Meeting the Challenge of Our Time

Northwest Deep Decarbonization Pathways Study
Washington State Report

Prepared for **Clean Energy Transition Institute** by **Evolved Energy Research**

October 2019

Washington Agency & Governor Staff Agenda | 10.24.2019

- Background
- Northwest Deep Decarbonization Pathways study
- Key Washington state-level results
  - Emissions, energy demand, fuels and net costs
- Key regional results
  - Electricity sector
- Summary

Clean Energy Transition Institute

Independent, nonpartisan Northwest research and analysis nonprofit organization with a mission to accelerate the transition to a clean energy economy. Provide information and convene stakeholders.

- Identifying deep decarbonization strategies
- Analytics, data, best practices
- Nonpartisan information clearinghouse
- Convenings to facilitate solutions

Evolved Energy Research

Energy consulting firm addressing key energy sector challenges accelerated by changing policy goals and new technology development. Developer of planning tools to explore economy-wide decarbonization and electricity system implications

- National and sub-national deep decarbonization studies
- 2016 study for State of Washington Office of the Governor
- 2018 study for Portland General Electric

EVOLVED ENERGY RESEARCH

Background

Why a Northwest Deep Decarbonization Study?

Common set of assumptions to inform decisions about how the clean energy transition could unfold over the coming decades

- Unbiased, analytical baseline for the region
- Variety of pathways to lower carbon emissions
- Surface trade-offs, challenges, and practical implications of achieving mid-century targets
- Broaden conversations about actions needed

Study Questions

- **How does the energy sector need to transform** in the most technologically and economically efficient way?
- **How does electricity generation need to be decarbonized** to achieve economy-wide carbon reduction goals?
- **What if we can't** achieve high electrification rates?
- **What is the most cost-effective use** for biomass? What if biomass estimates are wrong?
- **What would increased electricity grid transmission** between the NW and CA yield?

Scope

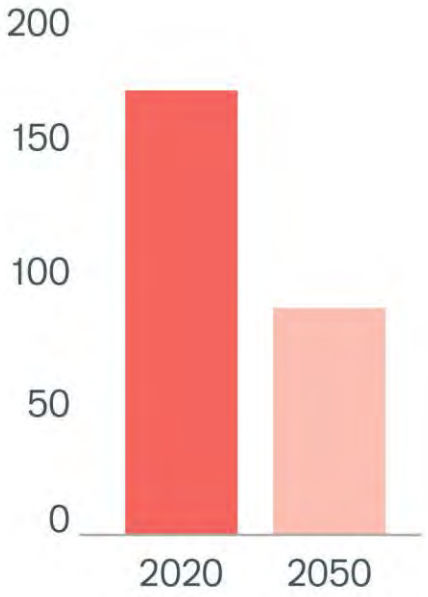
- **Scope:** WA, OR, ID, MT
- **All Energy Sectors Represented:**
  - Residential and commercial buildings
  - Industry
  - Transportation
  - Electricity generation

Evaluating holistically provides an understanding of cross-sectoral impacts and trade-offs

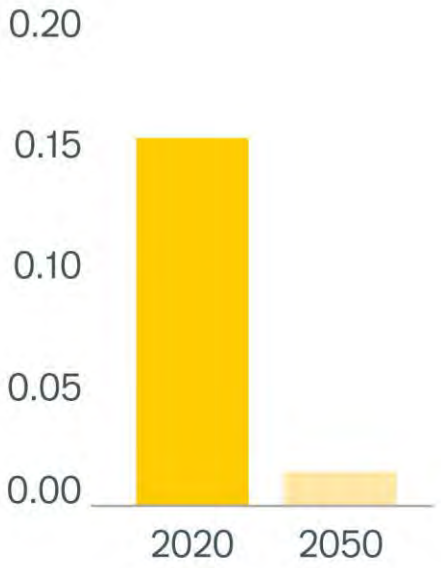
Key Findings

Five Decarbonization Strategies Deployed

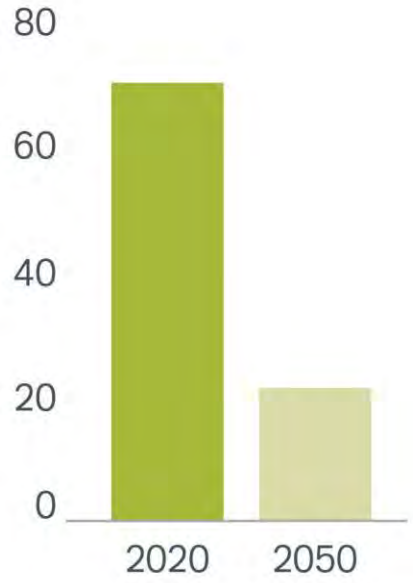
Energy Efficiency
Per capita energy decreases 50%



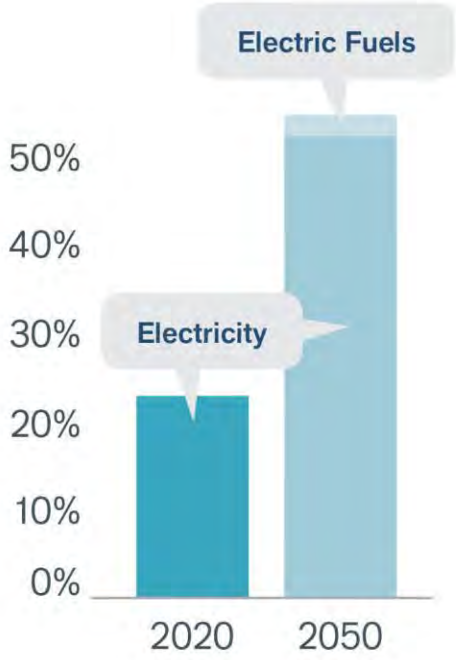
Electricity Decarbonization
96% Clean by 2050



