Washington State Energy Strategy Technical Consulting

Agenda-May 27, 2020 Scenario Development Webinar

- Scenario Development Philosophy
- Reference and Central Case
- Alternative Decarbonization Scenarios

Transforming Washington’s Energy System

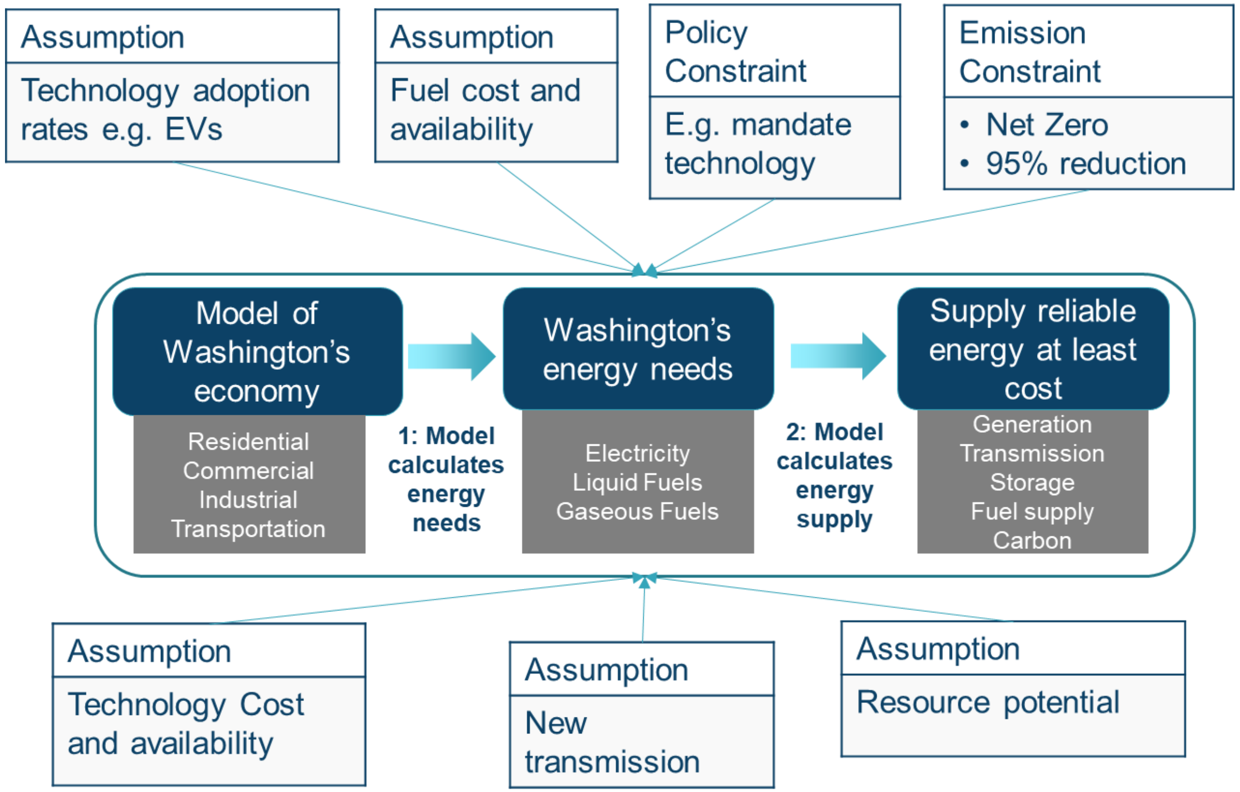
- Transformational rather than incremental change
- Aggressive action needed across all energy sectors
- Many options to get there
  - Process designed to find the best path forward for Washington State’s priorities
    - Equity, affordability, reliability, competitiveness
- Building on a foundation of past studies and efforts in other states

Emissions targets for State Energy Strategy:

2020: 1990 levels
2030: 45% below 1990
2040: 70% below 1990
2050: 95% below 1990
2050: Net zero

