Table 7.1 Electricity Overview

Mark Robinowitz
PeakChoice.org

Peak Electricity USA

2007 peak before fracking
2018 peak with fracked gas

Source: U.S. Energy Information Administration
The North American Electric Reliability Council is a consortium of electric utilities that operate three major grids in the USA: west, east and Texas. No man is an island and no utility is an island, either. Electric grids balance generation and demand in real-time, constantly, every day. A utility that has local hydropower is still interconnected with a broader grid and keeping all of the uses powered, non-stop, requires careful attention to ensuring generation all over the country with a variety of energy sources.

The Pacific Northwest has had an electricity exchange with California for decades. California’s electric demand is greatest during summer heat waves (to power the air conditioners). Cascadia’s peak use has been the coldest times of winter (electric heaters). This coincides with excess generation capacities with the other region - when snowmelt in the warm months provides the most capacity for Columbia River dams that is when California needs the extra power. California has extra generation capacity in the winter when the air conditioners are not on so their utilities generate more to send north to Oregon and Washington heaters. Since California’s top energy source for generating electricity is natural gas, this further ensures that “electric only” uses in Cascadia are totally dependent on gas.

The largest energy source for the western grid is burning unnatural gas, as it is for the other two major US grids. The Quebec grid is primarily powered with giant dams in northern Quebec, which had major ecological damage to the boreal forests (flooded forests rotting converted mercury in the soil to a toxic version that entered the food chain, poisoning Native peoples dependent on eating fish).
The Western Electricity Coordinating Council is the utility consortium that integrates electric generation and demand in the western US, BC, Alberta, northern Baja. The next several slides are from their “State of the Interconnection” reports and show how natural gas is critical for grid operations.

The top graphic shows electric generation across the US and Canada, the lower graphic is for WECC only. MWh stands for megawatt hours — power generated.

Fossil fuels includes nat. gas and coal. Almost no oil is used to generate electricity. Hydropower is locally significant but a smaller component. The western grid has a higher percentage of hydro than the Texas and Eastern grids, but fossil fuels is still more than dams. Fracked nat. gas has increased substantially in the past decade while coal has continued its drop, ostensibly due to climate concerns but also because the highest quality coal is depleting.

Nuclear power has a higher percentage on the eastern grid than the western. As of 2022, there are six reactors powering WECC: Columbia Generating Station at the Hanford site in eastern Washington, three reactors west of Phoenix and two reactors at Diablo Canyon on the California coast (between SF and LA). Two reactors at San Onofre, near San Diego, were shut down in 2013 (they were too expensive to repair).

There is very little electricity exchange between the major grids. Each grid is further split into regions that do exchange electrons, those exchanges are monitored non-stop to keep generation and demand in balance. Few people consider the complexity of keeping their things constantly powered throughout the year with a variety of inputs that each have significant challenges.

“Variable” in these charts is mostly wind power, with a supporting role from solar panels.
WECC western grid generation

**entire western grid**

- GigaWatt hours
- NW section: OR, WA, ID, MT, NV, UT (mostly)

**NW dams**

- Gas
- Nuke
- Coal

**2014-2019 Net Generation by Fuel Type**

- Wind
- Dam
- Solar
- Gas
- Nuke
- Coal

**2014 Net Generation Mix**

- Wind
- Dam
- Solar

**2014-2019 Net Generation by Baseload Fuel Type**

- Gas, Coal, Nuke

**2014-2019 Net Generation by Fuel Type**

- Gas
- Solar
- Wind

**2014 Net Generation Mix**

- Gas
- Solar
- Wind

**baseload (gas, coal, nuke)**

- Gas
- Solar
- Wind

**baseload (gas, coal, nuke)**

- Gas
- Solar
- Wind

**Wind in CA**

- Solar
- Nuke
- Coal

**2014-2019 Net Generation by Fuel Type**

- Gas
- Solar
- Wind

**2014 Net Generation Mix**

- Gas
- Solar
- Wind

**baseload (gas, coal, nuke)**

- Gas
- Solar
- Wind

**baseload (gas, coal, nuke)**

- Gas
- Solar
- Wind

www.wecc.org/epubs/StateOfTheInterconnection/Pages/State-of-the-Interconnection.aspx
Boardman coal burner closed in 2020.
Capacity refers to power that can be generated by a particular source.

Total generation over time is more important, it refers to how much electricity is actually made.

Capacity factors indicates how often a particular source is on.

All sources are less than 100% available. Some are better suited for baseload than others.

