Northwest Low-Carbon Pathways
Electricity

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Agenda

- Why electrify everything
- Renewables growth
- Integrating renewables
- Grid redesign & interaction
- Smart grid
- Storage
- Scaling challenges
Electrify Everything

- Transport: 46%
- Residential & Commercial: 10%
- Industry: 21%
- Agriculture: 6%
- Electricity: 17%
- Waste: 4%
- Buildings: 12%
- Industrial: 17%
- Electricity: 17%
- Agriculture: 9%
- Transport: 27%
- Electricity: 29%
- Industry: 21%
- Agriculture: 6%
- Waste: 4%
- Residential & Commercial: 10%
Strategic Electrification in the context of decarbonization. Graphic: Northeast Energy Efficiency Partnerships
Why Electrify Everything?

- Global warming consensus
- Growing understanding of the need for a path to zero-carbon electricity
Why Electrify Everything? -2-

- Know how to achieve zero carbon electricity (wind, solar, nuclear, hydro, geothermal, coal/gas with CCS)
How Clean the Grid is Crucial

- As the grid gets cleaner, whatever is powered by it, gets cleaner
- Profound implications
New Electricity = More RE on the Grid

Figure 2: The duck curve shows steep ramping needs and overgeneration risk. Net load - March 31.

- Ramp need: ~13,000 MW in three hours.
- Overgeneration risk.
Emissions Efficiency

- Get the same amount of work with less carbon
- Increase load from transportation and building heat; consumption could rise and efficiency could fall, but economy-wide carbon emissions could decline
Renewables Growth
Solar Growth 2012-2017

Source: GTM Research / SEIA U.S. Solar Market Insight, Q4 2017
Wind Growth

- August 2017 US DOE released three wind market reports
- Continued growth in wind energy nationwide
- More than 8,200 MW of capacity, 27% of all new energy capacity in 2016
- Supplied 6% of U.S. electricity
- 14 states now get more than 10% of electricity from wind
Figure 2. Annual and cumulative growth in U.S. wind power capacity

Source: AWEA project database
Evolution of wind turbine heights and output

Sources: Various, Bloomberg New Energy Finance

Bloomberg New Energy Finance
Intermittency

- Intermittent vs. predictable power that is dispatchable
- Natural gas, coal, nuclear, and hydro less variable than solar & wind
- Capacity factors for coal-NG 90%; for wind 22-43% and solar 12-20%
Storage

- Amount of energy system can store
- Amount of power system can absorb or deliver
- Energy density
- Carbon footprint of technology
- Energy stored on Investment (ESOI)
- Geologic, hydrogen, batteries
Grid Redesign

- 20th century grid distributed power from large centralized coal, gas, nuclear, and hydro generating plants to far-flung end uses
  - Track demand patterns with daily peaks
  - Meet spikes with peaking power generators (NG)
  - Peaking and redundancy costs and those are passed on to consumer

- 21st century grid accommodate numerous smaller and geographically distributed power inputs, largely variable
Yesterday vs. Tomorrow’s Power
Distributed Generation

- Do away with the centralized grid entirely; generate and store at the community scale
- Challenge for intermittency; needs to be linked
- Decentralizing encourage energy more in line with natural flows of renewable energy
- Communities be more self-sufficient
- Less complex; less vulnerable
Smart Grid

- Set of related technologies to reduce power consumption during peak hours and incorporate grid energy storage
- Both make it easier to integrate wind and solar
- Integrated communications
- Sensing and measurement (smart meters; sensors on transmission network)
- Management and forecasting software
- Additional transmission to balance
Smart Meters

- Smart meters communicate real-time pricing can shift usage times
- Requires sensors, communications links, software, data management
- Will help reduce times of oversupply or undersupply of electricity and increase affordability
- But must redesign grid
- Internet of Things: appliances connected wifi or hard line, be set to respond to utility co. to adjust usage to price at time
Smart Meters

How Smart Meters Work

- Single Family Home
- Your Smart Meter
- Communication Device on Utility Pole
- Utility Office
Demand Management

- Geared to when consumers use energy and how much they use
- Voluntary programs; economic incentives
  - Dynamic pricing
  - Smart appliances and equipment
- Dynamic pricing: change the price of electricity on hour-by-hour basis
  - Shift usage to when supplies are abundant and prices low
  - Have to be able to communicate with users
Grid Interactive Tech in Buildings

An example of "grid interactive" technologies in buildings. Graphic: Digi-Key Electronics
EVs as Storage

- Cars parked an average of 95% of the time
- Leave EV plugged in when electricity could flow to power lines and back
- Decentralized storage of electrical energy
- Throttle charging rate (known as vehicle-to-grid (V2G))
- Need the batteries to get to the stage where they can provide this service
Costs of the Transition

▪ Tens of trillions of dollars required—where will it come from?
▪ Retiring all of the fossil fuel plants still in their projected operating lifetimes
▪ Storage, redundancy, grid expansion, redesign more costs
▪ How long do we have to subsidize solar and wind?
Scaling Challenges

- Solar and wind financing investment is upfront
- “Fuel” is free
- Maintenance relatively inexpensive
- Not worry about fluctuating fuel prices
- Coal and gas power plants advantage lower tax burden, costs deducted
- Property taxes (solar & wind take up more land)
Scaling Challenges

- **Raw materials**
  - Rare earth minerals for electromagnets in wind turbines and lithium for batteries
    - ✓ 10% annual growth in annual extraction rates, current lithium reserves last 50 years

- **Technical potential of wind power**

- **Location issues**
  - ✓ Low-frequency wind noise disturbing people
  - ✓ Solar much real estate for util-scale solar
  - ✓ Habitat species in deserts
  - ✓ Panels washing; concentrated solar needs cooling. Water use where it is scarce
Summary

- Clean electricity mission critical
- Renewables key and growing
- Poses major design issues
- Financial & scaling challenges
Thank you

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Transitioning from Fossil Fuel to Clean Energy
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