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Energy+Environmental Economics

Long-Term Energy Scenarios In California

Implications for Building Decarbonization

CEC EPIC-14-069 Study Results

2018 IEPR Workshop on Achieving Zero Emission Buildings

June 14th, 2018

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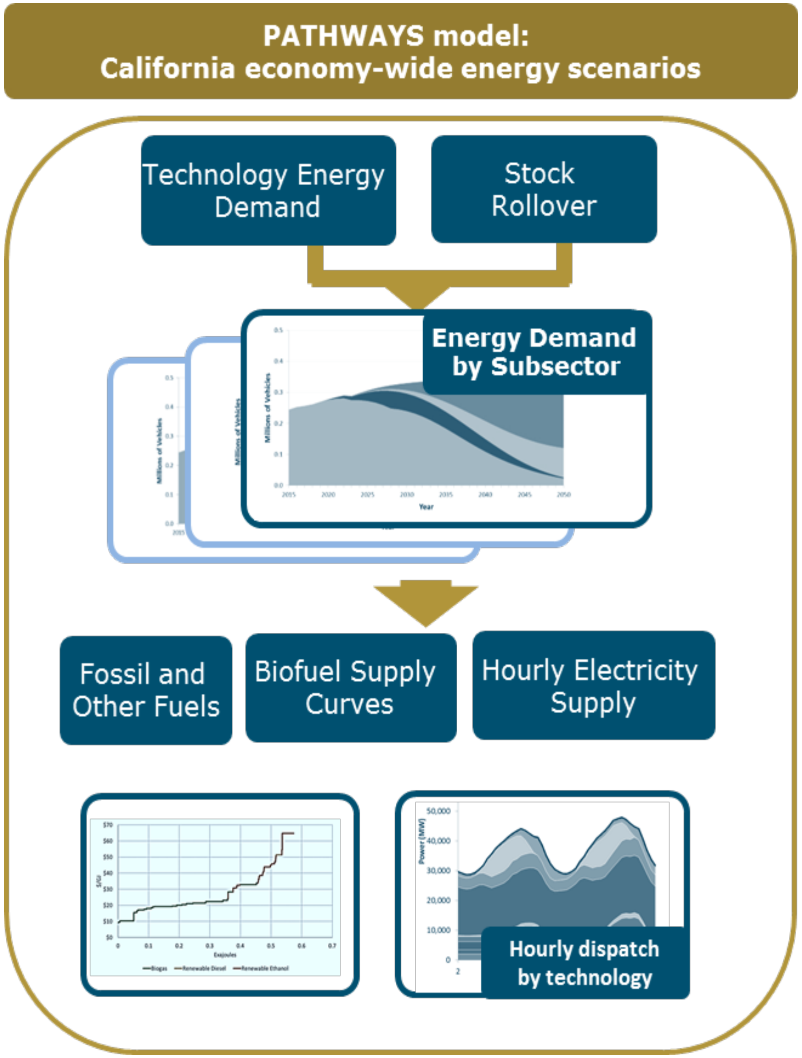
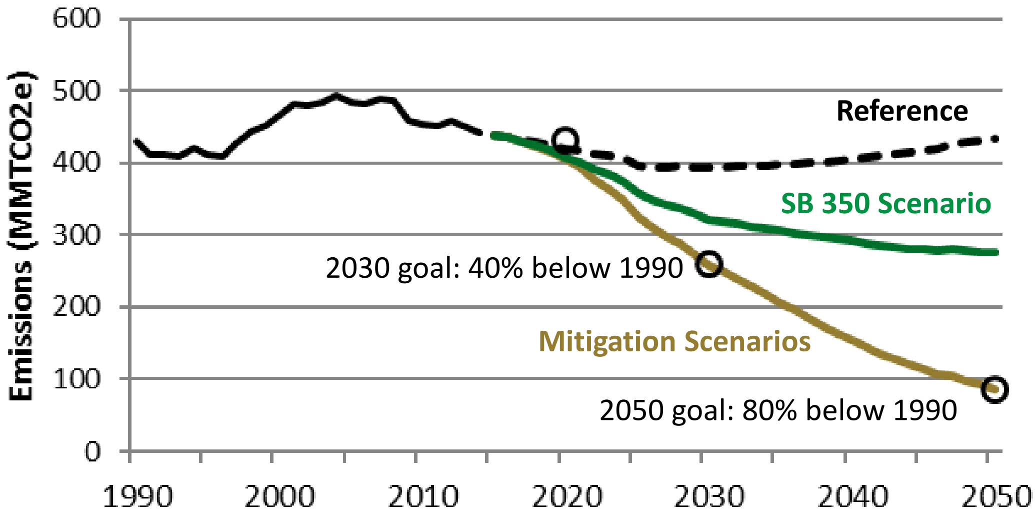
Agenda

