Unit Types not addressed in Manual 15:
Educational Document

Cost Development Guidelines - Where we are today

Currently Manual 15 provides cost development guidelines for Nuclear, Fossil Steam, Combustion Turbines, Diesel, and Combined Cycle Units. Pumped Storage Hydroelectric units costs are partially but not fully developed. There are no cost development guidelines for:

- Non-Fossil Steam Units (such as biomass or solid waste)
- Run-of-River Hydroelectric Units
- Wind Units
- Solar Units, or
- Energy Storage Units (such as flywheels and batteries)

Many units of these types are entering the PJM footprint and becoming more significant in dispatch and generation profile. There is no adequate basis currently to evaluate the cost based offers of these units.

Biomass Fired Steam Units[1]

Biomass Fired Steam units use a wide range of materials that can be used as a source of chemical energy to generate steam. Biomass is anything that is or was recently alive. This includes but is not limited to the following fuels: wood, bark, sawdust, straw, vine clippings, leaves, grasses, bamboo, sugar cane, palm oil, peat moss or coffee grounds. Biomass Fired Steam Units may be either dedicated generation or cogeneration facilities. Biomass is typically burned on a traveling grate and can be burned in combination with other traditional fossil fuels. Biomass fuel systems can be quite complicated and maintenance intensive due to the varying characteristics of the fuel. For many biomass fuels, special fuel preparation equipment may be needed to provide effective overall combustion.

Solid Waste Steam Units[2]

Solid Waste Steam units incinerate refuse to generate steam. This is generally non-liquid, non gaseous non-toxic residential and commercial waste. Two main techniques are used for burning municipal refuge, distinguished by the degree of fuel preparation. Solid waste is incinerated either by mass burning in an as-received state or as refuse derived fuel (RDF) whereas-received fuel is separated, classified and recyclable material reclaimed. Mass burning boiler are typically stoker grate type boilers. RDF boilers can be stoker grates or fluidized beds type boilers. Finely shredded RDF can be fired in suspension to supplement conventional fuels in large boilers.

Run of River Hydroelectric Units[3]

Run-of-the-river (ROR) hydroelectricity is a type of hydroelectric generation whereby a considerably smaller water storage called pondage or none is used to supply a power station. Run-of-the-river power plants are classified as with or without pondage. A plant without pondage has no storage and is therefore subjected to seasonal river flows. It thus generates much more power during times when seasonal river flows are high and much less during drier summer months.

Wind Units[4]

Wind Units convert the kinetic energy of the wind into electricity. Electricity generated from wind power can be highly variable at several different timescales: from hour to hour, daily, and seasonally. Annual variation also exists, but is not as significant. In a wind farm, individual turbines are interconnected with a medium voltage (often 34.5 kV), power collection system and communications network. At a substation, this medium-voltage electric current is increased in voltage for connection to the high voltage electric power transmission system. Wind turbines can rotate about either a horizontal or a vertical axis, the former being both older and more common. Horizontal-axis wind turbines (HAWT) have the main rotor shaft and electrical generator at the top of a tower, and must be pointed into the wind. Small turbines are pointed by a simple wind vane, while large turbines generally use a wind sensor coupled with a servo motor. Most have a gearbox, which turns the slow rotation of the blades into a quicker rotation that is more suitable to drive an electrical generator. Induction generators, often used for wind power, require reactive power for excitation so substations used in wind-power collection systems include substantial capacitor banks for power factor correction.

Solar Units[5]

Solar units are made up of photovoltaic cells collectors made from semiconductors which convert solar radiation directly to electricity. Generation of power from solar radiation encounters the inherent problems of intermittent availability and relatively low intensity. Very large collection areas are essential for meaningful electrical outputs (100 ft^2 for 1 kW at 10% conversion). Additionally, inverters are required to convert the DC output of the solar cells to useable AC power.

