Capacity:
an evolving concept

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NW Energy Coalition

for a clean and affordable energy future

NW Energy Coalition

The NW Energy Coalition is an alliance of about 100 environmental, civic, and human service organizations, progressive utilities, and businesses in Oregon, Washington, Idaho, Montana and British Columbia. We promote development of renewable energy and energy conservation, consumer protection, low-income energy assistance, and fish and wildlife restoration on the Columbia and Snake rivers.

NW Energy Coalition

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www.nwenergy.org

Electric Resource Capacity: standard definitions

- Generator capacity: The maximum output, commonly expressed in megawatts (MW), that generating equipment can supply to system load, adjusted for ambient conditions.

- Generator nameplate capacity (installed): The maximum rated output of a generator, prime mover, or other electric power production equipment under specific conditions designated by the manufacturer. Installed generator nameplate capacity is commonly expressed in megawatts (MW) and is usually indicated on a nameplate physically attached to the generator.

US Energy Information Administration
https://www.eia.gov/tools/glossary/

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Capacity: conventional wisdom

- The main focus is annual system coincident peak hour
  - does not address other system stress conditions
- Capacity is provided by (thermal) generation
- Does not directly include reactive power (Vars) and ancillary services
- Assumes constant fuel input (nameplate == capacity)
- Out of focus:
  - variable generation (hydro, wind, solar) and storage
  - demand side resources
- Standard unit is a gas combined cycle or peaker
  - “flexible capacity” or “dispatchable capacity” conceptually based on what a gas plant can provide

Nameplate capacity: “maximum output”

- Some standards (e.g. ISO 3977-2 for gas turbines)
- Manufacturer self-certification under reference conditions
- *Your mileage may vary!*
  - gas turbines: elevation/atmospheric pressure, ambient temperature
  - wind turbines: hub heights and wind regime
  - PV solar: direct/diffuse insolation, flat or tilted, fixed or tracking, dc vs ac output (and inverter loading ratio)

Nameplate capacity: but . . .

- Station service
- Forced outage (typically 3-8%, not constant, can increase under system stress)
- Fuel delivery/availability (PJM “polar vortex”, NW Arctic Express)
- Shaft risk (CGS, Colstrip, Boardman, 1260 MW in CAISO on Tuesday)
- Transmission and distribution constraints (contingencies, Remedial Action Schemes)
- Transmission and distribution losses

Forced outage/shaft risk . .

Energy Northwest: Nuclear power plant shut down unexpectedly

Tri-City Herald

DECEMBER 18, 2016 07:05 PM, UPDATED DECEMBER 18, 2016 08:05 PM

The nuclear power plant near Richland shut down unexpectedly at 11:24 a.m. Sunday.

Equipment malfunctioned at the Bonneville Power Administration's Ashe Substation near the Columbia Generating Station, which is operated by Energy Northwest.

Cold weather caused the loss of the 500 kilovolt line connecting the nuclear plant's main output transformers to the substation, according to Energy Northwest.

The nuclear plant's output breakers responded as they are designed to perform and separated the plant from any potential grid transients. Columbia's operating crew then successfully stabilized the plant.

Forced outage/shaft risk . .

FLEX ALERT
FLEXALERT.ORG

California ISO

FOR IMMEDIATE RELEASE | June 11, 2019

Contact: Media hotline at (888) 516-NEWS | ISOMedia@caiso.com

Flex Alert – a call for energy conservation – in effect today

FOLSOM, Calif. – Due to high temperatures and high energy demand, the California Independent System Operator Corporation (ISO) has issued a statewide Flex Alert calling for voluntary electricity conservation from 4 p.m. to 10 p.m. today.

Consumers are urged to conserve electricity especially during the afternoon when air conditioners typically are at peak use. Consumers can help avoid power interruptions by turning off all unnecessary lights, using major appliances before 4 p.m. and after 10 p.m., and setting air conditioners to 78 degrees or higher.

Because of widespread heat, the ISO anticipates energy demand reaching a peak of 42,800 megawatts (MW) this evening. Also, two units with a total generation of 1,260 MW are offline due to mechanical failures. The Flex Alert is being called in response to the high electricity demand and the reduced generation.

The ISO earlier in the day issued a Restricted Maintenance Operations (RMO), which requires generators and transmission owners to postpone scheduled maintenance, to keep grid assets available for use.

Nameplate capacity: operational issues matter too . . .