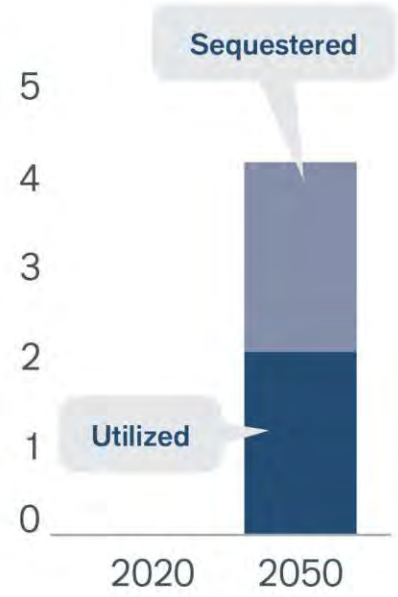
Fuel Decarbonization
70% decrease



Electrification
Doubles from 23% to 55%

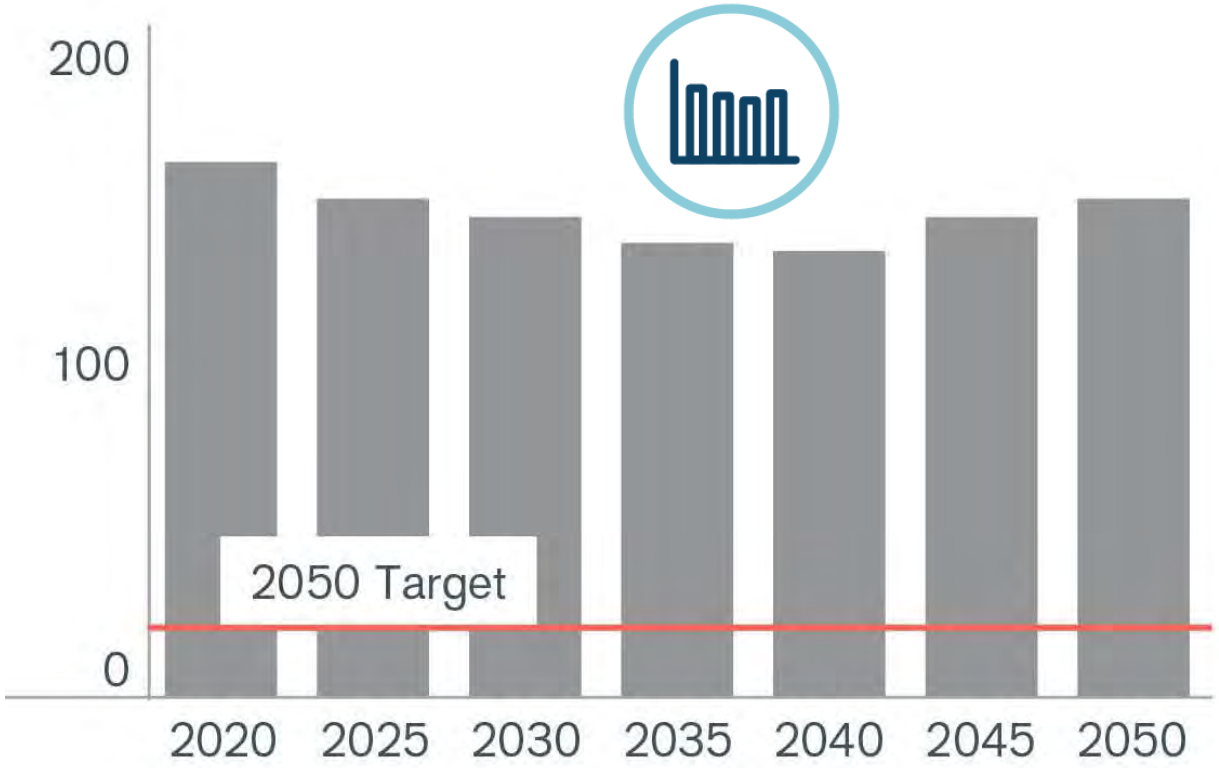


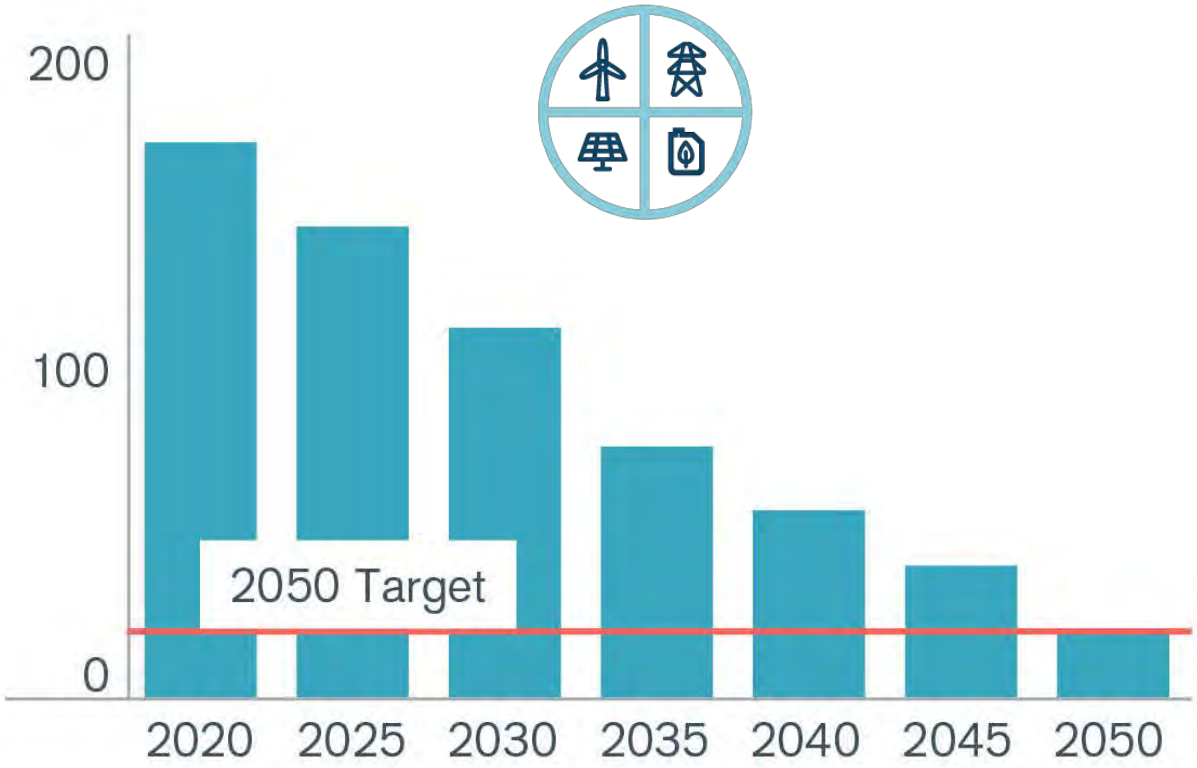
Carbon Capture
1/2 fuel; 1/2 sequestered



Business as Usual vs. Central Case

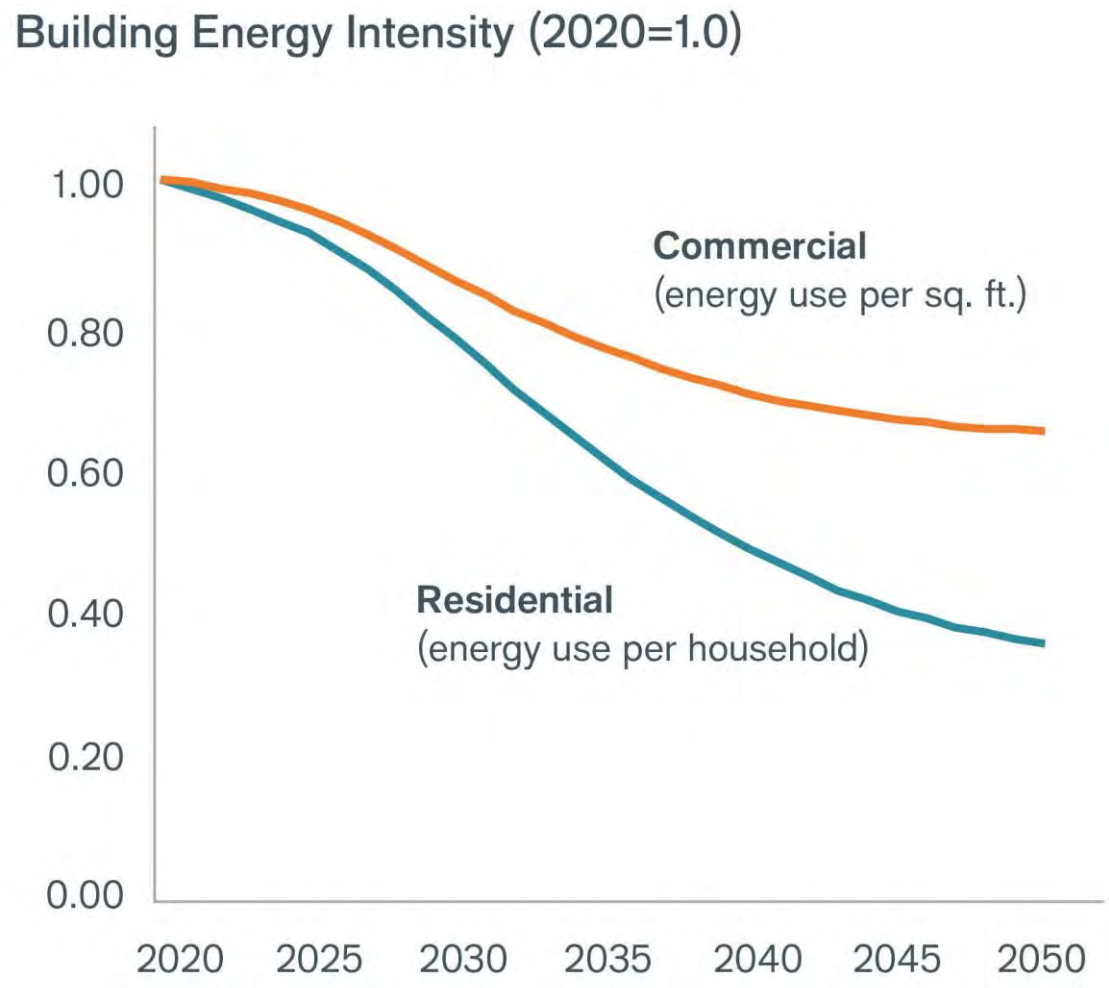
In the Business as Usual Case emissions trajectory falls far short of the 2050 reduction goal, while the Central Case meets the mid-century energy CO_2 emission target of 86% below 1990 levels.





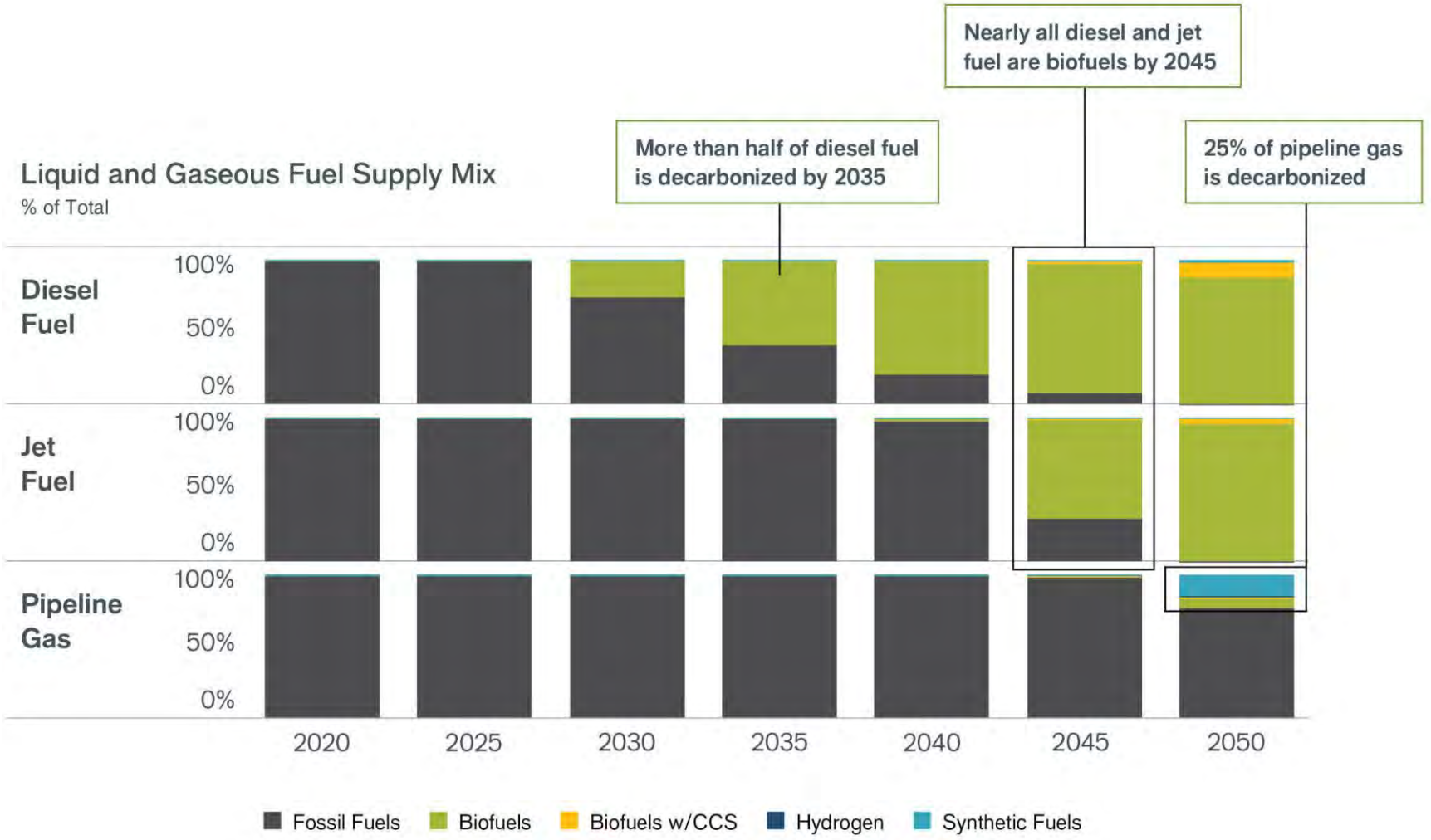
Buildings: Energy Efficiency & Electrification Impacts

Decline in building energy intensity for commercial and residential buildings from 2020 to 2050.



