Energy+Environmental Economics

Electrification and Low-Carbon Gas

GHG Reduction Strategies in Buildings, Transport & Industry

Northwind Electricity Invitational Forum
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About E3

- San Francisco-based consultancy with 45 professionals focusing on electricity sector economics, regulation, planning and technical analysis
- Leading consultant to California agencies governing renewables, energy efficiency, demand response, and distributed generation programs
- Consultant to many of the world's largest utilities and leading renewable developers

Agenda

- California's 2030 climate strategy
- 2050 carbon mitigation strategies
- Comparison to Ontario – what's different?
- What is the future of natural gas in Ontario?

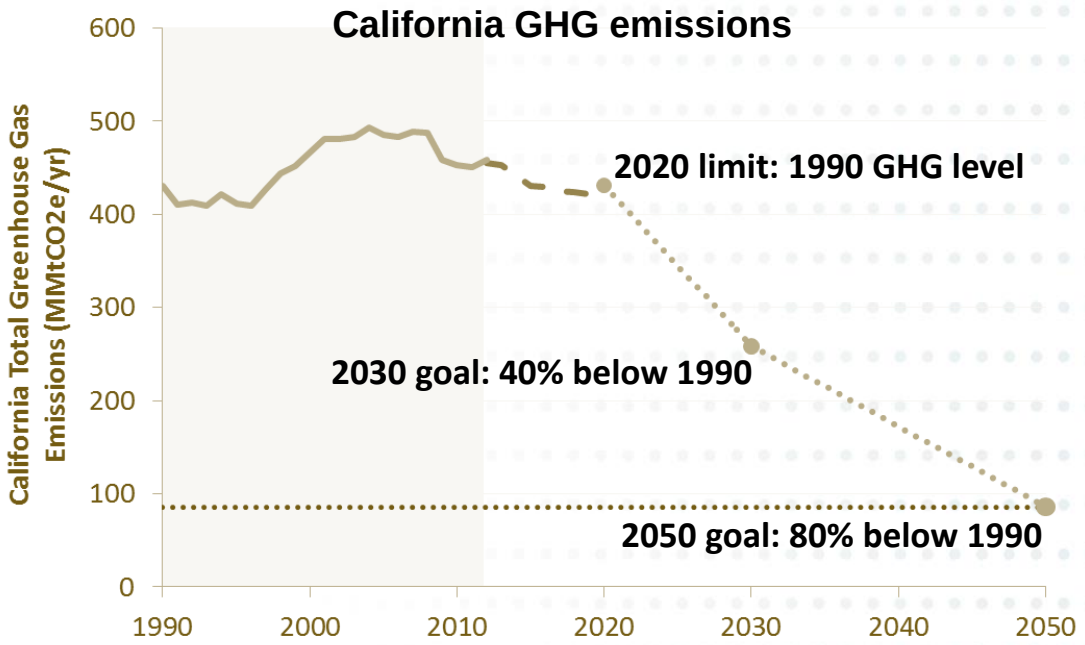
California PATHWAYS analysis

California's ambitious carbon goals:

- Return to 1990 levels by 2020
- 40% below 1990 GHG levels by 2030
- 80% below 1900 GHG levels by 2050

E3's PATHWAYS modeling has informed:

- Governor's choice for the 2030 GHG goal
- California Air Resources Board 2030 Scoping Plan Update



2015 study results: https://ethree.com/public_projects/energy_principals_study.php
ARB Scoping Plan Update: https://www.arb.ca.gov/cc/scopingplan/scopingplan.htm

