Meeting the Challenge of Our Time: Pathways to a Clean Energy Future for the Northwest

An Economy-Wide Deep Decarbonization Pathways Study • June 2019

NW Power Planning Council Agenda | 08.13.2019

- Clean Energy Transition Institute & Evolved Energy Research
- Northwest Deep Decarbonization Pathways Study
- Summary of Scenarios
- Key Findings
- Next Steps
- Q & A

Clean Energy Transition Institute

Independent, nonpartisan Northwest research and analysis nonprofit organization with 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

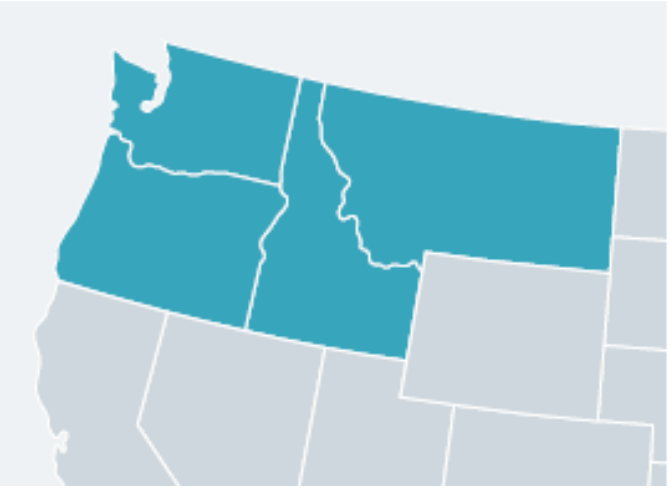
- National and sub-national deep decarbonization studies
- 2016 study for State of Washington Office of the Governor
- 2018 study for Portland General Electric

EVOLVED ENERGY RESEARCH

Why a NW Deep Decarbonization Study?

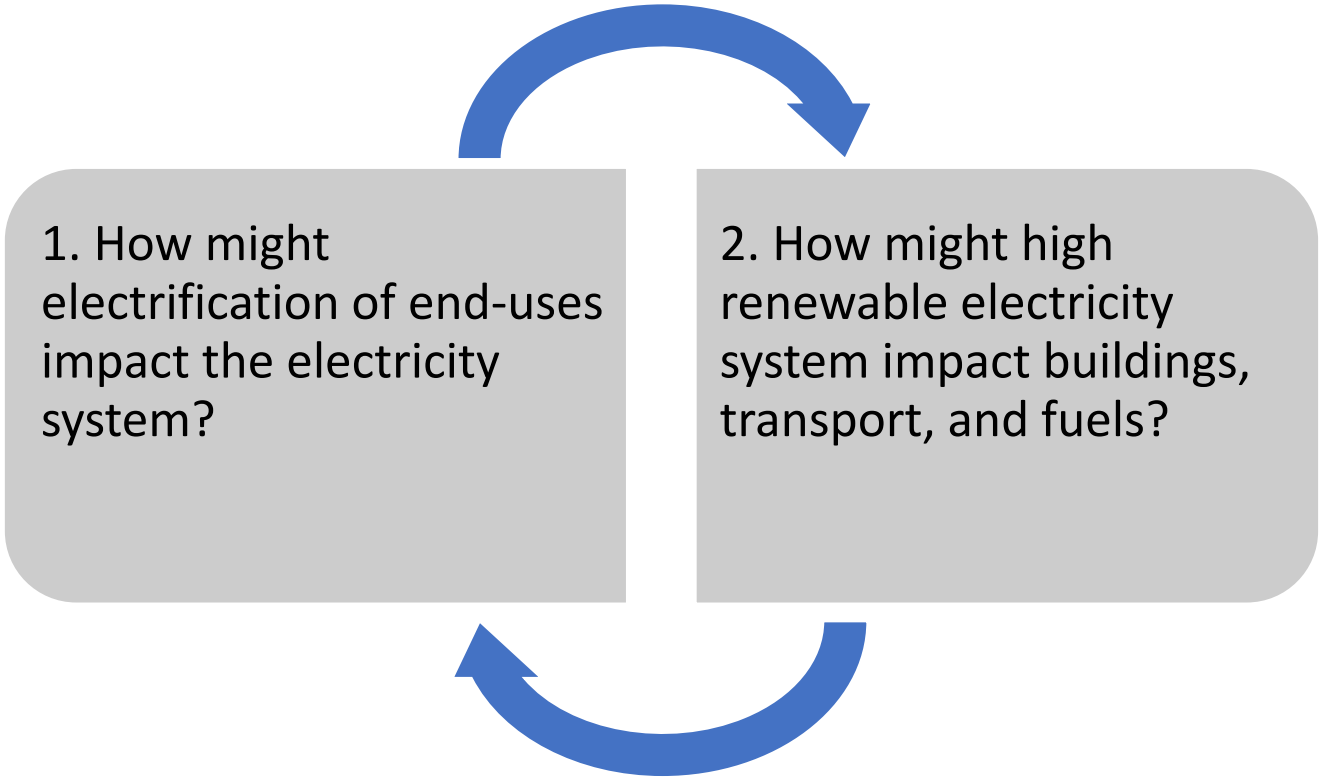
Common set of assumptions to inform decisions about how the clean energy transition could unfold over the coming decades

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



Relevancy to Power Planning

Economy-wide decarbonization interacts with electricity sector

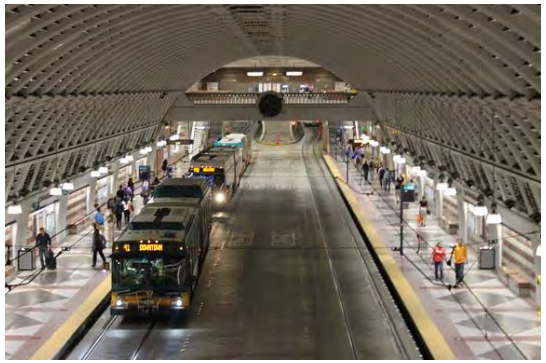


Study Questions

- 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 California yield?

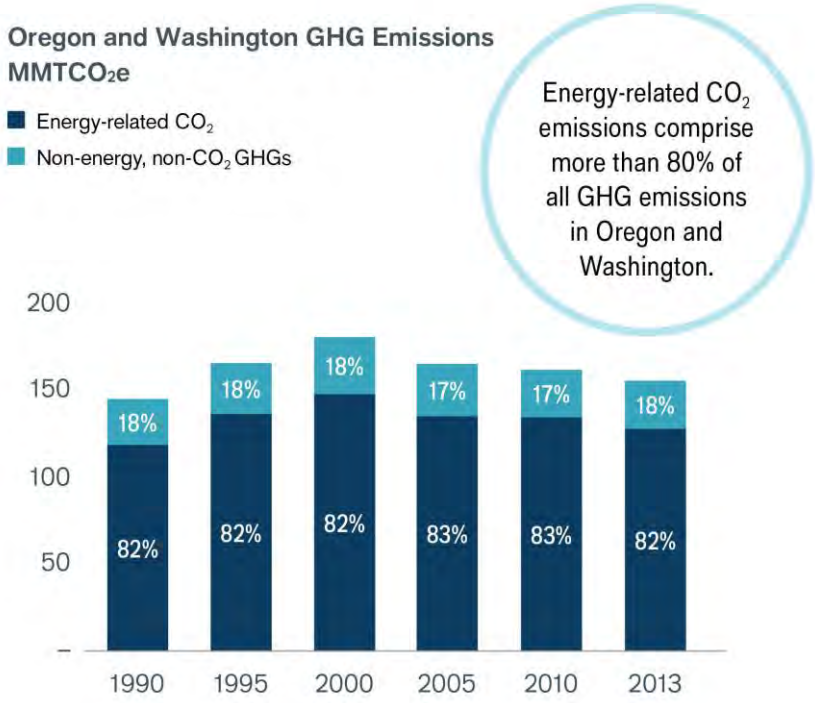
Methodology

- Study examines how each state in the Northwest can achieve deep decarbonization
  - Achieves mid-century climate targets
  - All energy sectors represented
- Study incorporates unique approaches:
  - Develops cost-optimal energy supply portfolios
  - Incorporates new electric loads (direct air capture; fuel production; steam production)
  - Accounts for changing dynamics outside of the region (California energy policy)
- Conducted by Evolved Energy Research (EER)



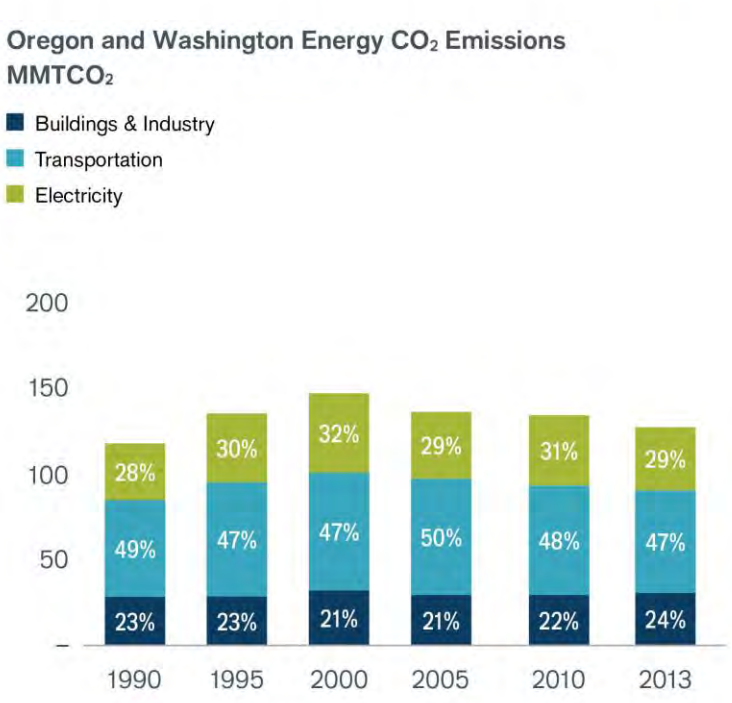
Historic Energy-Related CO_2 Emissions

Energy GHG emissions dominate in Washington and Oregon.