Scenario Development Philosophy

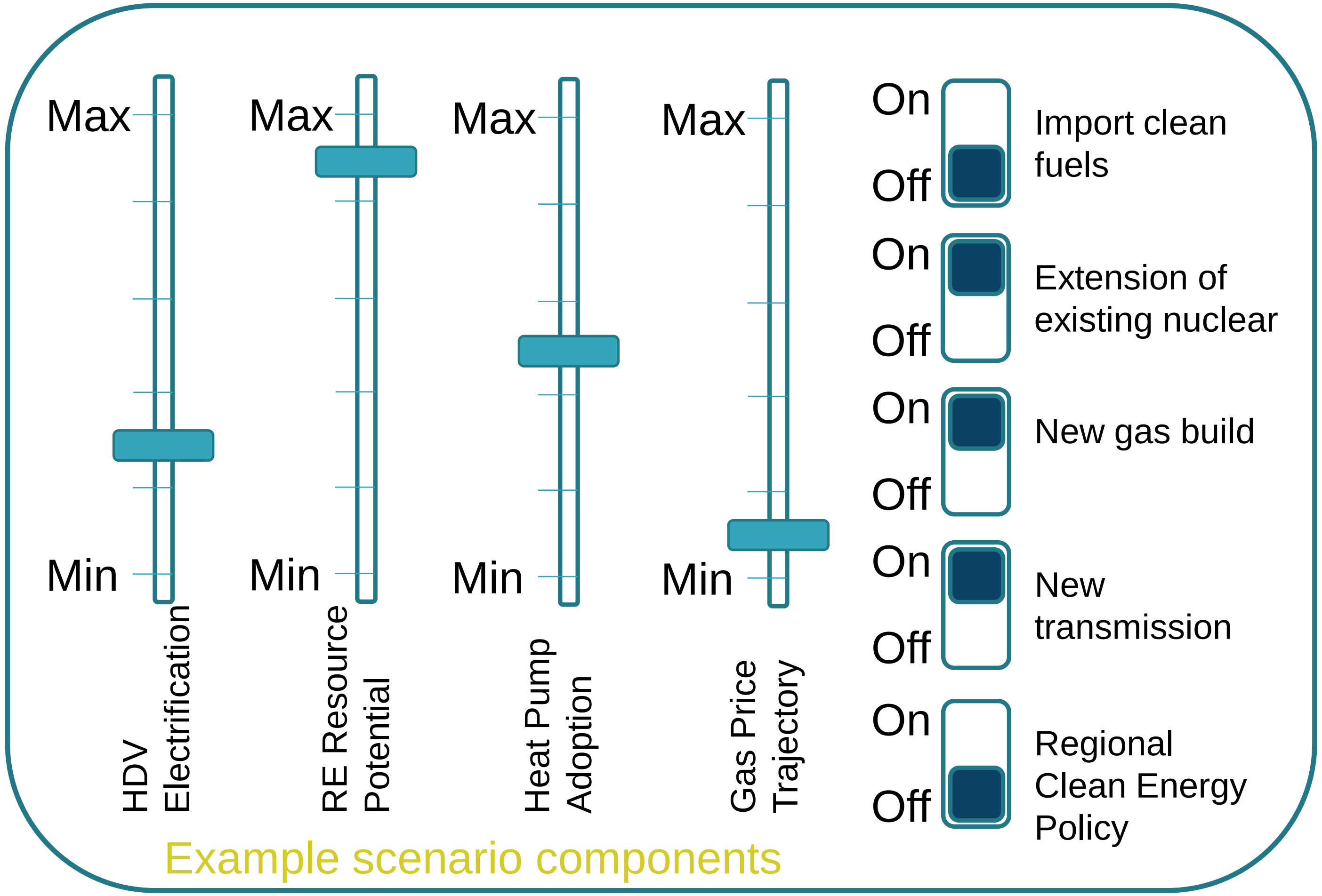
Scenario Development: Investigate State Objectives