4 Pillars of the Energy Transition: Commonalities Across All Scenarios

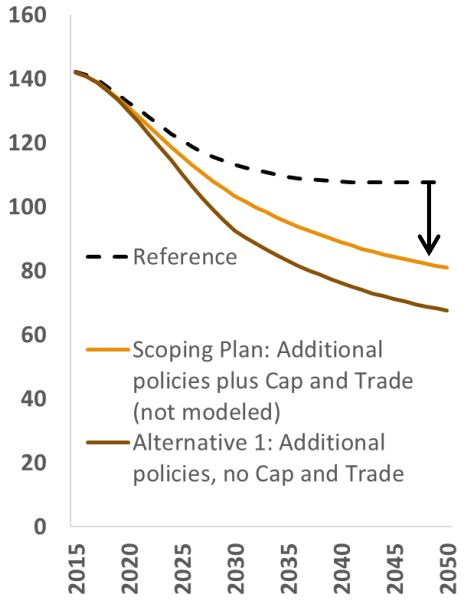
1. Efficiency and Conservation

2. Electricity as Fuel

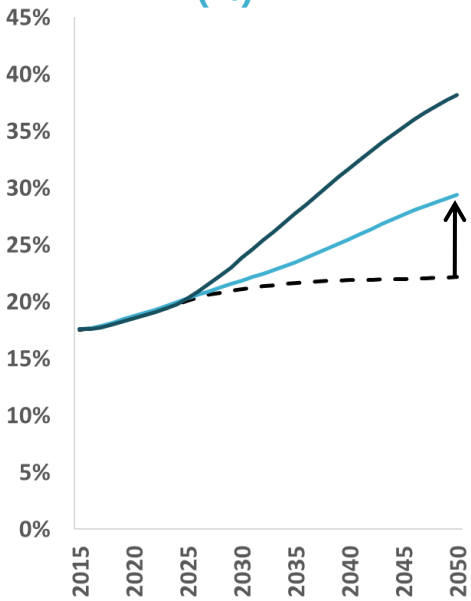
3. Decarbonize electricity

4. Decarbonize fuels (liquid & gas)

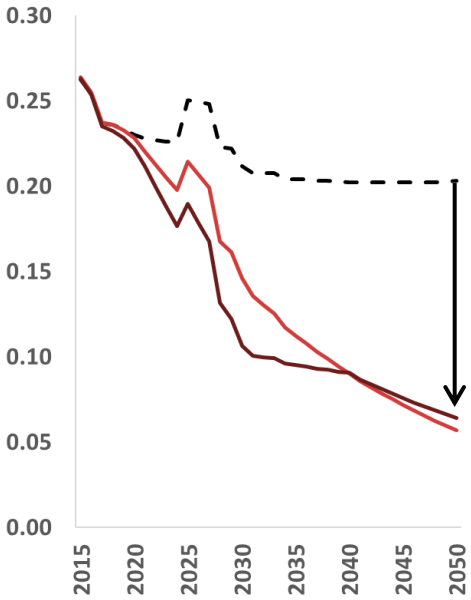
Energy use per capita (MMBtu/person)



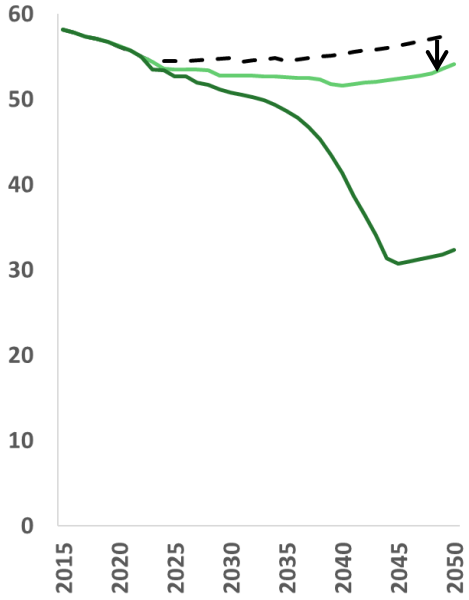
Share of electricity & H_2 in total final energy (%)



Emissions intensity (tCO2e/MWh)



Emissions intensity (tCO2/EJ)

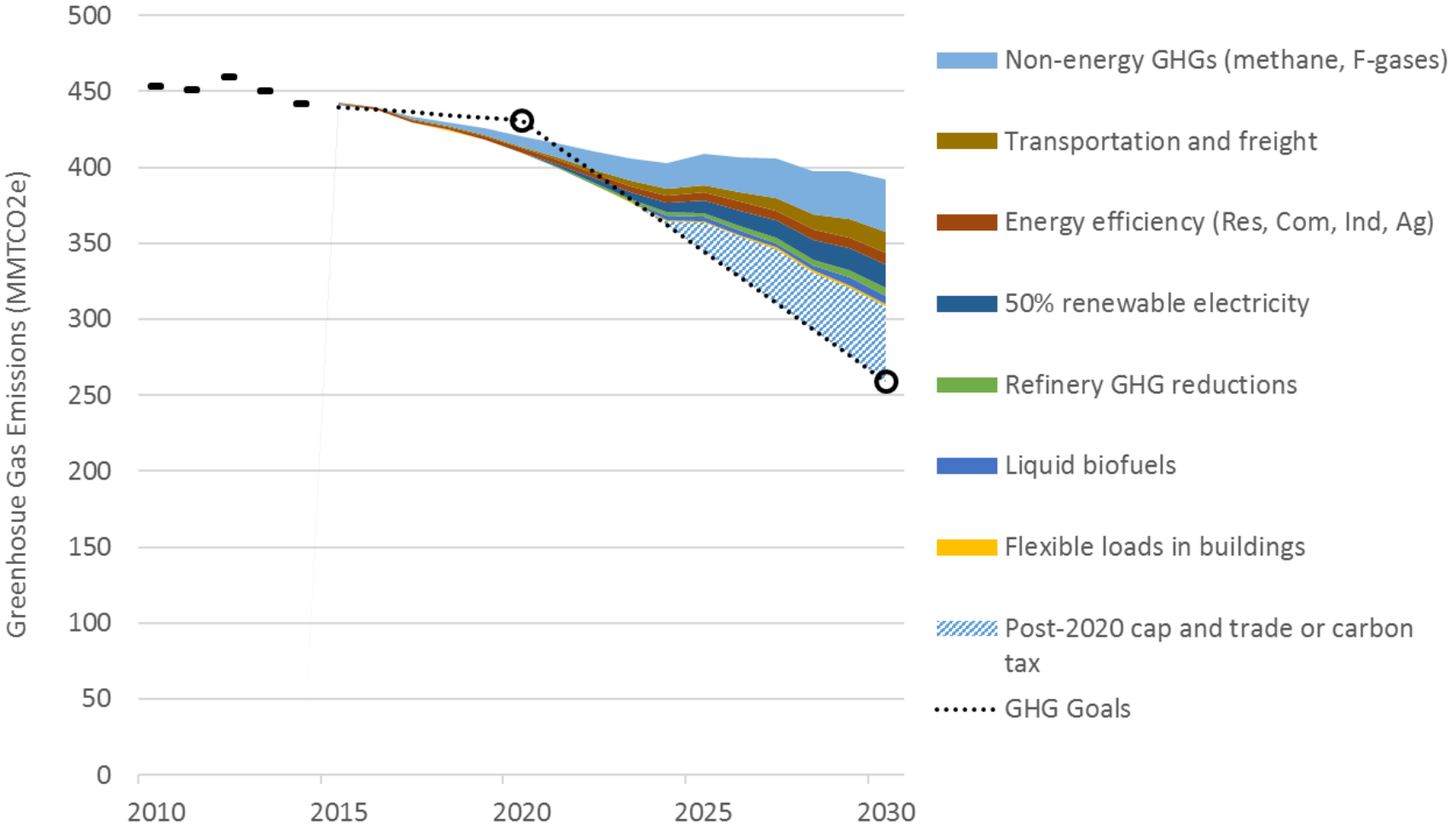


Where will California's 2030 GHG reductions come from?