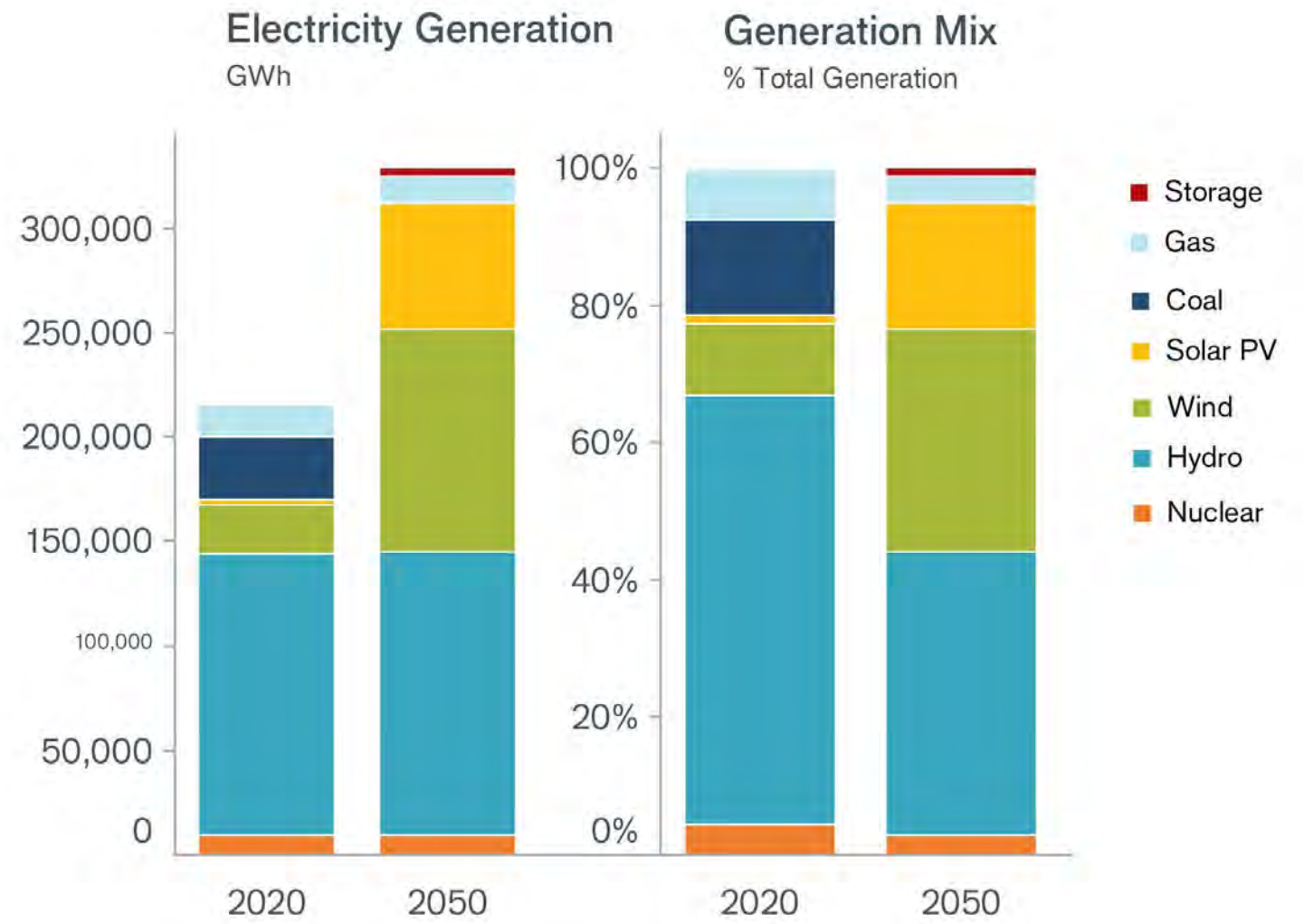
Decarbonizing Diesel, Jet, & Pipeline Gas

The composition of the liquid and gaseous fuel supply mix in the Central Case in five-year increments from 2020 to 2050.



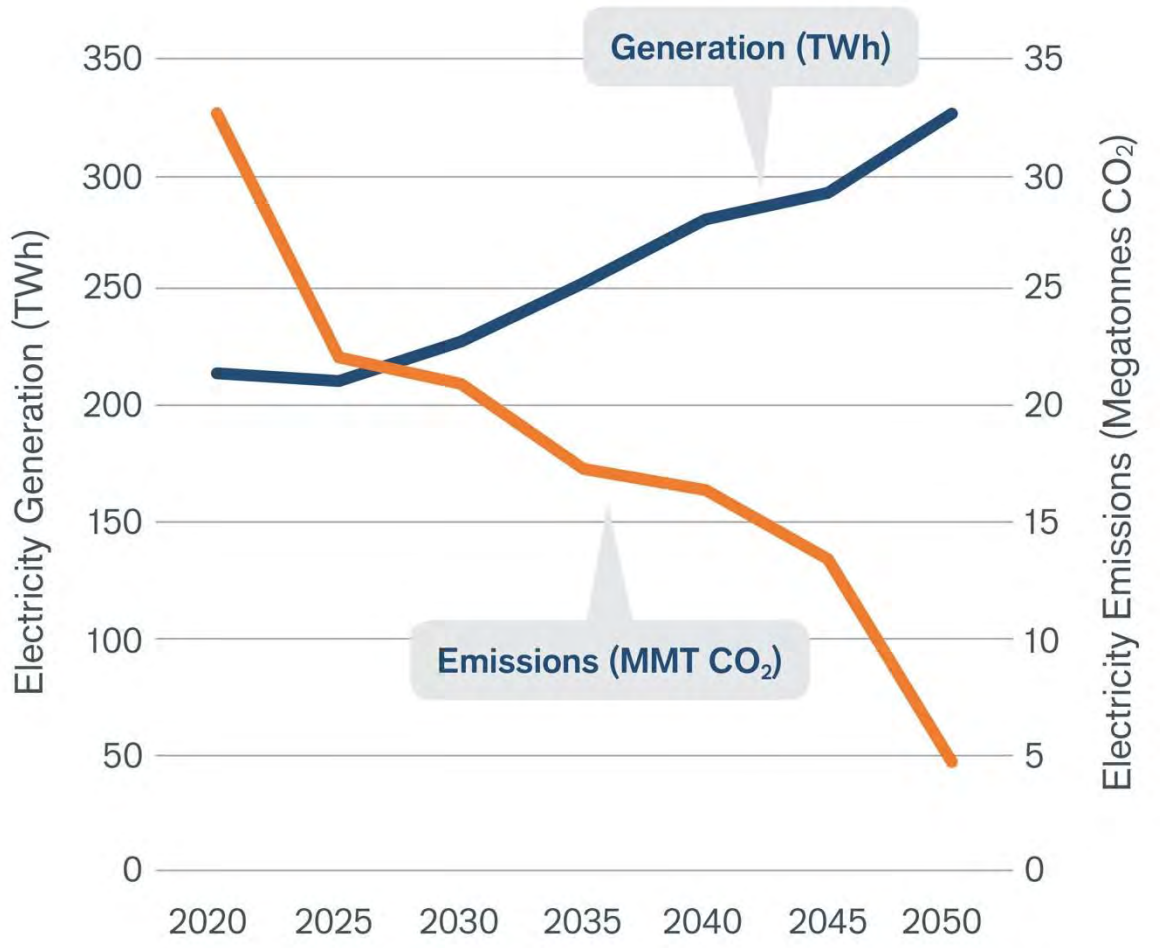
Carbon-Free Electricity

Amount of electricity generation and the generation mix for electricity supply in the Central Case.



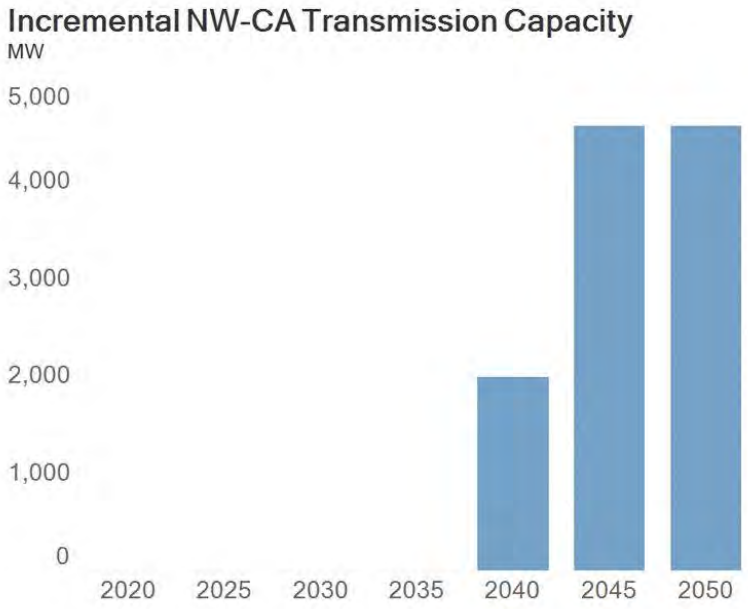
Buildings: Electricity Emissions & Generation

