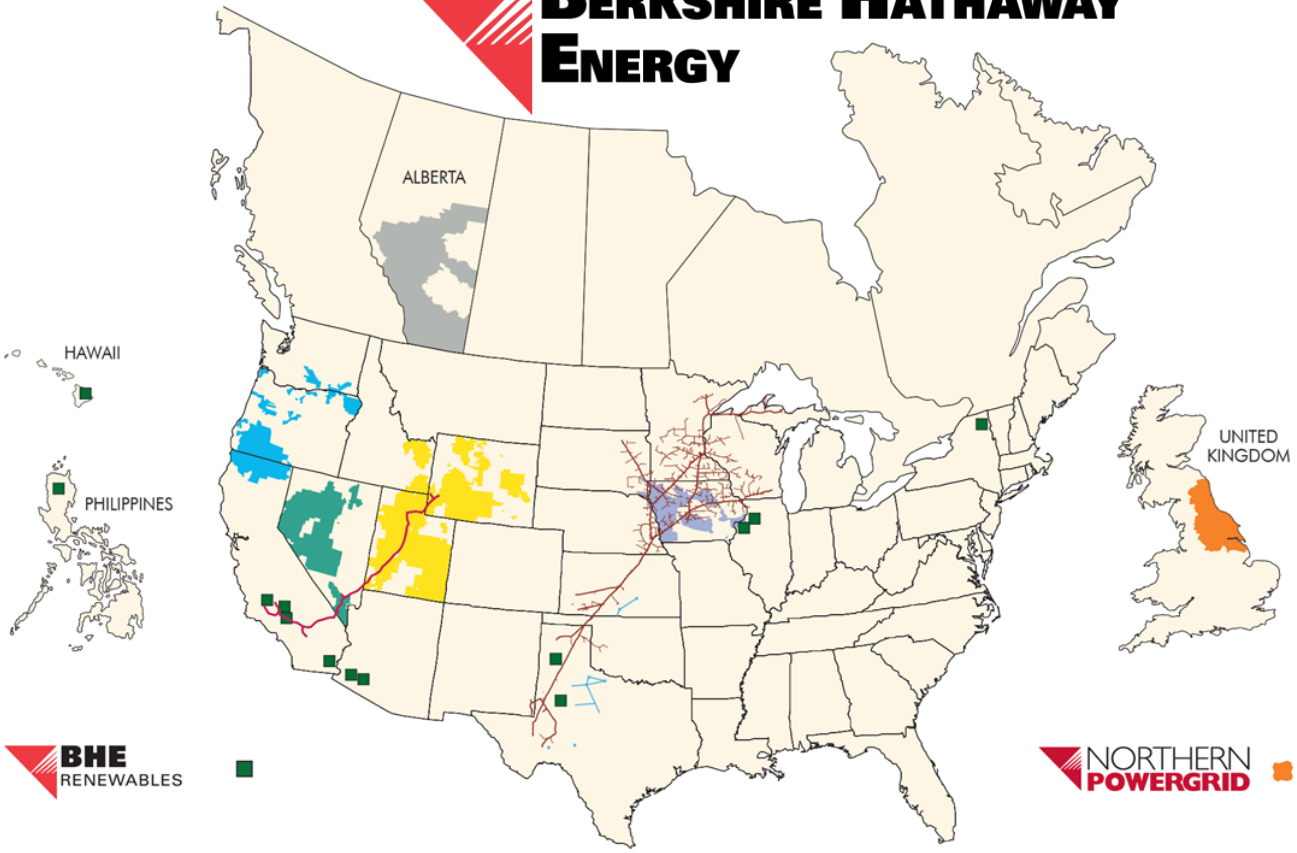
PacifiCorp - Rocky Mountain Power

Water Use in Electric Energy Generation
July 27, 2016

PACIFICORP

Let's turn the answers on.

Berkshire Hathaway Energy



Assets	$82 billion
Revenues[1]	$17.9 billion
Customers[2]	8.5 million
Employees	20,900
Transmission Line Miles	32,600
Natural Gas Pipeline Miles	16,400
Generation Capacity MW[3]	29,200
Natural Gas	35%
Coal	35%
Renewables	28%
Nuclear and Other	2%

(1) Pro forma 2014 including AltaLink

(2) Includes both electric and natural gas customers and end-users worldwide. Additionally, AltaLink serves approximately 85% of Alberta, Canada's population

