

Clean Energy and Electrification Assessment & Research efforts in Canada

Workshop on the Development of an Open Modelling Platform for Electrification and Deep Decarbonisation Studies

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Overview: EPRI's Efficient Electrification Initiative

Why Efficient Electrification Is Important

- Means for a clean electric future

Efficient Electrification Research & Insights

- Key messages from recent assessment

What We Can Achieve

- Canadian Clean Energy & Electrification Assessment

EPRI and Our Canadian Members...

- **Independent, collaborative, non-profit organization**
conducting R&D related to the generation, delivery, and use of electricity – scientific, fact based information to guide decisions
- Over \$420 M in funding annually
 - EPRI members generate about 90% of the electricity in the US
 - About 30% of EPRI's RD&D is international (> 450 participants in 35 countries)
- **Thought leadership, industry expertise, and collaborative value**
- Research across all sectors of the electric industry each focused on a particular area of industry interest

BC Hydro

FORTIS ALBERTA

ENMAX

Capital Power

SaskPower

hydro one

Manitoba Hydro

COG
CANOU Omeca Group

TransCanada
In business to deliver

NOVA SCOTIA
POWER
An Emera Company

TransAlta

Hydro Québec

ATCO Power

ONTARIO POWER
GENERATION

Bruce Power

Énergie NB Power

ieso
Independent Electricity
System Operator

Emera

Teck

Advancing safe, reliable, affordable, and environmentally responsible electricity for society

Comprehensive Energy System Analysis (REGEN Model)

Energy Use



- Climate zones
- Building types
- Household characteristics
- Industrial mix
- End-use technology detail

SYNCHRONIZED
Hourly Load,
Renewables & Prices



Model Outputs:

- Generation Capacity
- Wholesale Price
- End-use Mix
- Emissions, Air Quality & Water
- Demand Profiles

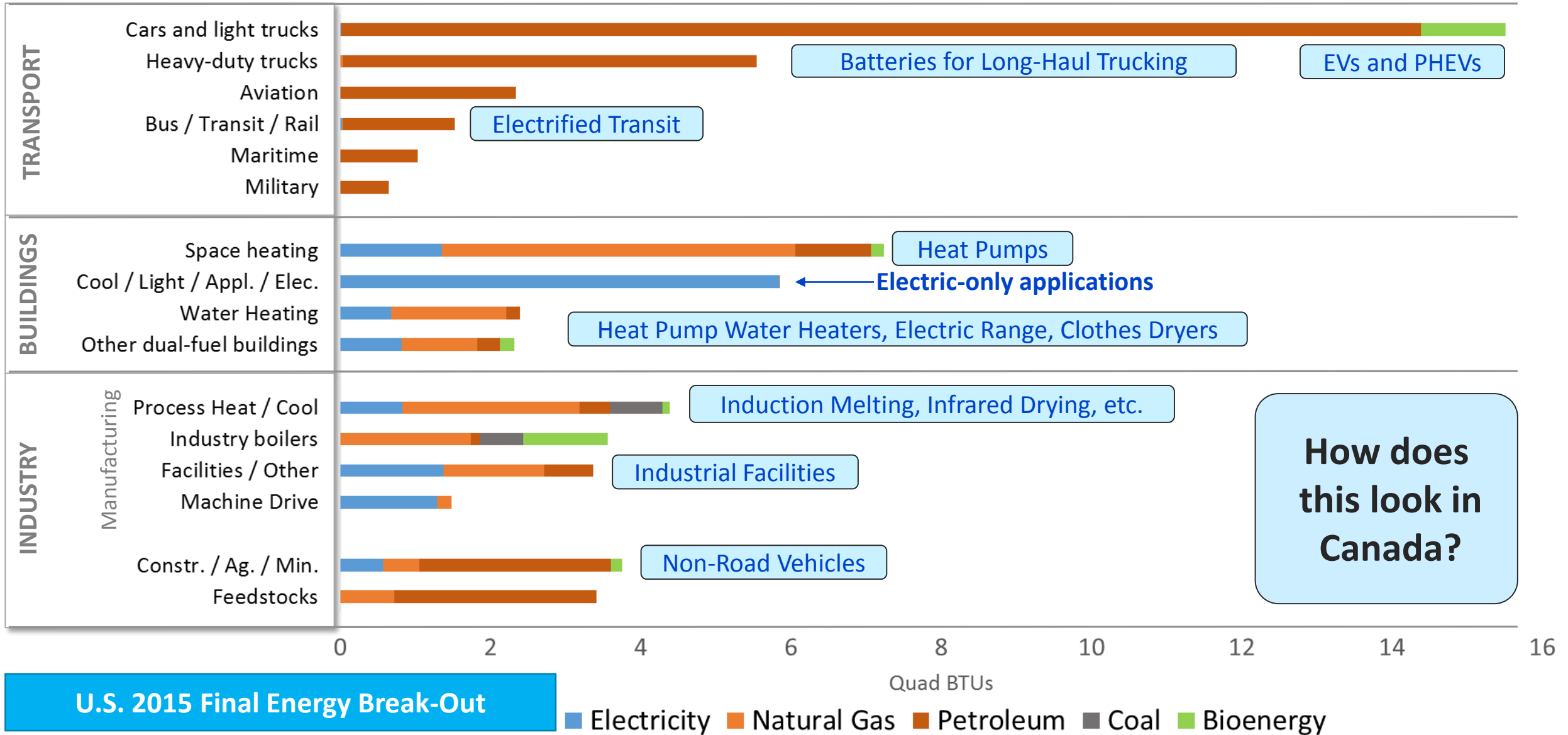
Electric Sector



- Investment and dispatch
- Transmission and interchange
- Integration of renewables
- Electrification
- Energy and capacity requirements
- Region policies and constraints

EPRI's State-of-the-Art Modeling System Synchronizes Energy End-Use and Electric Sector Scenarios

Potential for Efficient Electrification Varies by End-Use Application



Canada REGEN End-Use Model Level of Detail by Sector



Transportation



Buildings



Industry

Cars and Light Trucks

- Bus and Passenger Rail
- Aviation (domestic)
- Aviation (international)
- Light Commercial Trucks
- Heavy Trucks
- Freight Rail (non-energy)
- Shipping (domestic)
- Shipping (international)
- Military
- Fuel Transport (rail)
- Pipeline

- ICEV
- PHEV
- EV

Residential and Commercial

Space Cooling

Space Heating

- Water Heating
- Clothes Dryers
- Cooking
- Lighting
- Other Appliances
- Electronics
- Ventilation
- Other Building

- Central A/C
- Window A/C
- Air-Source Heat Pump
- Ground-Source Heat Pump
- Electric Furnace/Resistance
- Gas Furnace
- Oil/LPG Furnace
- Wood Furnace/Stove

Agriculture

- Construction
- Mining (non-energy)
- Non-Building Commercial
- Water Services
- Bulk Chemicals
- Iron and Steel
- Paper/Pulp/Wood
- Food
- Cement
- Other Manufacturing
- Refining
- Upstream Energy Extraction

- Boilers
- Co-gen Boilers
- Process Heat
- Machine Drive
- Feedstocks
- Facilities