- **CEC EPIC PATHWAYS project: "Deep Decarbonization in a High Renewables Future"**
- **Implications for Building Decarbonization**
- **On-going research**
  - CEC PIER Project on the Long-term Strategic View of the Future of Natural Gas



Mitigation Scenarios achieve CA's 2030 and 2050 GHG Goals

1. **Reference Scenario**
   - ✓ Reflects pre-SB 350 policies (e.g. 33% RPS, historical energy efficiency goals)
2. **SB 350 Scenario**
   - ✓ Includes SB 350 (50% RPS by 2030), mobile source strategy Cleaner Technology and Fuels, plus additional reductions in non-combustion GHGs
3. **Mitigation Scenarios**
   - ✓ We evaluated 10 mitigation scenarios, all meeting 2030 and 2050 GHG goals



Two scenarios evaluate "bookend" building decarbonization strategies

High Electrification

- Electrification of buildings
- Electrification of transportation
- High energy efficiency
- Renewables
- Limited biofuels

Hybrid scenarios combining these strategies were not evaluated here; nor were high biofuels scenarios

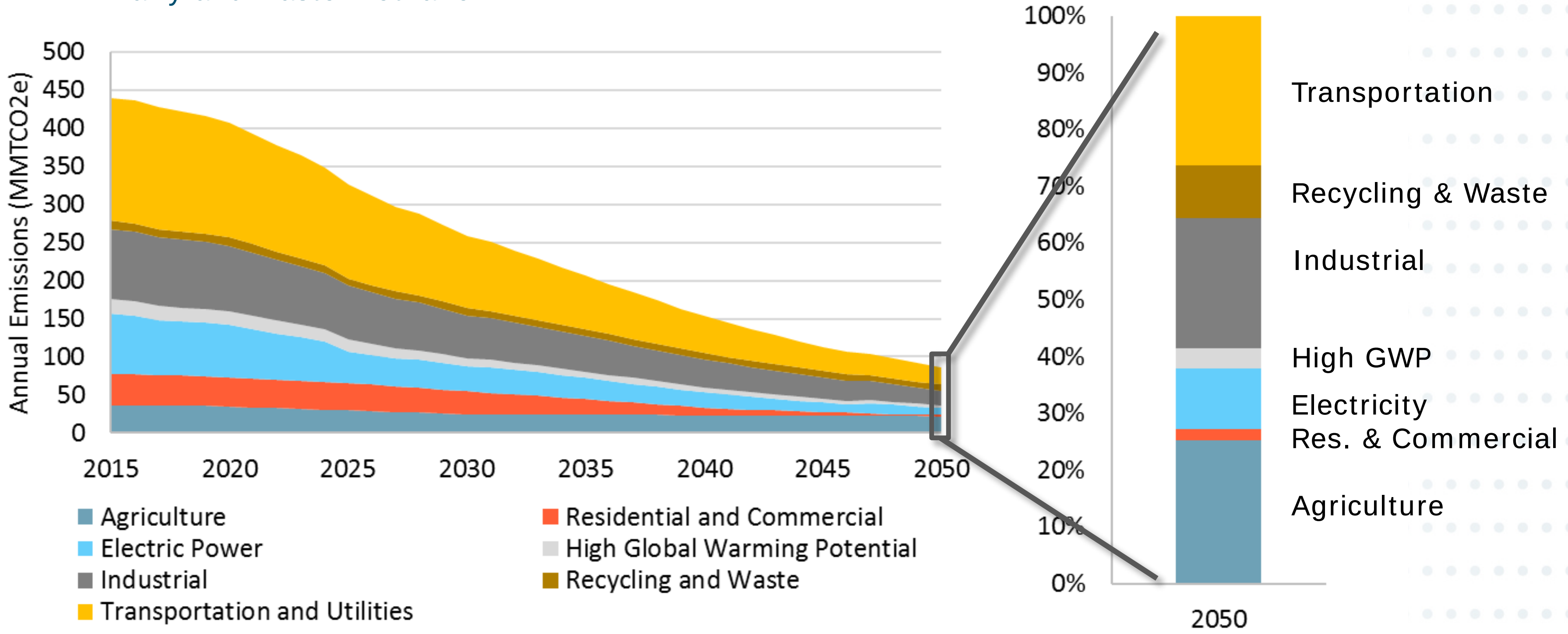
No Building Electrification with Power-to-Gas