(3) Net MW owned in operation and under construction as of Dec. 31, 2014

BHE RENEWABLES

NORTHERN POWERGRID

PACIFICORP

PACIFIC POWER

ROCKY MOUNTAIN POWER

NVEnergy

MidAmerican ENERGY

BHE PIPELINE GROUP

Northern Natural Gas

Kern River GAS TRANSMISSION COMPANY

ALTALINK

BHE U.S. TRANSMISSION

PacifiCorp Generation Sources

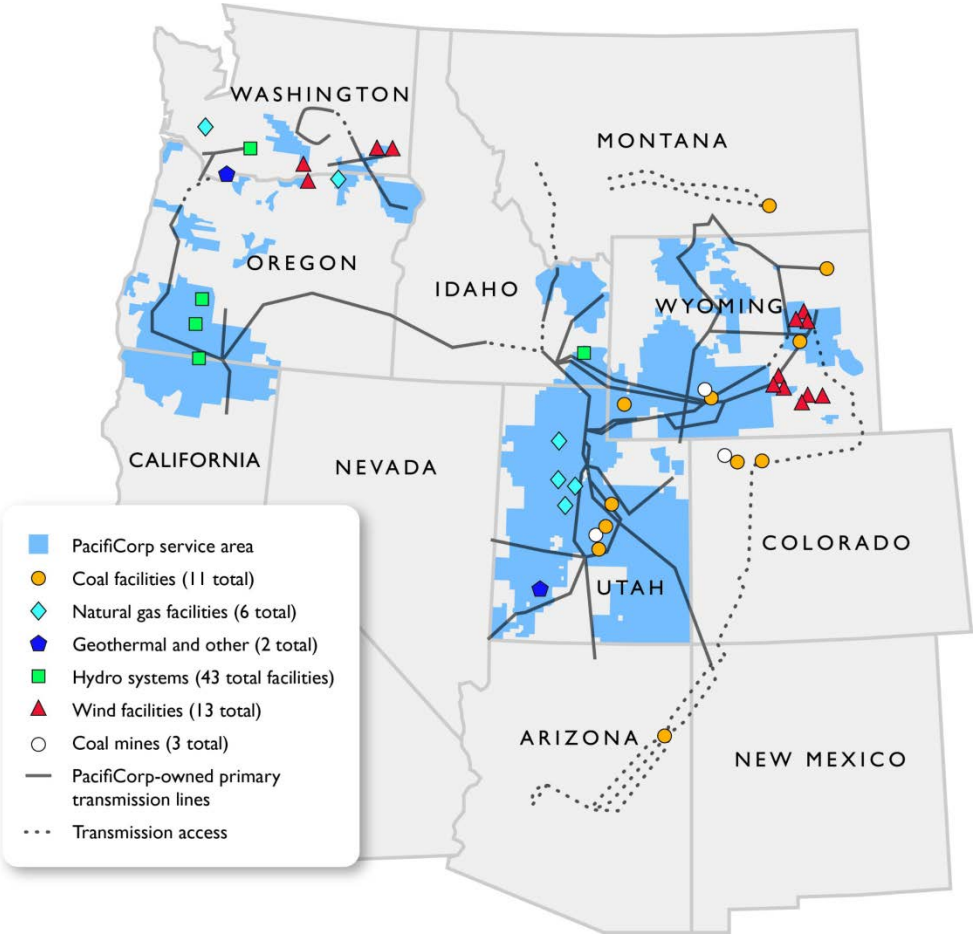
11,018 MW owned generation capacity[1]

- 5,935 MW coal
- 2,866 MW gas
- 1,135 MW hydroelectric
- 1,033 MW wind
- 33 MW geothermal
- 16 MW other (incl. solar)

1.8 million customers

64,000 miles distribution

16,500 miles transmission

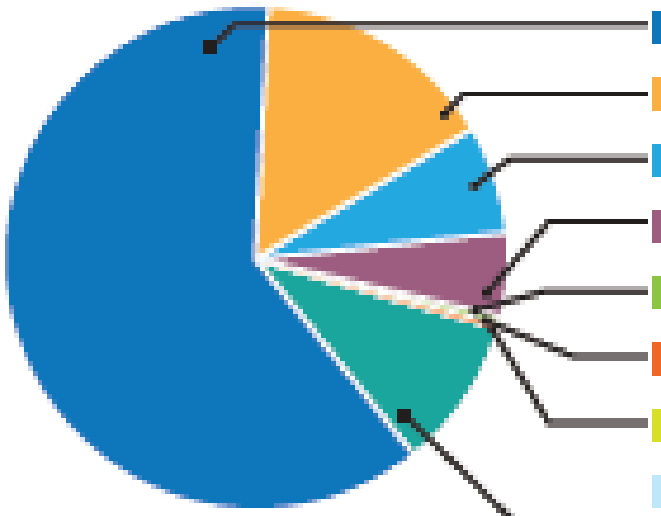


[1] *Net MW owned in operation as of Feb. 1, 2016; excludes purchases and contracts.*