SECTORS / ACTIVITIES

END-USES

TECHNOLOGIES

Full Report Roll

<https://www.epri.com/#/pages/product/3002013582/>

EPRI | ELECTRIC POWER
RESEARCH INSTITUTE

U.S. National Electrification Assessment



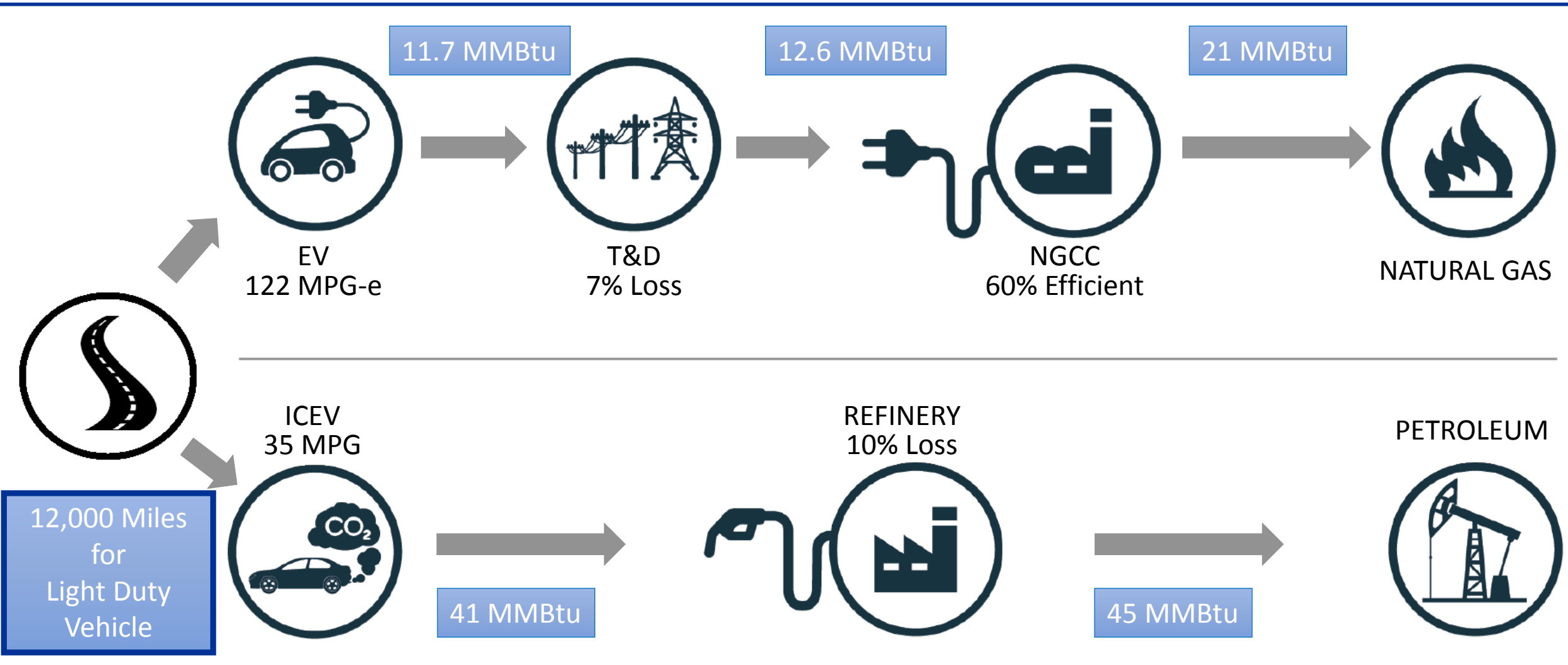
Key Assumptions for NEA Scenarios

	CONSERVATIVE	REFERENCE	PROGRESSIVE	TRANSFORMATION
Light-Duty Vehicle Costs	Slower decline in battery costs	EPRI/ANL estimates	EPRI/ANL estimates	EPRI/ANL estimates
Other Technology Costs	EPRI estimates	EPRI estimates	EPRI estimates	EPRI estimates
Efficiency Improvements	EPRI estimates	EPRI estimates	EPRI estimates	EPRI estimates
Economic Growth / Service Demands	AEO 2017	AEO 2017	AEO 2017	AEO 2017
Primary Fuel Prices (Natural Gas, Oil)	AEO 2017 Low Price Case	AEO 2017 Low Price Case	AEO 2017 Low Price Case	AEO 2017 Low Price Case
Electric Sector Policies	State RPS only	State RPS only	State RPS + \$15/tCO₂ in 2020, rising at 7%	State RPS + \$50/tCO₂ in 2020, rising at 7%
End-Use Sector Policies	None	None	\$15/tCO₂ in 2020, rising at 7%	\$50/tCO₂ in 2020, rising at 7%

Transportation

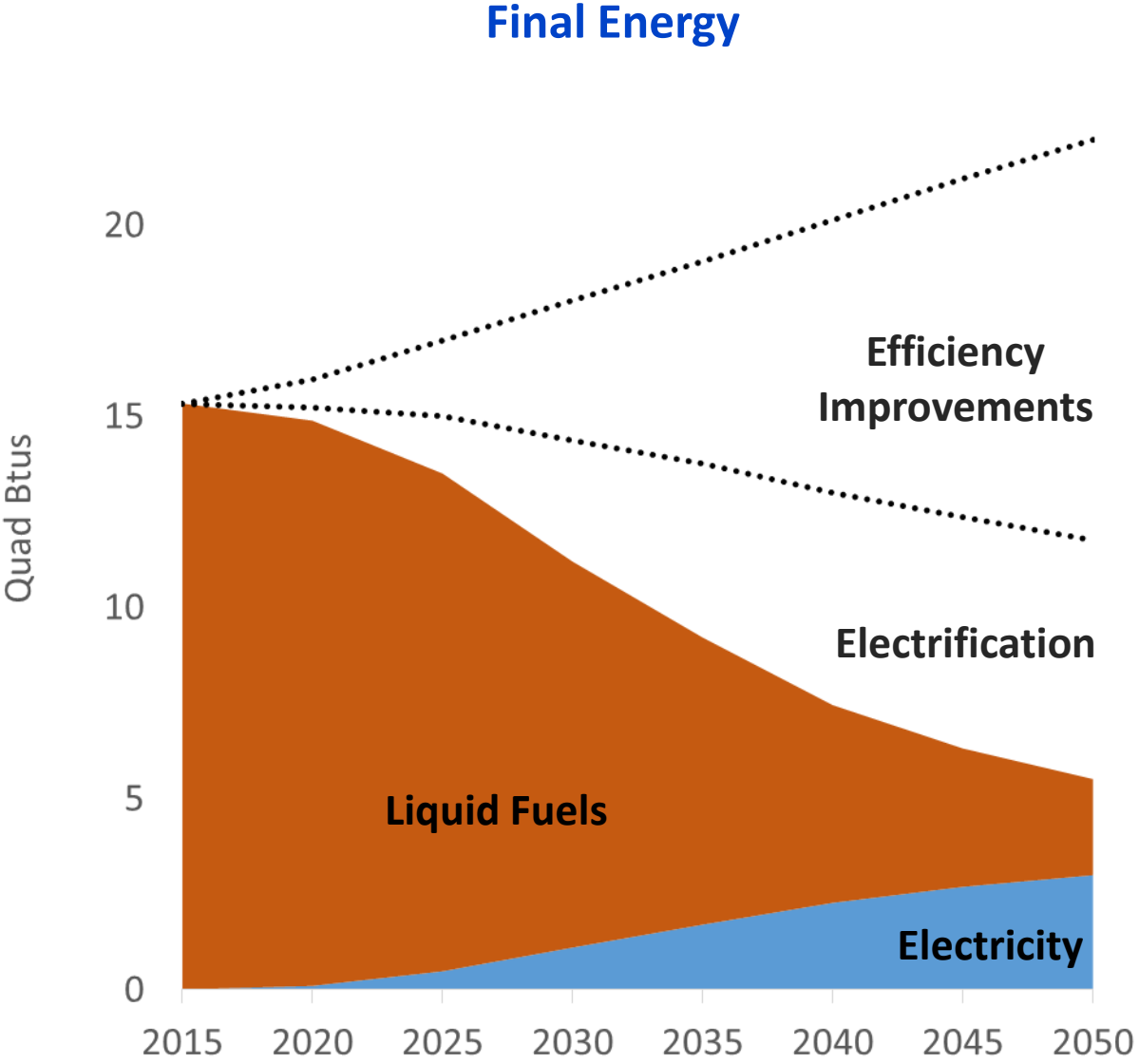
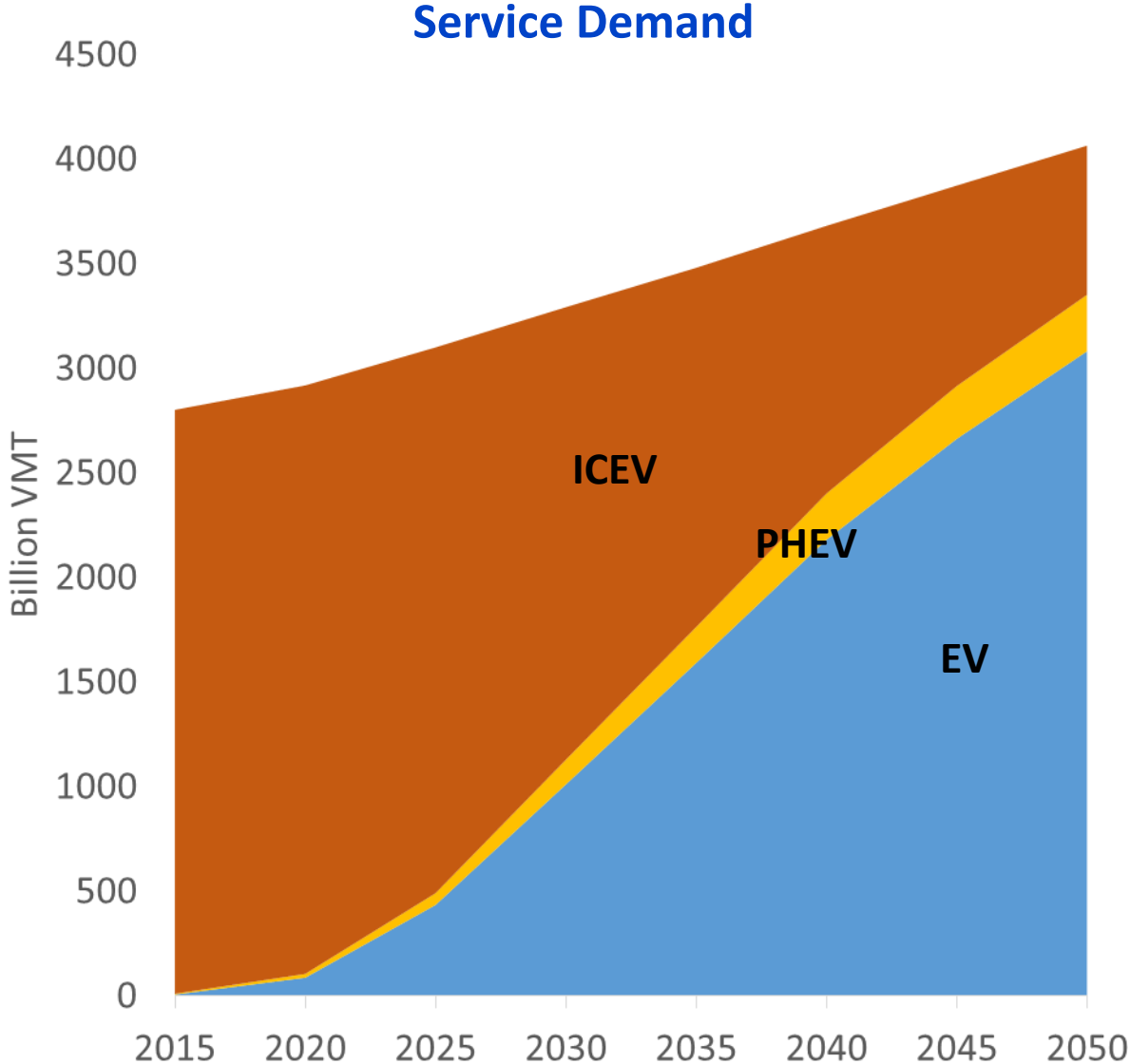