- No heat pumps or building electrification
- Use of hydrogen and synthetic methane in the gas pipeline
- Limited biofuels

Large reductions are required in all sectors

- **Challenging sources dominate remaining 2050 emissions:**
  - Freight and off-road transportation petroleum
  - Natural gas in industry
  - Dairy and waste methane

California 2050 GHGs: High Electrification Scenario (86 MMT)



Although the analysis ends in 2050, climate stabilization requires bringing net emissions to zero globally.

Four strategies to decarbonize buildings

Energy efficiency & conservation

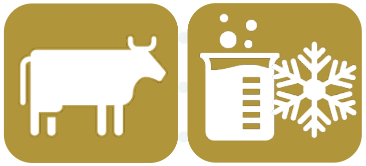
- ✓ LED lightbulbs, efficient plug-loads & appliances
- ✓ Whole-home retrofits & new construction codes
- ✓ Gas heat pumps

Electrification

- ✓ Electric heat pumps for water heaters and space heating/cooling
- ✓ Electric dryers and cookstoves

Low-Carbon Fuels

- ✓ Renewable electricity
- ✓ Biomethane
- ✓ Hydrogen from renewable energy
- ✓ Climate neutral synthetic methane



Reduce non-combustion GHGs

- ✓ F-gas replacement for refrigerants with lower global warming potential gases
- ✓ Mitigation of fugitive methane leaks

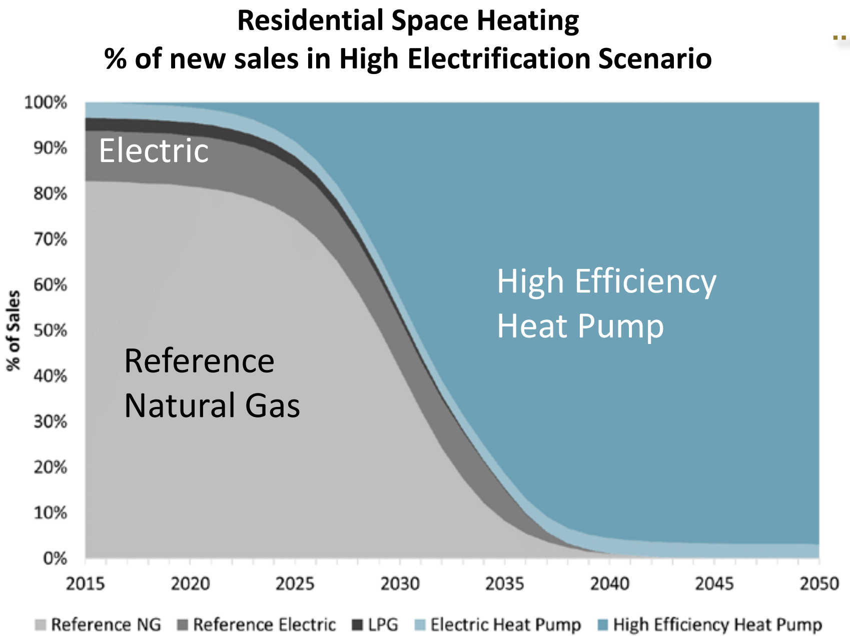
+ **Each of these strategies face implementation challenges**
+ **Electrification and/or renewable natural gas (RNG) are critical to decarbonizing building energy**