- **Proposed plan includes significant increase in reliance on cap and trade, biofuels, energy efficiency & electric vehicles**
- **No electrification of buildings or industry**
- **No renewable gas (biogas) in the pipeline**

Proposed Scoping Plan Measures	% of 2030 GHG reductions
Flexible loads in buildings	1% - 2%
Liquid biofuels	2% - 4%
Mandated reduction in refinery GHGs	2% - 3%
Energy efficiency: buildings, industry, ag.	4% - 6%
50% Renewables Portfolio Standard	8% - 13%
Transportation measures (cars, trucks, etc.)	8% - 12%
Non-energy GHGs (methane, F-gasses)	17% - 19%
Cap and trade	45% - 55%

California's Proposed 2030 Scoping Plan



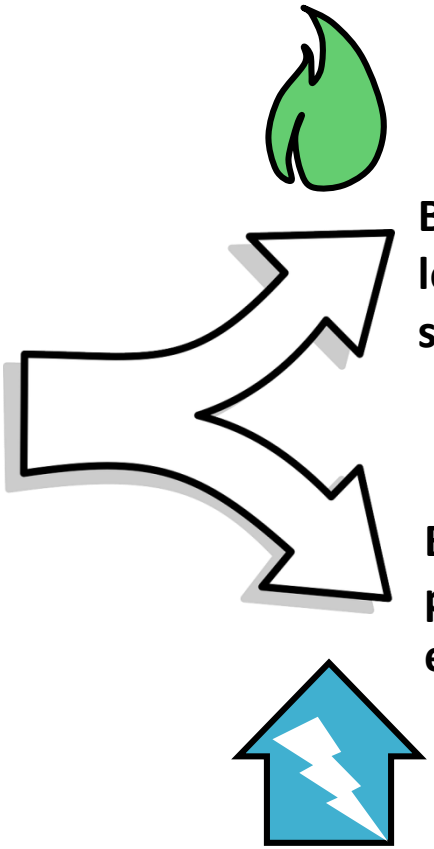
2050 CARBON MITIGATION STRATEGIES

How will we power our buildings?

Building strategy

Mostly space heating
And water heating

Also cooking, clothes drying, fireplaces, etc.



Biogas, H_2 and low-carbon synthetic methane

Electric heat pumps, electrification

Implications

Utilize existing gas pipeline infrastructure to deliver low-carbon fuels

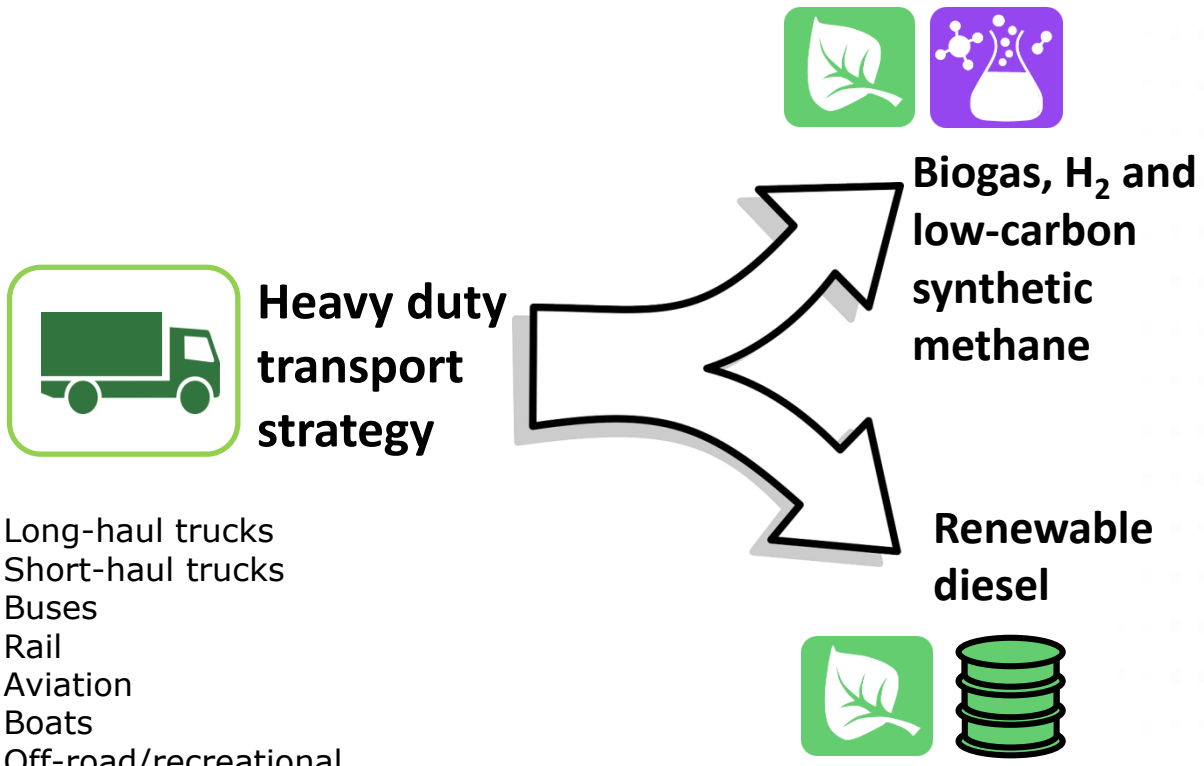
"Drop-in" fuels mean customers only see changes in their utility bill, not in their homes

Retrofit buildings to use heat pumps

All-electric new construction

Wind-down the gas distribution pipeline company

How will we power our trucks and heavy–duty transportation?



