

Sustainable Transportation Energy Pathways (STEPS)

Research Ideas: Transportation Fuel Infrastructure Vulnerability and Resiliency to Climate Change

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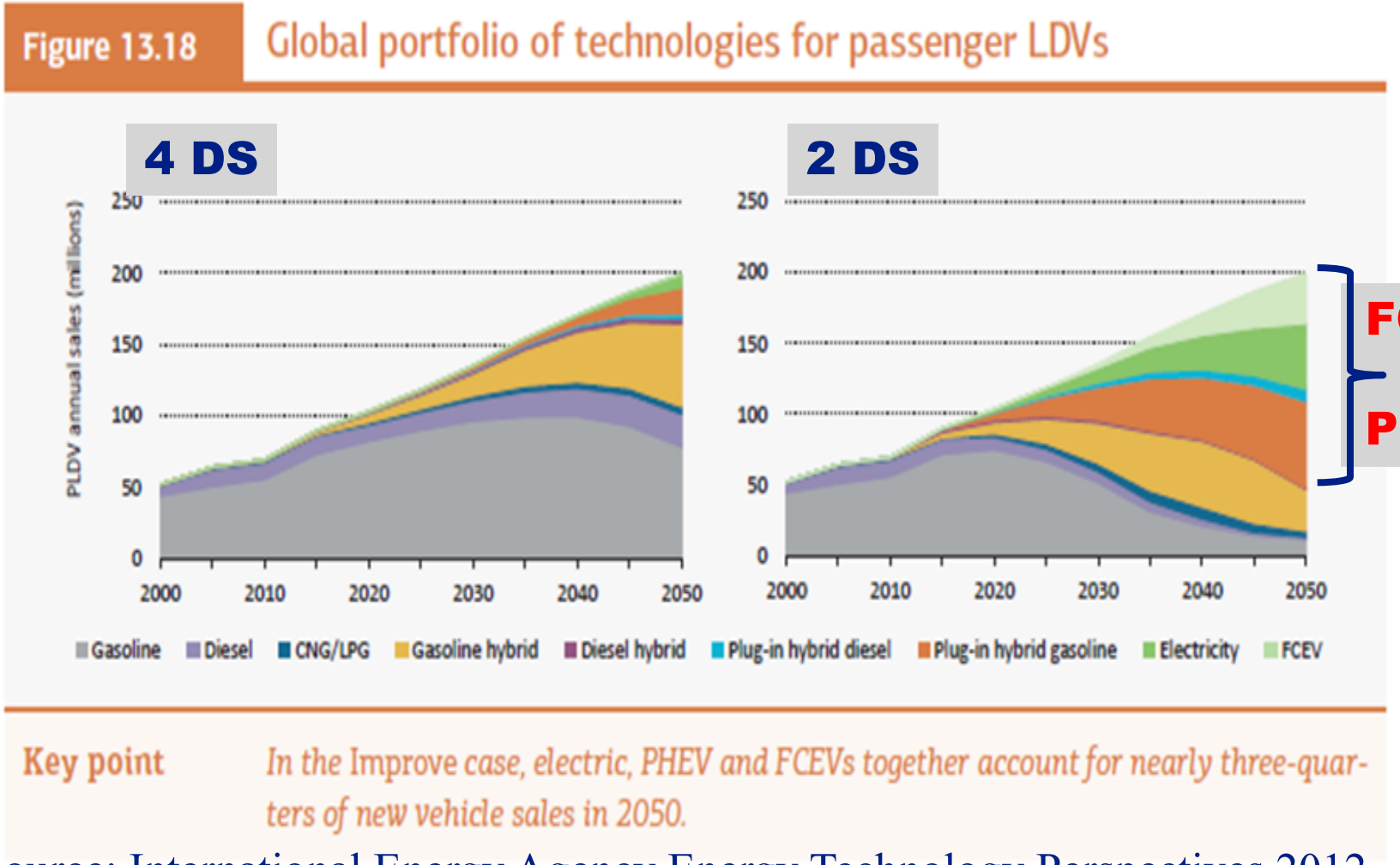
Joan Ogden
Yueyue Fan
Amy Jaffe

ITS UCDAVIS
INSTITUTE OF TRANSPORTATION STUDIES

www.steps.ucdavis.edu

Integrated Assessment Modeling =>
Elec. Drive, Low-C Fuels Play Major Role in 2º Scenario