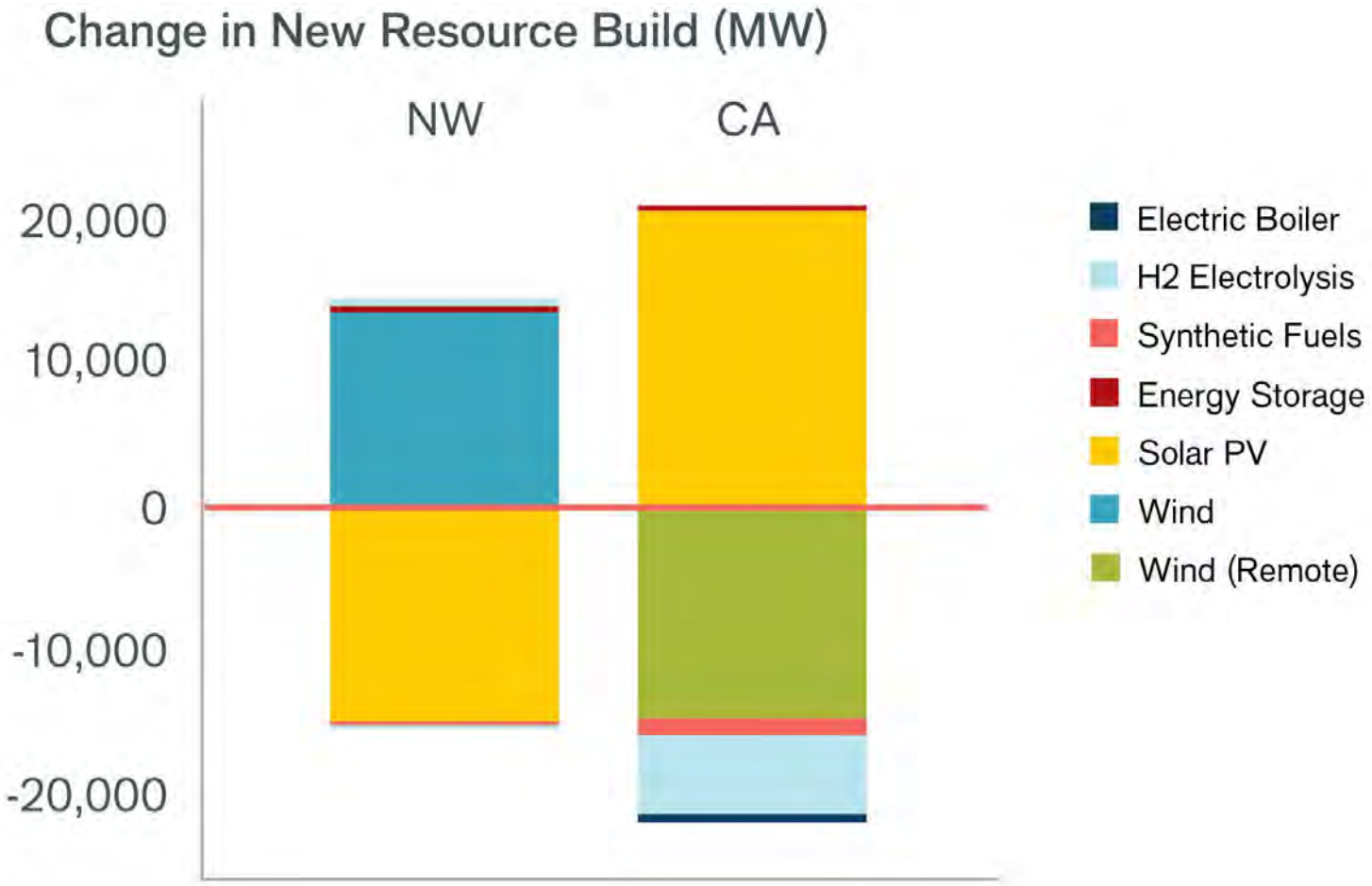
Electricity emissions decline: electricity generation increases.



Increased Northwest-California Transmission

- 4,500 MW new capacity
- 7,000 GWH increased exports
- $11.1B NPV savings
- Changing supply mix





Key Findings: Deep Decarbonization Achievable

- **Electricity generation approaches 100% clean** without a specific mandate
- **Aggressive vehicle electrification and highly efficient built environment** powered by clean electricity are **essential**
- **Biomass primarily allocated to jet and diesel fuel**, even after partial electrification of freight
- **Thermal generation important for reliability** in periods of low hydro and renewable output (low capacity factor)
- **New technologies and flexible electric loads combined with storage likely to play key role** producing pipeline fuels & balancing the grid
- **Significant cost savings** if the Northwest and California **grids are better integrated**

Transformations Needed on the Demand Side

- **Aggressive demand-side electrification** with commensurate reductions in fuel demand
  - Either fuels are quantity constrained (biofuels) or Fuels become increasingly expensive per unit of fuel produced (electric fuels)
- **Electrifying transportation**
- **Biomass most efficiently allocated to jet and diesel** fuel rather than pipeline gas

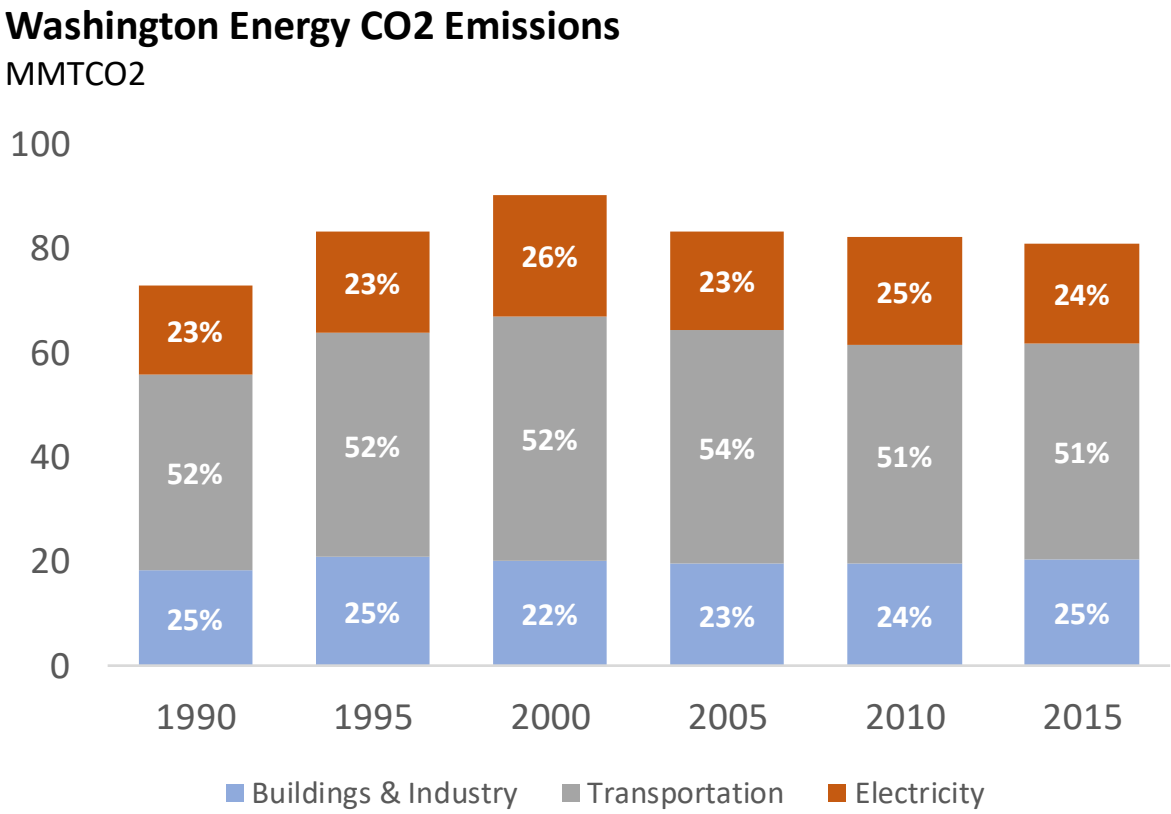
Transformations Needed in Electricity Supply

- **Significant cost savings possible with expanded interties** between regions of the West
- **New technologies can play a key cross-sector role**
- **Thermal generation as a capacity resource** important for reliability
- **Role for carbon capture** on biofuels facilities or direct air capture (DAC)

Washington State Results

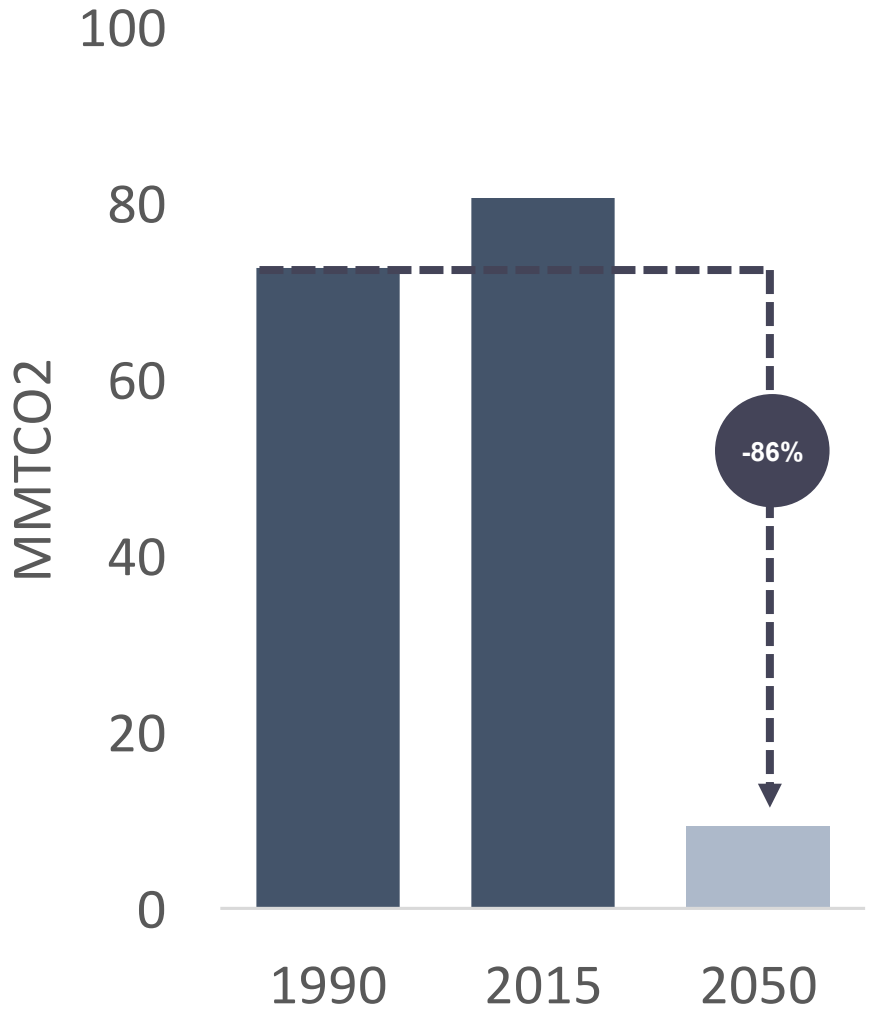
Historical Energy-Related CO_2 Emissions