Source: Northwest Deep Decarbonization Pathways Study, May 2019, Evolved Energy Research, page 11. Data are from Oregon's Department of Environmental Quality and Washington's Department of Ecology.

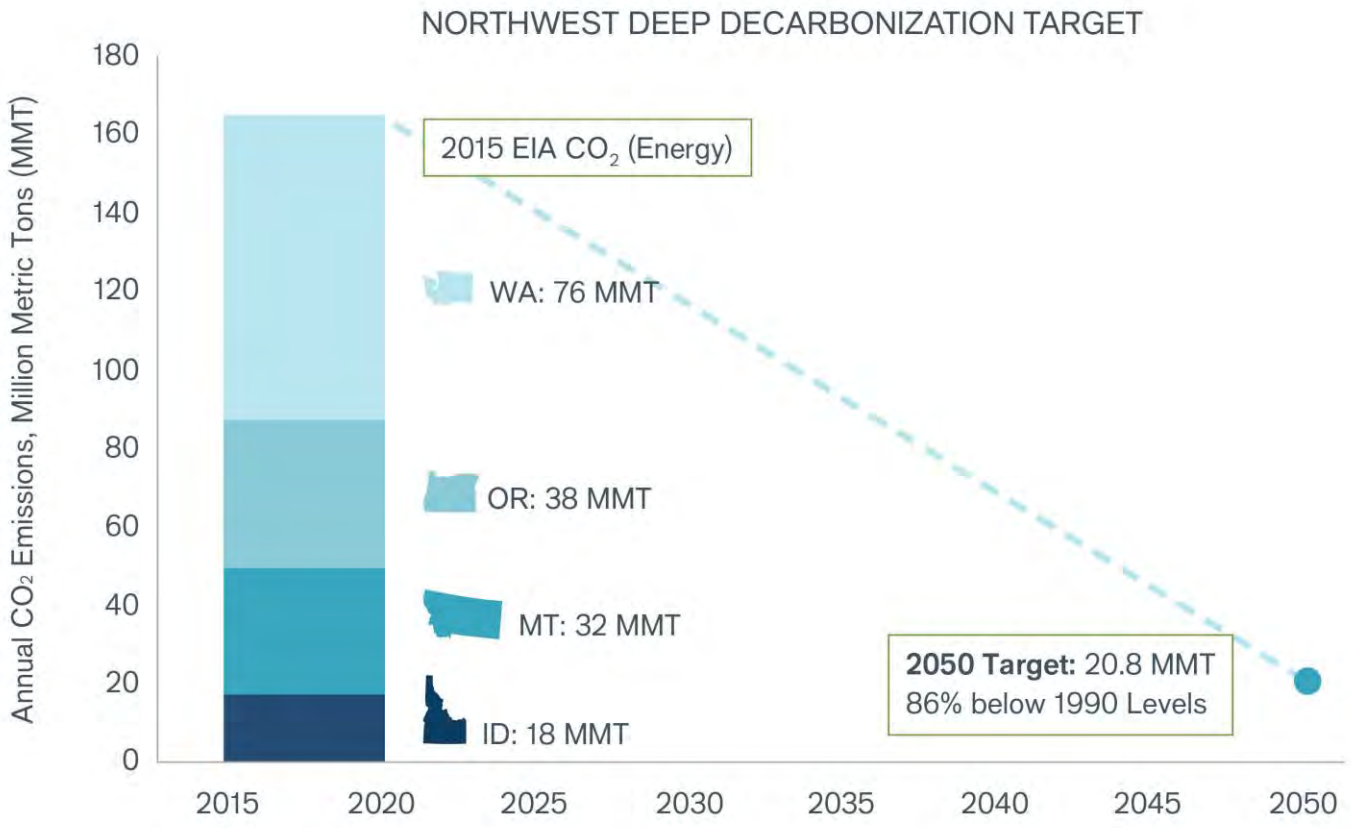
Transportation emissions are nearly half of all CO_2 emissions in Washington and Oregon.



Source: Northwest Deep Decarbonization Pathways Study, May 2019, Evolved Energy Research, page 12. Data are from Oregon Department of Environmental Quality and Washington Department of Ecology.

Northwest Deep Decarbonization Target

An 86% reduction in energy-related CO_2 emissions below 1990 levels by 2050 is required to achieve an overall Northwest deep decarbonization target.



Source: Northwest Deep Decarbonization Pathways Study, May 2019, Evolved Energy Research, page 15.

Clean Energy Transition Institute

Eight Pathway Scenarios Examined

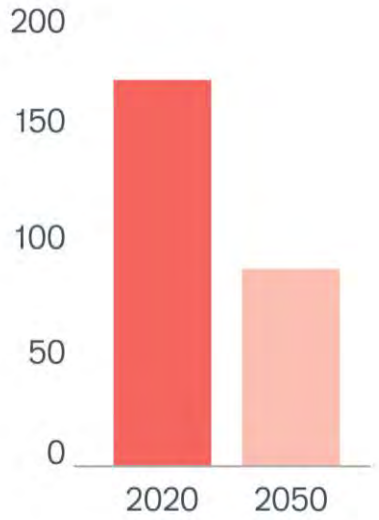
- Business as Usual
- **Central Case**
- 100% Clean Electricity Grid
- Limited Electrification & Efficiency
- No New Gas Plants for Electricity
- Increased NW-CA Transmission
- Limited Biomass for Liquid Fuels
- Pipeline Gas for Freight Vehicles

Key Findings

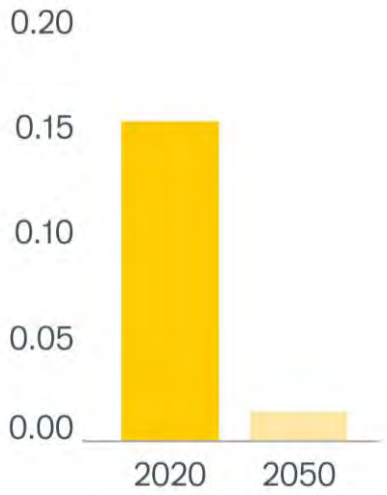
- **Electricity generation approaches 100% clean** without a specific mandate
- **Aggressive vehicle electrification and a highly efficient built environment** powered by clean electricity are **essential**
- **Biomass primarily allocated to jet and diesel fuel**, even after partial electrification of 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**

Five Decarbonization Strategies Deployed

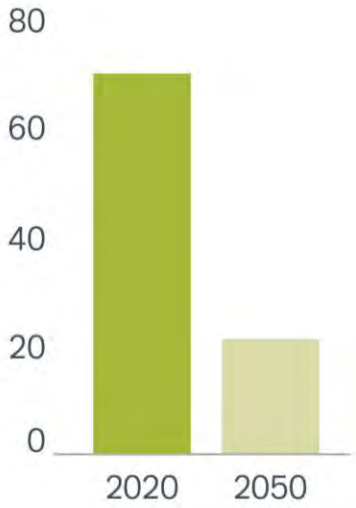
Energy Efficiency
Energy Consumption Per Person (MMBtu)



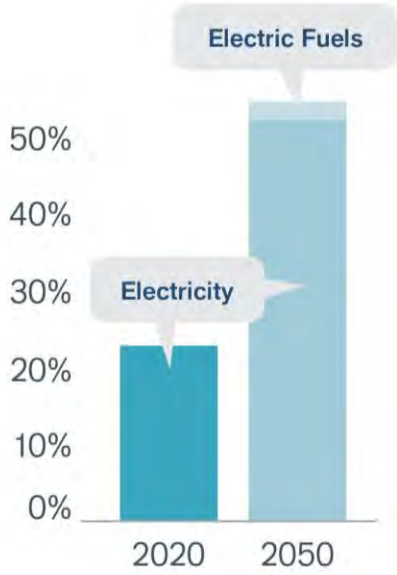
Electricity Decarbonization
Electricity Carbon Intensity (tonnes CO_2 per MWh)



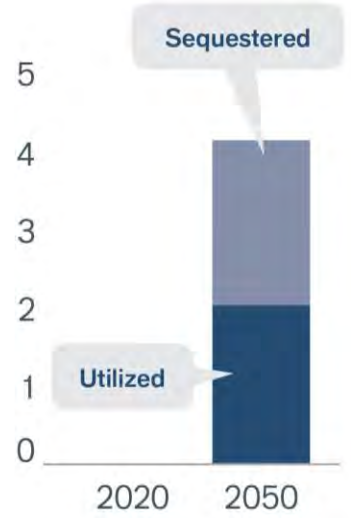
Fuel Decarbonization
Fuels Carbon Intensity (kg CO_2 per MMBtu)

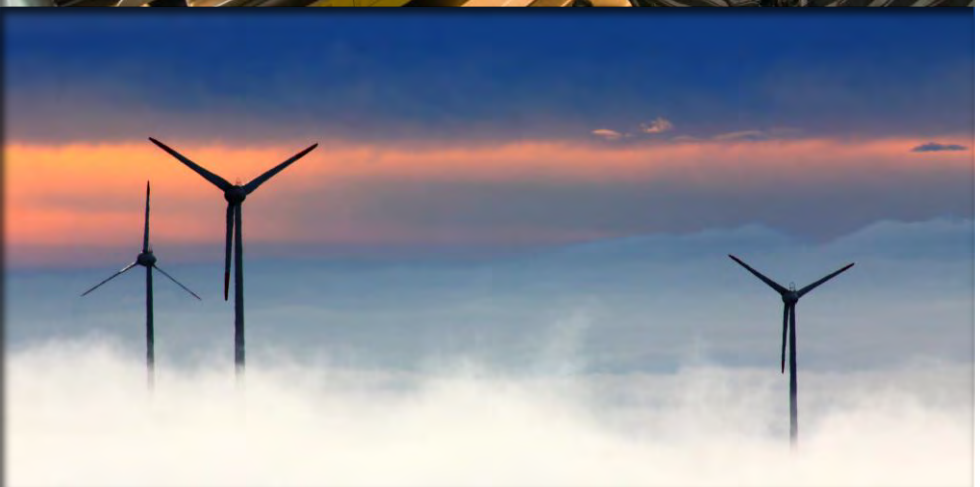


Electrification
Electricity Share of Total Energy (percentage)



