Low-Carbon Pathways for the Northwest

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Agenda

- History of Decarbonization Pathways
  ✓ 2050 Pathways Calculator 2010
  ✓ California Pathways 2050 Target 2012
  ✓ U.S. DDPP Study 2014-15
  ✓ California Pathways 2030 Target April 2015
  ✓ U.S. Mid-Century Strategy Dec 2015
  ✓ Risky Business Project 2016
  ✓ Washington DDP Feb 2017
  ✓ Portland Gas Electric Feb 2018

- PNW Economy-Wide Pathways Study
2050 Pathways Calculator (2010)

- Sir. David John Cameron MacKay of Cambridge University created the first pathways calculator
- UK Department of Energy and Climate Change (DECC)
- Online interactive tool
2050 Pathways Calculator -2-

- Sector-sector analysis and scenario approach
- Four different trajectories
  ✓ Level 1: No decarbonization
  ✓ Level 2: Ambitious but reasonable
  ✓ Level 3: Very ambitious; needs tech breakthroughs
  ✓ Level 4: Pushes physical and technical limits
California Pathways 2012

- January 6, 2012 Jim Williams Science magazine
- 1st time work done to determine what it would take for California (and any state) to achieve 30 of 1990 x 2020 & 80 x 50 targets
California Pathways to 2050

The diagram illustrates the reductions from various sources over the years to 2050. The categories include:
- Energy Efficiency
- Electricity Decarbonization
- Smart Growth
- PV Roofs
- Biofuels
- Non-Energy, Non-CO₂
- Electrification

The baseline emissions are shown, along with the remaining emissions, aiming to achieve 80% below the 1990 level by 2050 (90% below the 2050 baseline).
Deep Decarbonization Pathways Project (2014-15)

- November 2014 DDP study tech supplement November 2015

- Deep Decarbonization Project collaborative global initiative countries reduce GHG consistent limiting increase in global mean surface less than 2 degrees Celsius.
Figure ES 2. Stock Lifetimes and Replacement Opportunities

- **Electric lighting**: 4 replacements
- **Hot water heater**: 3 replacements
- **Space heater**: 2 replacements
- **Light duty vehicle**: 2 replacements
- **Heavy duty vehicle**: 1 replacement
- **Industrial boiler**: 1 replacement
- **Electricity power plant**: 1 replacement
- **Residential building**: 0 replacements

**Equipment/Infrastructure Lifetime (Years)**
Features of a Low Carbon Energy System

Figure 6. Pathways Determinants: Critical Elements that Determine the Features of a Low Carbon Energy System

- **Electricity Mix**
  - What is the mix of renewables, nuclear, and fossil fuels with CCS in electricity generation?

- **CCS**
  - Is CCS feasible in power generation, industry, and biomass refining; if so, how much?

- **Electricity Balancing**
  - How much storage is needed to balance electricity supply and demand; what is the technology mix?

- **Fuel Switching**
  - How much switching of fuels (e.g., gasoline to H₂) and fuel types (e.g., liquid fuels to electricity) is needed, given constraints?

- **Biomass Supply and Use**
  - What is the maximum limit on sustainable biomass energy resources; where is bioenergy used?
Regional Per Capita CO₂ Emissions Intensity
Figure 1. Emissions trajectories for energy CO2, 2010-2050, showing most ambitious reduction scenarios for all DDPP countries. 2050 aggregate emissions are 56% below 2010 levels.
California Pathways 2015

1. Efficiency and Conservation

- Energy use per capita (MMBtu/person)

2. Fuel switching

- Share of electricity & H₂ in total final energy (%)

3. Decarbonize electricity

- Emissions intensity (tCO₂e/MWh)

4. Decarbonize fuels (liquid & gas)

- Emissions intensity (tCO₂/EJ)

* Example from California PATHWAYS results
Renewables Account for 50-60% Annual Energy in CA by 2030

Average renewable additions are ~2,400 MW/year (plus rooftop PV) through 2030, mostly solar and wind resources.