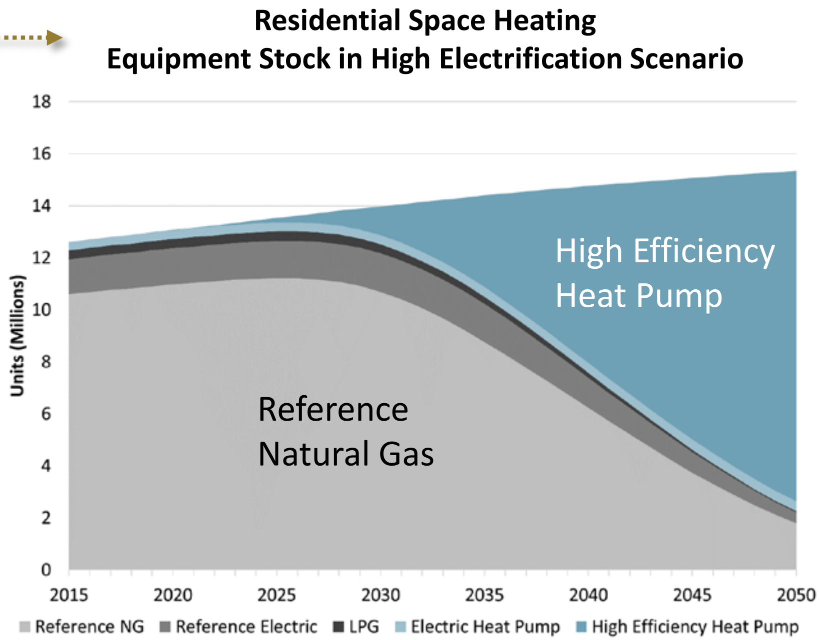
Hydrogen and synthetic methane derived from renewable electricity are sometimes referred to as "power-to-gas" (P2G). A non-fossil CO_2 source is needed to produce climate-neutral methane, such as direct air capture (DAC).

Slow turnover of building equipment means transformation must begin early

+ Most existing buildings will need heater replacement with electric heat pumps or high efficiency natural gas furnaces and heat pumps

- Additional installation costs may be associated with heat pump retrofits relative to self-replacement or new construction.
- Delayed progress could lead to costly need for additional retrofits as well as early retirement of building equipment.



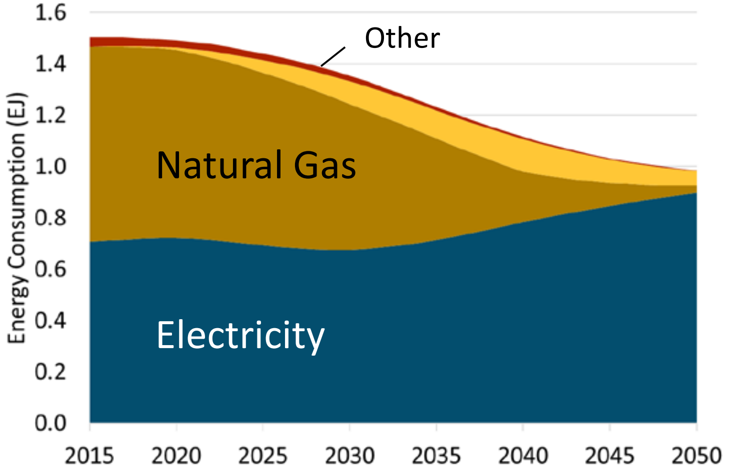


Natural gas use in buildings declines in all scenarios, and is replaced by electricity, biomethane or P2G