Carbon Capture
(Megatonnes CO_2)

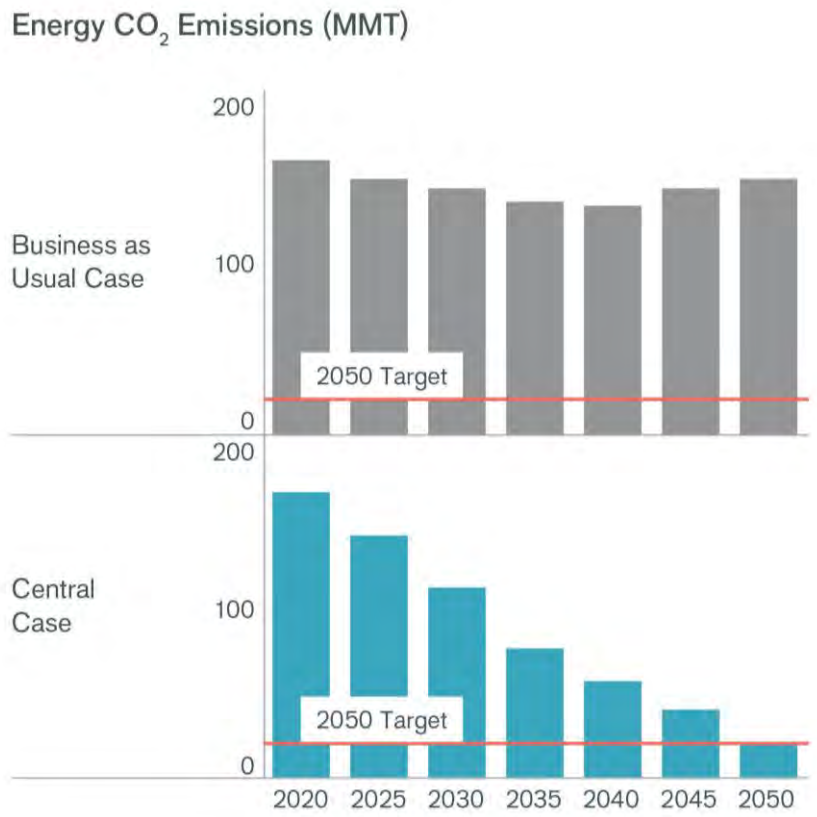




Optimal Decarbonization Scenario (Central Case)

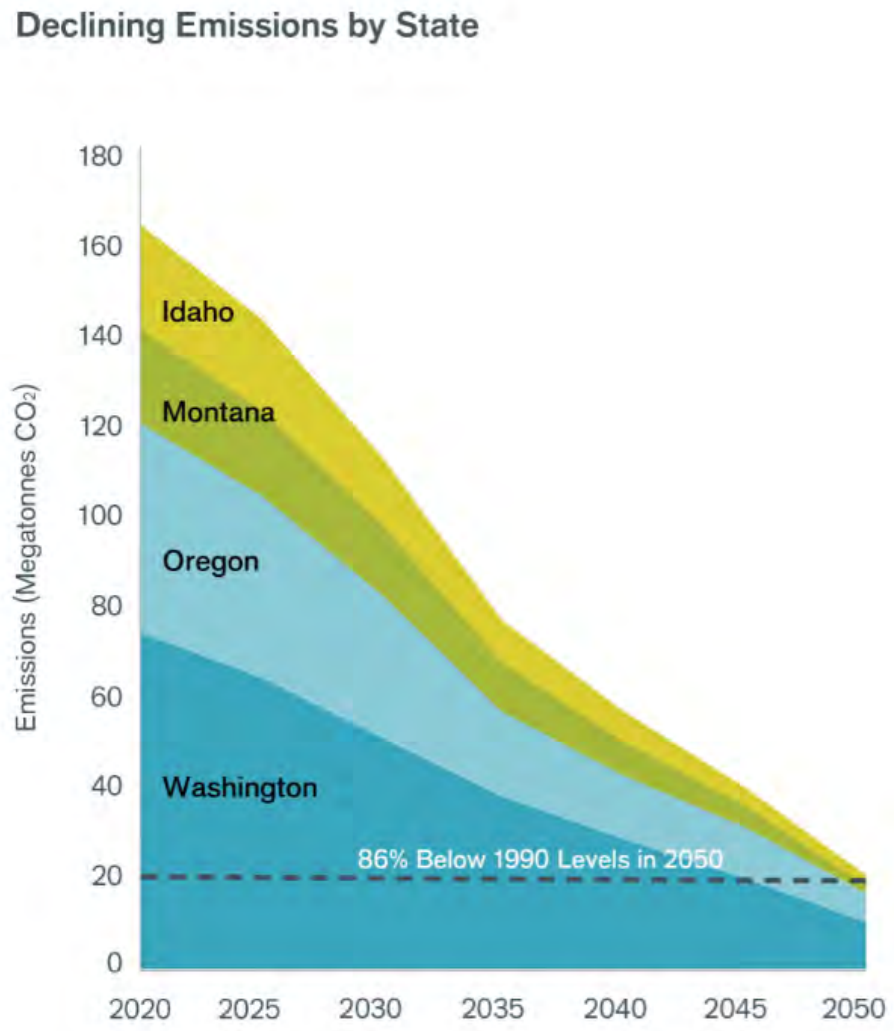
Business as Usual vs. Central Case

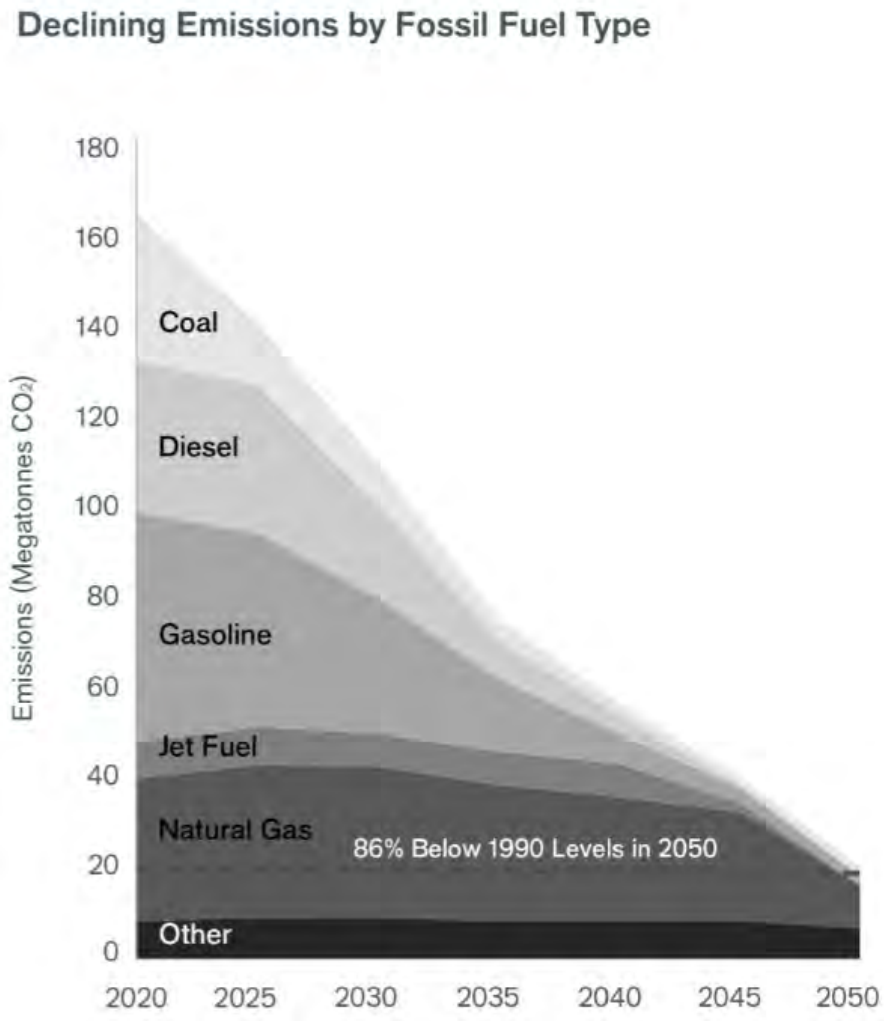
- BAU emissions trajectory falls short of 2050 reduction goal
- Electrification, energy efficiency, and decarbonization of energy supply in the Central Case enable all Northwest states to meet the mid-century energy CO_2 target



Source: Northwest Deep Decarbonization Pathways Study, May 2019, Evolved Energy Research, page 62.