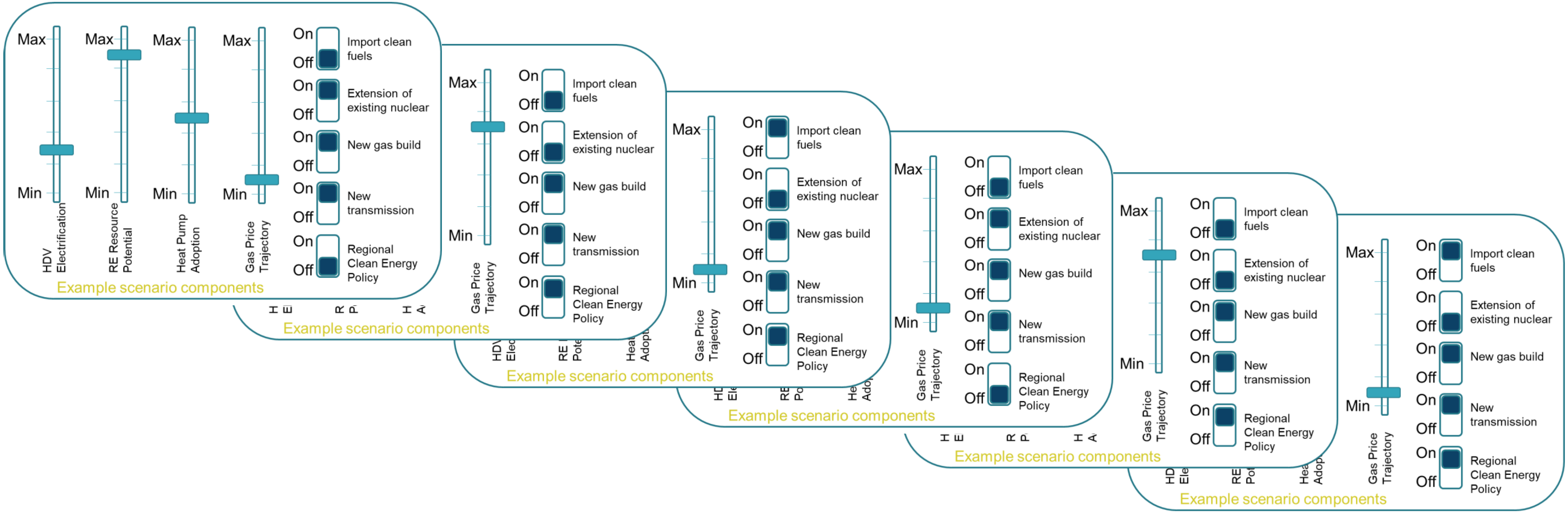
- Translate State objectives and potential policy pathways into constrained scenarios
  - How hard should we push on particular actions or strategies?
- Understanding the tradeoffs
  - How much does one pathway cost versus another?
    - Counterpoint for policymakers and stakeholders
  - Provides a target for near-term policy and action design to hit
- Understanding the uncertainties
  - How does an uncertain future impact our decisions?

Components of a Scenario

- Many assumptions go into projecting a decarbonization pathway
- Sets the parameters for the world within which our model optimizes decisions
  - ✓ Assumptions on how uncertainties now manifest in the future
  - ✓ Assumptions on how policies/actions/ customer behavior manifest in driving energy needs and how they can be served



