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Zero Code

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The Federal Power Commission was created by the Federal Water Power Act of June 10, 1920. Before passage of this act, Congress or the responsible Departments approved hydroelectric projects. The name of the Commission has been changed to the Federal Energy Regulatory Commission (FERC).

Originally the Secretaries of Agriculture, Interior, and War were members of the Federal Power Commission. However, because of the increasing workload, the makeup of the Commission was changed to five Presidential appointees. Section 4(e) of the Federal Power Act took on added significance as it provided that the Secretaries retained direct control over actions on reserved land under their jurisdiction.

Besides administering the licensing of hydroelectric power projects, FERC also regulates the rates and charges for the transportation and sale of natural gas, the transmission and sale of electricity, and the transportation of oil by pipeline as well as the valuation of such pipelines.

The FERC has regulatory jurisdiction over hydroelectric projects in the following instances:

1. The project involves Federal land.

2. The project involves navigable waters.

3. The project involves use of a Federally owned dam.

4. The project involves interstate commerce (grid connection).

The Public Utility Regulatory Policies Act (PURPA) of 1978 (P.L. 95-617), states that public utilities must buy power produced by small renewable-resource power plants on an avoided cost basis.

Section 408 of the Energy Security Act of 1980 (P.L. 96-294) amended section 405 of PURPA to allow FERC, under certain conditions, to grant exemptions from Part 1 of the Federal Power Act (Licensing) for small hydroelectric projects that generate 5 megawatts or less.

Section 213 of PURPA amended Part 1 of the Federal Power Act to allow FERC to exempt certain conduit hydroelectric facilities 15 megawatts or less.

05 - Definitions

1. Avoided Cost. The cost of the power that a utility would either purchase or generate to meet the top 10 percent or top 100 megawatts of customer demand, whichever is greater.

2. Baseload. The minimum load in a stated period of time.

3. Baseload Capacity. The electric power output that can be produced continuously; usually computed by considering equipment that the operator (utility) intends to run at least 70 percent of the time. This is distinguished from peaking or cycling capacity.

4. Cumulative Impact. An impact that can be (1) the same (or similar) impact for a number of projects in an area, or (2) impacts of one or more projects which add up year after year. If there are unmitigated impacts, the possibility exists for cumulative impacts depending on the number of existing and potential projects and/or the additive nature of the impacts (40 CFR 1508.7).

5. Capacity. The load for which a generator, turbine, or system is rated.

6. Dam. Any artificial barrier, together with appurtenant works, that affects the water flow and water level of a natural body of water. A barrier to control the flow or raise the level of water.

7. Demand. The rate at which electric energy is delivered to or by a system, expressed in kilowatts, at a given instant or averaged over any designated period of time.

8. Diversion. The point on a stream where water is diverted into the system.

9. Diversion Structure. Any structure used to divert water from a stream into a pipeline or other water conveyance system.

10. Drawdown. The distance that the water surface of a reservoir is lowered from a given elevation as the result of the withdrawal of water.

11. Energy. That which does or is capable of doing work. Electric energy is usually measured in kilowatt-hours.

12. Firm Power. The amount of power it would be possible to produce continuously during a repetition of the most adverse hydro year on record.

13. Flow. Volume of water per unit of time. Can be expressed in gallons or cubic feet per minute (gal/min, CFM) or in cubic feet per second (CFS), and so forth.

14. Flow Duration Curve. A curve showing the percentage of time (in certain time

period) that a river's flow was equal to or greater than a given discharge value (flow volume on y-axis; time (days per year) on x-axis).

15. Francis Turbine. A reaction turbine used to turn the generators in large hydroelectric projects. Most often used in projects with moderate head and high flow conditions.

16. Grid. An electric utility's system for distributing power.

17. Grid Connection. A connection joining a plant that generates electricity to an electric power utility's system so that electricity can flow in both directions between the utility system and plant.

18. Gigawatt-hour. Equals one million kilowatt-hours.

19. Head. The differences in elevation between two water surfaces; it is the amount of fall of the stream that is used to develop power.

a. Critical Head. The head at which the full-gate output of the turbine equals the nameplate generator capacity.

b. Design Head. The head at which the turbine operates to give the best overall efficiency under various operating conditions.

c. Gross Head. The difference in water surface elevation between the forebay (impoundment) and the turbine.

d. Net Head. The gross head less all hydraulic losses sustained in bringing water to the turbine, except those chargeable to the turbine.