CO_2 Emissions Decrease by State and Fossil Fuel Type

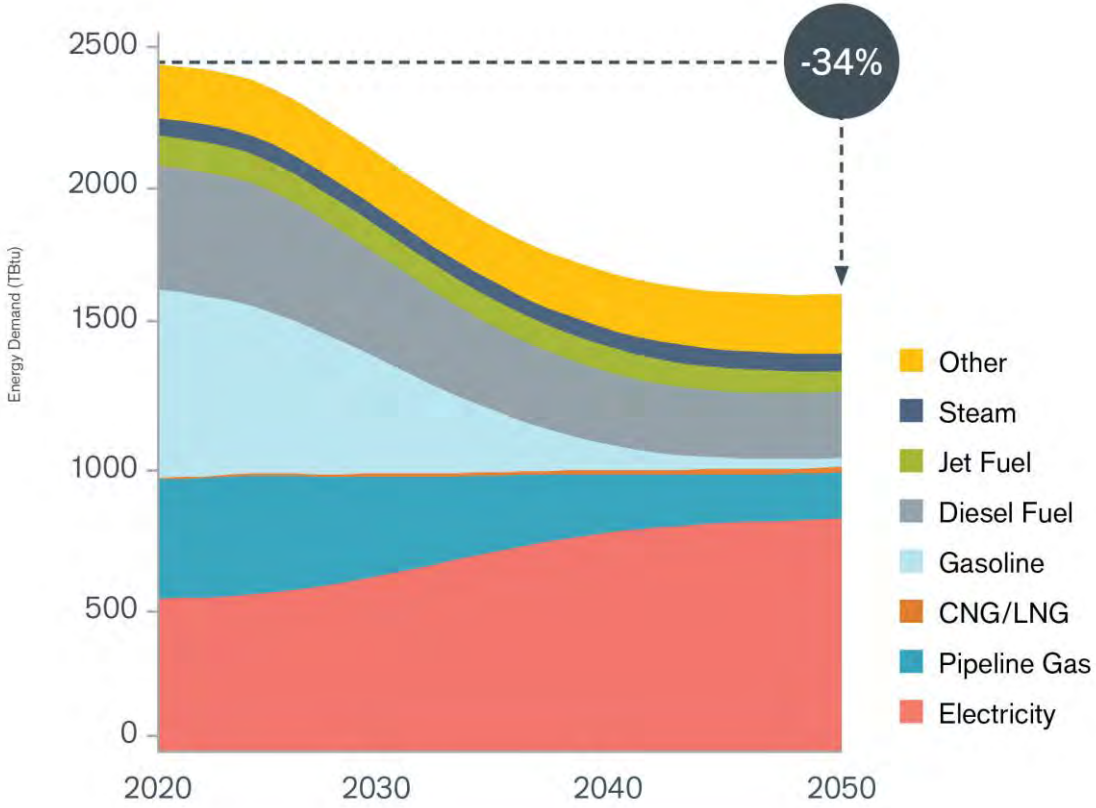




Final Energy Demand

- Overall end-use demand in 2050 is more than one-third below today
- Electricity consumption increases by more than 50% and comprises one-half of all end-use demand by 2050
- Liquid fuels decrease from one-half of demand today to one-fifth by 2050 as on-road vehicles transition to electricity

In the Central Case energy demand is down 34% and electricity consumption is up more than 50% in 2050.

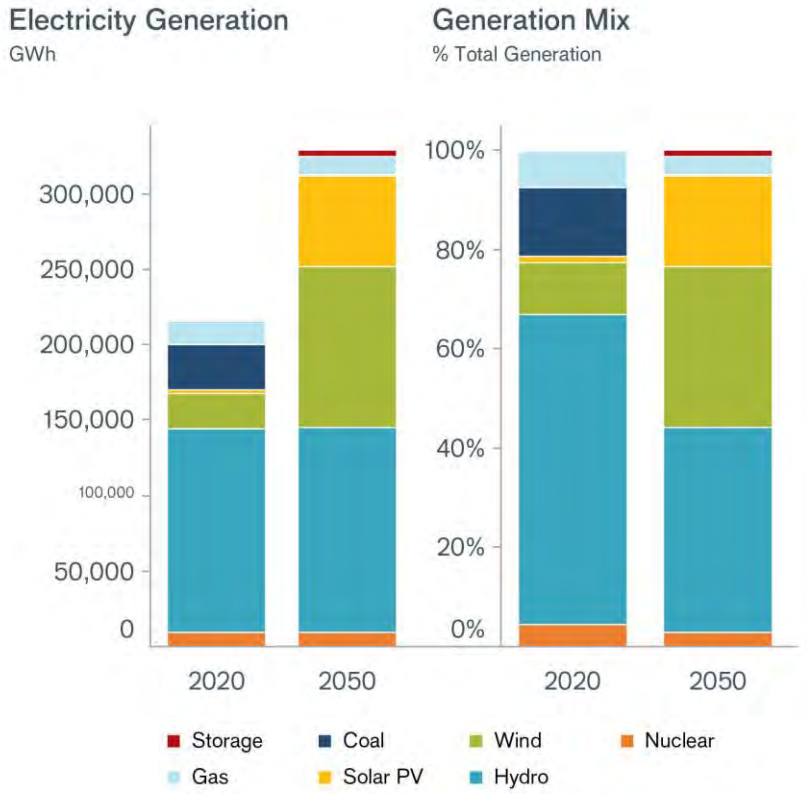


Source: Northwest Deep Decarbonization Pathways Study, May 2019, Evolved Energy Research, page 67.

Carbon-Free Electricity

- New wind and solar PV added to decarbonize electricity generation and meet growing electricity demand
  - Wind generation nearly equals hydro generation by 2050
  - Gas-fired generation share is ~4% in 2050, while coal-fired generation is eliminated
- Nuclear is extended after 2043 and operates through 2050

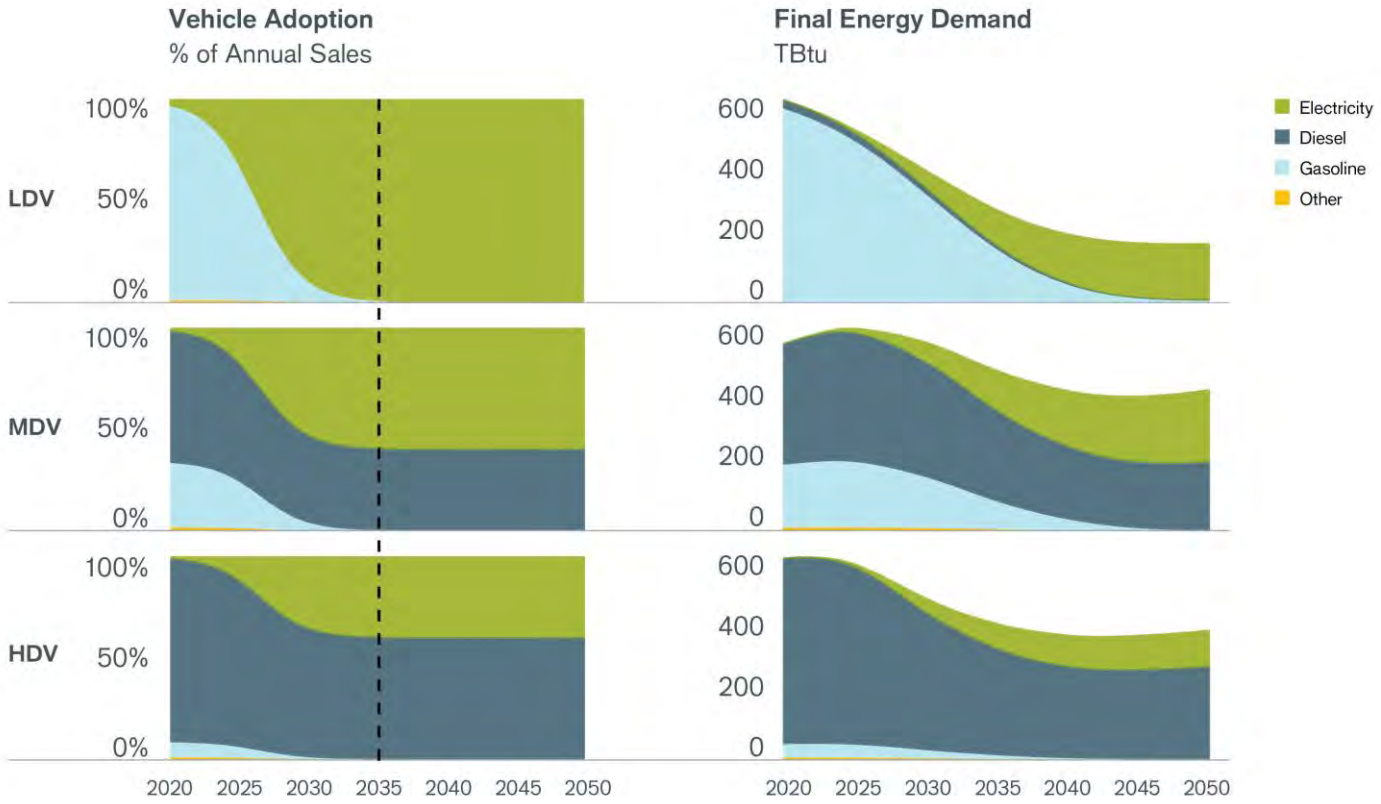
Amount of electricity generation and the generation mix for electricity supply in the Central Case.



Source: Northwest Deep Decarbonization Pathways Study, May 2019, Evolved Energy Research, page 72.