Long-haul trucks
Short-haul trucks
Buses
Rail
Aviation
Boats
Off-road/recreational

Implications

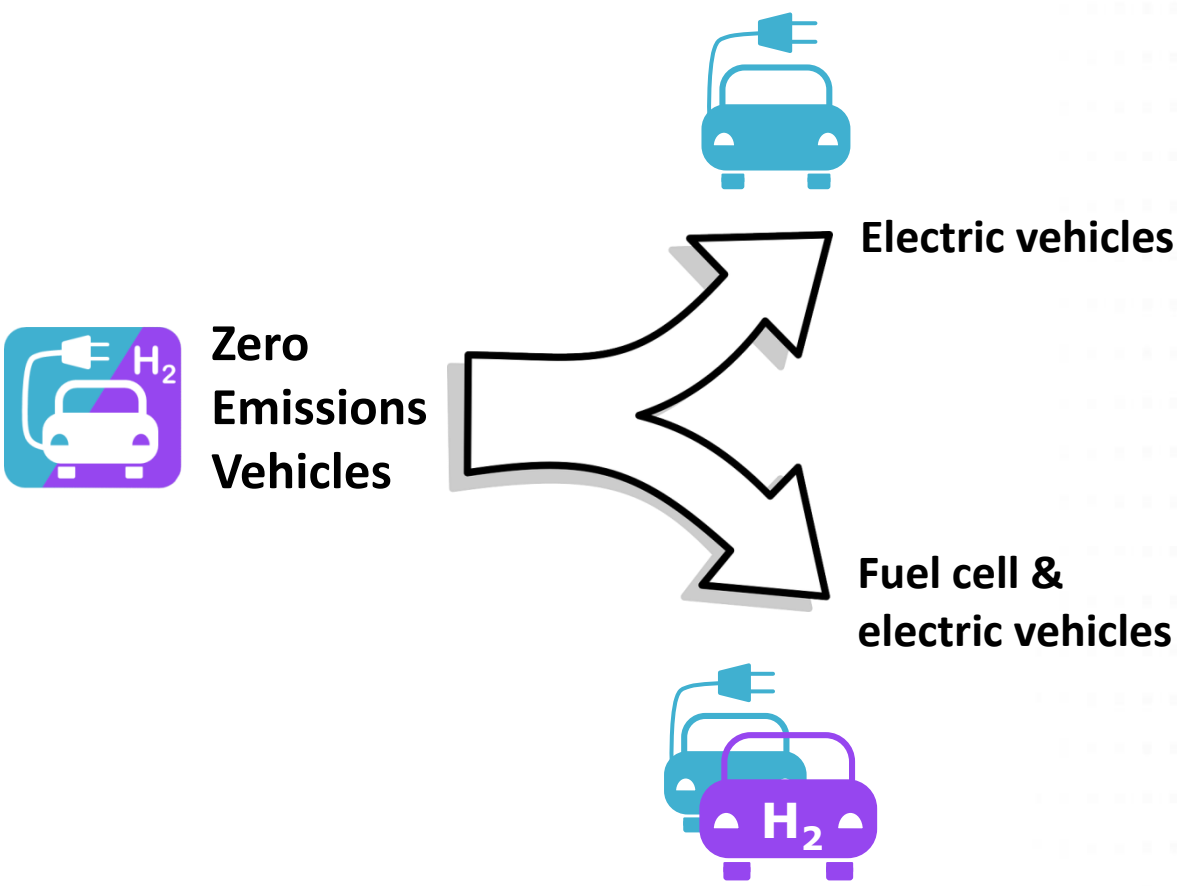
New vehicle technologies and fueling infrastructure would need to be built out

Hydrogen production and/or synthetic methane have co-benefit of providing long-term energy storage for the electric grid

"Drop-in" fuel means changes in fuel cost, but no change in vehicles or infrastructure

Will sufficient quantities of sustainable biofuels be available?

How will we power our cars and light trucks?



Implications

Electric vehicles are ahead of fuel cell vehicles on commercialization

Will consumers adopt all-electric vehicles en-mass?