Solar has free fuel, but doesn’t work at night. Rainy days generate less than sunny ones. Fortunately this variation can be anticipated, which makes it easy to balance its daily rise and fall.

Wind can work at night but is notoriously variable in most locations.

Fossil fuels and dams can be increased and decreased, assuming the fuels (coal, gas, water) are available.

Nuclear is usually on all the time but reactors can suffer unplanned shutdowns and accidents that cause generation to drop from full to nothing in an instant.

All of these sources have to be coordinated in an intricate dance to keep the lights on, all the time.

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**Resource Portfolio**

The Western Interconnection has a diverse mix of resources, including large amounts of hydro and renewable resources. Although the generation capacity of the Western Interconnection represents approximately 20 percent of total capacity in the United States and Canada, it encompasses over 70 percent of all solar capacity and one-third of all hydro capacity.

In 2016, the combined nameplate capacity of all utility-scale resources in the Western Interconnection was 267,000 MW. This is a 1 percent increase from 2015. Retirement of coal and steam-turbine gas units leads to slight decreases in capacity from these fuel types, while the installed capacity of utility-scale solar increased by over 6,000 MW.

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**2016 Capacity Factors by Fuel Type**

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<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Capacity Factor</th>
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<tbody>
<tr>
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<td>0.59</td>
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<tr>
<td>Geothermal</td>
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<tr>
<td>Hydroelectric</td>
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<tr>
<td>Natural Gas</td>
<td>0.36</td>
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<td>Nuclear</td>
<td>0.88</td>
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<tr>
<td>Solar</td>
<td>0.18</td>
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<tr>
<td>Wind</td>
<td>0.25</td>
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**2016 Net Generation by Fuel Type (GWh)**

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<th>Net Generation (GWh)</th>
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<tbody>
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<tr>
<td>Geothermal</td>
<td>19,210</td>
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<td>Hydroelectric</td>
<td>43,810</td>
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<td>Natural Gas</td>
<td>233,050</td>
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<td>Nuclear</td>
<td>60,911</td>
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<td>Other</td>
<td>6,317</td>
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<tr>
<td>Solar</td>
<td>23,303</td>
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<td>Wind</td>
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**Net Capacity by Fuel Type (MW)**

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<th>Fuel Type</th>
<th>Net Capacity (MW)</th>
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<td>7,579</td>
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<td>Other</td>
<td>5,528</td>
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<tr>
<td>Solar</td>
<td>10,675</td>
</tr>
<tr>
<td>Wind</td>
<td>23,062</td>
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Bonneville Power Administration is a federal agency that sells electricity from the Columbia River dams and the Columbia Generating Station nuclear power reactor at Hanford. This chart shows the first few days of fall in September 2019. A front passed through the region, generating lots of wind power. After it passed, the wind became calmer and the power was more intermittent - green line. In response, BPA increased water flows through the dams - blue line - to keep the total generation - red line - able to meet demand. The two flat lines represent nuclear in purple / blue and biomass (burning trees) in brown. BPA is a subset of the Western Electricity Coordinating Council western power grid, but is regionally significant in its role in keeping the grid balanced (too little generation and the network would have voltage drops and brown outs).

A problem with "100% clean" electricity is the clean sources - solar and wind - are variable. Sometimes there is a lot of sunlight and sometimes there is a lot of wind, but not always.

When I first learned how to use solar electric panels in 1990 the primary lesson was to adapt one's demands to what was available. This lesson applies at all levels from the individual to the neighborhood to the entire planet. Digging up coal, uranium, natural gas forces Nature to provide on demand, non stop, without consideration of consequences.

Living with solar panels, especially in the winter, is far more educational than reading technical reports and political polemics. Even powering small things like flashlights or radios solely with solar is a tremendous teaching tool.

Bottom line: using solar energy directly (electric, hot water, passive solar design, greenhouse agriculture, solar cooking) and indirectly (wind, firewood) is awesome but cannot sustain the unsustainable. The Earth is abundant and finite.

Entropy is not a good idea, it's the law.
In 2020 the Boardman, Oregon coal powered generator closed. No more coal is burned for electricity in Oregon, but we are connected electrically to coal burners on the rest of the Western Electricity Coordinating Council western power grid.

Natural gas is the largest energy source for WECC, which includes B.C., Alberta, Pacific Northwest, California, Arizona, Tijuana, Great Basin, Rocky Mountains.

2020 wind power increased about a quarter more than 2019. Natural gas dipped slightly. Gas and wind have similar amounts of installed capacity but gas generates much more power because it is constant (baseload) and wind is variable.