One Year of Driving: Electric vs. Non-Electric



ICEV Uses 3.5 Times More Final Energy and Emits 3 Times More CO₂ than EV

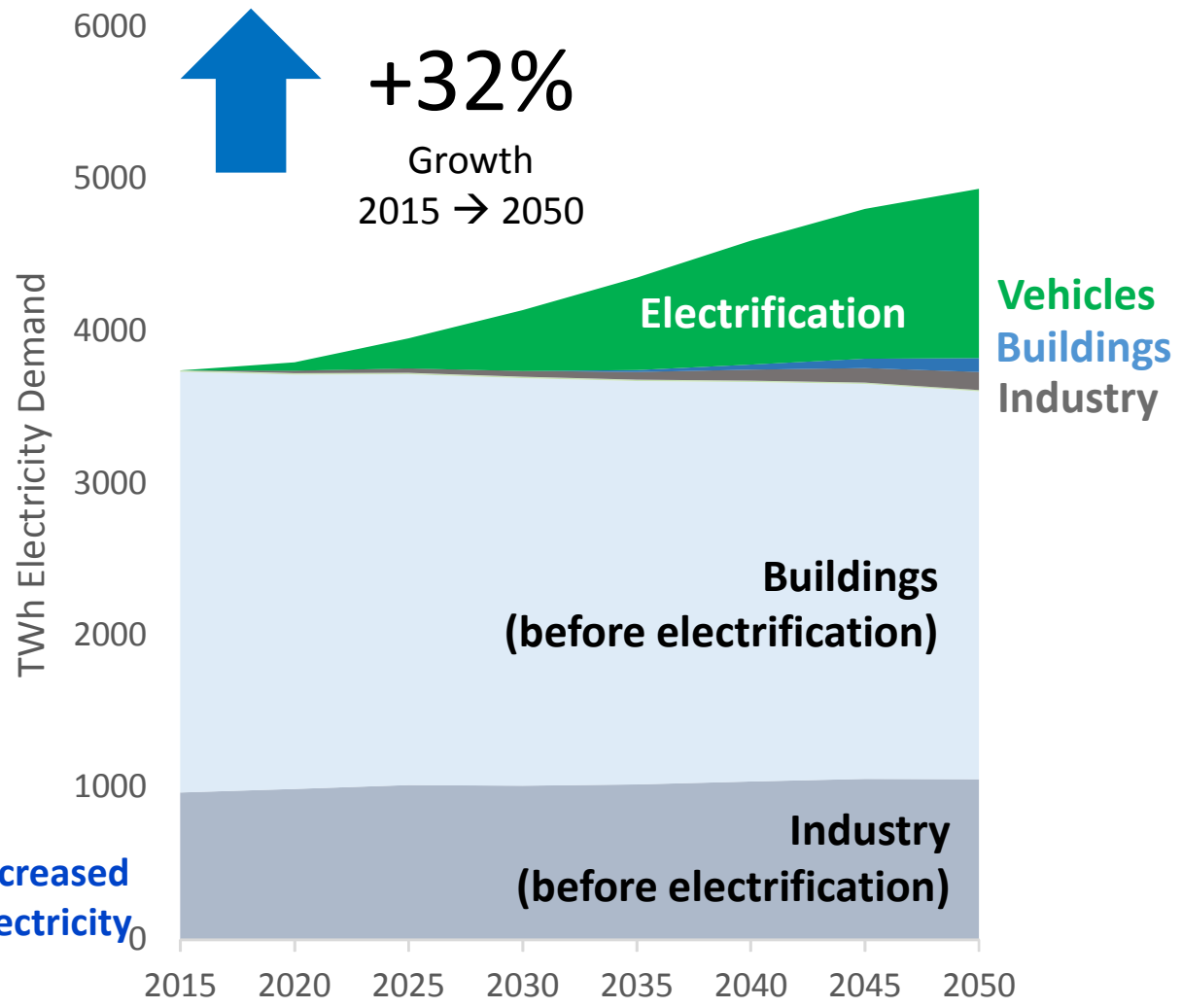
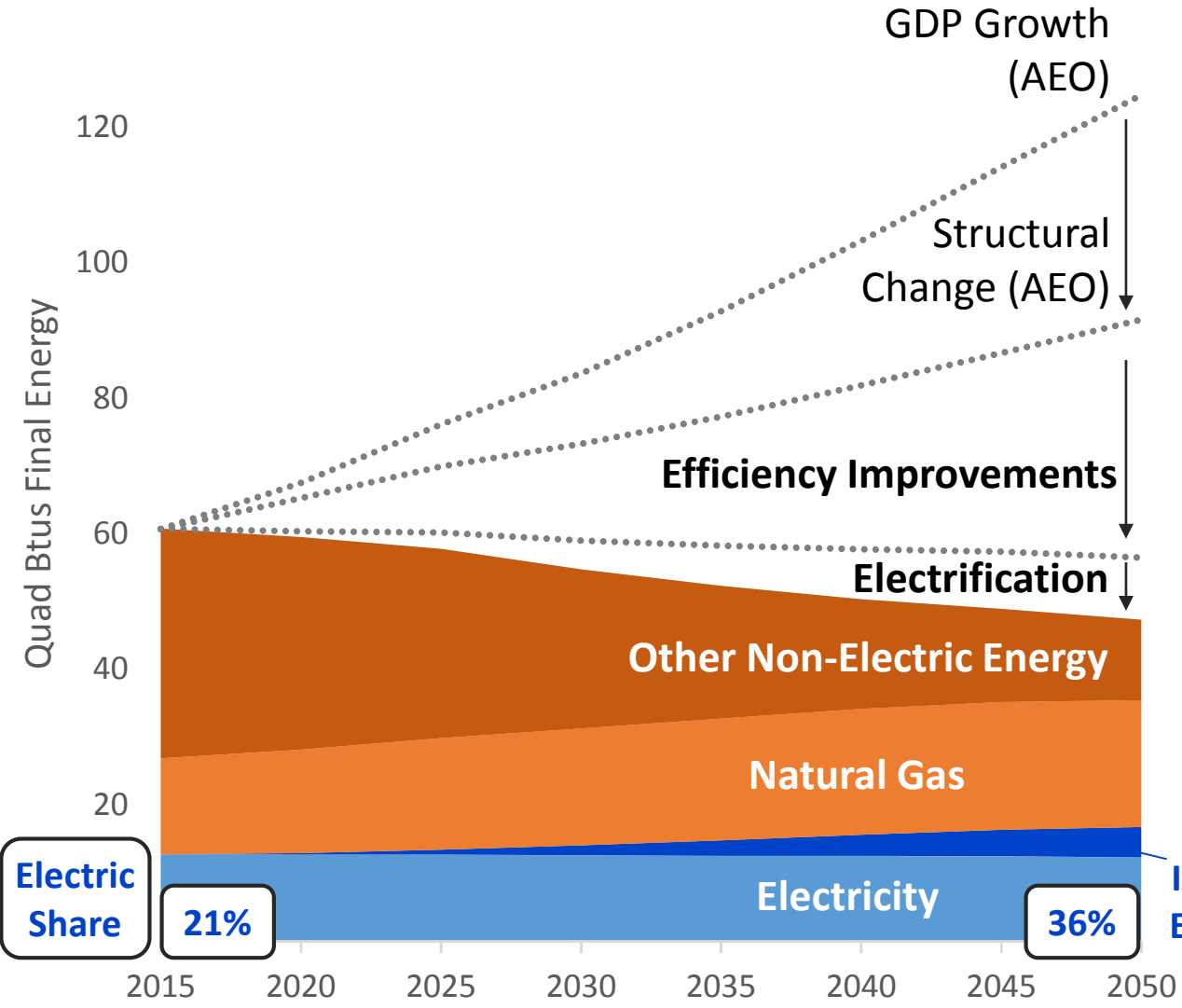
Reference Projections for US Light-Duty Vehicles