- CO_2 emissions from fossil fuel combustion spread across three major sectors:
  - Electricity
  - Transportation
  - Buildings and Industry
- The transportation sector accounts for half of all energy-related CO_2 emissions, primarily due to liquid fossil fuel consumption:
  - Gasoline fuel in passenger transportation
  - Diesel fuel in freight transportation
  - Residual fuel oil in marine vessels
  - Jet fuel in aviation



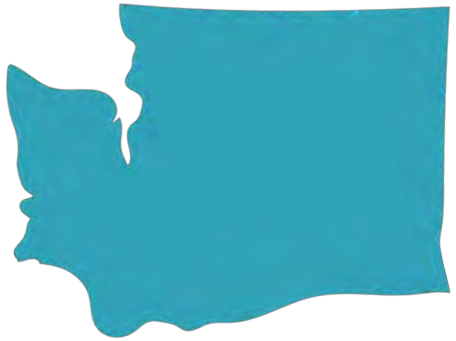
Deep Decarbonization Target

- Target: 86% reduction in energy-related CO_2 emissions below 1990 levels by 2050
  - Consistent with EER's 2016 Deep Decarbonization Pathways Analysis for Washington State report
- Energy target is consistent with an economy-wide GHG reduction target of 80% below 1990 levels by 2050
  - Allows for reductions below 80% for non-energy CO_2 and non-CO_2 GHG emissions, where mitigation feasibility is less understood



Regional Context-Washington Results

- The Northwest Deep Decarbonization pathways (NWDDP) analysis was conducted using state-level granularity to determine least-cost pathways
- The study released in June 2019 summarized results for the region as a whole—Idaho, Montana, Oregon and Washington
- This report presents results and insights specific to Washington
  - The exception is the electricity sector, where operations and planning are already integrated regionally, and investments in resources benefit multiple states

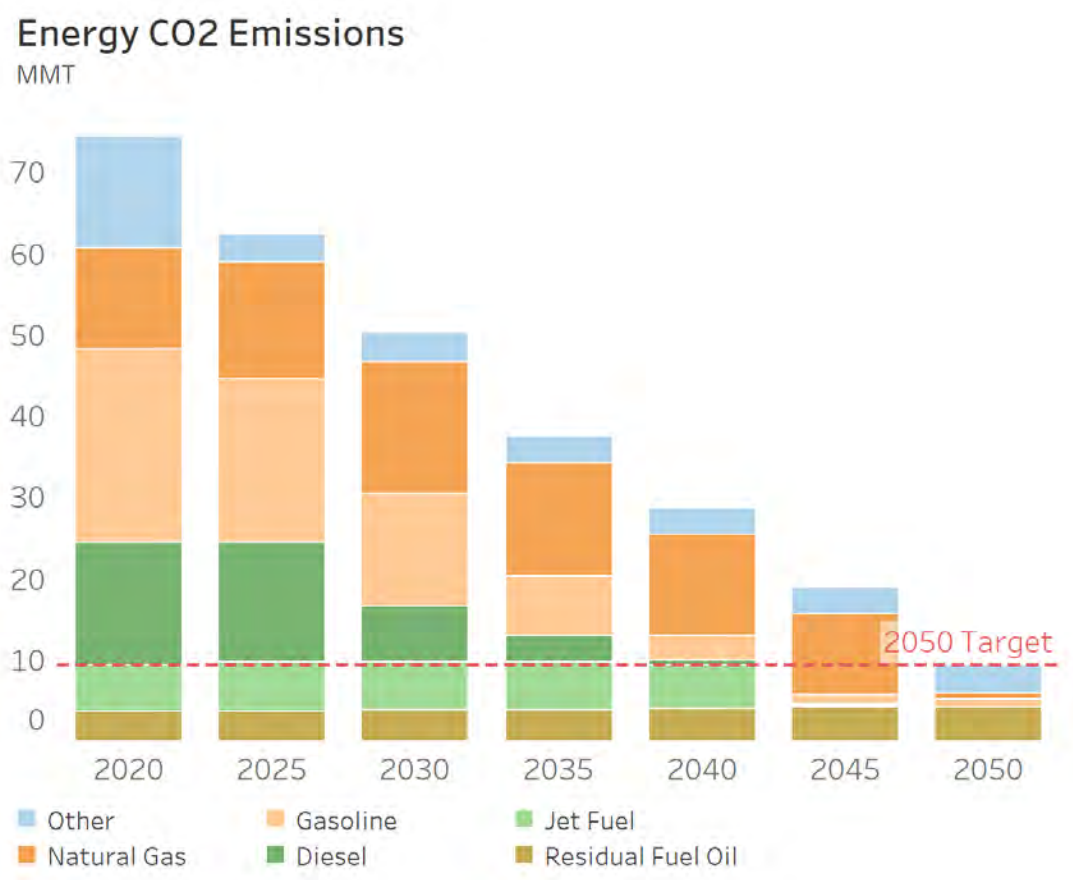


State Goals and Policies

- **2008:** established limits on greenhouse gas (GHG) emissions, including a 50% reduction below 1990 levels by 2050
- **2016:** Department of Ecology recommended strengthening that limit to 80%
- **2019:** Package of legislation passed to meet 2035 statutory GHG limits
  - Transitioning to 100% clean electricity generation by 2045
  - Decarbonizing buildings and transportation
  - Eliminating hydrofluorocarbons

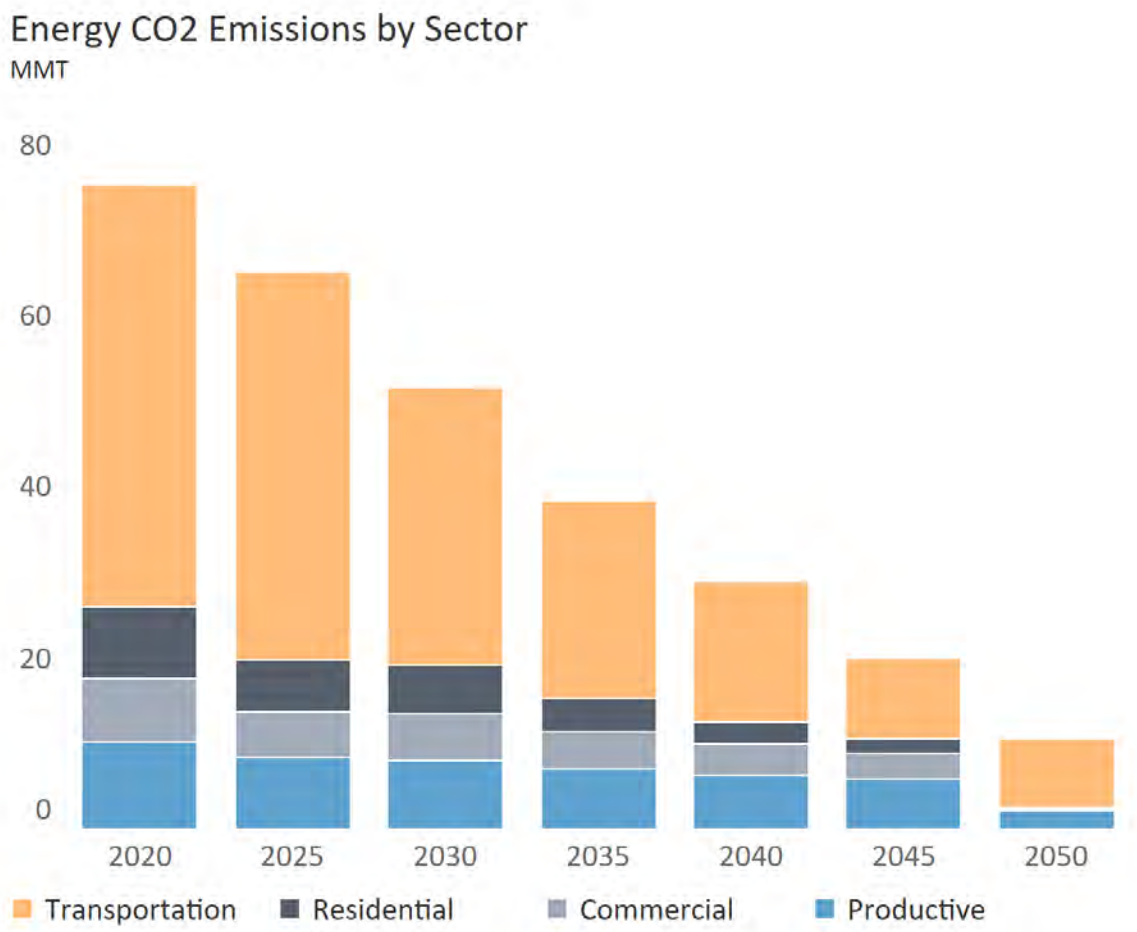
Energy CO_2 Emissions By Fossil Fuel Type