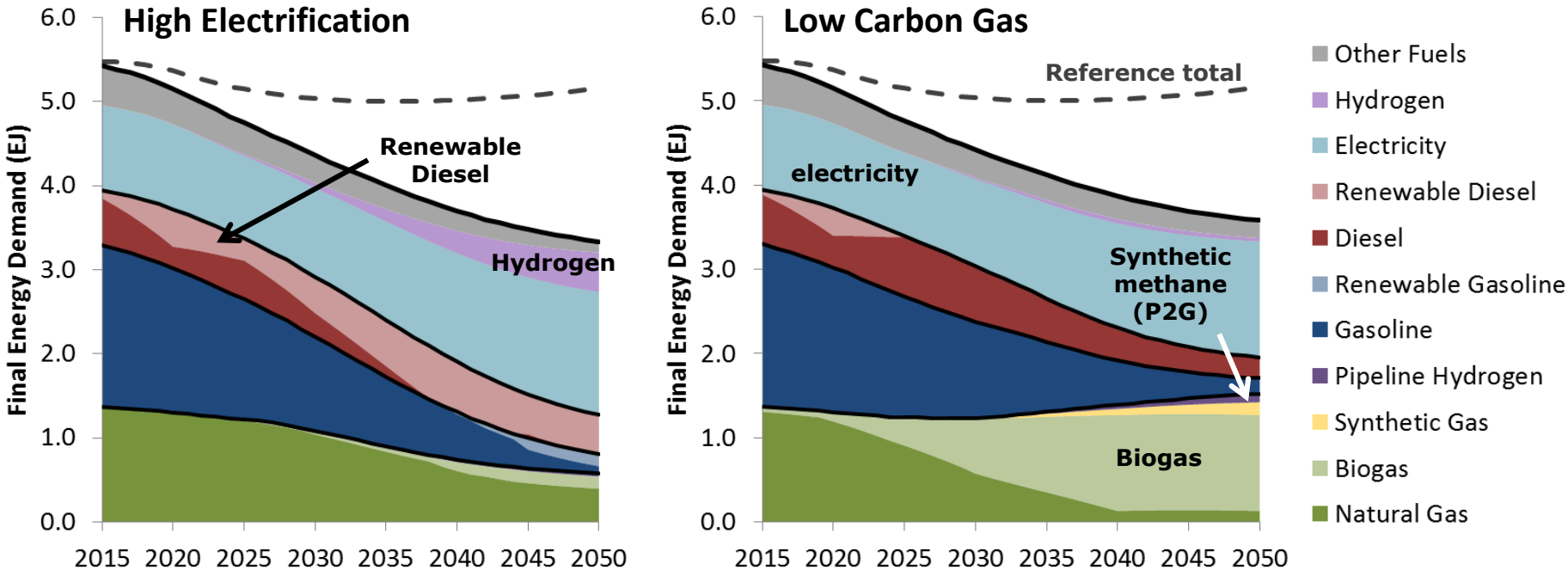
Fuel cell vehicles require new hydrogen distribution infrastructure

Hydrogen production has co-benefit of providing *long-term* energy storage for the electric grid

Different options for use of biofuels, but sustainable supplies are limited

- **Sustainable biomass supply is limited**, insufficient supply to displace both natural gas & diesel consumption (assuming CA's share of U.S. resource)
- **Straight line/Electrification scenario uses biomass for renewable diesel in trucks; Low-carbon gas scenario uses biogas in buildings & trucks**

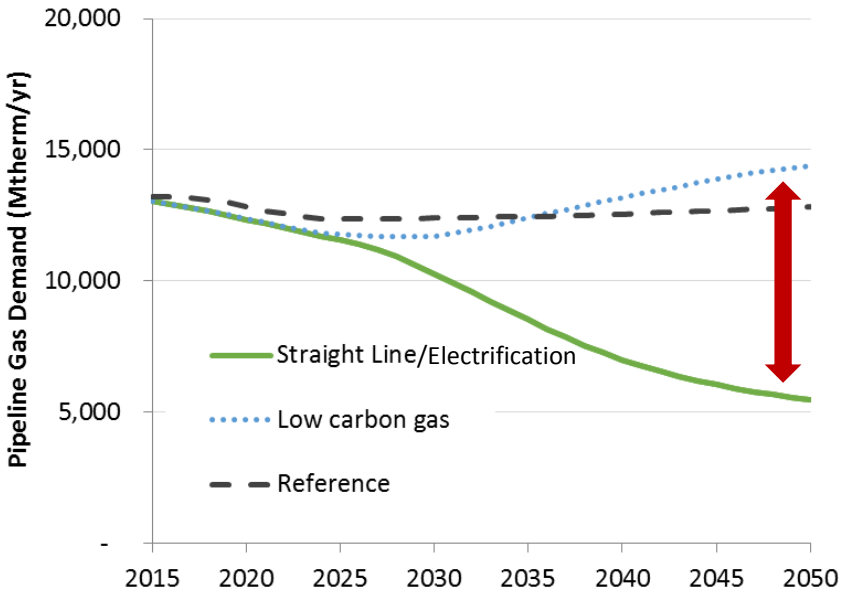
Final Energy Demand by Major Fuel Type



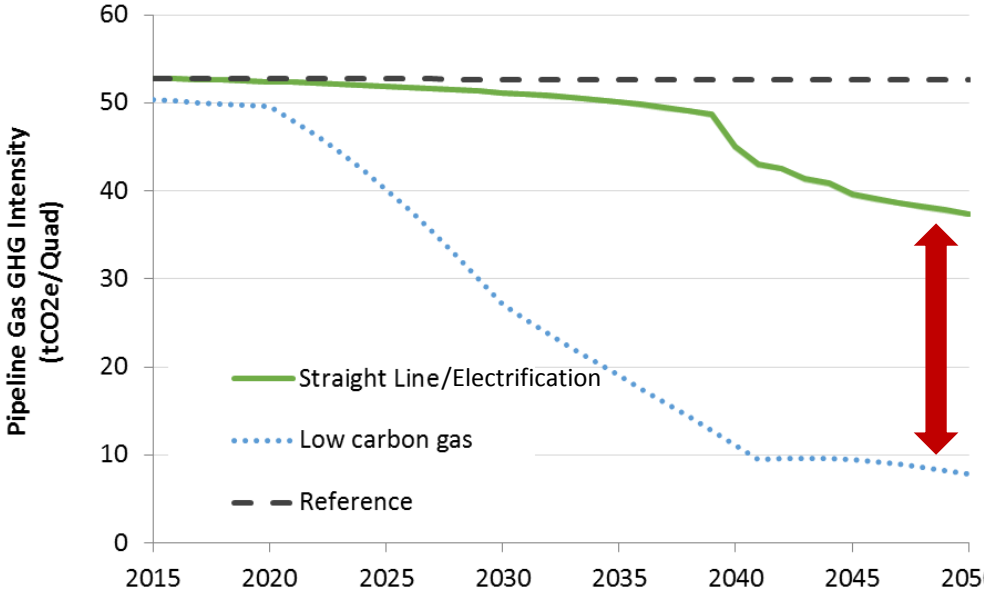
Gas Distribution Pipeline Future Depends on Low-Carbon Building Strategy