Renewable Resources under Contract

- 1,455 MW currently under contract (mostly wind), increasing to:
- 2,262 MW by the end of 2016 (mostly Utah solar PV)

PacifiCorp 2015 Energy Resource Mix



Energy resource mix*

(energy production 2015)

Coal	61.96%
Natural Gas	15.40%
Wind	7.10%
Hydro	5.18%
Biomass	0.43%
Geothermal	0.38%
Solar	0.08%
Nuclear	0.00%
Other	9.47%

Water is Critical to Serving Our Customers

- Pass-through use for hydroelectric power generation
- Primary consumptive use – heat rejection in evaporative cooling towers used to cool circulating water that condenses low pressure steam from steam turbines
- Combustion turbine inlet cooling and environmental control
- Process water used for boiler makeup and environmental compliance systems (Flue Gas Desulfurization systems - scrubbers)
- Cooling and conveyance water for ash handling and storage
- Process water in power generation (steam generators)
- Service water

Merwin Hydro Electric

Just renting

Jim Bridger Plant – Evaporative Cooling

Scrubber Process Water

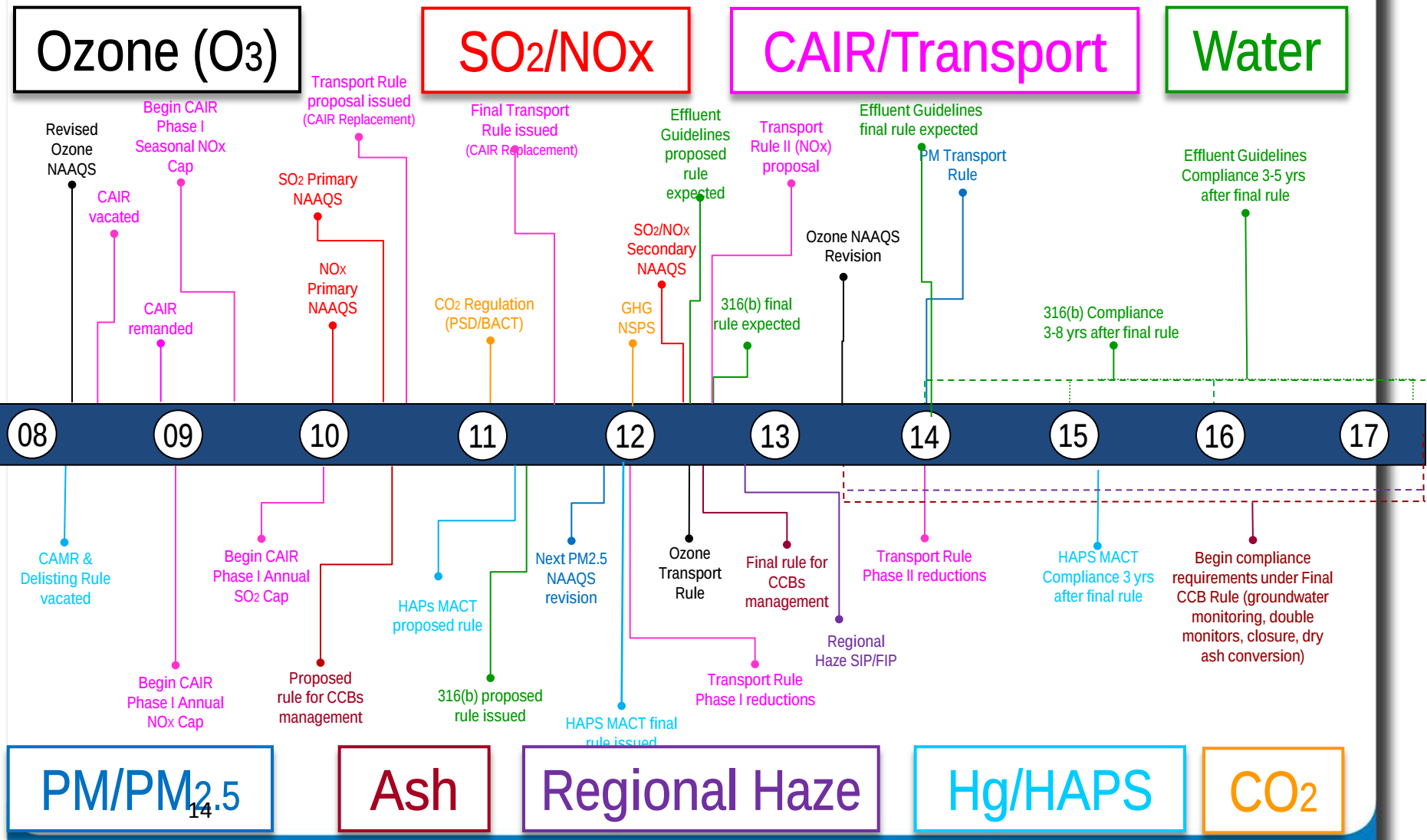
Combustion Turbine Inlet Cooling

Geothermal plants consume water

Thermal Plant Water Consumption

Plant	Type	Zero Discharge?	Basis for Reporting	Cooling	Ac-Ft/Yr	Gals/ MWH	GPM/ MW
Chehalis	Gas-Combined Cycle		2015	Air	52	15	0.3
Currant Creek	Gas-Combined Cycle	Yes		Air	86	12	0.2
Dave Johnston	Pulverized Coal			Water	8,968	569	9.5
Gadsby	Gas-Rankine/Open Cycle			Water	259	510	8.5
Hunter	Pulverized Coal	Yes		Water	17,079	595	9.9
Huntington	Pulverized Coal	Yes		Water	10,299	520	8.7
Jim Bridger	Pulverized Coal	Yes		Water	23,866	557	9.3
Lake Side	Gas-Combined Cycle		2015	Water	3,369	241	4.0
Naughton	Pulverized Coal			Water	7,215	480	8.0
Wyodak	Pulverized Coal	Yes		Air	300	38	0.6

Regulatory Environment for Thermal Plants



Water Issues Facing Generating Utilities

- Competing demands for water
- Coal plant life uncertainty
- Stricter water quality standards and regulations
- Coal combustion residuals regulations
- Environmental compliance at hydro facilities
- Efficiency improvements (conveyance upgrades)
- Water acquisition strategies
- Sedimentation impacts on reservoir capacities
- Inefficient water use at existing plants (designed-in)
- Bio-fouling (quagga/zebra mussels)

Competing Demands for Water

- Competing demands for water
  - Population growth
  - Reduced availability (drought, drawdown) – finite resource
  - Over allocation; water just isn’t available
  - Types of water drive design
  - Water is pricey!
  - Environmental uses

Water Quality Standards & Regulations

- Coal Combustion Residuals (CCR)
- New Effluent Limitation Guidelines (ELG)
- Cooling Water Intake Rules (316b)
- Wastewater disposal options
- Difficult constituents in makeup water

Coal Combustion Residuals

- Regulations include coal ash and FGD wastes