Energy Storage Units

Energy storage units can be battery arrays, including plug-in hybrid electric vehicles (PHEVs), flywheels, and compressed air energy storage[6]

Battery energy storage Battery systems connected to large solid-state converters have been used to stabilize power distribution networks. Batteries are generally expensive, have high maintenance, and have limited life spans, mainly due to pure chemical crystals that form inside the cells during the charge and discharge cycles. These crystals usually cannot be re-dissolved back into the electrolyte. They can grow large enough to apply significant mechanical pressure to interior structures inside the battery to bend plates, bulge battery casings, and short out individual cells.[7]

Flywheel energy storage (FES) works by accelerating a rotor (flywheel) to a very high speed and maintaining the energy in the system as rotational energy. When energy is extracted from the system, the flywheel's rotational speed is reduced as a consequence of the principle of conservation of energy; adding energy to the system correspondingly results in an increase in the speed of the flywheel. A typical system consists of a rotor suspended by bearings inside a vacuum chamber to reduce friction, connected to a combination electric motor/electric generator. An additional limitation for some flywheel types is energy storage time. Flywheel energy storage systems using mechanical bearings can lose 20% to 50% of their energy in 2 hours. Conversely, flywheels with magnetic bearings and high vacuum can maintain 97% mechanical efficiency.[8]

Pumped Air Storage or "Compressed Air Energy Storage (CAES) is the term given to the technique of storing energy as the potential energy of a compressed gas. Usually it refers to air pumped into large storage tanks or naturally occurring underground formations… When energy is available, it is used to run air compressors which pump air into the storage cavern. When electricity is needed, it is expanded through conventional gas turbine expanders. Note that some additional energy (typically natural gas) is used during the expansion process to ensure that maximum energy is obtained from the compressed gas."[9]

References to PJM Documents

Manual 15: Cost Development Guidelines details the standards for determining cost components for markets where products or services are provided to PJM at cost-based rates, as referenced in Schedule 1, Section 6 of the PJM Operating Agreement. Generation Owners use Manual 15 to develop their cost based offers. Manual 15 Section 7 provides information for the development of Hydro or Hydro Pumped Storage cost offers.[10]

Operating Agreement of PJM Interconnection (OA) mentions "Unit Types not addressed in Manual 15 in the following ways:

1. "Energy Storage Resource" shall mean flywheel or battery storage facility solely used for short term storage and injection of energy at a later time to participate in the PJM energy and/or Ancillary Services markets as a Market Seller.[11]
2. Station Power does not include any energy …. (ii) used for pumping at a pumped storage facility; (iii) used for charging an Energy Storage Resource: …[12]

The Open Access Transmission Tariff (OATT) mentions "Unit Types not Addressed in Manual 15" in the following ways:

1. "Energy Storage Resource" shall mean flywheel or battery storage facility solely used for short term storage and injection of energy at a later time to participate in the PJM energy and/or Ancillary Services markets as a Market Seller.[13]
2. Station Power does not include any energy …. (ii) used for pumping at a pumped storage facility; (iii) used for charging an Energy Storage Resource: ….[14]
3. Reactive power requirements for wind powered and other non-synchronous generating facilities are specified in Section 4.7.[15]
4. Schedule H provides the interconnection requirements for a wind generation facility.[16]
5. Peak Hour Availability Charges and Credits do not apply to wind and solar resources.[17]

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Summary

In general, additional guidance in Manual M15 should be provided to clearly delineate the actual components of costs for these unit types.

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[1] The Babcock & Wilcox Company. Steam its generation and use. Forty-first edition, 2005, chapter 30.

[2] The Babcock & Wilcox Company. Steam its generation and use. Forty-first edition, 2005, chapter 29.

[3] http://en.wikipedia.org/wiki/Run-of-the-river_hydroelectricity

[4] http://en.wikipedia.org/wiki/Wind_turbine

[5] The McGraw-Hill Company. Marks' Handbook for Mechanical Engineers. Eleventh Edition, Page 9-18

[6] http://www.pjm.com/~/media/about-pjm/newsroom/downloads/electricity-storage.ashx

[7] http://en.wikipedia.org/wiki/Grid_energy_storage

[8] http://en.wikipedia.org/wiki/Flywheel_energy_storage

[9] http://coen.boisestate.edu/WindEnergy/resources/ER-07-001.pdf

[10] Manual 15

[11] OA P161

[12] OA P169

[13] OATT P807

[14] OATT P847

[15] OATT P1120

[16] OATT P1252-1254

[17] OATT Attachment DD P1579