- The five decarbonization strategies reduce Washington's emissions over the next three decades
- The largest remaining source of emissions is residual fuel oil used in shipping
  - This contrasts with other states in the region, where natural gas is the largest remaining source



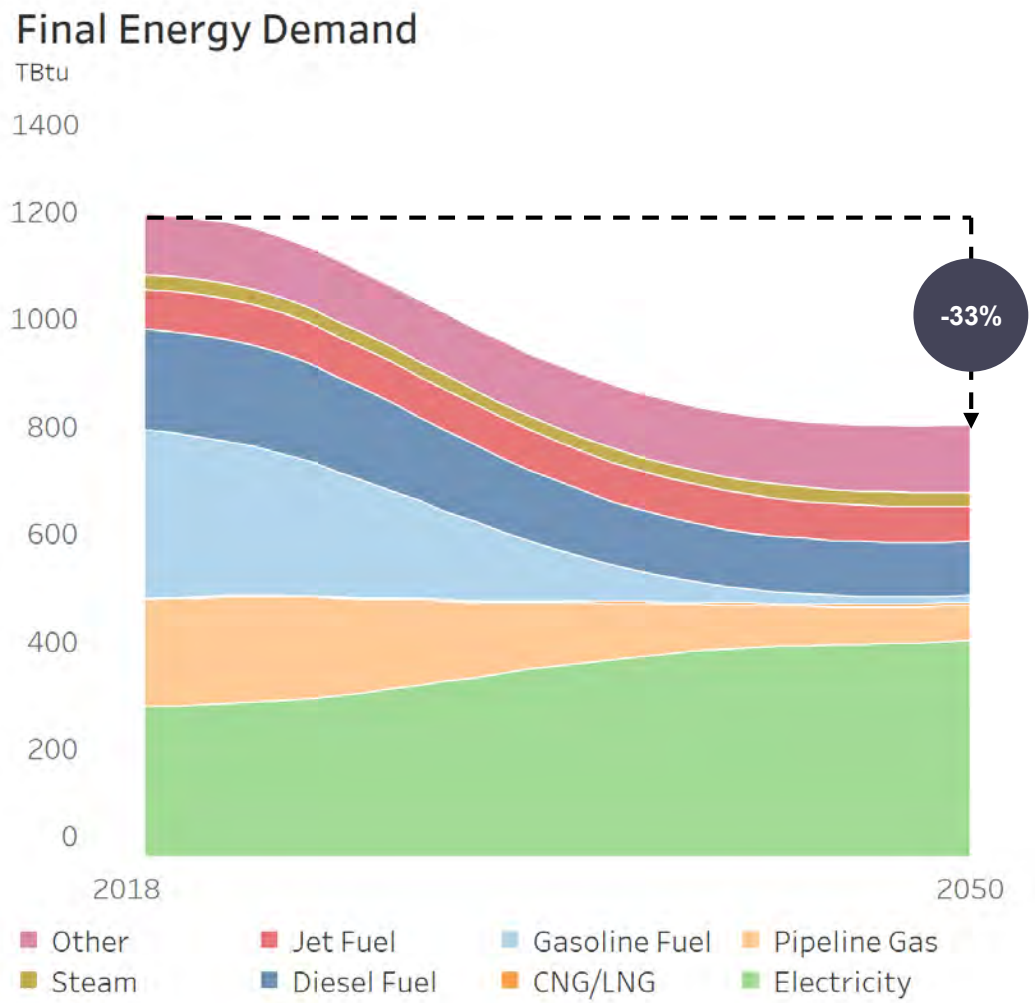
Energy CO_2 Emissions By Sector

- Overall emissions decrease across all sectors of the state's economy
- Transportation emissions decline significantly with on-road (LDV, MDV and HDV) emissions eliminated, while off-road (e.g., marine vessels) emissions making up the remainder
- Building emissions are less than 1 MMT by 2050 as heating services are electrified



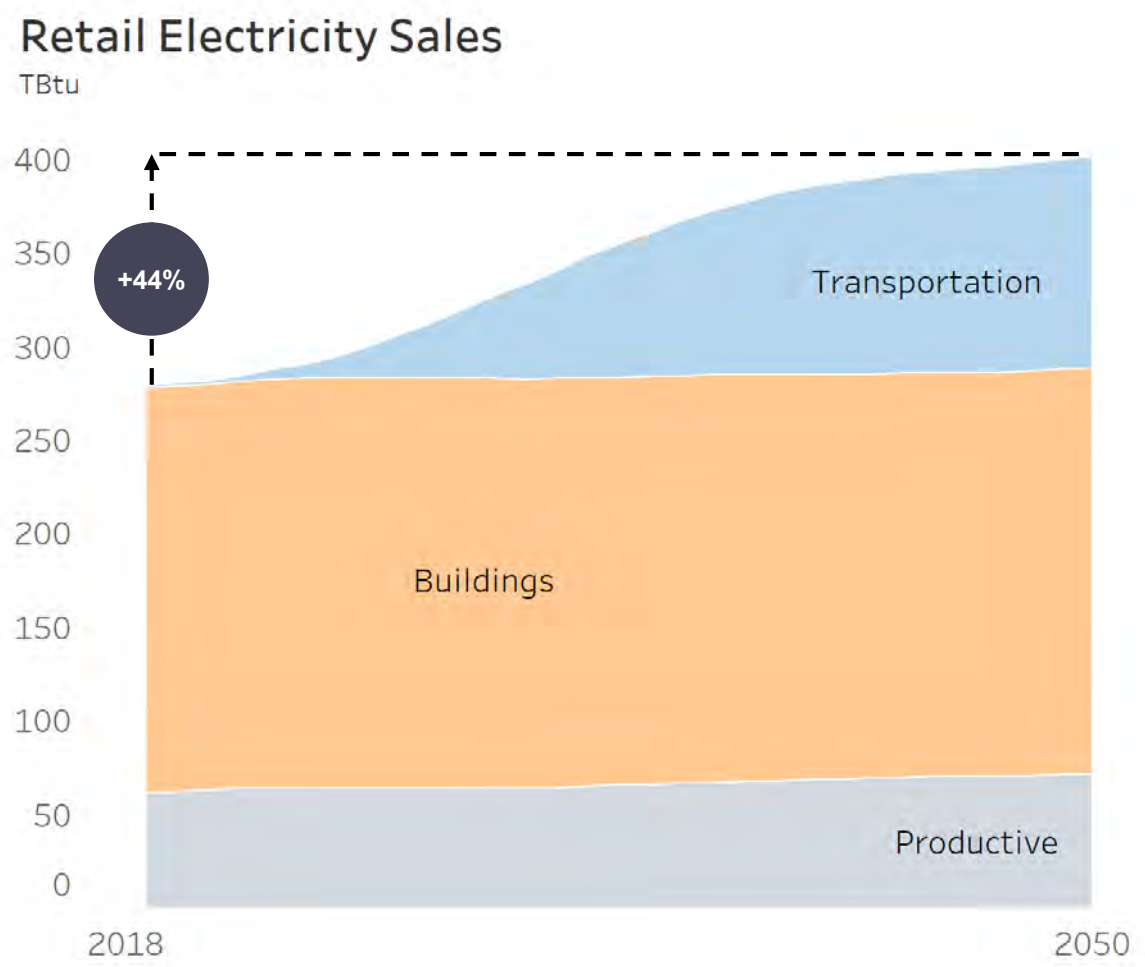
Energy Demand: End-Use Consumption

- End-use consumption or final energy demand represents energy used in the delivery of services such as heating or transportation
  - Excludes energy consumed in converting to other forms of energy (e.g., pipeline gas consumed by power plants)
- Overall end-use demand in 2050 is one-third below today
  - Electricity consumption increases by more than 40% and comprises one-half of all end-use consumption by 2050
  - Liquid fuels decrease from one-half of demand today to one-fifth by 2050 as on-road vehicles transition to electricity



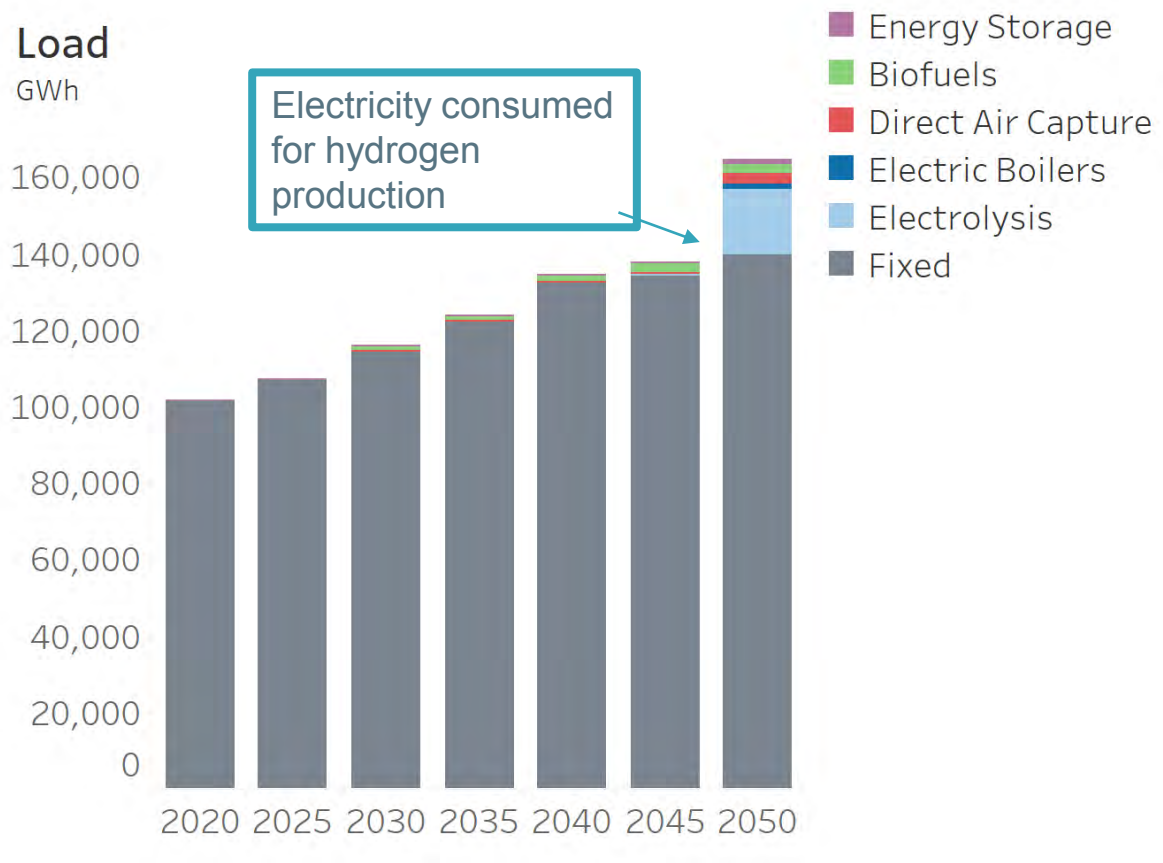
Energy Demand: Retail Electricity Sales by End-Use