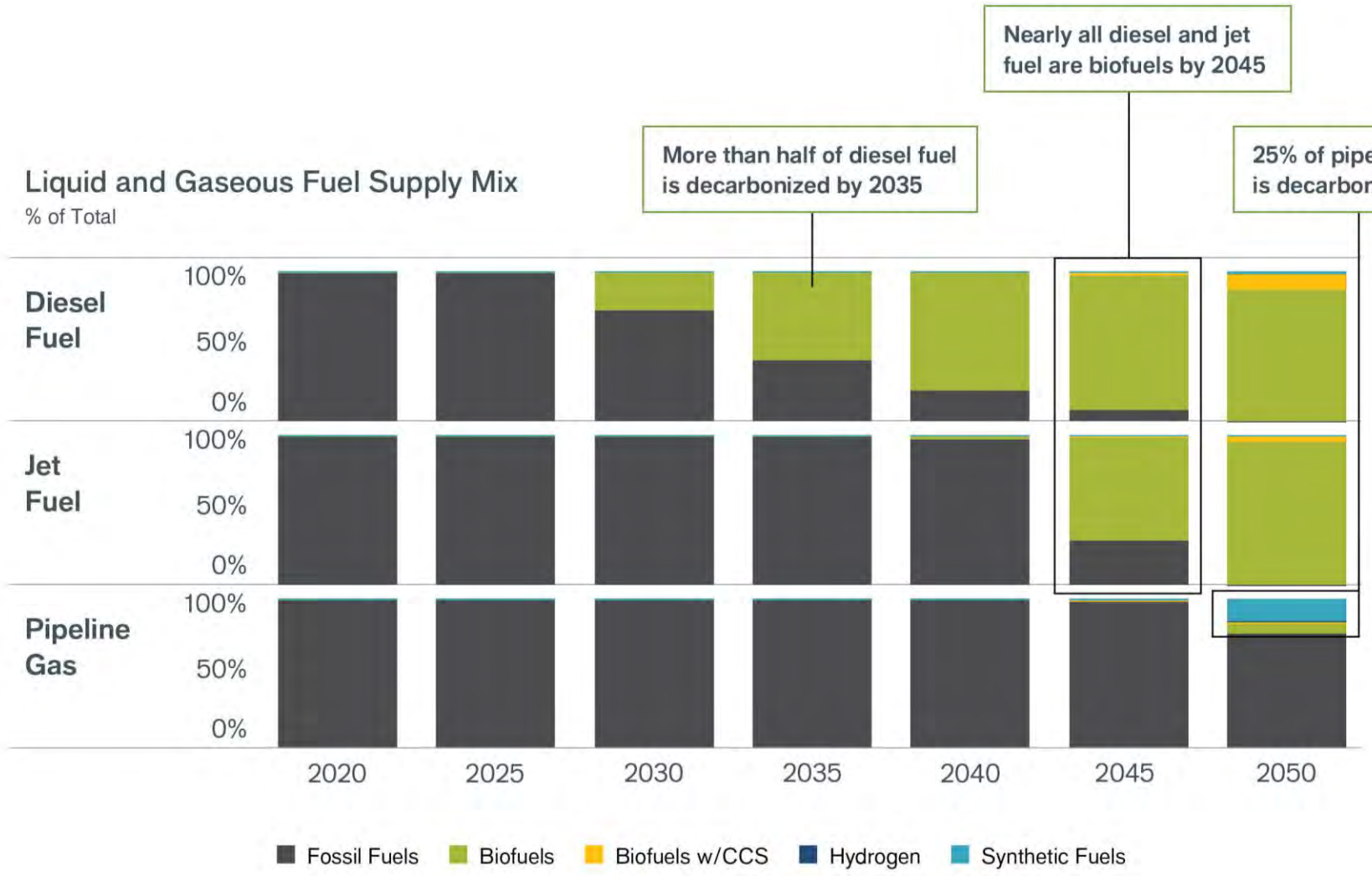
Transportation Electrification

The rate of vehicle adoption as a percentage of annual sales by fuel type from 2020 to 2050 in the Central Case.



Source: Northwest Deep Decarbonization Pathways Study, May 2019, Evolved Energy Research, page 69.

Decarbonizing Diesel, Jet, and Pipeline Gas



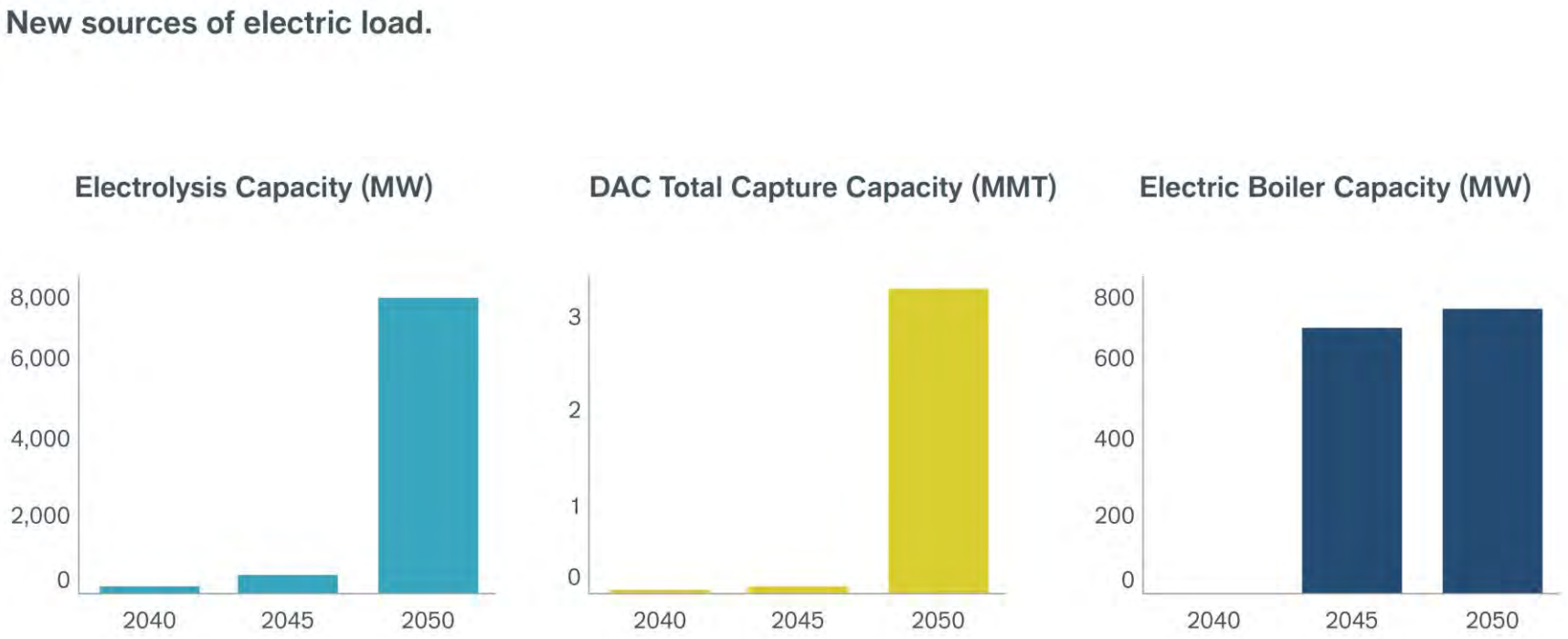
KEY TAKEAWAYS:

Biomass is largely allocated to liquid fuels

Synthetic electric fuels make up more than 10% of pipeline gas in 2050

Electric Fuels/Grid Balancing

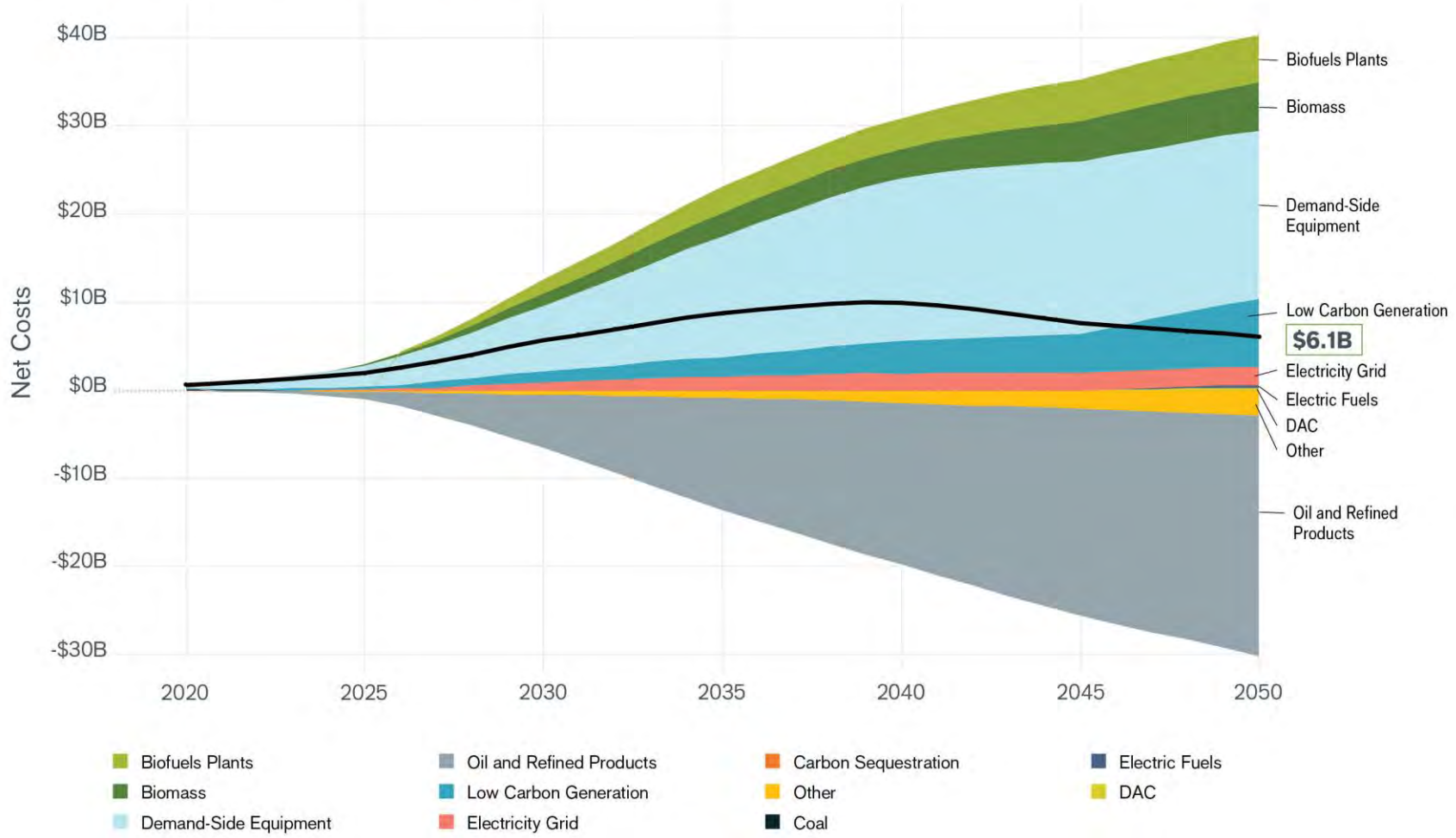
- In 2040s, new electric loads serve an essential role



Source: Northwest Deep Decarbonization Pathways Study, May 2019, Evolved Energy Research, page 77.