Connect Scenarios to Important Outcomes for the State

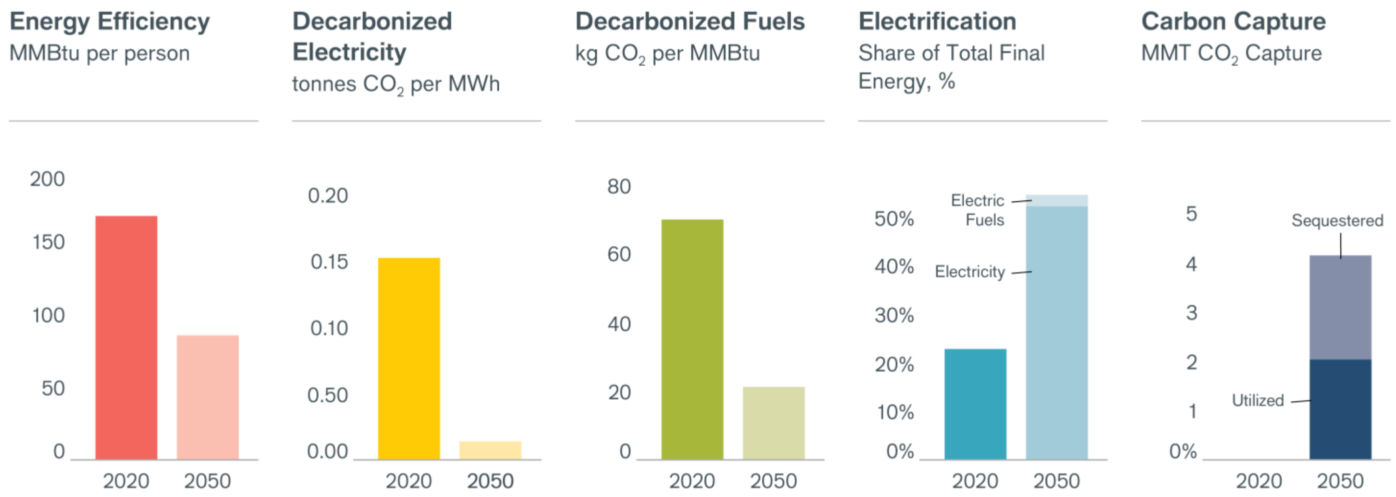


- Develop with the feedback from the State and Advisory Committee
- Provide valuable information for the policy development process for the SES

What Happens after Scenario Development?

Least Regrets Strategies

Cost effective outcomes from modeling to inform policy



Policy Development

How should we get there?

Creation of the SES

Rate reform?

Level playing field?

New business models?

Near term policies/actions that support long term goals

Transformational policy?

Infrastructure development?

2020 2025 2030 2035 2040 2045 2050

Reference and Central Cases

A “Reference Case” does not meet GHG Targets

What would WA do differently when meeting clean energy goals versus the status quo?

- Washington has policy it will achieve regardless of emissions targets such as CETA
- Reference Case achieves all key existing policies and holds them constant through 2050
  - ✓ e.g., carbon neutral electricity by 2030, 100% clean electricity by 2045
- Comparisons between decarbonization scenarios and the Reference Case show the differences in investments, operations, and overall costs needed for emissions goals

Key Washington policies and targets through 2030 and 2050

- **Electricity fuel mix disclosure**
- **Utility planned resource additions**
- **Energy code strategy**
- **Bioenergy coordination**
- **Energy Independence Act**
- **Appliance standards**
- **Power plant emission standards**
- **Clean Energy Transformation Act**