- Net increase in end-use electricity consumption is primarily related to electrifying passenger and freight transportation
- By 2050, all passenger vehicles on the road are electric, whereas about half of freight trucks are
  - Freight trucks that continue to use liquid fuels primarily consume renewable diesel in the 2050 timeframe

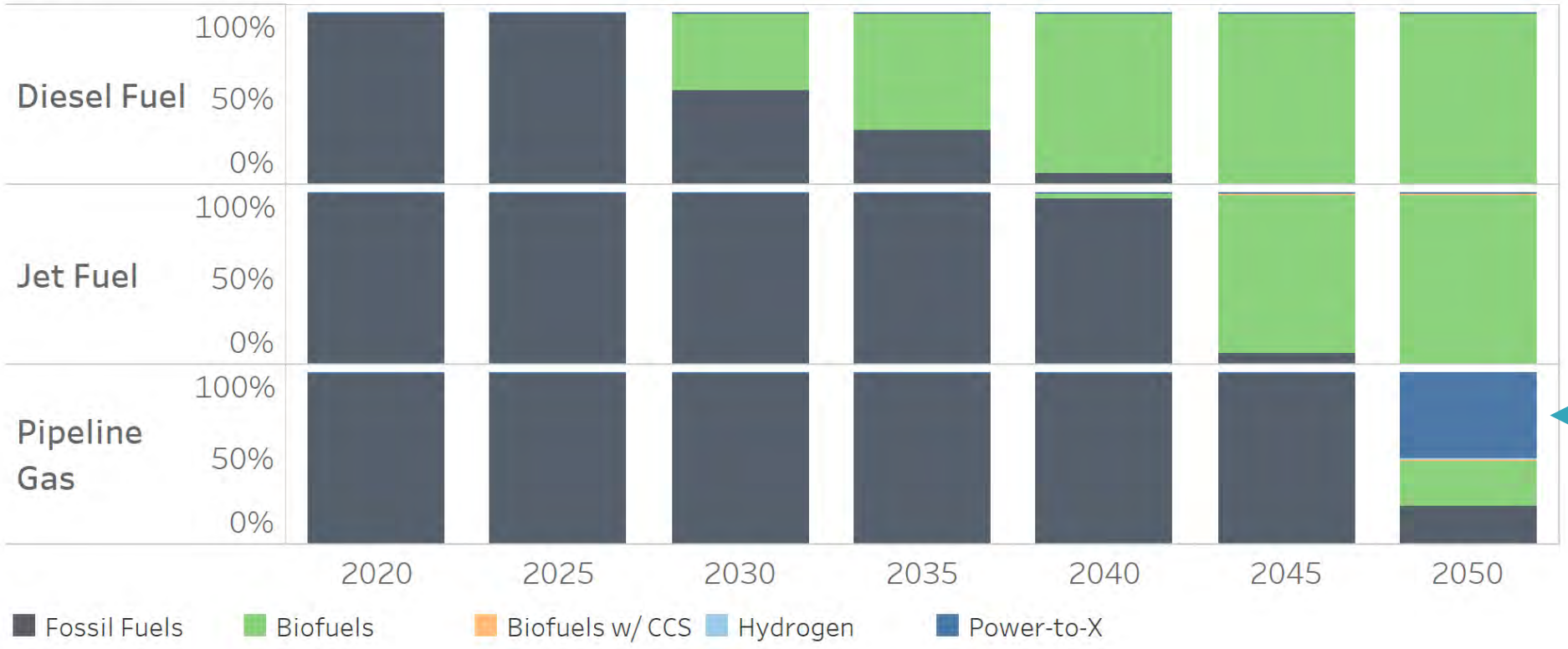


Energy Demand: Transmission-Level Electric Load

- Transmission-level load increases by more than 60% between 2020 and 2050
- A large portion of the net increase is from higher “fixed” loads (e.g., end-use retail sales)
- However, another significant portion of load growth in the state is from electrolysis facilities, which produce hydrogen primarily for synthetic fuels



Energy Supply: Fuels



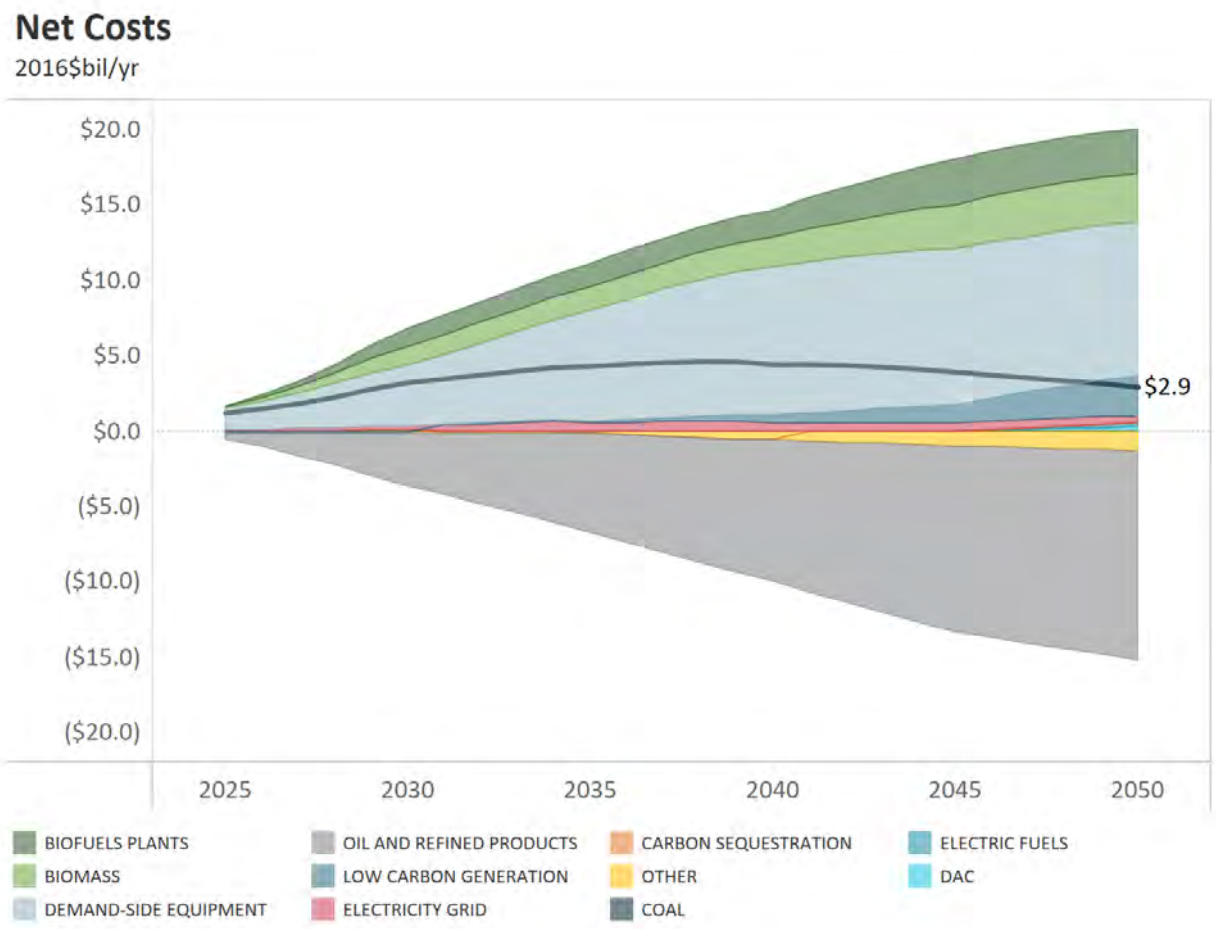
Biofuels are primarily allocated to **diesel and jet fuel**

Synthetic electric fuels make up half of **pipeline gas** in 2050, significantly higher than other states in the region

Net Costs

Estimated as the difference between the Central Case and Reference Case

- Net costs for the state primarily represent incremental:
  - Biofuel feedstocks and infrastructure;
  - Demand-side electrification and efficiency investments; and
  - Renewable power plants and supporting electricity infrastructure
- These incremental costs are mitigated by savings from avoided fossil fuel expenditures
- Net costs peak around 2040 as costs of key decarbonization technologies are still declining and the alternative cost of fossil fuels continues on an upward trajectory