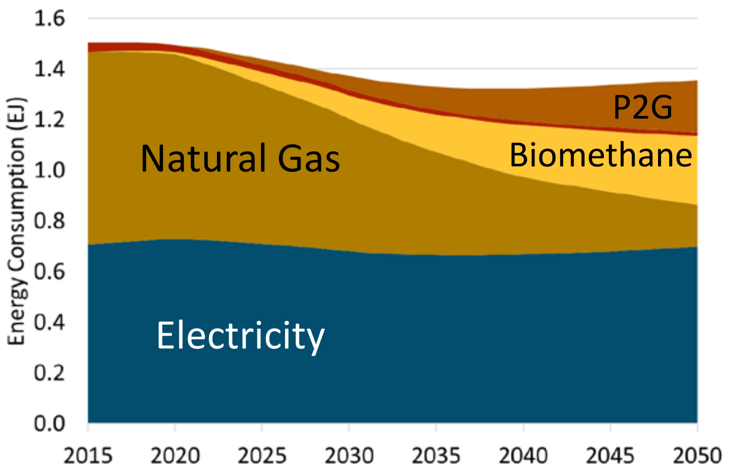
- "Conventional" energy efficiency reduces building energy demands through 2030 in all scenarios
- High electrification scenario assumes near-complete electrification by 2050
- Less building electrification necessitates high biofuels, EE breakthroughs, or power-to-gas (modeled here)

Building Energy Consumption

High Electrification Scenario



No Building Electrification with Power-to-Gas Scenario



Inexpensive and sustainable California biomethane supply is limited

- **Renewable natural gas (RNG) includes biomethane as well as hydrogen and synthetic methane (P2G)**
- **Four tranches of biomethane:**

~0.05-0.1 Quadrillion BTU (Quad)