1. Reference Case

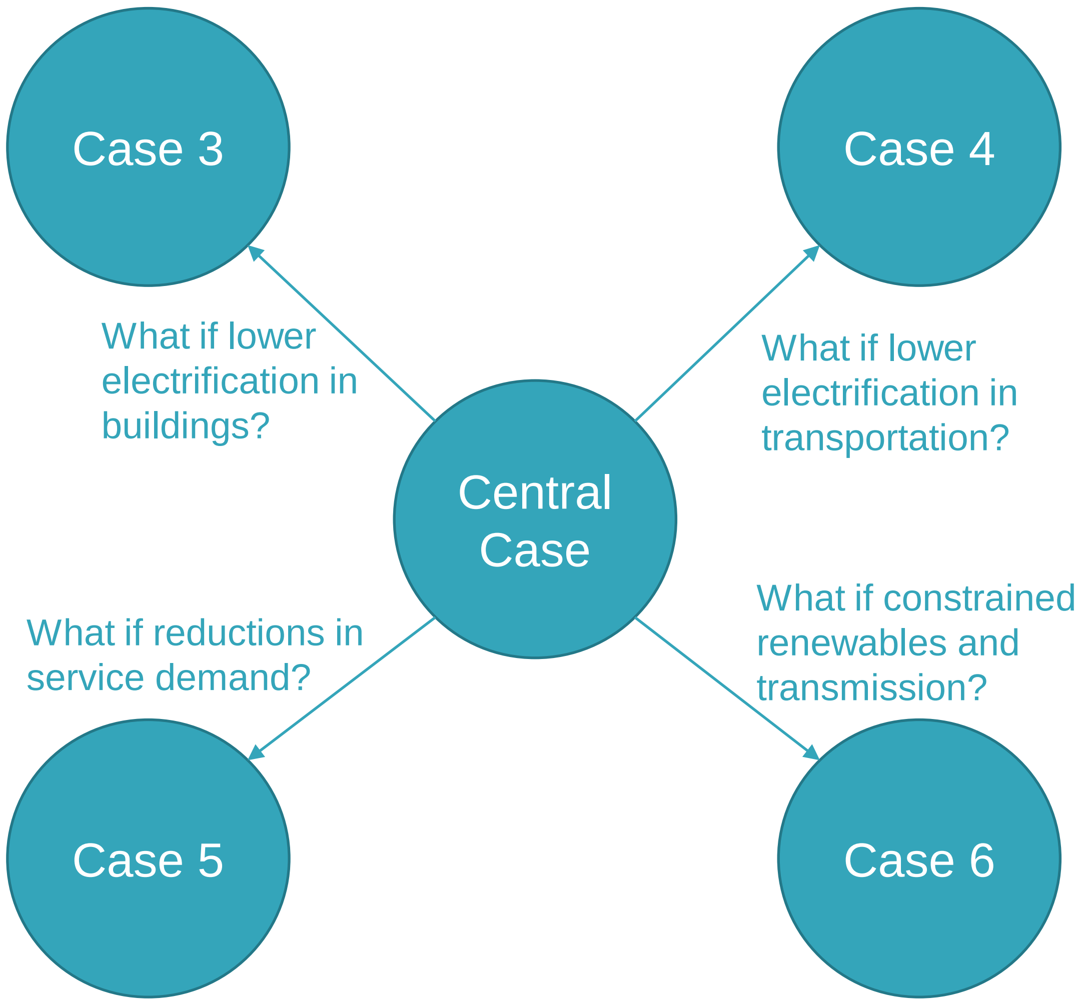
Description of Assumptions

- All existing demand side technology, its remaining lifetime, and replacement technologies
  - ✓ What do consumers buy when their current air conditioners, water heaters, vehicles etc., need to be replaced?
  - ✓ What equipment do businesses and industry install when they need to replace their old technology?
- Service demands for energy across all sectors
  - ✓ Includes impact of load growth/changes by sector
- All existing energy supply side technology and transport infrastructure
  - ✓ The electricity grid and transmission
  - ✓ Fuels availability and pricing
- The cost, efficiency, and operating characteristics of all new technology options
- Existing policy

2. Central Case

Meets decarbonization goals and baseline for all other decarbonization cases

- Case that all other cases are compared to
- Relatively unconstrained technology availability in-state and out of state
- Aggressive electrification and efficiency
- No measures taken to reduce service demands
  - ✓ Conservative, can we decarbonize even without behavior changes?
- Other scenarios change something about the Reference Case
  - ✓ “What if?”



2. Central Case

Description of Assumptions – Starts with assumptions from the Reference Case

- Aggressive on efficiency and electrification – what is achievable?
- Regional clean energy policy:
  - ✓ WECC states, non-Northwest, existing clean energy policy, Northwest: 80% below 1990 levels by 2050 target from NWDDP
- WA can utilize out of state resources to count towards clean energy requirements in-state
- Service demands remain business as usual through 2050
- All resource options permitted for electricity and fuels production
- Fuels trading between states, including pipeline construction
- DOE Billion Ton study for biomass availability
- Transmission expansion between states permitted
- Load management through dispatch of new flexible load technologies

Alternative Decarbonization Scenarios

3. Low Electrification and Efficiency in Buildings and Industry

- Investigating the challenges of reaching decarbonization targets with slower action in buildings and industry
  - ✓ Policy: Are these favorable measures to emphasize in decarbonizing the economy?
  - ✓ Uncertainty: Will barriers to implementation slow action?
- How will decarbonization costs be affected if we can't deliver on efficiency and electrification in buildings and industry?