- **Pipeline gas through-put (non-electric generation) *decreases* in electrification scenario; Pipeline gas throughput (non-electric generation) remains flat or *increases* in low carbon gas scenario**
  - Emissions intensity of pipeline gas declines due to blending of biogas and hydrogen with natural gas

Pipeline gas demand (Mtherms/yr)



Pipeline gas emissions intensity (tCO2e/Quad)



Low Carbon Gas Scenario Findings

+ Benefits

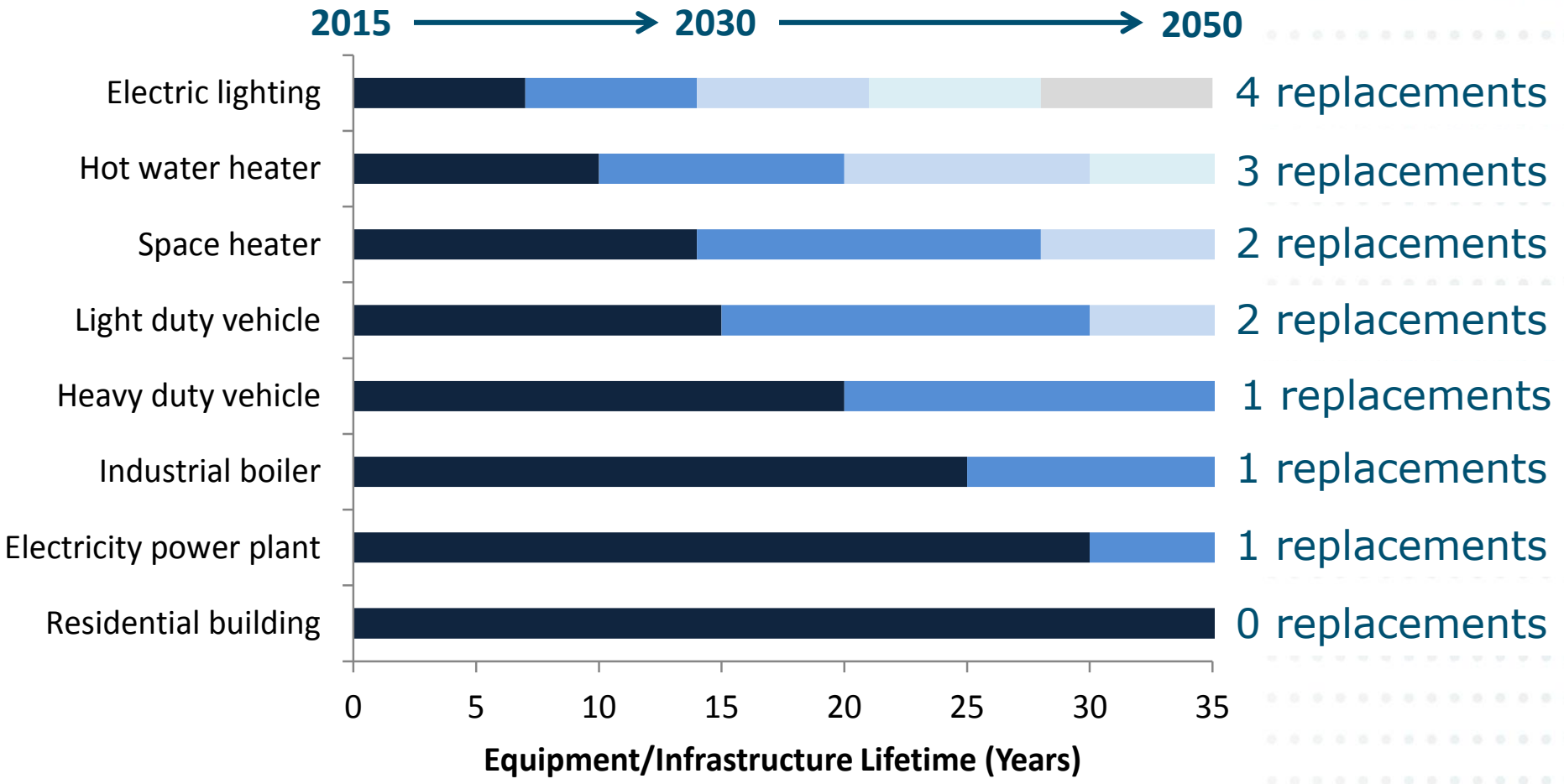
- Helps to diversify the technology risk of deep decarbonization and increase customer choice in buildings
- Reduces GHGs in sectors that may be difficult to electrify: e.g. heavy trucks, existing buildings, industrial processes
- Enables the continued use of the existing gas pipeline distribution infrastructure
- Production of hydrogen and synthetic low-carbon methane could play an important role in integrating variable renewable generation