Source: International Energy Agency Energy Technology Perspectives 2012

Infrastructure Implications of 2° scenario

TRANSPORTATION TAPS INTO EVOLVING ELECTRIC GRID *(w/increasing % variable renewable power)*

- EV charging, power-to-gas, power-to-liquids

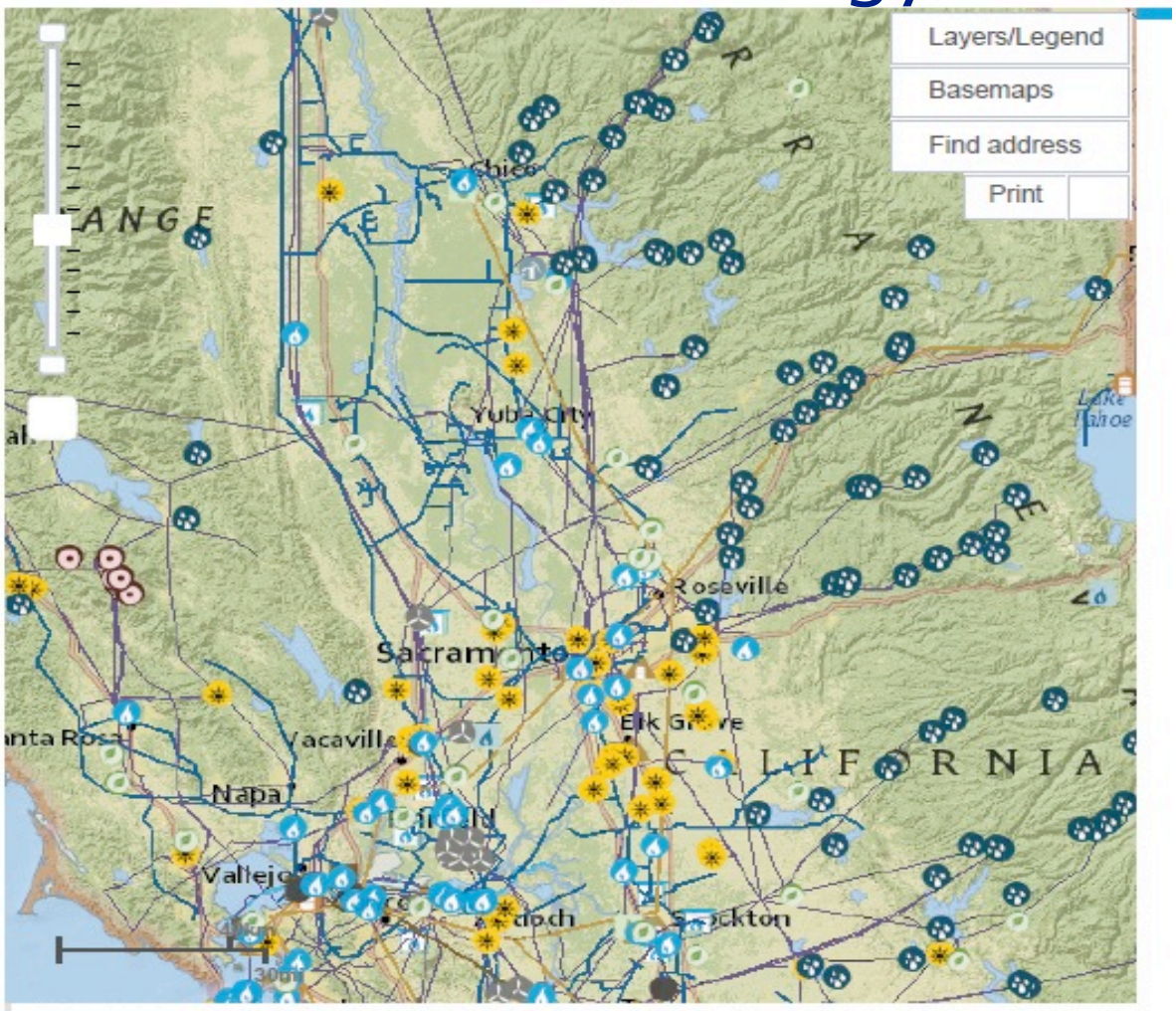
NEW FUELS =>

- Adapt/use existing infrastructure, (Drop-in biofuels? Blend H2 w/ NG? Smart elec. grid)
- New dedicated infrastructures