20. Headrace. A low pressure pipeline (can also be a flume).

21. Impoundment. Any artificial structure used to collect water in a pond, reservoir, penstock, and so forth, as for irrigation or power generation to stop the natural flow of water.

22. Impulse Turbine. A turbine in which available head is converted into kinetic energy or velocity head in a constricting nozzle(s) before acting upon a cup-like bucket. See Pelton Wheel.

23. Installed Capacity. The total of the generation capacities shown on the nameplates of all generators in a hydro electric plant.

24. Intake. The beginning of the power generation system. This is the point where water enters the pipe.

25. Interconnection. The physical connection of an electricity-generating plant to an

electric utility system so that electricity can flow in both directions between the utility system and the plant.

26. Intermediate Load. The amount of electrical power needed for use when the base load does not fill demand.

27. Intertie. The connection of two or more electric utility systems to transfer surplus power from one to the other.

28. Kilovolt (kV). This is 1,000 volts, a measure of electric potential in a powerline.

29. Kilovolt-amp (kVA) - at unity power factor; a VA = Watt; or kVA = kW.

30. Kilowatt hour (kWh). A kilowatt of power used for one hour; 1 kWh = 3,414 Btu.

31. Load. The average demand on electrical equipment or on an electric system.

32. Load Factor. The ratio of average demand to maximum demand or to capacity.

33. Load Management. Any method or device that evens out electrical demand by eliminating uses during peak periods or shifting usage from peak times to off-peak times.

34. Low Pressure Pipeline. (Also referred to as zero-grade pipeline.) Pipe constructed merely to carry water from a source to the point where it enters the penstock. It is usually built on a slight grade--only enough to ensure that the water flows--and is not designed to carry water under pressure.

35. Micro Water Power Project. A small hydro project with an installed generating capacity of 100 kilowatts or less. This definition is not an official FERC category or name.

36. Megawatt (MW). This is 1,000 kilowatts or 1,000,000 watts.

37. Natural Water Feature Exemptions. Exempt projects that utilize natural water features for the generation of electricity, such as a perched lake or waterfall, without the need for any dam or impoundment (16 U.S.C. 2708(b)). The head-works (diversion) structure for such a project must not obstruct the flow to such a degree as to adversely affect the natural water feature.

38. Nitrogen Entrainment. The entrapment of bubbles of atmospheric nitrogen in the water column at supersaturation levels that occurs in nature as water drops over falls or cascades into deep plunge pools. In a hydroelectric project, this happens if air is "gulped" at the intake of a pressurized system. This air drawn into the penstock dissolves under the negative pressure head developed as water flows to the power-house. The supersaturation of the water with nitrogen affects the fish by introducing nitrogen bubbles into their blood system. They then suffer from a condition similar to the bends with death often resulting.

39. Off Peak. Times when power demand is below average; for electric utilities this is generally night and weekends.

40. On Line. The process of generating electricity and sending it over the transmission lines.

41. On Site. The use of electricity or heat at the same location where it is produced.

42. Outage. The period when a generating unit, transmission line, or other facility is out of service.

43. Output. Amount of power or energy delivered from a piece of equipment, station, or system.

44. Peak Load. Maximum load, produced or consumed, in a stated period of time.

45. Peak Periods. Peak load times are when demand for electricity is high, such as summer weekday afternoons or winter weekday evenings. Different utilities may define the peak period narrowly to include only a few hundred hours per year or broadly to include several thousand hours per year.

46. Peaking Capacity. The capacity of generating equipment that is normally operated only during the hours of highest power demand.

47. Pelton Wheel. An impulse turbine consisting of a series of buckets acted upon by one or more jets of water. A water turbine used to drive a generator in a hydroelectric project characterized by a high head and low flow. It is possible to vary nozzle size to alter the flow of available water, such as between winter and summer. This is typical of small hydro projects (sec. 10.52) utilizing mountain streams.

48. Penstock. The high pressure pipeline that serves the powerhouse. The penstock can originate at the diversion or at the transition point from one or more low pressure conduits.

49. Pondage. Reservoir storage capacity of limited magnitude that provides only daily or weekly regulation of streamflow.