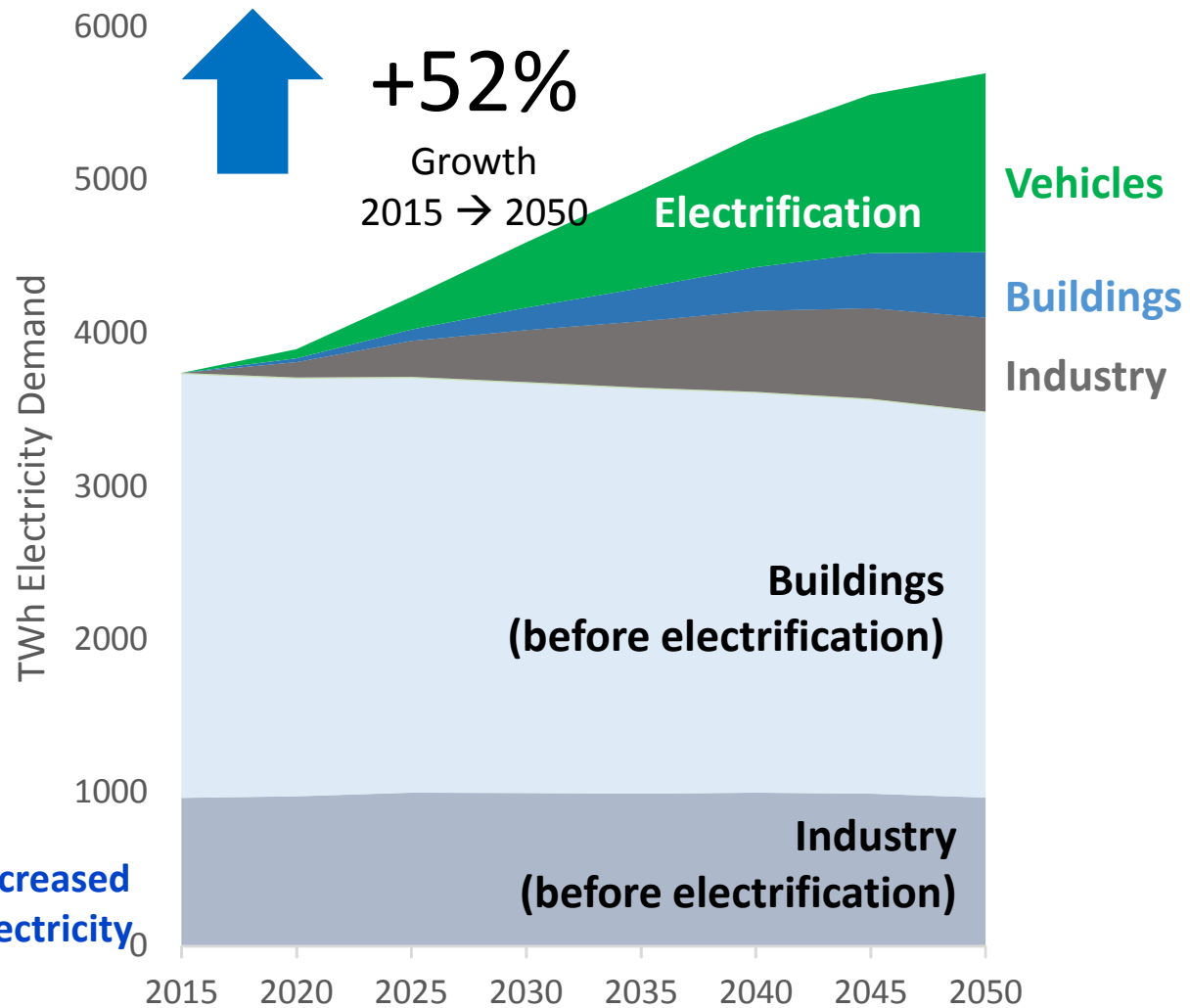
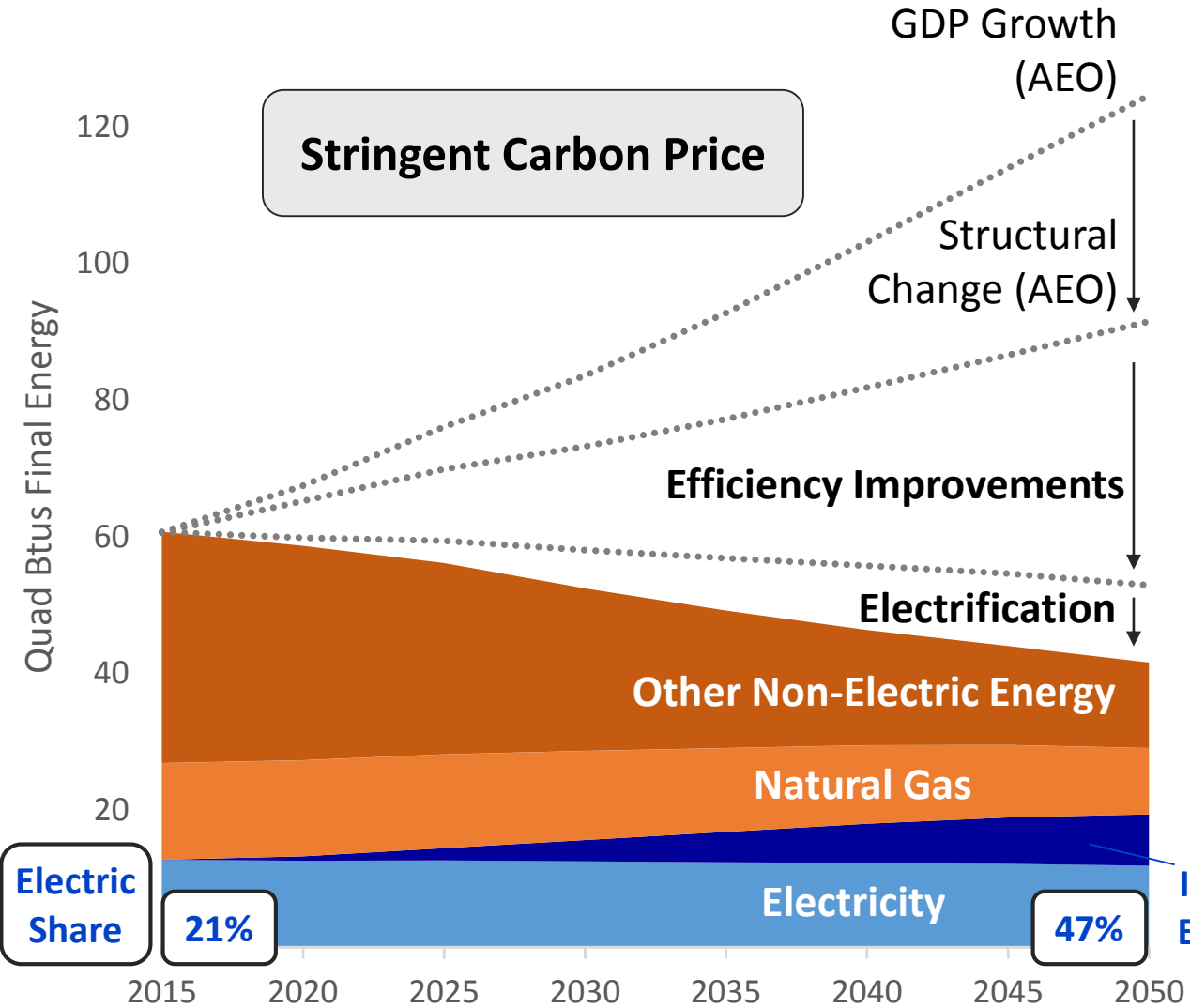
Summary of Total Final Energy