Net Annual Energy Costs

Annual net energy system costs for the Central Case relative to the Business as Usual Case 2020–2050.



Insights from Alternative Pathway Scenarios

Electricity Sector Insights: Part One

- **100% Clean Electricity Grid Case**
  - Gap between 100% Clean Electricity and Central scenarios much small than anticipated
  - Achieving 100% clean electricity easier with economy-wide decarbonization; resources with low-carbon co-products across the energy system (e.g., hydrogen) are considered
- **No New Gas Plants for Electricity Case**
  - Results in additional energy storage and renewables that can provide reliable supply
  - Cost of implementing managed by electric fuels using excess renewables
  - Approximately double the incremental costs of the Central Case

Electricity Sector Insights: Part Two

- **Increased NW-CA Transmission Case** explores how increased transmission between the two regions could achieve decarbonization at potentially lower costs
  - Evaluating long-term transmission and resource planning changes beyond near-term challenges and issues (e.g., EIM)
- Impacts
  - 4,500 MW of incremental transmission capacity
  - Expanded interties alter optimal electricity portfolios in each region; avoiding development of low-quality renewables; CA exports high-quality solar to NW; NW exports high-quality wind to CA
  - Net present value of savings across study period is $11.1 billion; higher transmission investment costs offset by resource cost savings
- Scale of benefits indicates deeper investigation needed

Electrification & Biomass Implications

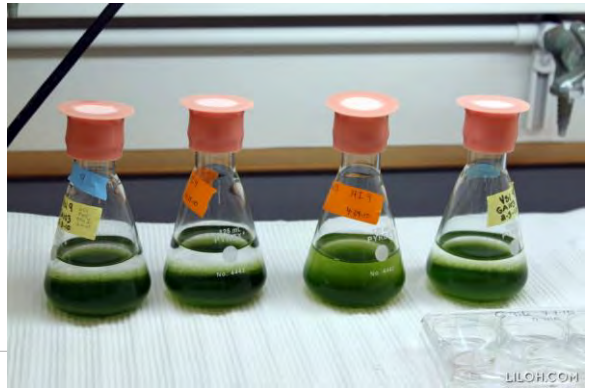
- Failure to electrify customer side has enormous implications for energy supply
  - The scale of new wind, solar, direct air capture, electrolysis, and power-to-X facilities could be considered prohibitive in implementation, and may ultimately require imports of electric fuels produced elsewhere
- Restricted availability of net-zero-carbon biomass results in similar energy system impacts
- If consumers don't electrify or biofuels are not available, then the "backstop" resource to decarbonize is synthetic electric fuels
  - There are implementation challenges to develop at scale

Bottom Line
Deep Decarbonization Achievable, Requires:

- Energy System Transformation
- Deployment of Multiple Strategies
- Investment and R & D
- Technology, Business Model, and Policy Innovation

Study Implications

- Implementing widespread, regional transportation electrification
- Severely limiting natural gas in buildings, transport, and the grid
- Achieving better grid integration between the Northwest and California
- Assessing actual biomass in the Northwest for jet and diesel biofuels
- Determining the role power-to-X, electrolysis, direct air capture in the Northwest



Next Steps

- Convenings to Accelerate Deep Decarbonization
  - Role of Natural Gas in Buildings, Transport, Grid
  - Transportation Electrification
  - Northwest-California Grid Integration
- Potential Additional Runs of the Model
  - Change assumptions about hydroelectricity, nuclear availability, coal plant retirements, natural gas pricing and carbon intensity.
- Policy Implications for the Northwest

Thank you!

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

Gabe Kwok,
Principal, Evolved Energy Research
gabe@evolved.energy

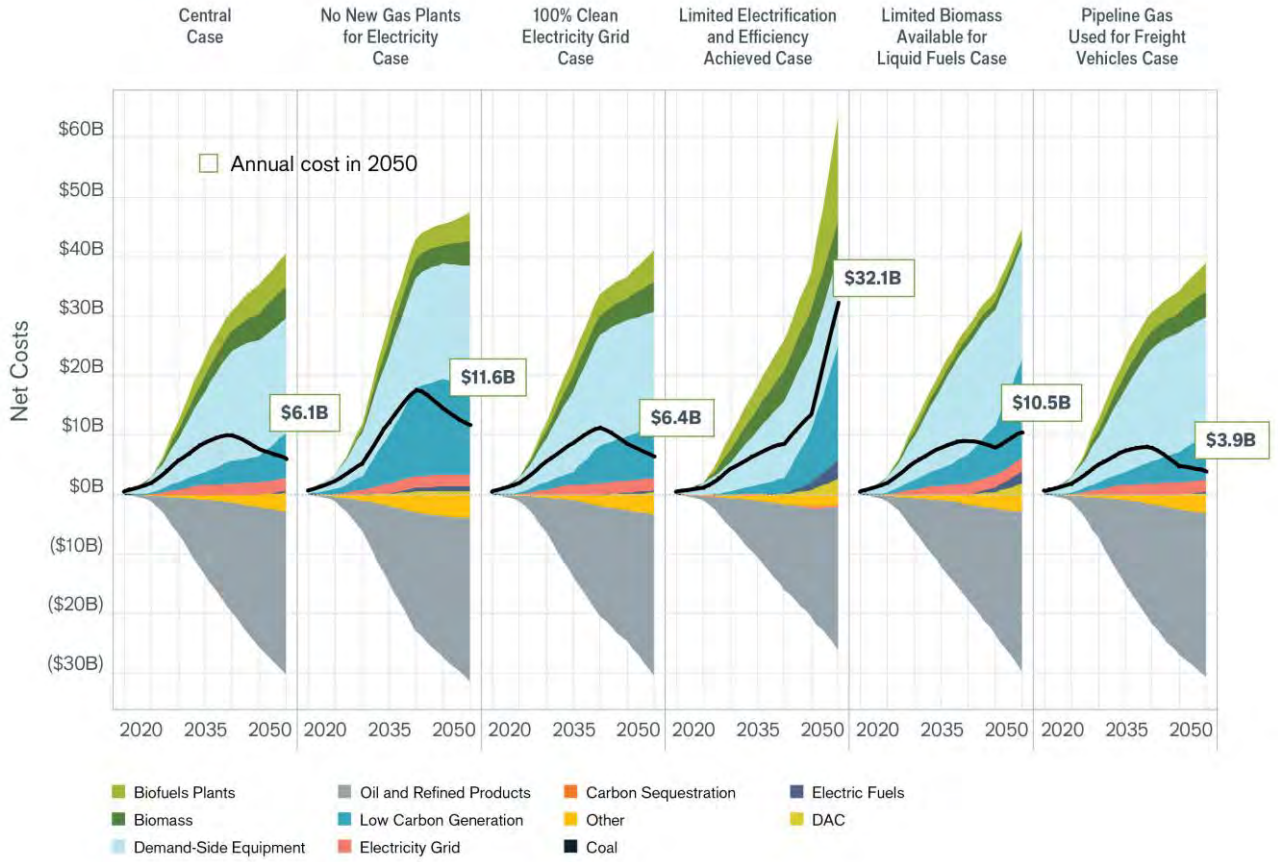
@CETransition

cleanenergytransition.org

Clean Energy Transition Institute

Annual Net Energy System Costs Six Cases

Annual net energy system costs for six cases compared to the Business as Usual Case.

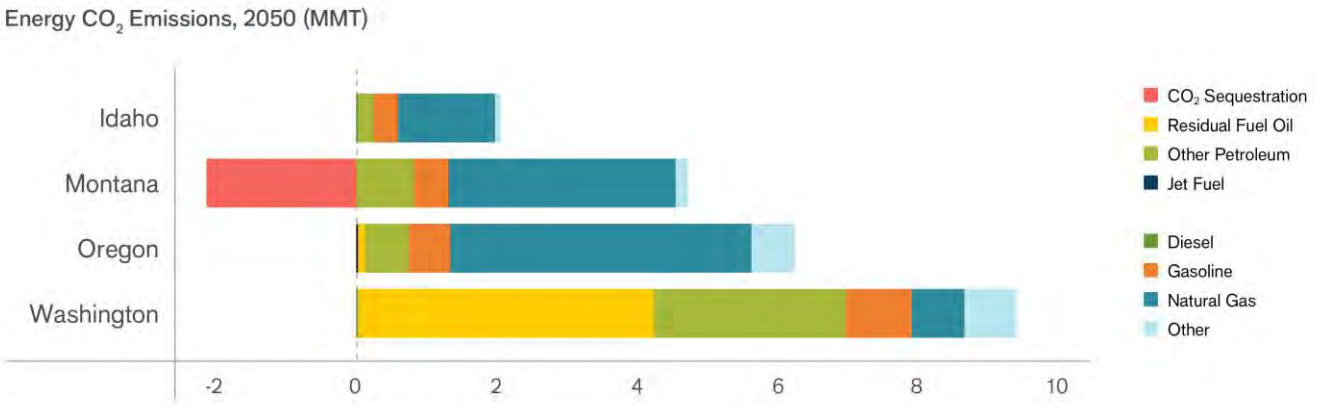


Source: Northwest Deep Decarbonization Pathways Study, May 2019, Evolved Energy Research, page 107