- Requires installation of new lined ponds or process changes to dry systems to allow for solid waste landfills

ELG Regulations: Dry Bottom Ash Transport

- **Submerged Scraper Conveyor System**

Pictures courtesy of Sargent & Lundy

CCR Impacts:
Double HDPE Lined Ponds w/leachate collection system (Naughton FGD Pond 4)

Pictures courtesy of Sargent & Lundy

Hydro Facilities Environmental Compliance

- Competing requirements placed on dam owners
  - Fish passage
  - Agriculture
  - Recreation
  - In-stream flows

Efficiency improvements (conveyance upgrades)

- Need for upgrades on small hydro projects to improve water conveyance efficiency (losses)

Water Rights Acquisition

- Our strategy to ensure long term generation availability is to secure senior water rights and to have sufficient water to eliminate the potential for curtailment during drought years

Sedimentation impacts on reservoir capacities

- Sedimentation reduces reservoir capacities
- Impacts water intake infrastructure
- Very costly and challenging to manage sediment once deposited

Inefficient water use at existing plants

- Once designed and constructed, a thermal generating plant has most of its underlying resource needs (fuel and water) “baked in”
- Costs to modify existing thermal plants to make material water requirement reductions are economically unattractive and result in reduced performance
- Structure of underlying types of water rights creates waste (i.e. need to meet return agricultural water rights requirements)

Technologies Currently Under Consideration

- Dual alkali systems
- Waste water spray dryers
- Mechanical vapor compression
- Enhanced pond evaporation
- Water softening
- Cost effective waste water treatment
  - Operate cooling tower at higher cycles of concentration
  - Selenium removal technologies
- Deep well injection

Technology Needs

- Cost effective waste water treatment and water recovery
  - Operate cooling tower at higher cycles of concentration
  - Removal of key constituents (i.e. selenium)
  - Entrained stack moisture
- Water treatment from deep well saline aquifers – addresses two issues:
  - Carbon capture and sequestration produced waters
  - New water source
- Climate variability forecasting
- Address Quagga mussel proliferation
- Water law changes to support serial reuse

Future Thermal Generation

- New / replacement thermal generation will likely be natural gas-fueled open and combined cycle resources which have much lower water requirements
- Company has adopted air cooling (i.e. air cooled condensers) for future designs (except maybe for brownfield sites and locations with space constraints); plume abated towers will be a consideration
- Cost effective water recovery from stacks (a significant amount of moisture is generated burning natural gas)

Currant Creek Plant

Air Cooled Condenser

Thank You For Listening

Questions?