Net Costs Relative to the State's Economy

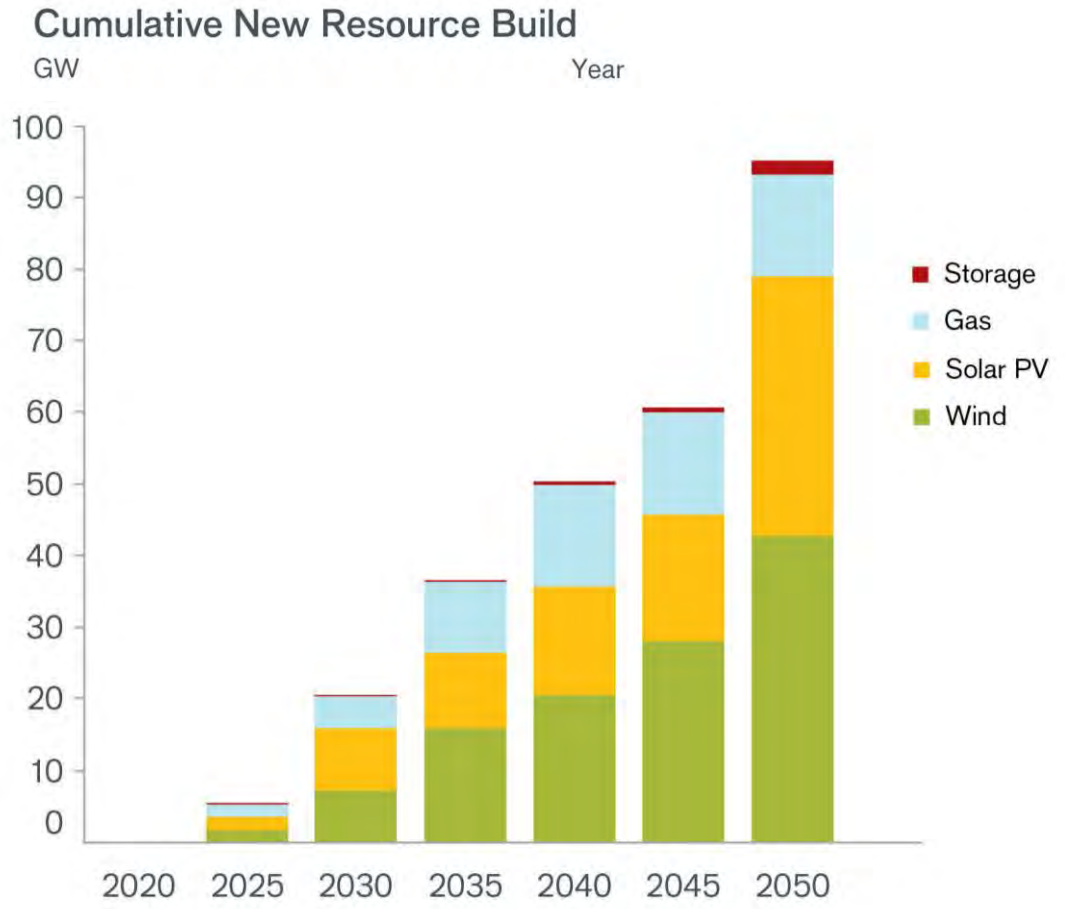
Share of GDP

- Magnitude of net costs are small relative to the size of the state's economy
  - Washington's gross domestic product in 2018 was $563 billion
- Between 2030 and 2050, net costs for the Central Case are between 0.5% and 0.8% of today's economy
- These costs would be even smaller if future economy growth and benefits from avoided climate change and pollution are considered

Key Regional Results: Electricity Sector

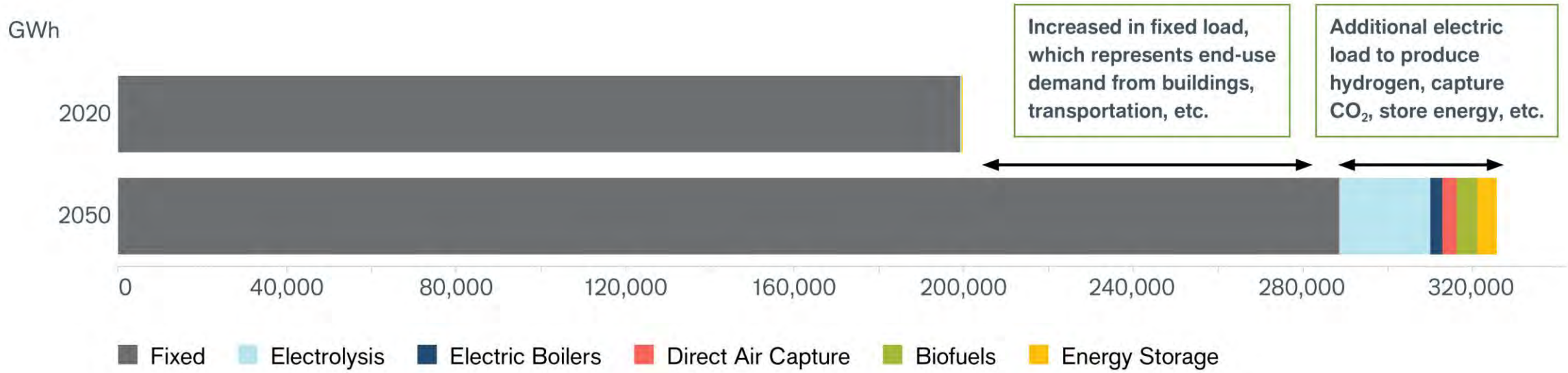
Capacity Expansion

- Northwest electricity sector adds nearly 100 GW of new electricity supply resources by 2050
- Renewable resources dominate capacity additions, with more than 40 GW of new onshore wind developed and 35 GW of solar PV
- Gas and storage resources are added primarily to provide resource adequacy and balancing
  - The capacity factor (utilization) of the gas-fired fleet is below 10% in 2050



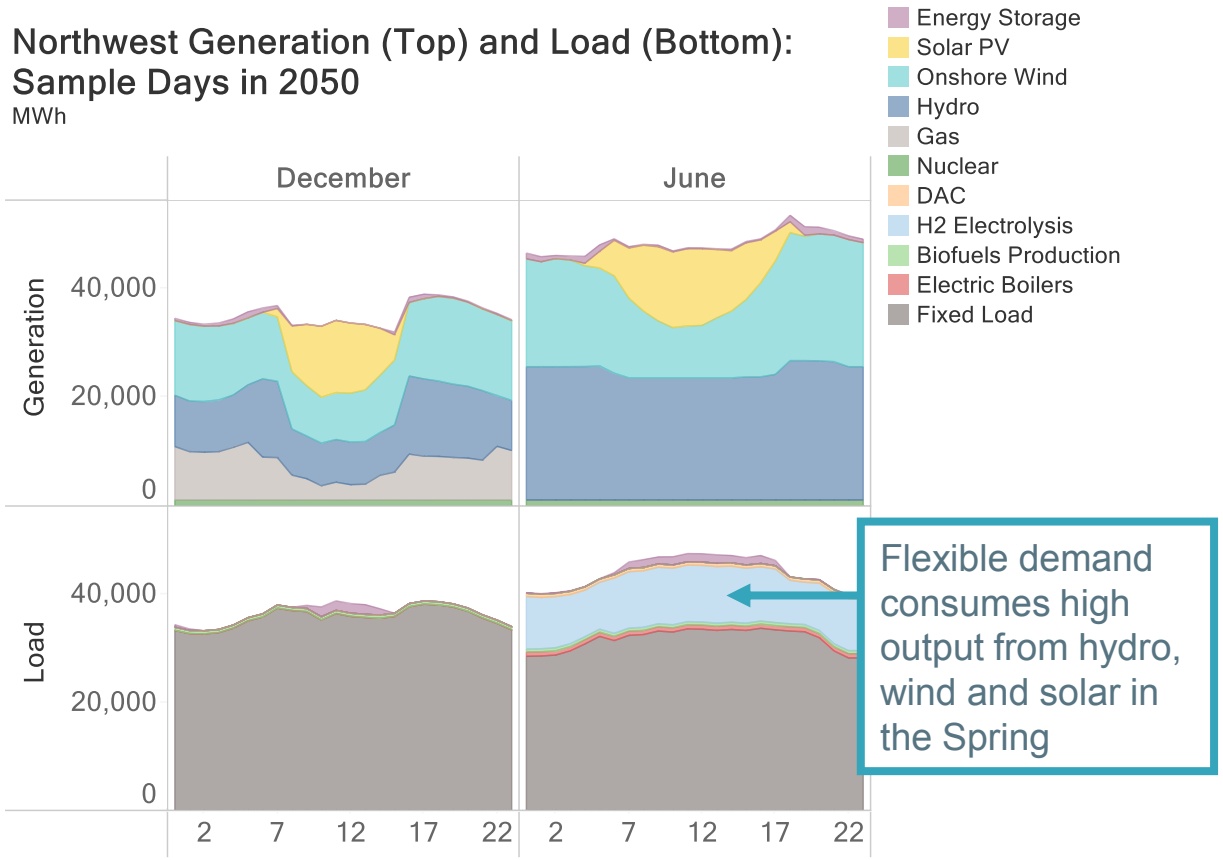
Load

- Load increases by more than 60% between 2020 and 2050
- A large portion of the net increase is from higher “fixed” loads, such as transportation electrification
- However, a significant portion is from other demand sources, including the production of hydrogen, capturing CO_2 and using electric boilers to produce steam



Hourly Electricity Operations

- Electricity balancing – key challenge of decarbonized system
- Many studies of low-carbon electricity limit balancing to thermal and energy storage resources
- Limited options - specifically when dealing with imbalances that can persist over days and weeks
- This study expands the portfolio of options
  - Including flexible electric fuel production (e.g., electrolysis) in addition to energy storage, thermal, and transmission



Summary

Insights

- Washington able to achieve mid-century climate targets despite a variety of potential implementation challenges
- Among the variety of alternative pathways studied, low levels of electrification would have the highest cost impact on the state
- Unlike other states in the region, Washington relies on synthetic fuels to decarbonize pipeline gas and meet GHG goals
  - The state has significant energy demand from off-road transportation (e.g., aviation; marine vessels) and limited biofuels
  - A highly renewable electricity grid incentivizes power-to-gas and direct air capture

Thank you

Eileen V. Quigley
Executive Director
Clean Energy Transition Institute
eileen@cleanenergytransition.org

Ben Haley
Principal
Evolved Energy Research
ben@evolved.energy

Jeremy Hargreaves
Principal
Evolved Energy
Jeremy@evolved.energy