State-Level Energy CO_2 Emissions in 2050

- Majority of remaining emissions from natural gas combustion
- Except Washington—residual fuel oil used in shipping largest remaining source of emissions
- Montana has geological CO_2 sequestration potential, allows for CO_2 capture and storage in saline aquifers

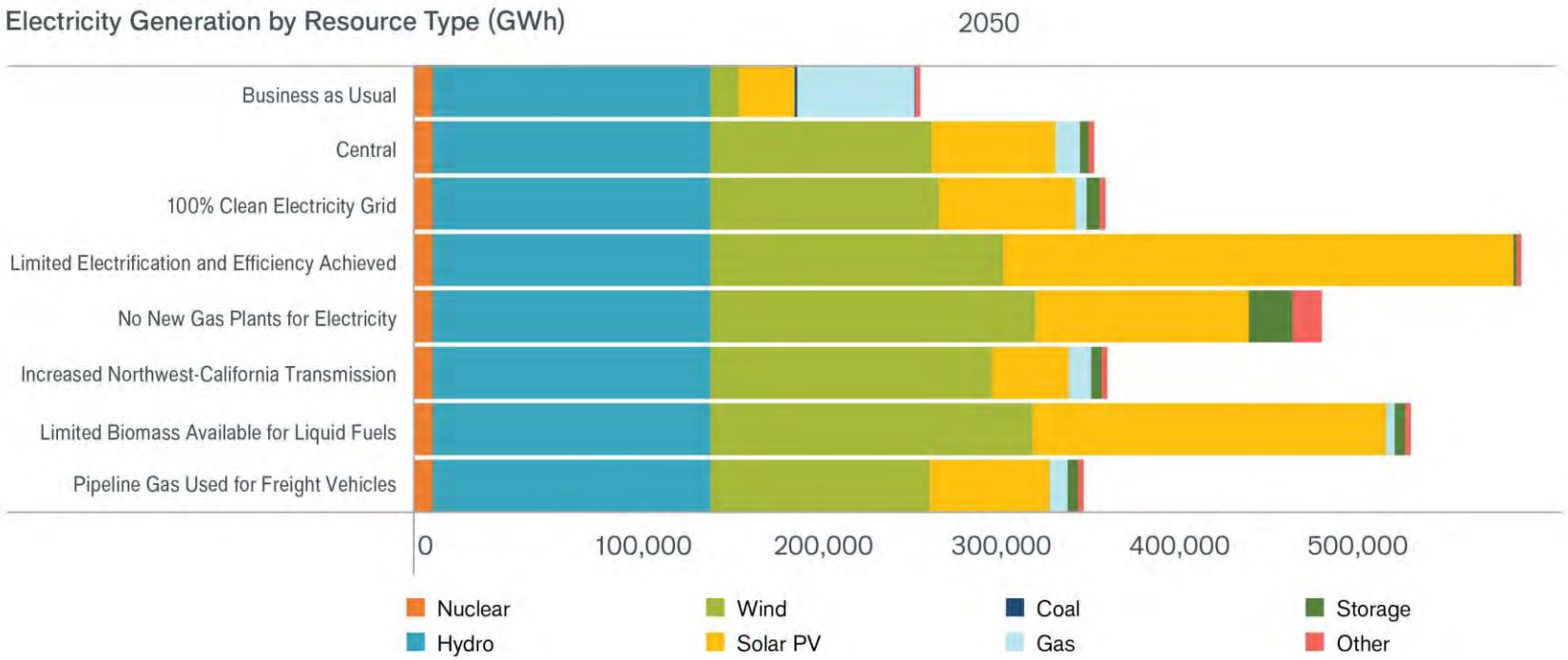
In three of the four states, the majority of remaining emissions in the Central Case in 2050 are from natural gas combustion.



Source: Northwest Deep Decarbonization Pathways Study, May 2019, Evolved Energy Research, page 79.

Electricity Resources All Cases in 2050

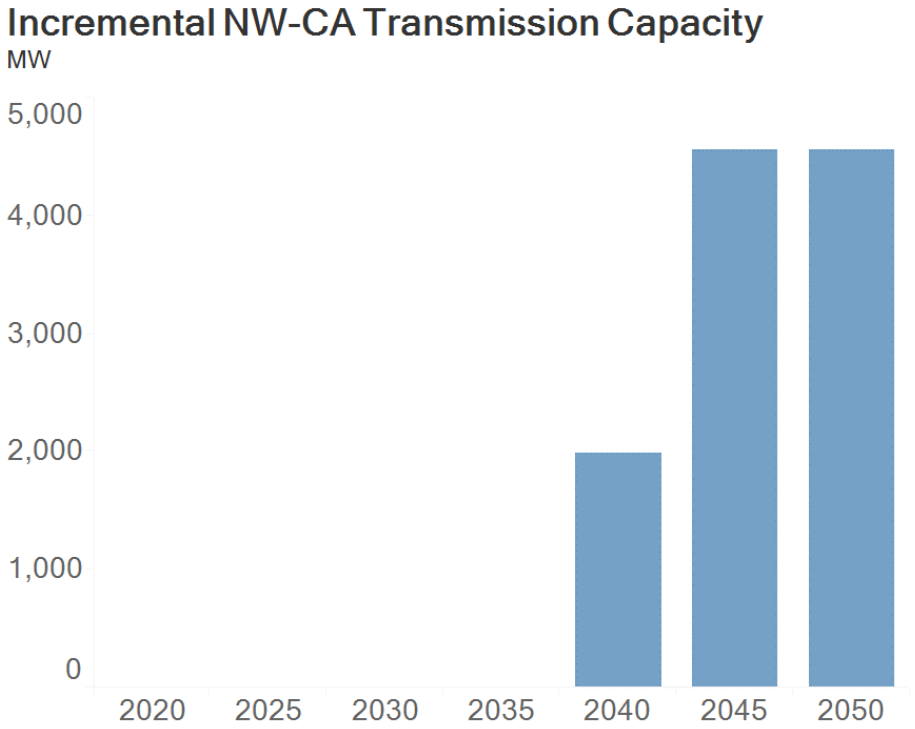
There are significant impacts on total electricity generation for the Limited Electrification and Efficiency Achieved Case, Limited Biomass Available for Liquid Fuels Case, and No New Gas Plants for Electricity Case.

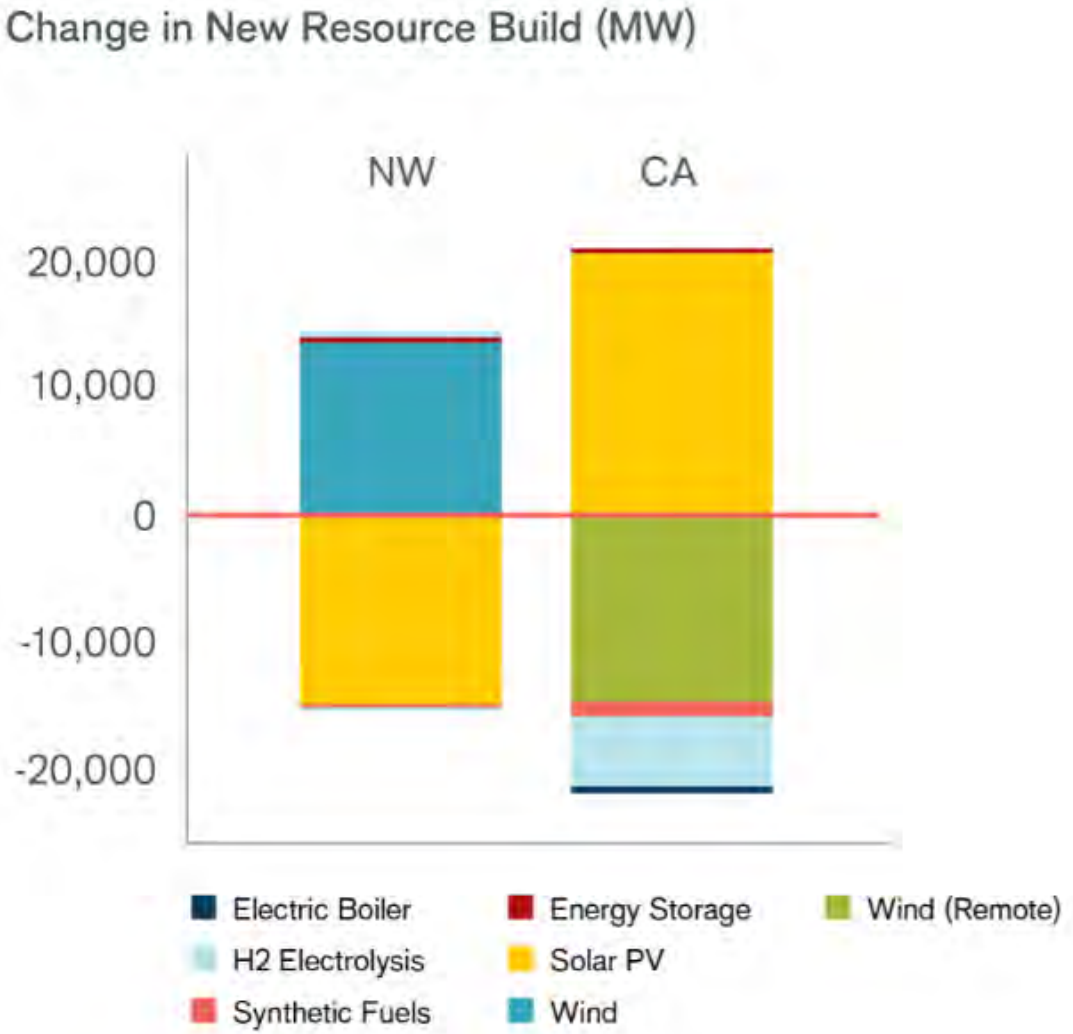


Source: Northwest Deep Decarbonization Pathways Study, May 2019, Evolved Energy Research, page 99.