Integration solutions are needed in all high renewables cases:

- regional coordination, renewable diversity, flexible loads, more flexible thermal fleet, curtailment energy storage, flexible fuel production for ZEVs
Sustainable Biomass Not Sufficient

- **Share of Final Energy Demand by Fuel Type: 2030**
  - **Low Carbon Gas Scenario**
  - **Straight Line Scenario**

- **Biofuels used in gaseous form in buildings & industry**
  - Natural Gas
  - Renewable Gasoline
  - Electricity
  - Biogas
  - Hydrogen

- **Biofuels used for liquid transportation fuels**
  - Gasoline
  - Renewable Diesel
  - Other Fuels

- **Graph titles:**
  - Low Carbon Gas Scenario
  - Straight Line Scenario
United States Mid-Century Strategy

- Paris agreement in December 2015: Parties agree to achieve net-zero global emissions in the 2nd half of century
- Countries submit near-term targets called “nationally determined contributions” (NDCs)
- Develop a “mid-century, long-term low greenhouse gas emission development strategies”
Importance of Sequestration

**Figure E1: U.S. Net GHG Emissions Under Three MCS Scenarios**

- **Net GHG**
  - CO₂
  - Non-CO₂
  - Land Sink
  - CO₂ Removal Technologies

Multiple pathways to 80 percent GHG reductions by 2050 are achievable through large reductions in energy CO₂ emissions, smaller reductions in non-CO₂ emissions, and delivering negative emissions from land and CO₂ removal technologies. Note: “No CO₂ removal tech” assumes no availability of negative emissions technologies like BECCS.
MCS Vision for 2050

U.S. ENERGY CO₂ EMISSIONS IN 2005 AND 2050 IN THE MCS BENCHMARK SCENARIO BY SECTOR

- Commercial Buildings
- Residential Buildings
- Industry
- Transportation
- Electricity

2005
5917 MMT

2050
1537 MMT
Risky Business Project 2016

- Aimed at addressing how to respond to the risks that climate change presented
- Contract with World Resources Institute hired Evolved Energy Research
Three Pillars of Clean Energy Economy

Three Pillars of a Clean Energy Economy: Strategies and Metrics

End use fuel switching to electric sources

Decarbonization of electricity

Energy efficiency

KEY METRIC OF TRANSFORMATION

Share of electricity and electric fuels in total Final Energy (%)

2015 2050

23% 51%

Mixed Resources Pathway

Key metrics for 2015 and 2050:

- Electricity emissions intensity (Kg of CO2/MWh)
- Final Energy Intensity of GDP (MJ/$2014 GDP)
Washington State DDP Study 2017

- Develop and evaluate technology pathways for DDP mid-century
Washington State Target Issue

Washington State GHG Targets
(Percentage of 1990 Emissions)

- Existing GHG targets
- Illustrative deep decarbonization pathway which achieves 80% below 1990 levels
- Under2 MOU Range of 2050 GHG Targets 80% to 95% below 1990 levels

Washington State GHG Emissions
(1990 Historical and Study’s 2050 Target)

- Non-energy, non-CO2 GHGs
- Energy-related CO2
- 80% overall reduction
- 50% reduction
- 86% reduction

Deep Decarbonization Pathways Analysis for Washington State
December 16, 2016
Decarbonized Pipeline Gas & Liquid

Illustration of Decarbonized Pipeline Gas

Primary Energy
- Natural Gas
- Biomass
- Hydro
- Wind
- Solar
- Geothermal
- Wave
- Nuclear

Conversion
- Natural gas processing
- Thermal Gasification
- Electricity Generation
- Electrolysis
- Methanation

Final Energy
- Decarbonized Pipeline Gas
- Hydrogen
- Synthetic natural gas
- Grid Electricity