1. In-state landfills, wastewater, & centralized dairy manure
   - Relatively inexpensive; benefits of avoided methane

~0.1 Quad

2. In-state forest and agricultural residues (e.g. via gasification)

~0.2-0.4 Quad

3. Out-of-state forest and agricultural residues

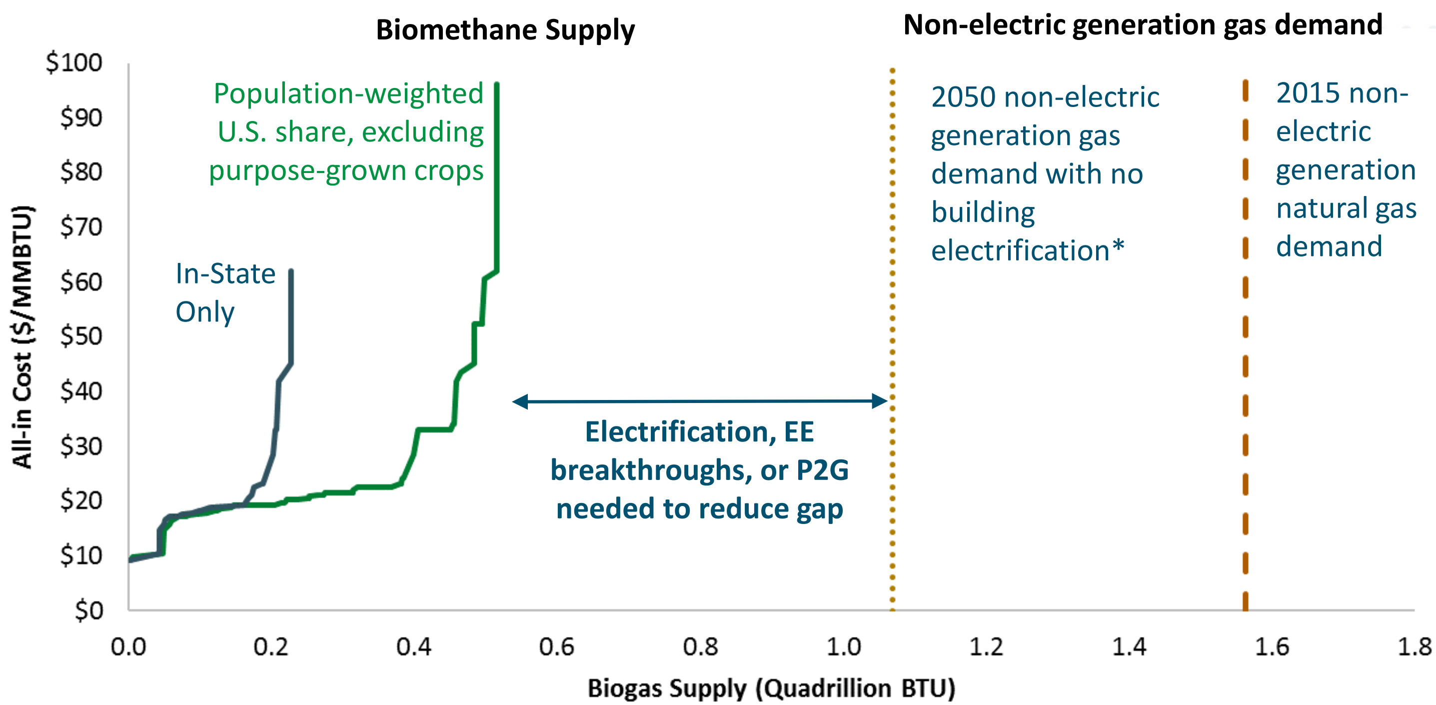
??

4. Advanced biomethane from purpose-grown crops and wood (mostly from outside California), and/or algae for biofuels
   - Speculative and large sustainability concerns