Efficient Electrification: Reference Scenario

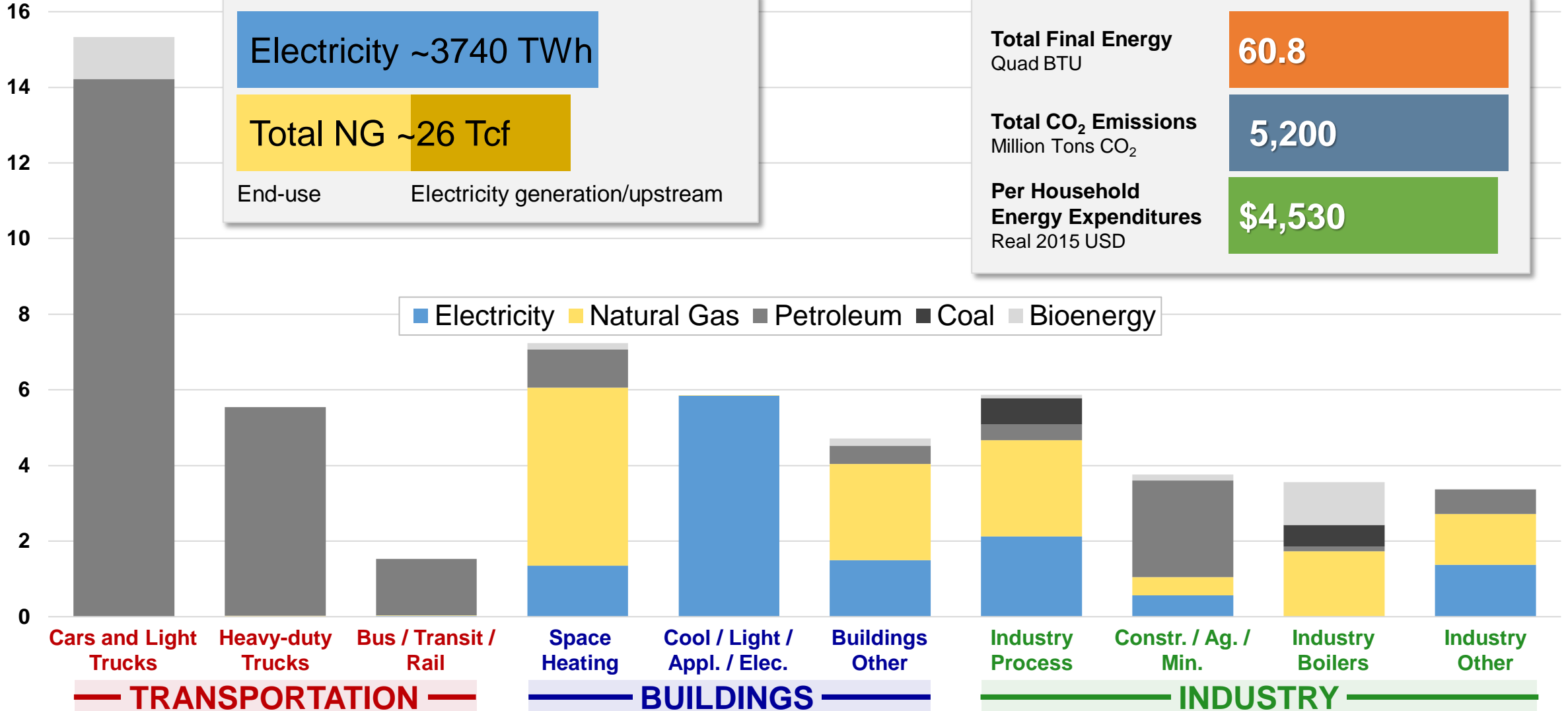


Efficient Electrification: Transformation Scenario



US Electrification Assessment: Use of Energy 2015

Quad BTUs

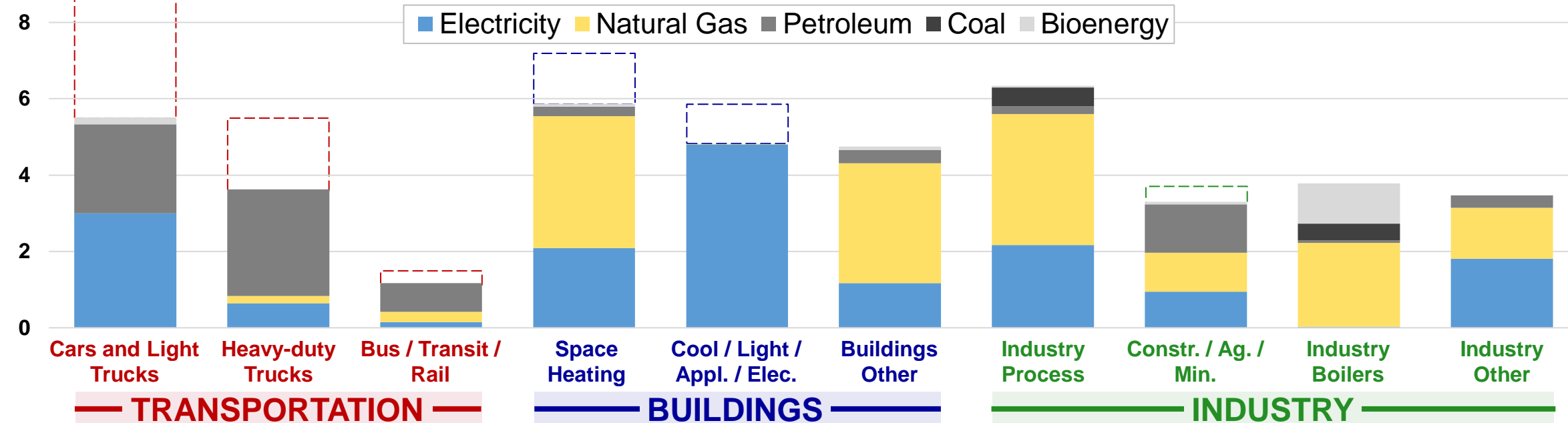
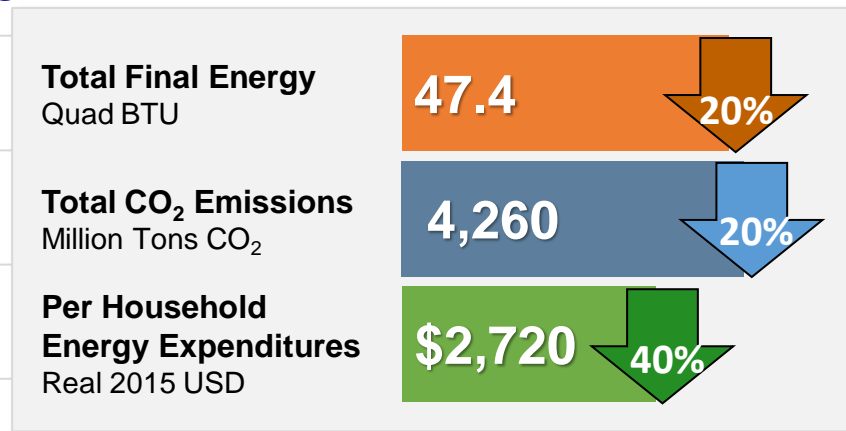


* Final Energy, excludes upstream and midstream energy use, e.g., power generation, oil and gas extraction, refining, and pipelines

US Electrification Assessment: Use of Energy 2015 - 2050

Quad BTUs

REFERENCE SCENARIO

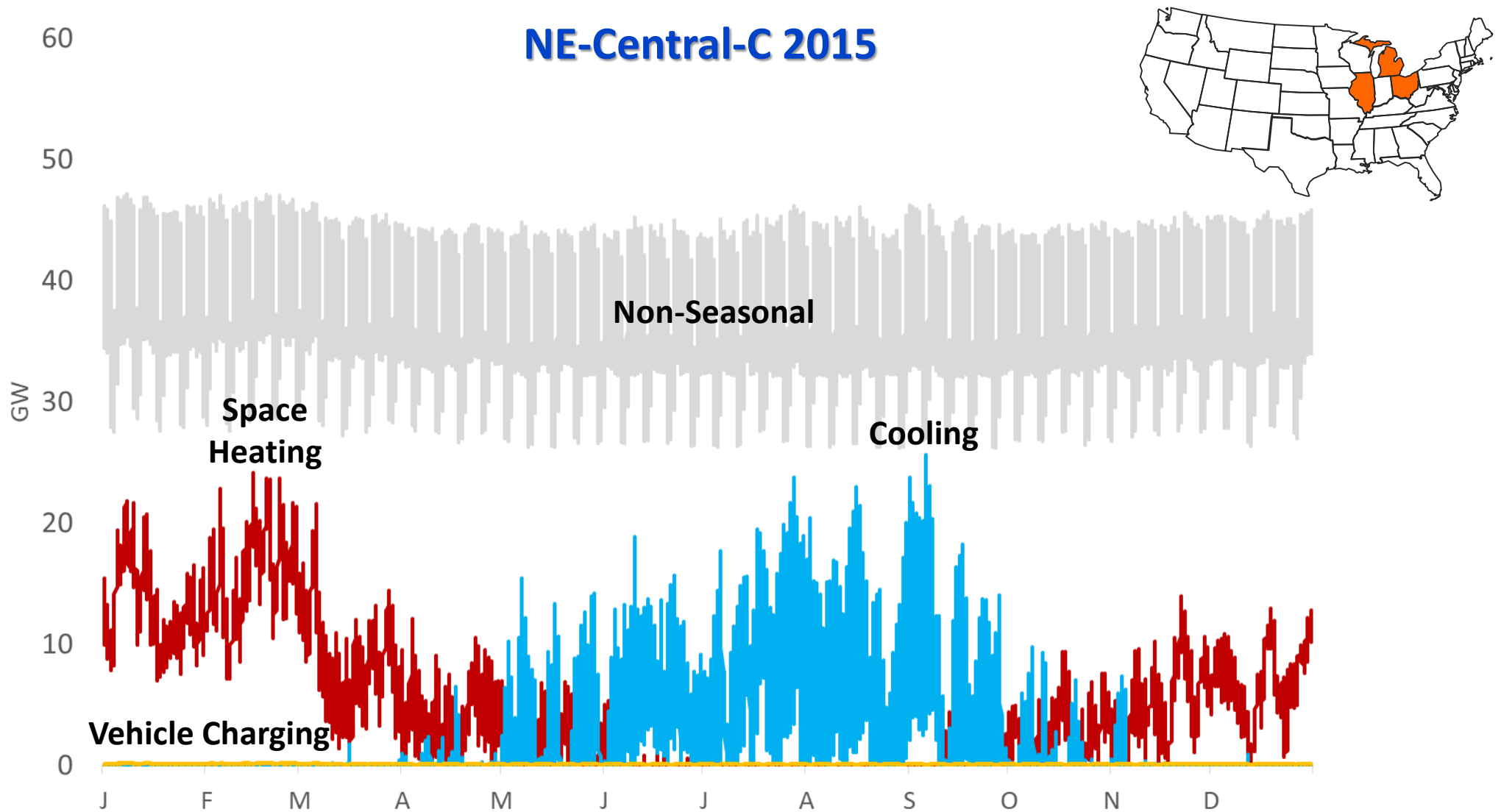


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Electric Generation and Emissions