NEW INFRASTRUCTURE FOR CARBON MANAGEMENT

- Carbon Capture (Chemical Process or Atmospheric)
- CCS (pipelines and storage)

Northern California Energy Infrastructure



- **ADAPTATION TO IMPACTS OF CLIMATE CHANGE**
- **EVOLUTION TOWARD LOW CARBON ENERGY SUPPLY**

CA Climate Change Projections

- Air and Water Temperature Rise
- Decreasing water availability
- Increasing intensity of storms, sea level rise, storm surge
- Increasing intensity and frequency of flooding
- More frequent and severe wildfires
- Changes in precipitation timing and decreasing snowpack

=> **potential impacts on energy system**

- Less efficient electric gen and T&D d.t. high temperature
- Wildfire damage
- Flood damage
- Storm damage
- Increased risk of physical damage and disruption to power and fuel facilities
- Disruption of rail and barge transport of crude oil, petroleum products
- Increased summer A/C and NG demand; less heat in winter

IMPACTS ARE GEOGRAPHICALLY SPECIFIC

RESEARCH AGENDA

- Conduct Regional Case Studies
  - Develop spatial/time scenarios for evolution of fuel supply system
  - Consider Adaptation + transition to clean energy
- Identify key vulnerabilities for energy infrastructure
- Optimize systems for resiliency
  - Operation of existing fuel systems
  - Buildout of new systems for low carbon fuel supply
- Capture risks, dynamics caused by evolving infrastructure and climate, and system interdependence.

extras

ELEC. GEN.	CA Climate Projection	Potential Risk/Impact
Thermo-electric power plants ***(NG, coal, geothermal, CSP, nuclear)***	• **Increasing air & water temp.** • **Decreasing water availability** • **Increasing intensity storms, sea level rise, storm surge** • Increasing intensity and frequency of **flooding**	• **Reduced plant efficiencies** & available **generation capacity** • increased risk of exceeding thermal discharge limits • impacts on coal, NG, and nuclear fuel supply chains • **Increased risk of physical damage & disruption to power facilities**
Hydropower	• Increasing temps & evap. loss • Changes in precipitation timing and decreasing snowpack • Increasing intensity and frequency of flooding	• Reduction in available generation capacity & changes in operations • Increased risk of physical damage and changes in operation
Solar	• Increasing air temperatures • Decreasing water availability	• Reduction in potential peak generation capacity (PV and CSP)
Wind	• Variability of wind patterns	• Net impact generation uncertain
ELEC. T&D	• Increasing air temperatures • More frequent and severe wildfires • Increasing intensity of storms • Increasing intensity, frequency of flooding	• Reduction in transmission efficiency and available transmission capacity • Increased risk of physical damage • Substations subject to flooding

	CA Climate Change Projection	Potential Risk/Impact
FUELS		
Natural Gas fuel processing, storage, pipelines	• Decreasing water availability • Increasing intensity of storm events, sea level rise, and storm surge • Increasing intensity and frequency of flooding	• Impacts on drilling and production • Increased risk of physical damage and disruption to coastal facilities • Increased risk of physical damage to inland facilities
Petroleum Production. Refineries, Transport	• Decreasing water availability • Increasing intensity of storm events, sea level rise, and storm surge • Reduction in river levels • Increasing intensity and frequency of flooding	• Impacts on drilling, production, and refining • Increased risk of physical damage and disruption to coastal facilities • Disruption of barge transport of crude oil, petroleum products • Disruption of rail and barge transport of crude oil, petroleum products
Bio-refineries; Bioenergy	• Increasing air temperatures • Extended growing season • Decreasing water availability • Sea level rise and increasing intensity and frequency of flooding	• Increased irrigation demand; risk of crop damage from extreme heat events • Increased biomass production • Decreased biomass production • Increased risk of crop damage

Climate change Implications

ENERGY DEMAND	
Electricity	Increased demand for summer A/C; reduction of winter space heat demand; demand side management and/or storage to match supply and demand.
Natural Gas	Reduction of winter space heat demand; more NG needed by power plants to compensate for lower efficiency at summer peak times.
Transportation Fuel	Depends on mix of fuel/vehicle types in light and heavy duty sectors, aviation, freight. Low Carbon Futures require higher efficiency vehicles, lower carbon fuels: Electricity, H2; biofuels; RNG