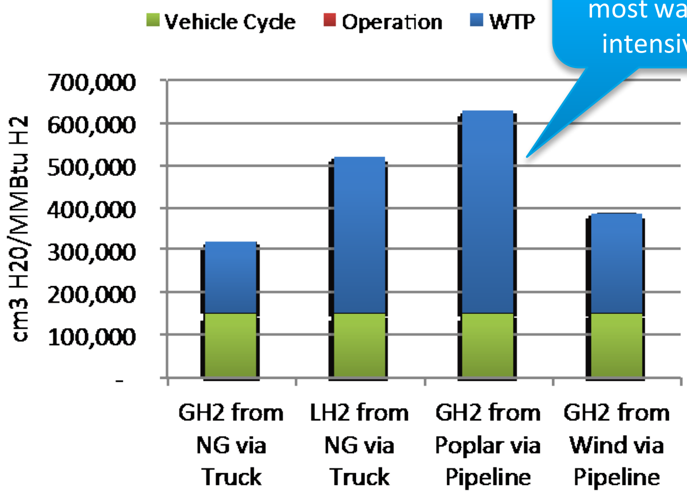
LH2 from NG is most GHG intensive

Life Cycle GHG-100 Emissions



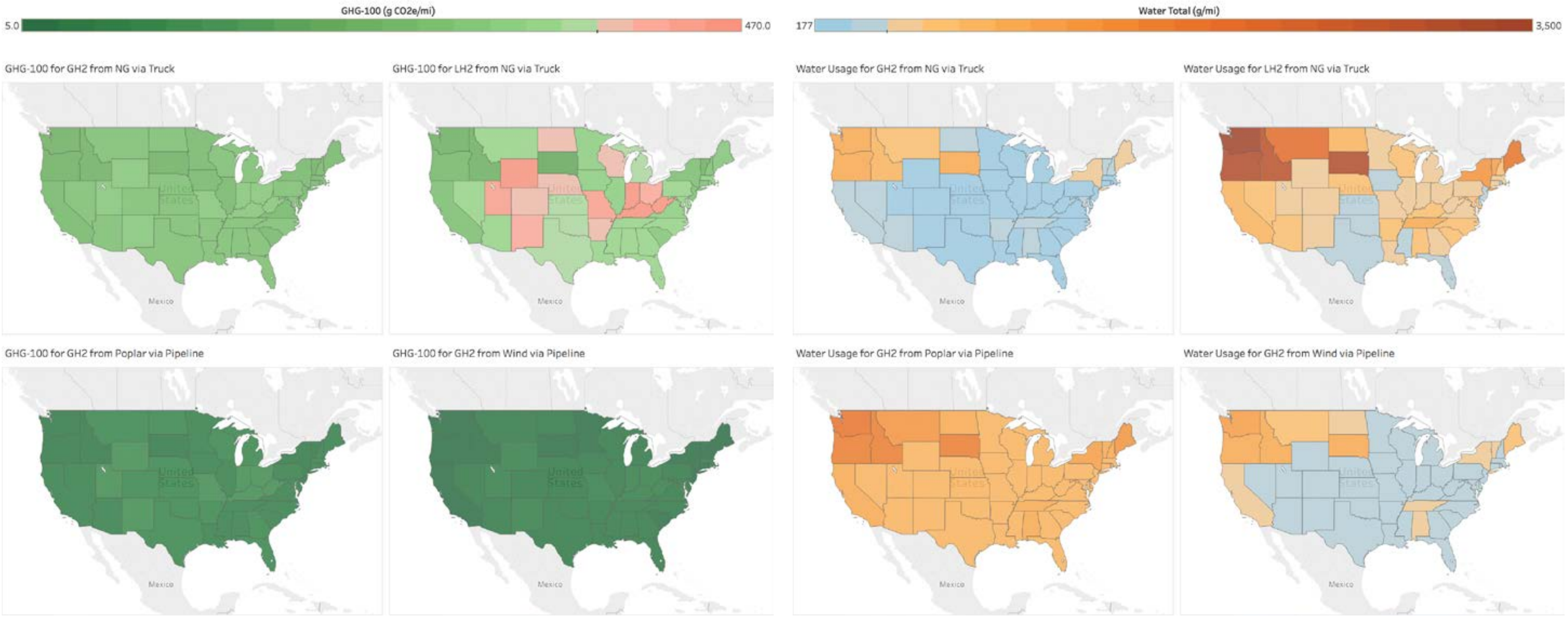
Life Cycle Water Demand

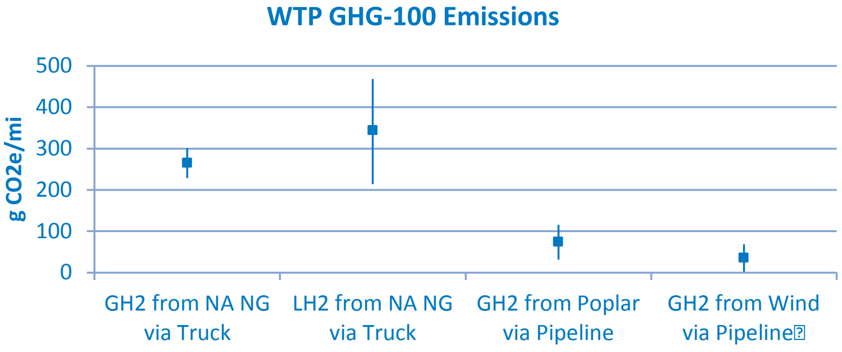
GH2 from poplar is most water intensive

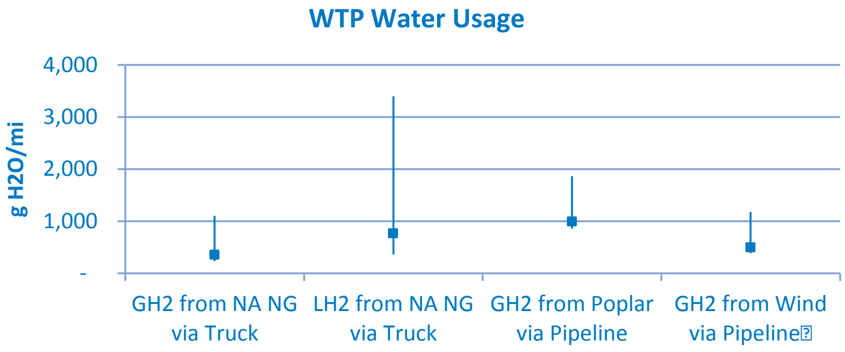


Importance of Spatial and Temporal Scale:

Sensitivity to Electricity Grid Mix

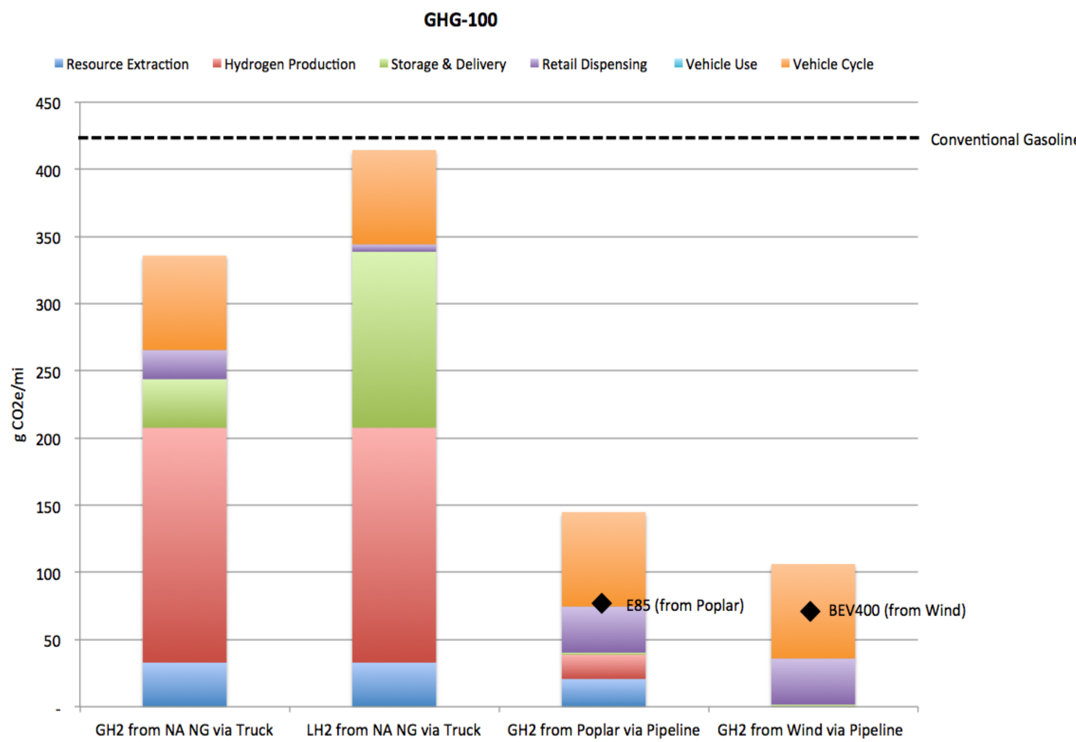






Future Work

- Prioritization of hydrogen supply chain configurations under scenarios of differing assumptions on:
  - Electricity generation
  - Technological efficiencies
  - Population densities
  - Consumer adoption rates
- Comparison of fuel cell electric vehicles against gasoline, biofuel, and electric vehicles on the basis of:
  - Cost to consumer
  - Economic impacts (job creation, GDP growth)
  - Environmental impacts
  - Health impacts, etc.



Questions?

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