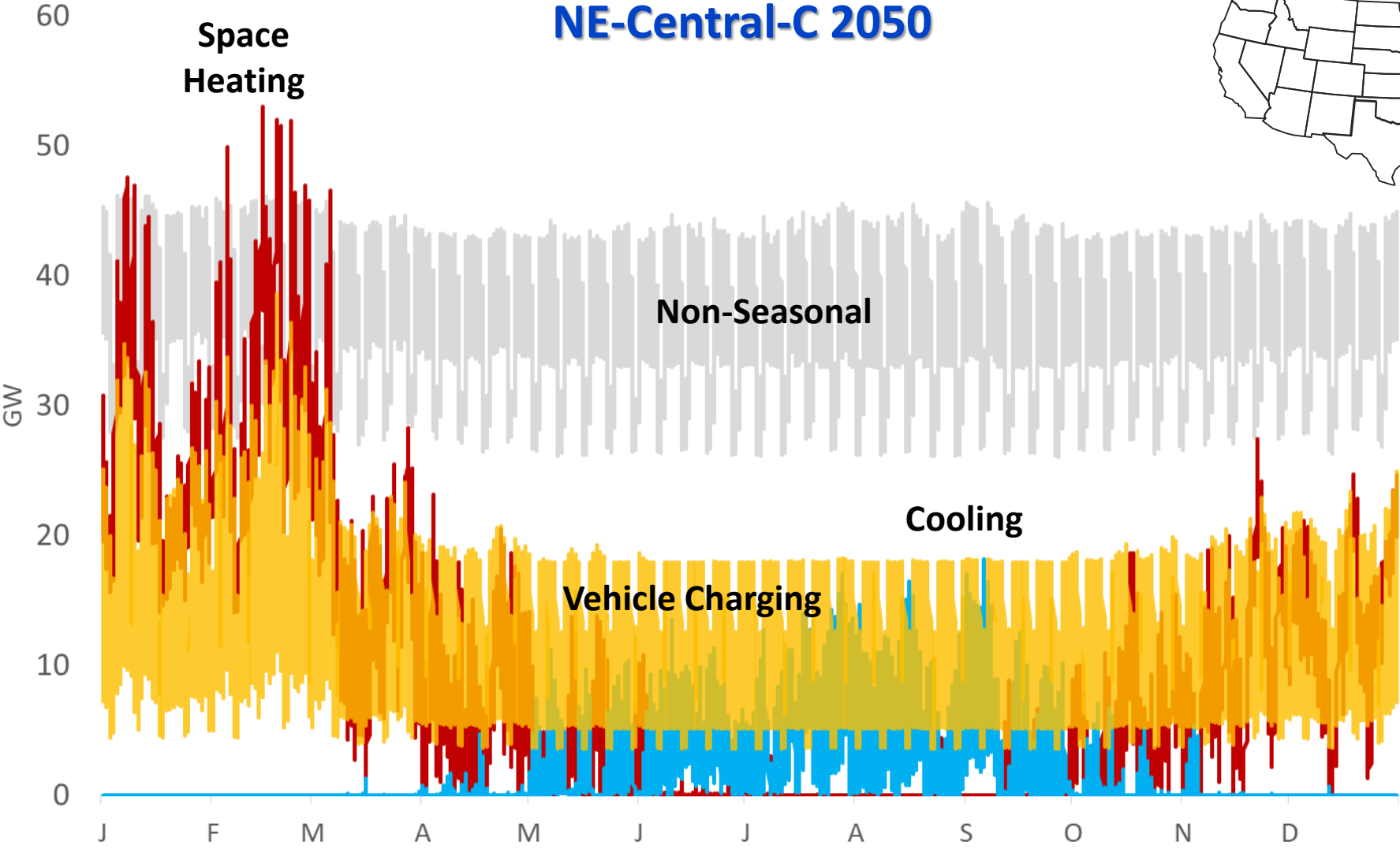


Load Shape Changes from Electrification and Efficiency



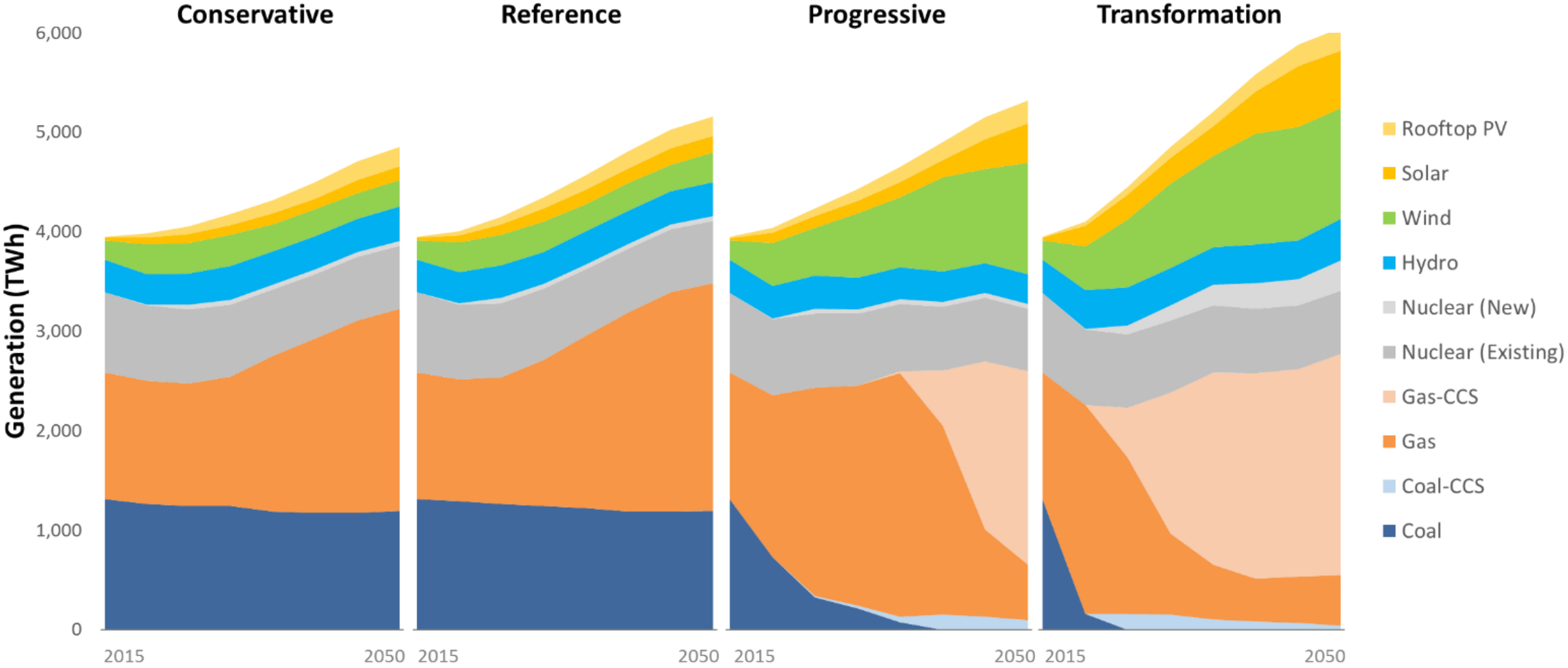
How Will Sectoral Loads Shift Over Time?

Load Shape Changes: What Are System Impacts?

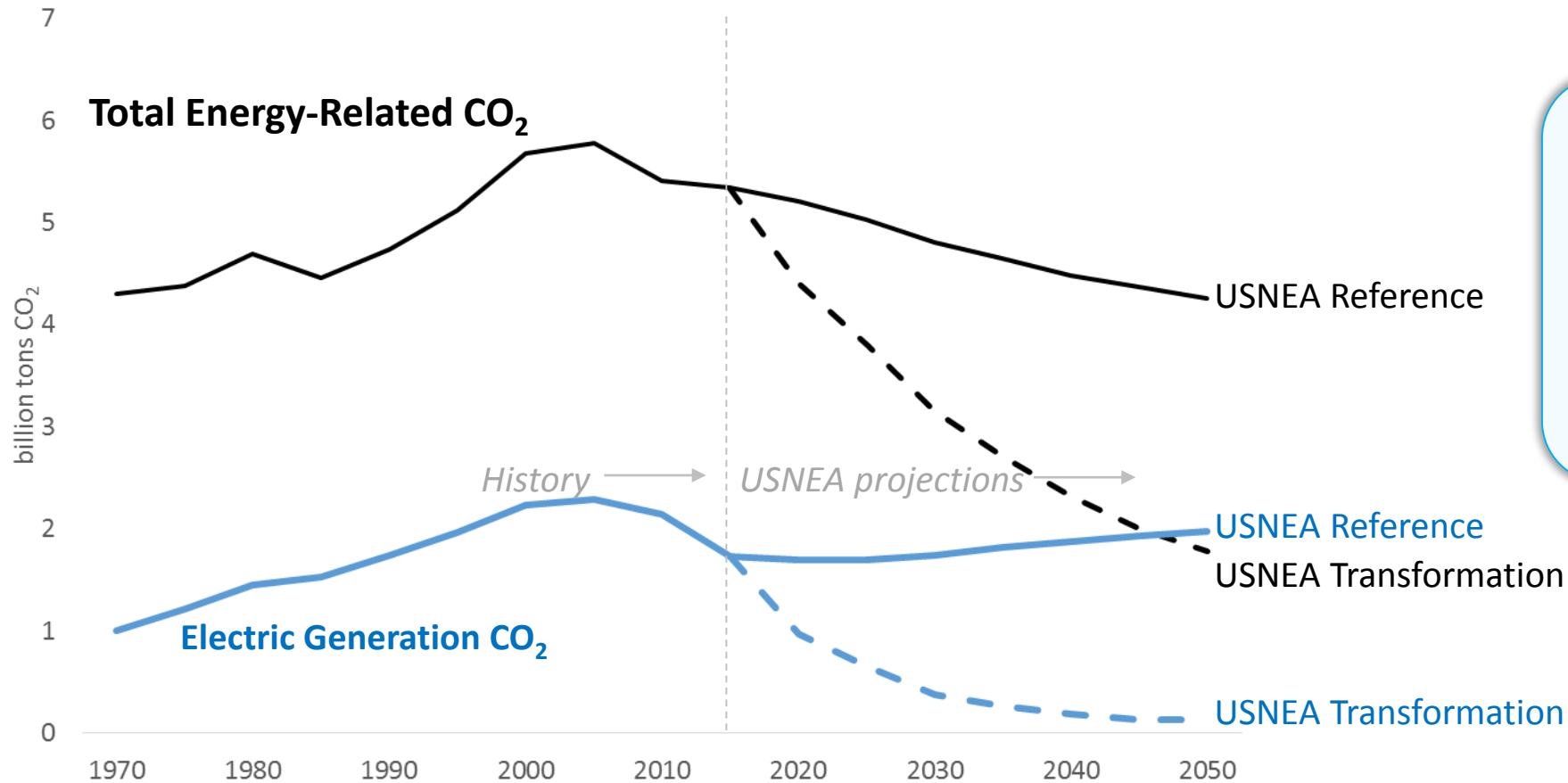


Significant Shift in Pattern and Size of Load

Electric Generation Mix Across USNEA Scenarios



Total and Electric Generation CO₂ Emissions



Increasing electrification leads to lower overall CO₂ emissions, even as emissions from electric generation increase in the USNEA Reference