Implementation

- **Same assumptions as the Central Case, except:**
  - ✓ **The transition to efficiency and electrification in buildings happens at a slower rate and less efficiency and electrification are achieved by 2050**

4. Low Electrification in Transportation

- Investigating the challenges of reaching decarbonization targets with slower action in transportation
  - ✓ Policy: Are these favorable measures to emphasize in decarbonizing the economy?
  - ✓ Uncertainty: Will barriers to implementation slow action?
- How will decarbonization costs be affected if electrification in transportation is less aggressive?

Implementation

- **Same assumptions as the Central Case, except:**
  - ✓ **Transportation retains a higher proportion of gas and diesel burning vehicles**

5. Changes in Service Demand

- Demand reductions for fundamental forms of energy – heat, light, movement – can reduce decarbonization costs
  - ✓ At the same time, these reductions could have other ancillary benefits
- How will decarbonization costs be affected if measures were taken to reduce service demand?
  - ✓ Policy: How favorable are these types of measures?
  - ✓ Uncertainty: Are these service demand reductions achievable?

Implementation

- **Same assumptions as the Central Case, except:**
  - ✓ **Vehicle miles traveled are reduced to reflect shifts in usage of different forms of transportation**
  - ✓ **Reductions in service demand in other end uses to reflect customer behavior changes**

6. Constrained Renewables and Transmission

- Siting and permitting renewables/ transmission often take significant time
  - ✓ Likely to become harder with many new renewables and new corridors needed
- If Washington were to face challenges in expanding both renewable and transmission capacity, how would investments and cost of decarbonization be impacted?
  - ✓ Uncertainty: Can siting and permitting challenges be overcome?

Implementation

- **Same assumptions as the Central Case, except:**
  - ✓ **Reduced resource potential and tighter caps on installation rates**
  - ✓ **Limited opportunities for expanding interties**

Thank you!

Appendix: Sourcing the data

Demand-subsectors

- EnergyPATHWAYS database includes 67 subsectors
  - Primary data-sources include:
    - Annual Energy Outlook 2020 inputs/outputs (AEO; EIA)
    - Residential/Commercial Buildings/Manufacturing Energy Consumption Surveys (RECS/CBECS/MECS; EIA)
    - State Energy Data System (SEDS; DOE)
    - NREL
  - 8 industrial process categories, 11 commercial building types, 3 residential building types
  - 363 demand-side technologies w/ projections of cost (capital, installation, fuel-switching, O&M) and service efficiency

commercial air conditioning
commercial cooking
commercial lighting
commercial other
commercial refrigeration
commercial space heating
commercial ventilation
commercial water heating
district services
office equipment (non-p.c.)
office equipment (p.c.)
aviation
domestic shipping
freight rail
heavy duty trucks
international shipping
light duty autos
light duty trucks
lubricants
medium duty trucks
military use
motorcycles

residential clothes washing
residential computers and related
residential cooking
residential dishwashing
residential freezing
residential furnace fans
residential lighting
residential other uses
residential refrigeration
residential secondary heating
residential space heating
residential televisions and related
residential water heating
Cement and Lime CO2 Capture
Cement and Lime Non-Energy CO2
Iron and Steel CO2 Capture
Other Non-Energy CO2
Petrochemical CO2 Capture
agriculture-crops
agriculture-other
aluminum industry
balance of manufacturing other

food and kindred products
glass and glass products
iron and steel
machinery
metal and other non-metallic mining
paper and allied products
plastic and rubber products
transportation equipment
wood products
bulk chemicals
cement
computer and electronic products
construction
electrical equip., appliances, and components
passenger rail
recreational boats
school and intercity buses
transit buses
residential air conditioning
residential building shell
residential clothes drying