Increased Northwest-California Transmission

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



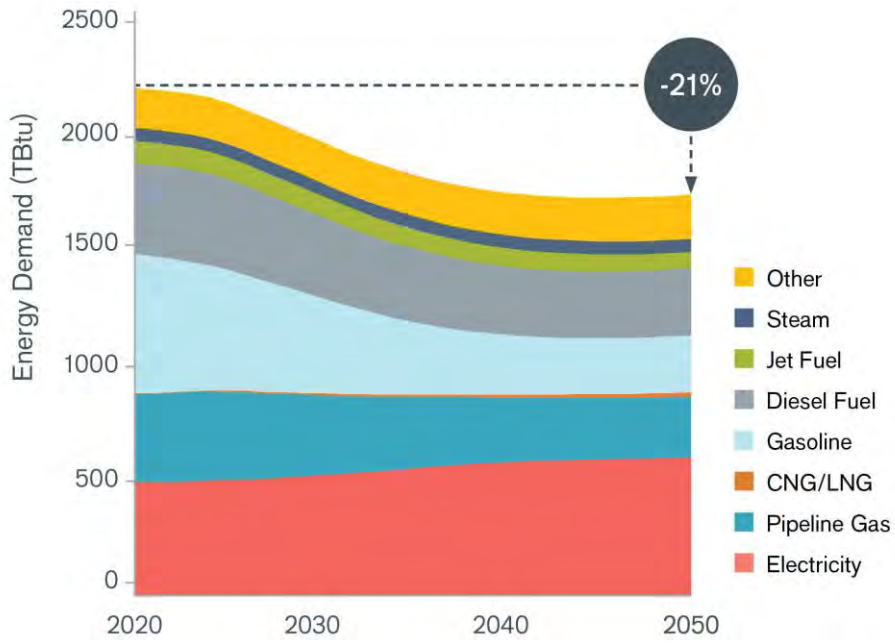


Source: Northwest Deep Decarbonization Pathways Study, May 2019, Evolved Energy Research, page

Limited Efficiency & Electrification

- Overall end-use demand declines relative to today, but to a lesser extent than the Central Case
  - **21% decrease versus 34% decrease**
- Lack of progress in fuel switching translates into large volumes of liquid fuels remaining in the energy system during the next three decades
- Weak demand-side progress places higher importance on the supply-side to achieve emissions reduction outcomes
- $32.2B in 2050, 5x optimal case

Energy demand declines by 21% in the Limited Electrification and Efficiency Achieved Case vs. 34% in the Central Case.

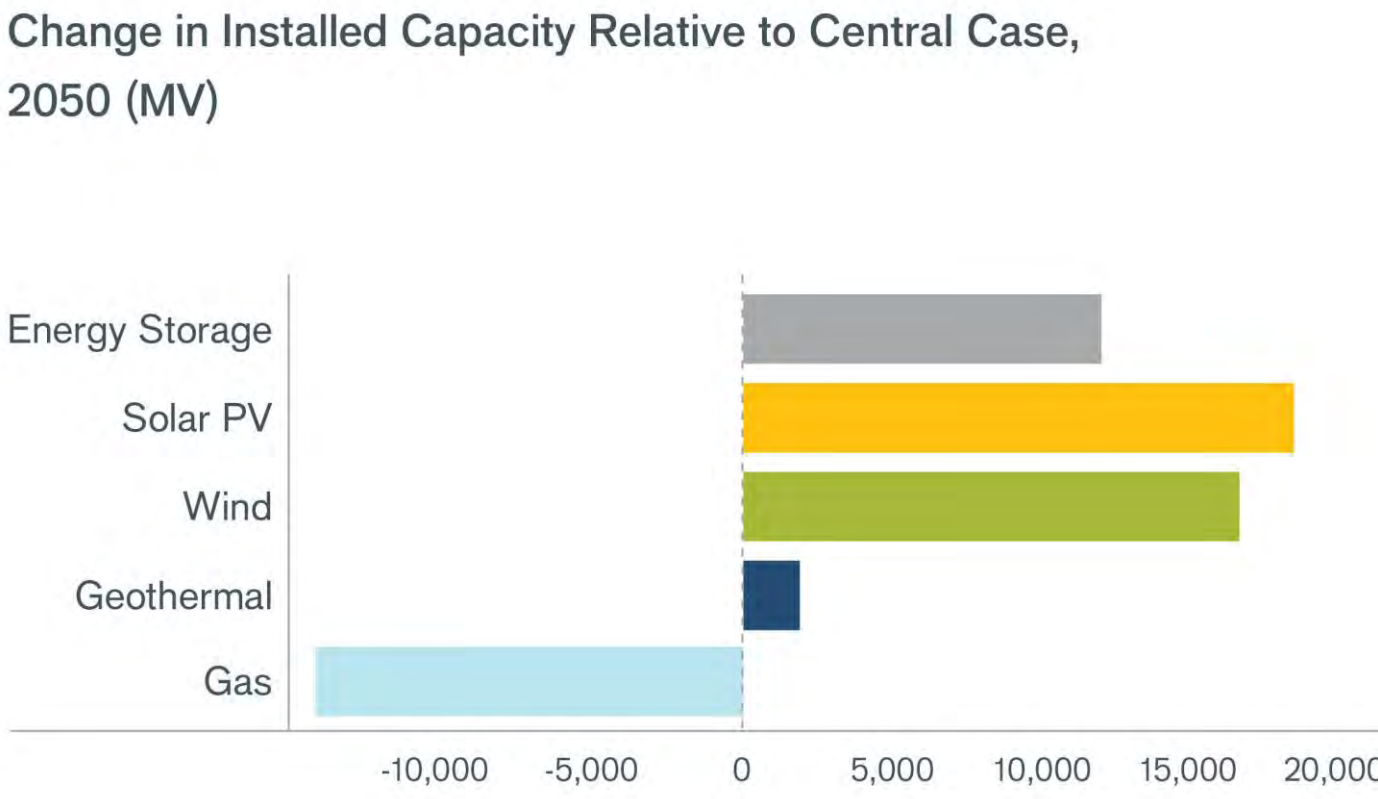


Source: Northwest Deep Decarbonization Pathways Study, May 2019, Evolved Energy Research, page 83.

No New Gas Plants

- Prohibiting development of new gas-fired generating resources in electricity sector results in:
  - **Higher levels of energy storage resources** to maintain resource adequacy (+12,000 MW)
  - **More than 35,000 MW of additional wind, solar, and geothermal resources** for energy storage to utilize for charging and to provide marginal resource adequacy
  - Incremental cost of $5.6B in 2050, to $11.7B

The No New Gas Case requires installing nearly three times as much renewable generation capacity.



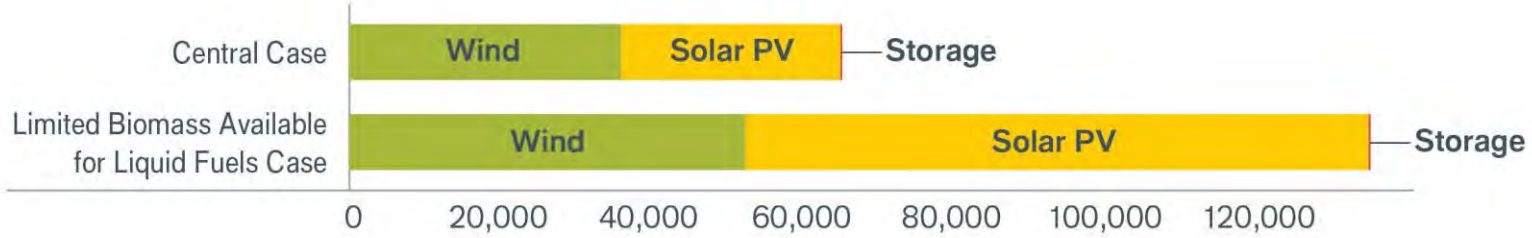
Source: Northwest Deep Decarbonization Pathways Study, May 2019, Evolved Energy Research, page 87.

Ltd. Biomass

- Reduced fuels decarbonization in 2030-2045
- Synthetic fuels replace biomass as alternative to diesel and jet fuel, 2045-2050
- $10.6B 2050 Cost, 74% higher than optimal

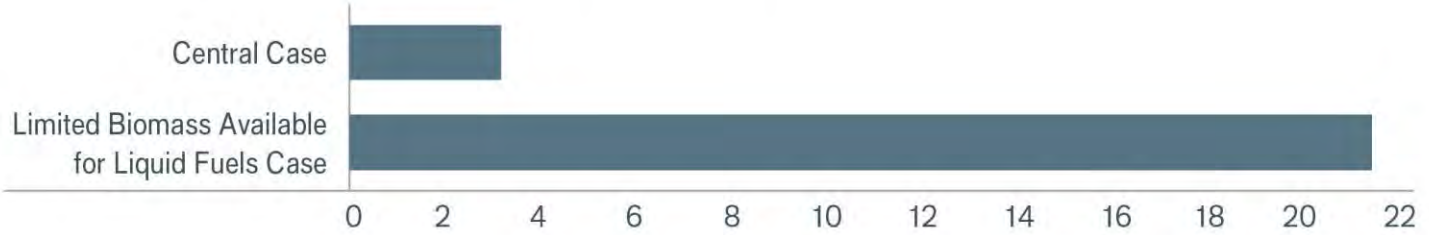
The substantial infrastructure implications of the Limited Biomass Available for Liquid Fuels Case.

Renewables: Installed Capacity, 2050 (MW)



Hydrogen Electrolysis, 2050 (MW)

Direct Air Capture, Total Capacity, 2050 (MMT per year)



Source: Northwest Deep Decarbonization Pathways Study, May 2019, Evolved Energy Research, page 92.