Note: note all final energy types shown. Size of arrows and box do not correspond to magnitude of energy flows or volume.
Washington DDP Results

Washington State GHG Emissions Summary

- Reference Case GHG emissions decrease but fall substantially short of 2050 target
  - Energy CO2 emission reductions offset by growth in non-energy, non-CO2 emissions
- All DDP cases reach GHG emissions below 17.7 MMTCO2e using alternative technologies and approaches

Note: GHG emissions include both energy-related CO2 and non-energy, non-CO2 GHGs
Conclusions

- It’s possible to develop a system at a reasonable cost that meets GHG mitigation goals, but it does require significant foresight to manage anticipated challenges
  - Gas pipeline (potential business model challenges)
  - Electric vehicle deployment (overcoming first-cost barriers)
  - Electricity balancing (to manage curtailment); and
  - Biofuels development (cost and sustainability)
- Washington has a unique opportunity to lead the transition with its industry (Boeing), technology (Microsoft, Amazon and Google), and academic and research institutions (WSU, UW, PNNL) all positioned to play key roles
Key Takeaways

• Decarbonizing Washington’s energy system commensurate with an economy-wide goal of 80% GHG reductions by 2050 can be achieved
  • At reasonable cost;
  • Without early retirement of existing infrastructure; and
  • Without the need for technology that has not yet been demonstrated

• Achieving deep decarbonization in Washington State will include reliance on the three pillars of energy system transformation
  • Energy efficiency
  • Electrification of end-uses
  • Decarbonization of electricity generation

• In the long-run, costs are likely to fall on difficult-to-electrify sectors like industry and heavy-duty trucking
  • Mitigation of these costs may come from unmodeled strategies like mode-shifting in freight, industrial fuel switching/deeper energy efficiency reductions, or explicit policies that help share the cost burden between sectors
Portland General Electric

- First ever DDP study for a utility service territory
- PGE serves 45-47% of the state’s total population
- Reference case and three scenarios
  - High electrification
  - Low electrification
  - High distributed energy
Portland General Electric DDP Conclusions

Study Findings

- Deep decarbonization of the PGE service territory’s energy economy is possible and can be achieved using a variety of technologies and strategies.
- Depends on a set of three pillars that are consistent with many studies examining decarbonization in the U.S. and abroad:
  1. Energy efficiency;
  2. Decarbonization of electricity generation; and
  3. Increasing share of electricity and electric fuels.
- Change evaluated in this study is transformational instead of incremental, and requires:
  • Both consumer and producer participation
  • New energy infrastructure
  • Timely planning to account for investment opportunities between now and 2050
- Transitioning to a low-carbon economy will change the composition of our energy bill, with more money spent on technology and less on fossil fuels.
Northwest DDP Pathways Study

- Clean Energy Transition Institute to engage Evolved Energy Research to conduct study
- Build on EER’s work for Washington State and Portland General Electric
- Economy-wide; represent WA, OR, ID, MT energy systems
  ✓ Detailed built environment
  ✓ Industrial energy demand
  ✓ Vehicle fleets/transport demand
NWDDP Study Objectives

- Examine pathways (1) for WA and OR to get to 80% of 1990 by 2050, and (2) get as close to zero emissions as possible by 2050
  ✓ (2) important to shed light on 100% Clean

- Target audience WA and OR
  ✓ Policymakers
  ✓ Legislators
  ✓ Businesses
  ✓ Advocates
NWDDP Study Value Proposition

- Independent (non-utility, non-state, non-advocacy, non-business only focus)
- Develop assumptions to solve for decarbonizing the Northwest
- Serve as a blueprint for more detailed analysis by sector or by region
- “Open source”
Summary

- Pathways analysis evolving over the past eight years around the globe
- Particular analysis in US in CA from E3 and EER
- WA & OR to be the next major effort
Thank you

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Transitioning from Fossil Fuel to Clean Energy

www.cleanenergytransition.net