In 2020, solar generated more megawatt hours than biomass for the first time.

Washington State generates more hydroelectricity than Oregon.

chart: Mark Robinowitz PeakChoice.org

data: https://www.eia.gov/electricity/data/browser/#/topic/0?
agg=2.0,1&fuel=vv&geo=000000000000&sec=g&req=A&start=2001&end=2019&ctype=linechart&ctype=pin&type=s&pin=&rse=0&motype=0
NATURAL GAS

There is significant fluctuation from year to year in the consumption of natural gas for electric power generation. Consumption in other sectors is relatively steady.

Natural gas consumption for electric power generation is driven by the availability of other resources, especially hydroelectric and variable energy resources, and demand for electricity overall. As penetration of variable energy resources increases, the system relies more on natural gas resources for ramping, load-following and changes in generation associated with these variable resources.

Pipelines and Power Plants

There are over 54,000 miles of natural gas pipeline in the Western United States. These pipelines carry gas long distances from production sites to consumers, including power plants.

California consumes more natural gas than any other state in the West. It is the primary fuel source for electric power generation in the state, as well as in Nevada. The amount of natural gas consumed for generation in California is expected to be steady or decrease in future years as the penetration of variable energy resources increases. However, natural gas and other conventional technologies that provide Essential Reliability Services remain critical for the reliability of the Western Interconnection.

Natural Gas Consumption by Sector (MMcf)

- Electric Power
- Industrial
- Residential
- Commercial

<table>
<thead>
<tr>
<th>Year</th>
<th>Electric Power</th>
<th>Industrial</th>
<th>Residential</th>
<th>Commercial</th>
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<tbody>
<tr>
<td>2008</td>
<td>1,758,270</td>
<td></td>
<td></td>
<td>1,271,755</td>
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<tr>
<td>2010</td>
<td>1,747,541</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td></td>
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</table>
In-State Electric Generation by Fuel Type
Source: Quarterly Fuels and Energy Reporting Regulations

- Wind
- Solar Thermal
- Solar PV
- Small Hydro
- Large Hydro
- Natural Gas
- Nuclear
- Geothermal
- Biomass
- Oil
- Waste Heat
- Petroleum Coke
- Coal

California
Energy Commission

Source: Quarterly Fuels and Energy Reporting Regulations

California’s Electric Generation by Fuel Type

Source: California Energy Commission, CEC-1304 Power Plant Data Reporting.

https://www.wecc.org/_layouts/15/WopiFrame.aspx?sourcedoc=%2FAdministrative%2FCAISO%2D2Gas%2DElectric%2DForum%2Dpresentation%2FNovember%202019%2Dpdf%2Daction-view
Western Electricity Coordinating Council

"state of the interconnection"
The main increase in the use of unnatural gas in the US in recent decades has been for electric grids. Nat. gas generators are easier to approve under the Clean Air Act than coal burners (and coal is in permanent geologic decline, a physical fact obscured by discussion of its more obvious pollution problems). However, gas supplies were never sized to both power electricity and heat cold cities in the winter. Conventional gas decline has been mitigated by the sudden, sharp increase in fracked gas since 2008, but fracked gas is not only more toxic than conventional gas wells, it’s also more expensive, takes more energy and talent. Fracked wells rise and fall faster than conventional drilling, so the fracking bubble is a short term boom and bust.

Campaigns to restrict nat. gas use in favor of more electricity ignore that gas is a primary power source for electricity. Here in Oregon, there has been a huge increase in nat. gas combustion east of the Cascades in Klamath Falls and Boardman, hard to notice in the liberal cities of Portland and Eugene, but gas is a key source of power. Burning that gas and sending the electrons over the Cascade mountains might be less efficient than just burning the fuel closer to where the energy is wanted. Using less energy, including less electricity, is usually belittled.
Fracked “tight oil” and “shale gas” - two thirds of US totals
baseload for power grids, heat for cold cities, industrial uses
damned if we drill, damned if we stop, damned as it runs out
USA conventional unnatural gas peaked 1973 fracking postponed rationing

- Gas wells
- Gas from oil wells
- Coalbed methane
- Fracked gas

2020: Fracked gas 70% total

Fracked gas was 8% of supply in 2007, in 2020 it was 70%

2017 Fracked gas (19.927 trillion) surpassed 1973 conventional gas peak (19.371 trillion)

2017 conventional gas and from oil wells combined (12.873 trillion), 1957 level (12.9 trillion)