+ Challenges

- Cost is uncertain, may be higher than electrification
- Technology advances needed in biogas and low-carbon synthetic gas

Timing for Action is Limited

- 2050 GHG goal is more feasible if implementation begins soon; drop-in low-carbon fuels may be more feasible than new infrastructure and equipment

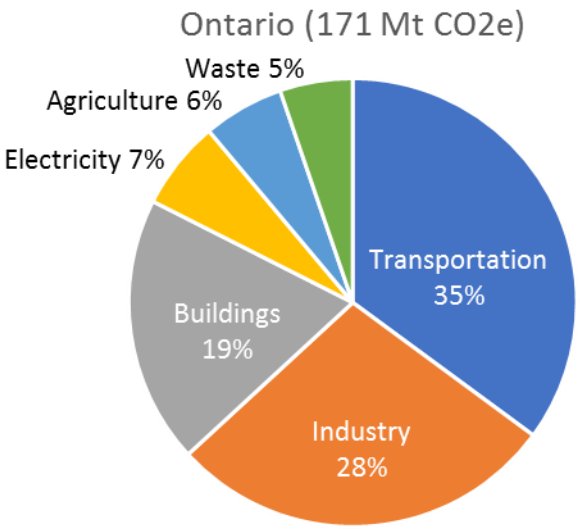


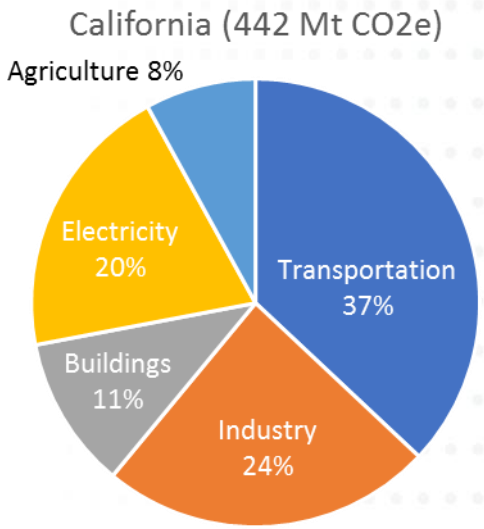
IMPLICATIONS IN ONTARIO

Differences between GHGs in Ontario & California

+ In Ontario:

- **Higher % of GHGs from direct fuel use in buildings**
  colder climate means larger heating needs, natural gas and fuel oil
- **Lower % of GHGs from electricity**
  greater reliance on nuclear energy





Source: Ontario's Climate Change Strategy, Figure 6a https://dr6j45jk9xcmk.cloudfront.net/documents/4928/climate-change-strategy-en.pdf
California 2030 Scoping Plan Update, Figure I-3 https://www.arb.ca.gov/cc/scopingplan/2030sp_pp_final.pdf

Role of natural gas in Ontario's low-carbon future?

- **By 2030, fossil natural gas will continue to play an important role in Ontario**
  - Currently, natural gas prices are low, making the economics of electrification and biogas challenging
  - Electrification options in buildings are not yet widespread
  - Biogas remains expensive, limited pilots in the pipeline
  - Turn-over of building and industrial equipment is slow
- **By 2050, natural gas in buildings and industry will need to be replaced with lower-carbon alternatives**
  - Low-carbon electricity and/or low-carbon gas (e.g. biogas)
- **What does the timing of this transition look like?**
  - Pilot programs to explore all-electric new construction and gain contractor experience with electric heat pumps
  - Pilot programs to bring down the cost of biogas and other biofuels

Key Carbon Reduction Strategies

- **Energy efficiency and electrification** – building energy efficiency programs must unlock deeper savings, pilots for building electrification in near-term
- **Electricity decarbonization** – electricity policy must drive near complete decarbonization by 2050
- **Transportation** – the majority of new light duty auto sales should be electric, fuel cell, or plug-in hybrid vehicles by 2030
- **Renewable Fuel Standards** – policy must encourage use of renewable electricity & fuels (e.g. hydrogen) produced from electricity, and encourage use of sustainable biomass to produce biofuels
- **Be proactive on distributional impacts of costs** – key to sustaining a long term policy effort

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Thank You!

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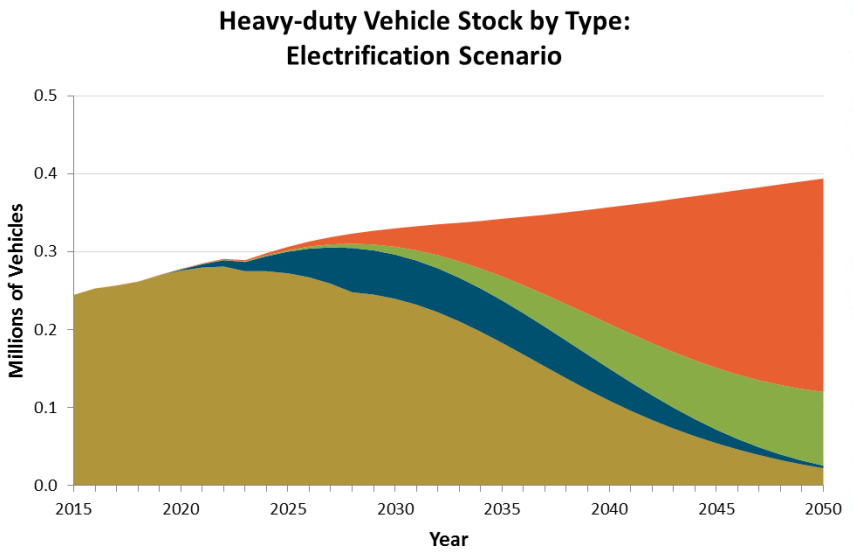
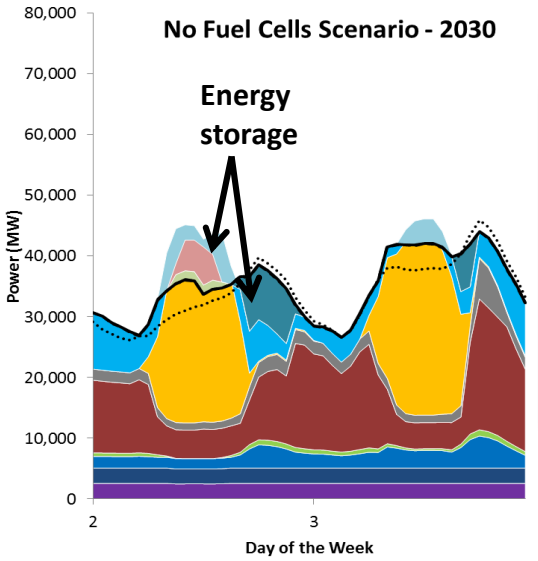
The PATHWAYS Model