- Cold start/warm start/minimum operating levels (Pmin)
- Ramp rate (MW/minute)
- Efficient operating range
- Displacement (slow start resources may provide cheap peak capacity but displace cheaper resources)
- Regulatory: emissions controls and exceedances
- Increased O&M (“wear and tear”)

More EIA definitions

- Base load capacity
- Capacity factor
- Capacity utilization
- Dependable capacity
- Design electrical rating (capacity) net
- Generator capacity
- Generator nameplate capacity (installed)
- Inoperable capacity
- Installed nameplate capacity
- Maximum dependable capacity, net
- Maximum generator nameplate capacity
- Net operable capacity
- Net summer capacity
- Net winter capacity
- Operable capacity
- Operating capacity
- Peaking capacity
- Storage capacity

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More BPA definitions

- assured system capacity
- baseload capacity
- fifty-hour peak capacity
- firm capacity
- installed capacity
- peak capacity
- peaking capacity
- reserve capacity
- surplus capacity
- surplus firm capacity
- surplus peaking capacity
- system capacity
- capacity factor
- capacity-only pricing
- capacity rating
- capacity service
- capacity value

https://www.bpa.gov/news/pubs/Pages/Definitions---C.aspx

More PNUCC definitions

- Base Load Capacity
- Busbar Capacity
- Gross Capacity
- Nameplate Capacity
- Net (Maximum) Available Capacity
- Net Dependable Capacity
- Net Summer Capacity
- Net Winter Capacity
- Nominal Capacity
- Peaking Capacity
- Rated Capacity
- Site-Rated Capacity

Capabilities of Electric Power Resources, PNUCC System Planning Committee (March 2011)
http://pnucc.org/sites/default/files/CapabilitiesofResourcesReportandMemoweb.pdf

Hydro capacity: FELCC

- Two important results of a hydroregulation study are the firm energy availability and the Firm Energy Load Carrying Capability (FELCC). Firm energy is the amount of energy that can be generated by the hydro system under worst-case water conditions. FELCC is the amount of firm energy that the region's generating system, or an individual utility within the project, can be expected to produce. It is comprised of both hydro and non-hydro sources, including power purchases. BPA determines firm energy figures and the FELCC in critical period studies to plan the non-hydroelectric resources required to meet expected future needs.

BPA Hydrosim manual (1997)
http://static1.squarespace.com/static/56d708792b8ddec113c79399/t/56dfa3828259b51394295fa0/1457496962192/Hydrosim+Section+1.pdf

Renewable capacity: Effective Load Carrying Capability (ELCC)

- ELCC decomposes the individual generator's contribution to system reliability. It can discriminate among generators with differing levels of reliability, size, and on-peak vs. off-peak delivery. Plants that are consistently able to deliver during periods of high demand have a high ELCC, and less reliable plants have a lower ELCC. For variable generators such as wind, the method can discriminate between wind regimes that consistently deliver during high-risk periods, sometimes deliver during high-risk periods, or never deliver during high-risk periods. In fact, ELCC can provide for a continuum of capacity values over these potential outcomes.

Milligan & Porter, Determining the Capacity Value of Wind: An Updated Survey of Methods and Implementation (2008)
https://www.nrel.gov/docs/fy08osti/43433.pdf

All capacity resources have constraints/risks

- Performance/availability/forced outage
- Fuel inputs
- Sustained duration
- Shaft risk (large resources)
- Regulatory (emissions)

System value
is the right perspective

Consistent method applicable to all energy resources:

- Generation
  - thermal, renewable, storage
- Demand side
  - energy efficiency, demand response, storage
- Consider aggregate resource, not just individual unit
  - availability, flexibility and diversity value
- Annual system coincident peak hour capacity as an important single case
- Capability value for other system conditions
  - monthly/seasonal need
  - daily load and generation following (“duck curve”)

A way forward? – “capability” not “capacity”

Definitions and Terms

The following terms help frame a discussion about resources and their capabilities. In many cases it is an industry standard to label each type of capability as a “capacity” measurement. However, the term capacity is too broad without additional description. Capacity does explain the level of production that can be achieved by a resource, or, alternatively, “how high it can go” such as a nameplate rating. But it is more accurate to describe many resource capabilities in a manner representing their inherent flexibility or ability to change output over time.

Capabilities of Electric Power Resources, PNUCC System Planning Committee (March 2011)
http://pnucc.org/sites/default/files/CapabilitiesofResourcesReportandMemoweb.pdf