Estimate of CA sustainable biomethane supply & non-electric gas demand in 2050

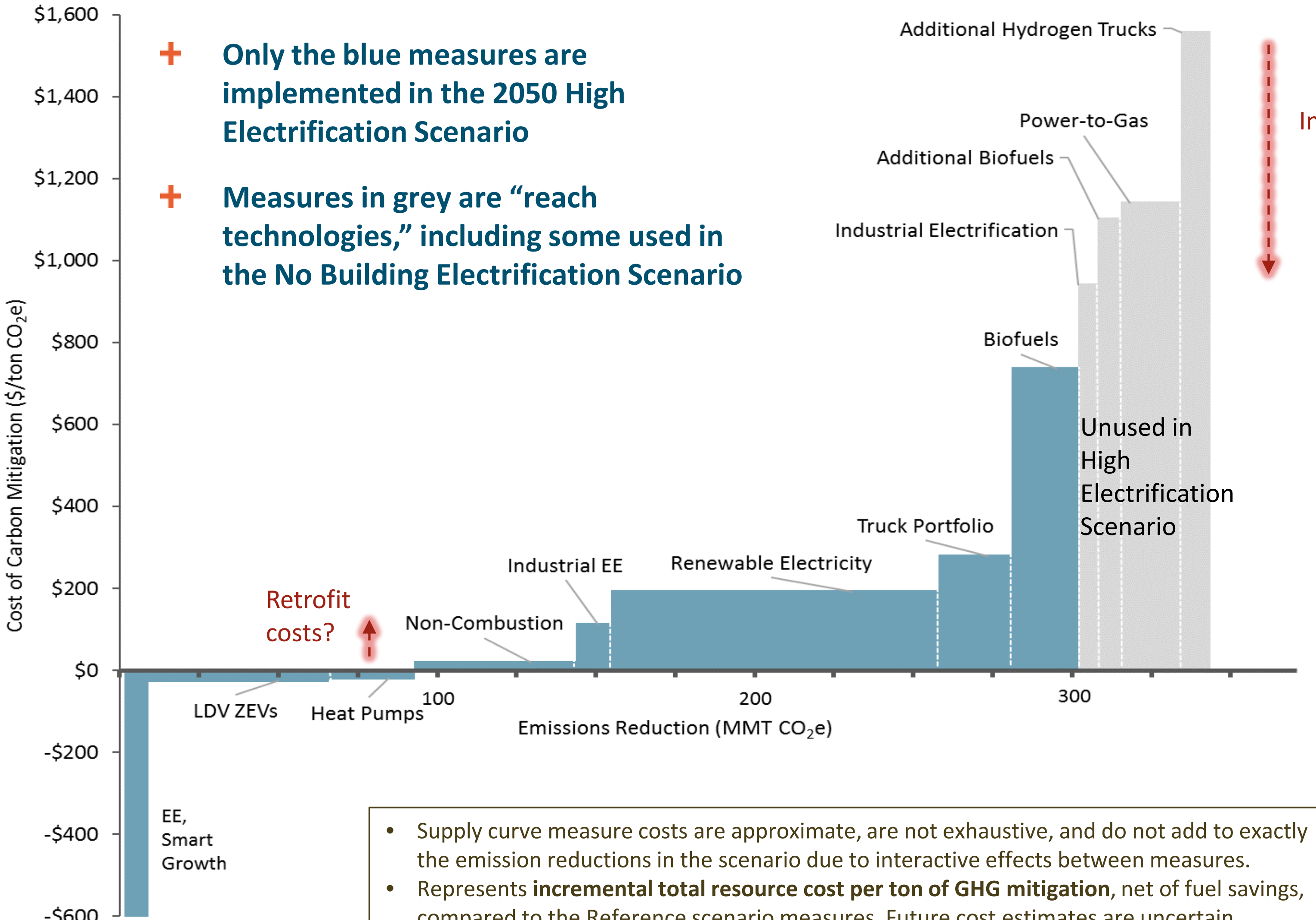
- **Without building electrification, gas demand from buildings & industry exceeds CA's population share of US biomethane supply from residue biomass.**
- **Electrification, natural gas heat pumps, power-to-gas, and/or purpose-grown biomass are needed to reduce the gap between supply and demand.**

Estimated Cost and Available Biomethane Supply to California



* Includes high natural gas efficiency and petroleum industry demand reduction

High Electrification Scenario appears to be lower cost with less dependence on "reach technologies"



- Supply curve measure costs are approximate, are not exhaustive, and do not add to exactly the emission reductions in the scenario due to interactive effects between measures.
- Represents **incremental total resource cost per ton of GHG mitigation**, net of fuel savings, compared to the Reference scenario measures. Future cost estimates are uncertain.
- Costs do not represent a cap-and-trade market price forecast nor participant costs.

Contrasting challenges and risks

Building Electrification

- Timing
- Consumer acceptance
  - Cost and hassle of retrofits
  - Upfront capital cost
  - Stoves

- Stranded assets and equity concerns for remaining natural gas customers

Renewable Natural Gas

- Technological readiness
- Resource potential
- Resource cost
- Sustainability

Miscanthus

Direct Air Capture

On-going research on the future of natural gas

- **<u>Goal</u>: Develop a strategic long-term vision of the role of natural gas and gas distribution in a carbon-constrained future**
- **Relative to prior project, greater focus on:**
  - Forecasting future costs for renewable natural gas technologies (biomethane, hydrogen, and synthetic methane)
  - Costs of building retrofits for electrification and potential gas pipeline phase-out
  - Distributional cost impacts of changes in natural gas demand and infrastructure, including participant and utility cost perspectives
  - Environmental justice considerations, including locational costs and benefits of changes in local air quality
- **Timing: Results in 2019**

THANK YOU

Full presentation on CEC EPIC project available at:

https://www.ethree.com/wp-content/uploads/2018/05/E3_2050Pathways_Draft_FullDeck_20180522.pdf