Load Shape Sources

<table>
<tr><th>Shape Name</th><th>Used By</th><th>Input Data Geography</th><th>Input Temporal Resolution</th><th>Source</th></tr>
<tr><td>Bulk System Load</td><td>initial electricity reconciliation, all subsectors not otherwise given a shape</td><td>Emissions and Generation Resource Integrated Database (EGRID) with additional granularity in the western interconnection</td><td>hourly, 2012</td><td>FERC Form No. 714</td></tr>
<tr><td>Light-Duty Vehicles (LDVs)</td><td>all LDVs</td><td rowspan="13">United States</td><td>month-hour-weekday/weekend average, separated by home vs. work charging</td><td>Evolved Energy Research analysis of 2016 National Household Travel Survey</td></tr>
<tr><td>Water Heating (Gas Shape)[a]</td><td>residential hot water</td><td rowspan="15">month-hour-weekday/weekend average</td><td rowspan="9">Northwest Energy Efficiency Alliance Residential Building Stock Assessment Metering Study (Northwest)</td></tr>
<tr><td>Other Appliances</td><td>residential TV & computers</td></tr>
<tr><td>Lighting</td><td>residential lighting</td></tr>
<tr><td>Clothes Washing</td><td>residential clothes washing</td></tr>
<tr><td>Clothes Drying</td><td>residential clothes drying</td></tr>
<tr><td>Dishwashing</td><td>residential dish washing</td></tr>
<tr><td>Residential Refrigeration</td><td>residential refrigeration</td></tr>
<tr><td>Residential Freezing</td><td>residential freezing</td></tr>
<tr><td>Residential Cooking</td><td>residential cooking</td></tr>
<tr><td>Industrial Other</td><td>all other industrial loads</td><td rowspan="3">California Load Research Data</td></tr>
<tr><td>Agriculture</td><td>industry agriculture</td></tr>
<tr><td>Commercial Cooking</td><td>commercial cooking</td></tr>
<tr><td>Commercial Water Heating</td><td>commercial water heating</td><td rowspan="3">North American Electric Reliability Corporation (NERC) region</td><td rowspan="3">EPRI Load Shape Library 5.0</td></tr>
<tr><td>Commercial Lighting Internal</td><td>commercial lighting</td></tr>
<tr><td>Commercial Refrigeration</td><td>commercial refrigeration</td></tr>
</table>

Load Shape Sources, Continued

Shape Name	Used By	Input Data Geography	Input Temporal Resolution	Source
Commercial Ventilation	commercial ventilation			
Commercial Office Equipment	commercial office equipment			
Industrial Machine Drives	machine drives			
Industrial Process Heating	process heating			
electric_furnace_res	electric resistance heating technologies	IECC Climate Zone by state (114 total geographical regions)	hourly, 2012 weather	Evolved Energy Research Regressions trained on NREL building simulations in select U.S. cities for a typical meteorological year and then run on county level HDD and CDD for 2012 from the National Oceanic and Atmospheric Administration (NOAA)
reference_central_ac_res	central air conditioning technologies			
high_efficiency_central_ac_res	high-efficiency central air conditioning technologies			
reference_room_ac_res	room air conditioning technologies			
high_efficiency_room_ac_res	high-efficiency room air conditioning technologies			
reference_heat_pump_heating_res	ASHPs			
high_efficiency_heat_pump_heating_res	high-efficiency ASHPs			
reference_heat_pump_cooling_res	ASHP s			
high_efficiency_heat_pump_cooling_res	high-efficiency ASHPs			
chiller_com	commercial chiller technologies			
dx_ac_com	direct expansion air conditioning technologies			
boiler_com	commercial boiler technologies			
furnace_com	commercial electric furnaces			
Flat shape	MDV and HDV charging	United States	n/a	n/a

[a] natural gas shape is used as a proxy for the service demand shape for electric hot water due to the lack of electric water heater data.