Key Messages from National Electrification Assessment

Electrification Trend Continues

Driven by technological change and consumer choice, further bolstered by policy

Energy Efficiency

Efficient electrification + end-use efficiency lead to falling final energy use

Natural Gas

Remains an important fuel for end-use and electric generation; demand rises in all scenarios

Environmental Benefits

Electrification enables cost-effective, economy-wide decarbonization

To realize the potential outlined here

Pro-active approaches and technology R&D are essential

Canadian Clean Energy and Electrification Assessment



Task 1:
Canadian Electric Sector Model
Development
(Underway - EPRI Funding)



Task 2:
Canadian Energy
End-Use Model
Development



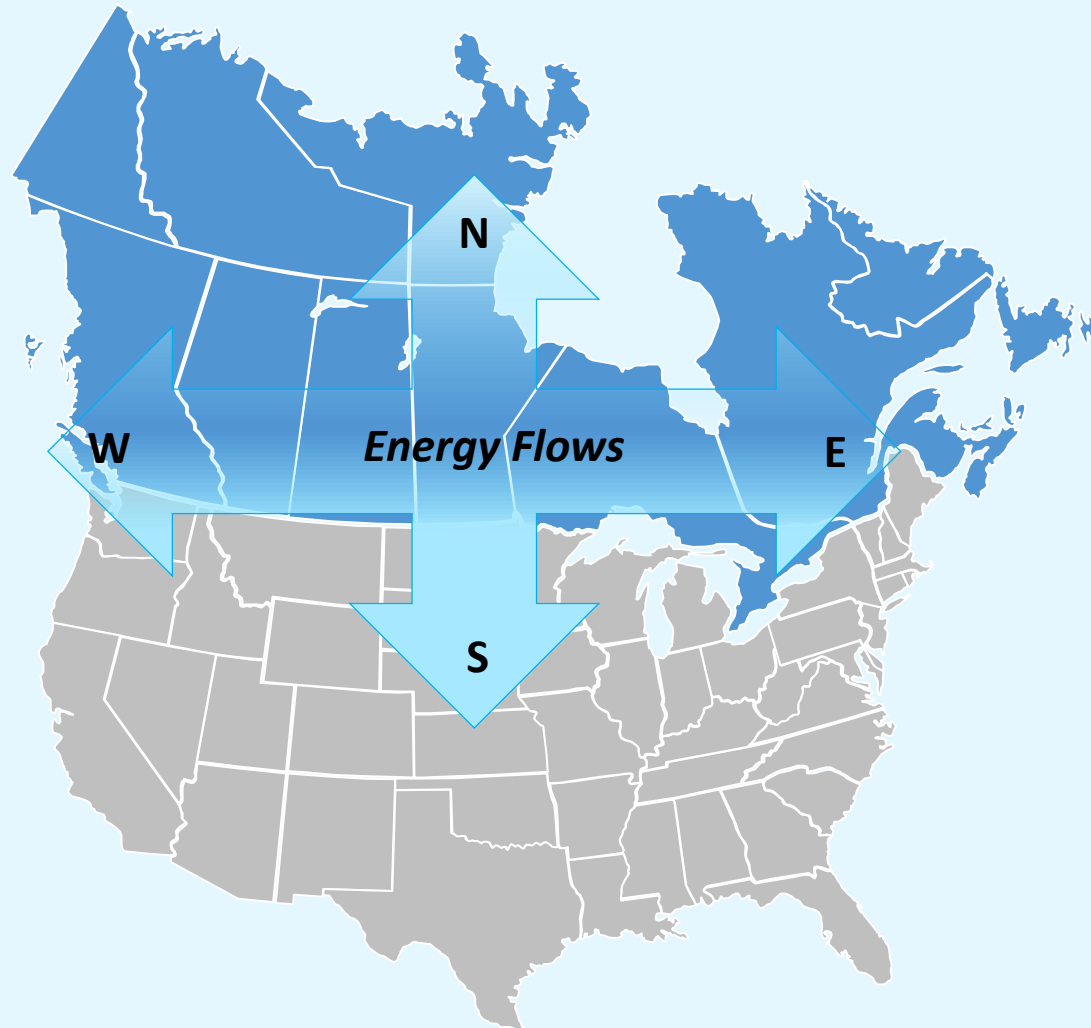
Task 3:
Clean Energy and
Electrification Assessment



Task 4:
Communication and
Outreach

Provincial-level Assessment In Progress: Ontario – Ontario Power Generation

Scientific Analysis for a Clean Energy & Low Carbon Future



Energy & Environmental Policies and Goals

- Greenhouse Gas (GHG) emissions reduction **target of 30% below 2005 levels by 2030**
- Evaluation of Canada's GHG target in relation to **global 1.5- and 2-degree climate targets**
- Federal **carbon price benchmark**
- Nationwide **phase-out of coal-fired power** generation by 2030
- **Carbon Dioxide (CO₂) limits on new and modified natural gas** power generation
- National **zero-emissions vehicle strategy**
- **Provincial energy and electricity policy initiatives**

Policies in Transition: GHG Emission Targets | Industry & Building Energy Efficiency and Electrification | Transportation Electrification | Renewable Energy

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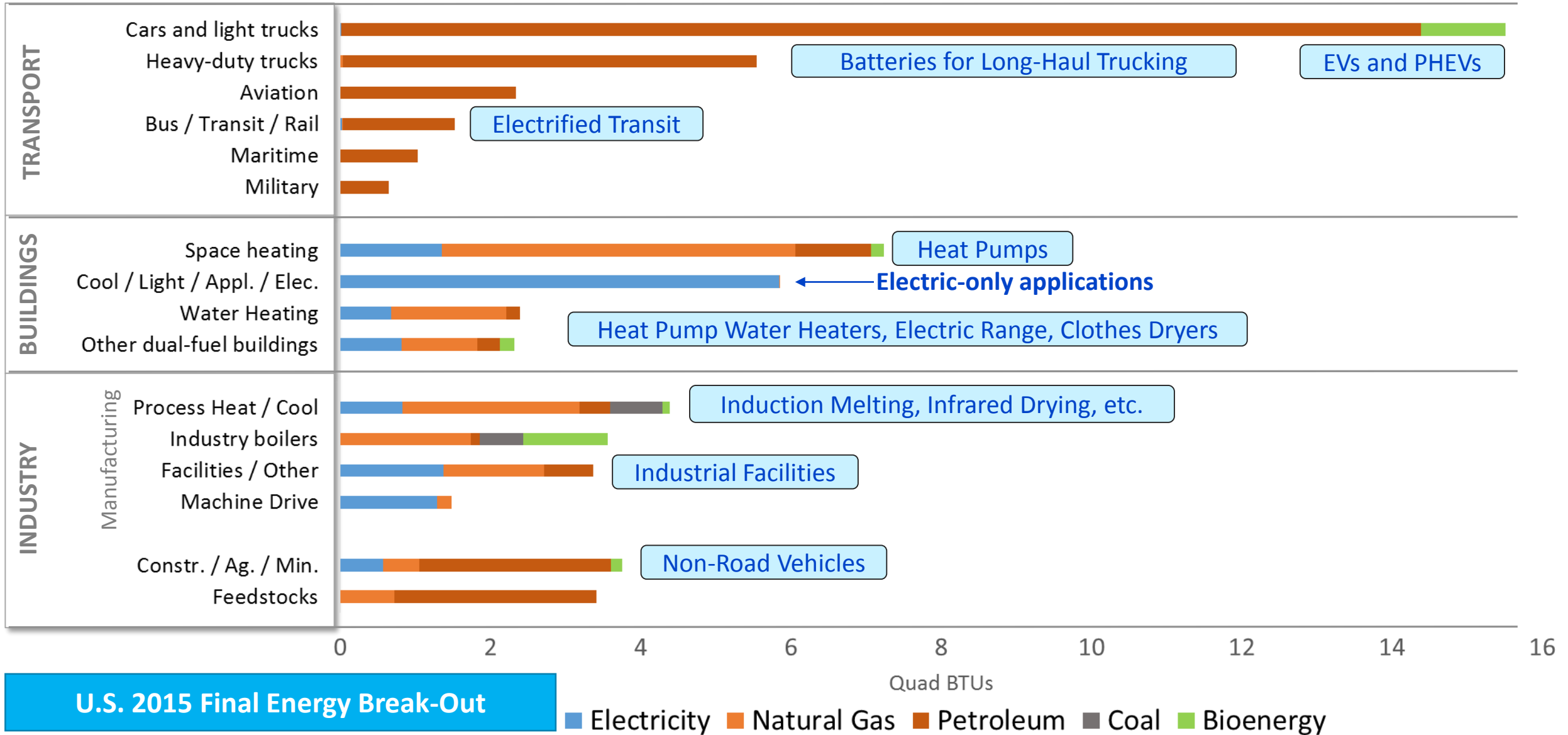
wfrost@epri.com