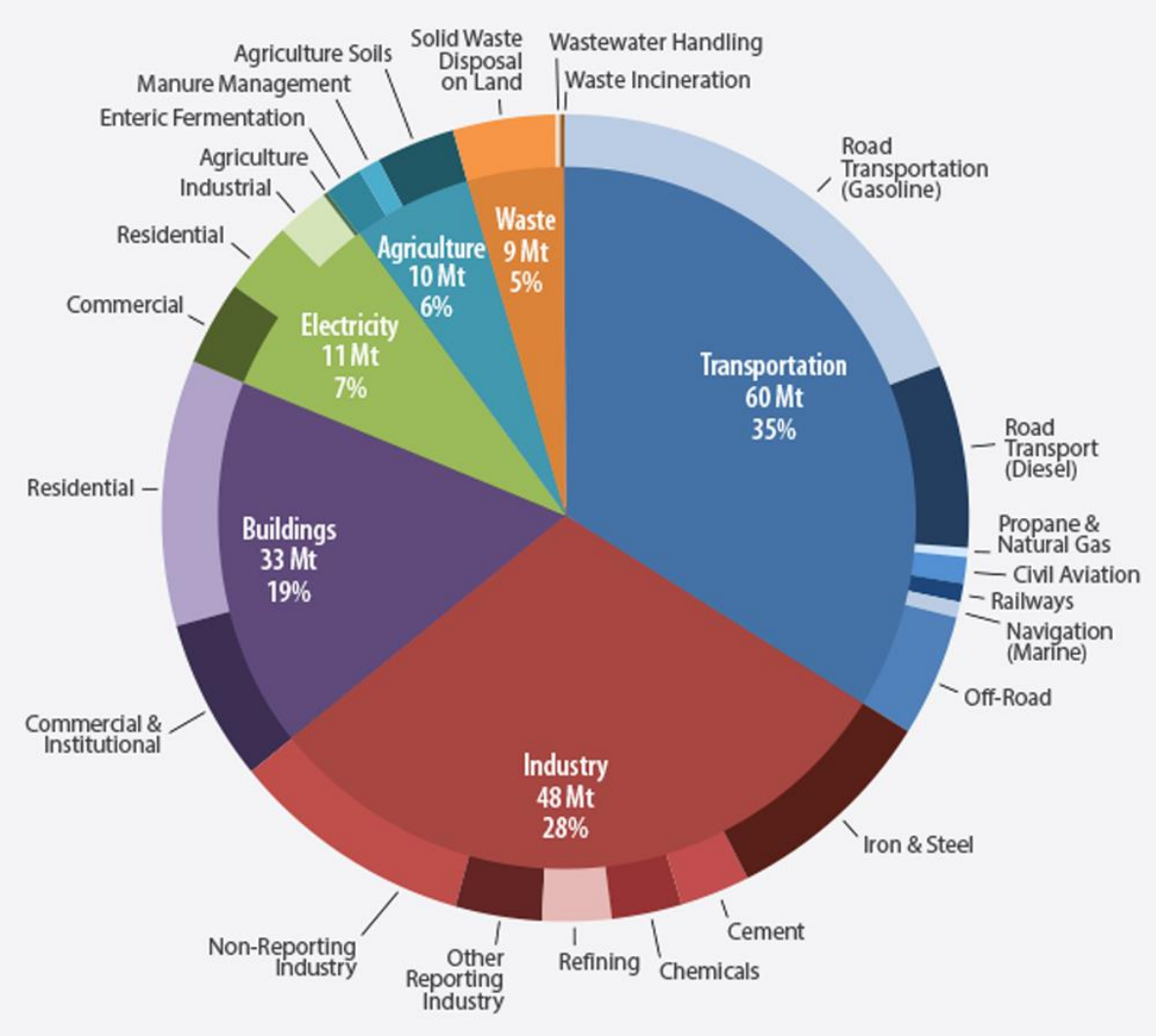
- **Back-casting, not forecasting**
- **Bottom-up, user-defined, non-optimized scenarios test "what if" questions**
- **Economy-wide model captures interactions between sectors & path-dependencies**
- **Annual time steps for infrastructure-based accounting simulates realistic stock roll-over**
- **Hourly treatment of electric sector**
- **Tracks capital investments and fuel costs over time**





Allows for development of realistic & concrete GHG reduction roadmaps

Ontario's Carbon Emissions (2013)



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