Supply-Side Data

Data Category	Data Description	Supply Node	Source
Resource Potential	Binned resource potential (GWh) by state with associated resource performance (capacity factors) and transmission costs to reach load	Transmission – sited Solar PV; Onshore Wind; Offshore Wind; Geothermal	(Eurek et al. 2017)
Resource Potential	Binned resource potential of biomass resources by state with associated costs	Biomass Primary – Herbaceous; Biomass Primary – Wood; Biomass Primary – Waste; Biomass Primary – Corn	(Langholtz, Stokes, and Eaton 2016)
Resource Potential	Binned annual carbon sequestration injection potential by state with associated costs	Carbon Sequestration	(U.S. Department of Energy: National Energy Technology Laboratory 2017)
Resource Potential	Domestic production potential of natural gas	Natural Gas Primary – Domestic	(U.S. Energy Information Administration 2020)
Resource Potential	Domestic production potential of oil	Oil Primary – Domestic	(U.S. Energy Information Administration 2020)
Product Costs	Commodity cost of natural gas at Henry Hub	Natural Gas Primary – Domestic	(U.S. Energy Information Administration 2020)
Product Costs	Undelivered costs of refined fossil products	Refined Fossil Diesel; Refined Fossil Jet Fuel; Refined Fossil Kerosene; Refined Fossil Gasoline; Refined Fossil LPG	(U.S. Energy Information Administration 2020)
Product Costs	Commodity cost of Brent oil	Oil Primary – Domestic; Oil Primary - International	(U.S. Energy Information Administration 2020)
Delivery Infrastructure Costs	AEO transmission and delivery costs by EMM region	Electricity Transmission Grid; Electricity Distribution Grid	(U.S. Energy Information Administration 2020)
Delivery Infrastructure Costs	AEO transmission and delivery costs by census division and sector	Gas Transmission Pipeline; Gas Distribution Pipeline	(U.S. Energy Information Administration 2020)
Delivery Infrastructure	AEO delivery costs by fuel product	Gasoline Delivery; Diesel Delivery; Jet Fuel; LPG Fuel Delivery; Kerosene Delivery	(U.S. Energy Information Administration 2020)

Supply-Side Data Continued

Data Category	Data Description	Supply Node	Source
Technology Cost and Performance	Renewable and conventional electric technology installed cost projections	Nuclear Power Plants; Onshore Wind Power Plants; Offshore Wind Power Plants; Transmission – Sited Solar PV Power Plants; Distribution – Sited Solar PV Power Plants; Rooftop PV Solar Power Plants; Combined – Cycle Gas Turbines; Coal Power Plants; Combined – Cycle Gas Power Plants with CCS; Coal Power Plants with CCS; Gas Combustion Turbines	(National Renewable Energy Laboratory 2020)
Technology Cost and Performance	Electric fuel cost projections including electrolysis and fuel synthesis facilities	Central Hydrogen Grid Electrolysis; Power – To – Diesel; Power – To – Jet Fuel; Power – To – Gas Production Facilities	(Capros et al. 2018)
Technology Cost and Performance	Hydrogen Gas Reformation costs with and without carbon capture	H2 Natural Gas Reformation; H2 Natural Gas Reformation w/CCS	(International Energy Agency GHG Programme 2017)
Technology Cost and Performance	Nth plant Direct air capture costs for sequestration and utilization	Direct Air Capture with Sequestration; Direct Air Capture with Utilization	(Keith et al. 2018)
Technology Cost and Performance	Gasification cost and efficiency of conversion including gas upgrading.	Biomass Gasification; Biomass Gasification with CCS	(G. del Alamo et al. 2015)
Technology Cost and Performance	Cost and efficiency of renewable Fischer-Tropsch diesel production.	Renewable Diesel; Renewable Diesel with CCS	(G. del Alamo et al. 2015)
Technology Cost and Performance	Cost and efficiency of industrial boilers	Electric Boilers; Other Boilers	(Capros et al. 2018)
Technology Cost and Performance	Cost and efficiency of other, existing power plant types	Fossil Steam Turbines; Coal Power Plants	(Johnson et al. 2006)

Impact of COVID-19

- None of the long-term forecasts include COVID impacts
- Long-term versus short-term
- Changes to near-term adoption rates of new technologies
  - Impacts on consumer spending for new appliances, vehicles etc.?
  - Accelerated action later? Delayed electrification?
  - Opportunity for economic development in post-COVID environment?
- Impact on fuel prices
  - Supply and demand imbalance