403.619.3213

Together...Shaping the Future of Electricity

Additional Background Reference

Potential for Efficient Electrification Varies by End-Use Application



Benefits of Efficient Electrification

Metric Options	Customer	Utility	Society
Economic Efficiency <ul style="list-style-type: none"> Costs less 	✓	✓	✓
Energy Efficiency <ul style="list-style-type: none"> Uses fewer BTU overall 	✓	✓	✓
Economic Development <ul style="list-style-type: none"> Jobs Creation and Retention Development of Community Assets 	✓	✓	✓
Environment <ul style="list-style-type: none"> Emissions Reduction, CO₂ & Water Savings 	✓	✓	✓
Grid Flexibility <ul style="list-style-type: none"> Integrating Supply and Demand Resources 	✓	✓	✓
Productivity Improvements <ul style="list-style-type: none"> Plant Output Increases Reduction in Energy Intensity Improved Product Quality 	✓		✓
Worker Safety Improvements <ul style="list-style-type: none"> Reduced Lost Time and Accidents 	✓		✓



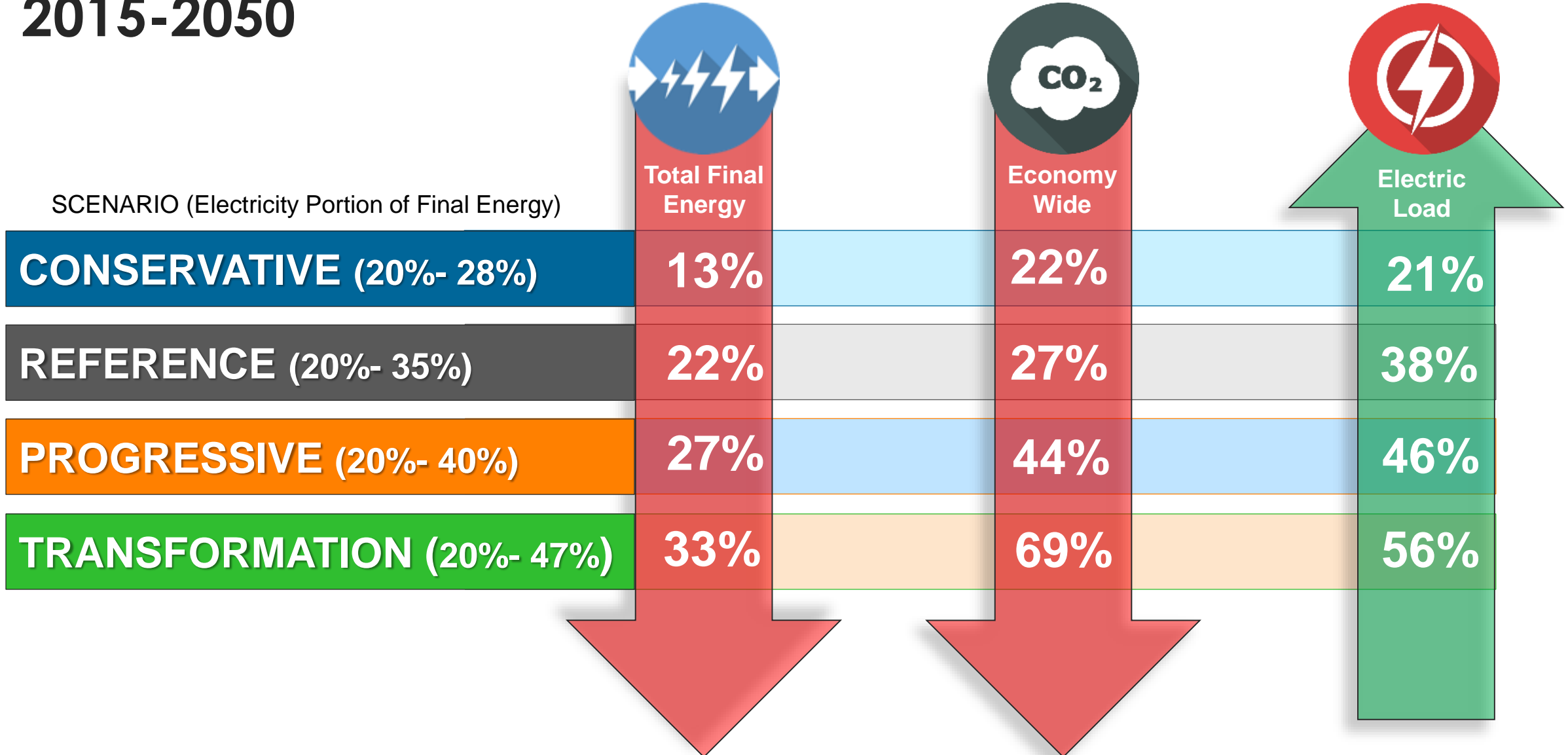
EPRI Experience:

Efficient Electrification:

- United States: 13 state electrification assessments with 16 utilities across the U.S.
- Canada: 1 Province

State of the Art Modeling of Power Generation with Energy End-Use Demand

Scenario Impacts on Efficiency, CO₂ and Electric Load; 2015-2050



CCEEA Project Status:



Project Status

Implementing **High-level Electric Sector Model** with EPRI TI Funding;

Collaborating with **Canadian SMEs** on Data

Executing **Province- and Federal-Level Government** Engagements

- Proposal to NRCan for National-level Project

Initiating Ontario Province Assessment with Member **Utility**

Outreaching to others in Ontario and Canada including **Universities**

Goal: National-level Assessment + Province-level Assessments
Current Participation: 1 Province with 1 Member

Projections of EV Economic Potential in Reference Case

Key Assumptions

Battery costs continue to fall rapidly

Car manufacturers develop wide range of EV models (~300 mile range)

Home or work charging is available for most drivers

EV maintenance costs are lower

NG prices remain low, moderate increase in oil price

ICEV fuel economy continues to improve

Economic Potential

EV / PHEV are most economical choice for **75%** of potential new vehicle decisions by **2030**

(90% by 2050)

Adoption

EV / PHEV represent **40%** of new vehicle market by **2030**

(75% by 2050)

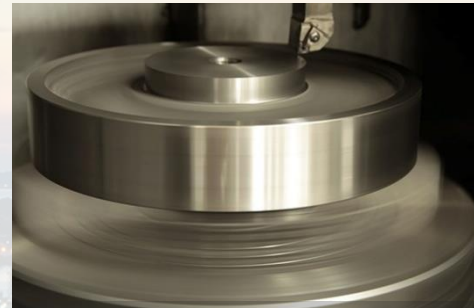


EPRI Research & Efficient Electrification

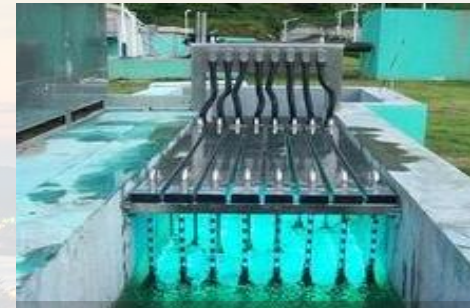
Using Cleaner
Energy Through
Efficiency and
Electrification

Producing
Cleaner
Energy

Integrating
Energy
Resources



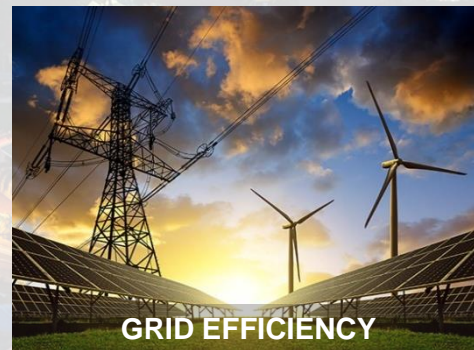
PRODUCTIVITY EFFICIENCY



HEALTH & SAFETY



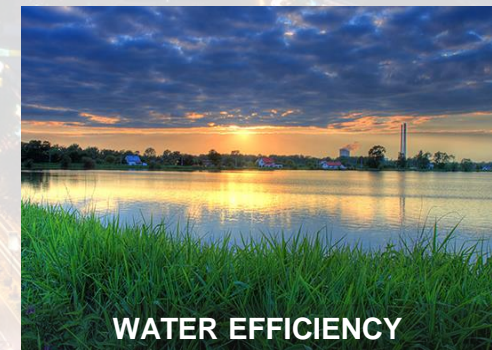
ENERGY EFFICIENCY



GRID EFFICIENCY



EMISSIONS EFFICIENCY



WATER EFFICIENCY

Efficient Electrification: achieving economic growth while reducing emissions and building resiliency with adoption of electric end-use technologies