50. Power. The time rate of transferring energy, usually measured in watts or horsepower. This term, as used by the electric power industry, includes power and energy.

51. Power Facilities Agreement. An agreement between the developer and the purchasing utility that defines each partner's responsibility for the transmission line and hook-up with the utilities system (ownership, construction, operation and maintenance, and so forth).

52. Power Pool. Two or more electric systems interconnected and operated on a

coordinated basis in order to economically supply their combined loads.

53. Power Purchase Agreement. An agreement between the developer of a qualifying facility (QF) (as defined by the Public Utility Regulatory Policies Act) and the purchasing utility that defines the type, amount, and method of payment for the power purchased. The State Public Utility Commission or similar body usually controls final approval of each agreement. Agreements are of many types, but utilities usually pay more for guaranteed (firm) capacity during peak load periods when the utility really needs the power.

54. Qualifying Facility (QF). A generating system that qualifies under the Public Utility Regulatory Policies Act so that utilities must purchase the power produced at avoided-cost rates.

55. Ramping Rate. The established rate at which the water flow is to gradually decrease in the tailrace and increase in the turbine bypass during shutdown (or vice-versa in the case of a start up). The purpose of establishing a flow rate change is to prevent the stranding of fish downstream from the power plant that may occur as a result of rapidly falling waters as well as to protect the public from sudden increases in streamflow.

56. Regional Power Grid. A system of transmission lines that interconnect the Region's utilities with the generation resources.

57. Retrofit. The process of adding new equipment or modifying existing equipment in an existing water distribution or storage facility.

58. Run-of-the-River Plant. A hydroelectric power plant that operates using the flow of a stream as it occurs (without a reservoir). Small hydro plants (sec. 10.52) of this type are limited in generating capacity to the flow in the stream.

59. Streamflow. The rate at which water passes a given point in a stream, usually expressed in cubic feet per second.

a. Minimum Streamflow. Minimum natural or regulated flow of stream during a specified time.

b. Regulated Streamflow. The controlled rate of flow at a given point during a specified period resulting from reservoir operation.

60. Tailrace. The discharge from the power plant. Refers to the water channel between the power plant and the stream into which the water discharges.

61. Transmission. The movement or transfer of electric energy in bulk.

62. Utility. In this case, any distribution of power; electric utility is the most general term which includes all power distributing/producing utilities.

a. Investor-Owned Utility (IOU). A privately owned utility serving the public; traditionally referred to as a public utility and regulated by FERC and State Commissions.

b. Municipal Utility. A publicly owned electric (or other) utility, generally serving a single city or town. These utilities are regulated by their own elected boards.

c. Public Utility. An investor-owned utility.

63. Wheeling. Usually, the transfer of bulk power from one utility to another through the transmission lines of a third utility.

06 - Calculation of Outputs, and Values

Exhibits 1, 2, 3, and 4 show the user how to analyze the tradeoffs associated with various alternatives and understand the developer's interest in a project. Perform the calculations for projects being evaluated when necessary or desirable.

Exhibit 01

Value of the Energy Resource

$$kW = \frac{(Q)(H)(e)}{11.8}$$

Where kW = Power in kilowatts.
Q = Volume of flow in cubic feet per second (cfs).
H = Usable head in feet. (static head less friction losses in penstock).
11.8 = Factor to convert units of potential energy into kilowatts.
e = Average efficiency factor: 70 percent efficiency for a small generating system; 80 percent efficiency for large systems.

Exhibit 2

Maximum Capacity of a Power Plant

Calculate the installed or maximum capacity for a hypothetical project with the following parameters:

Given:

Maximum diversion flow = 100 ft3/s
Average annual diversion flow = 20 ft3/s (during operating season).
Plant operates 10 months per year.
Penstock = 10,000 linear feet and 48-inch diameter.
Gross Head = 400 feet.
Head loss @ 100 ft3/s = 60 feet.
Net head @ max. flow = 340 feet.
Average plant efficiency = 70 percent.

Calculation:

Installed capacity in kilowatts =

$$\frac{(Q)(H)(e)}{11.8} = kW$$

$$\frac{(100)(340)(.70)}{11.8} = 2{,}016 \text{ kW or } 2.02 \text{ MW}$$

Exhibit 3

Changes in Head

In order to evaluate the monetary effects of locating the proposed structure or powerhouse up or down the stream, calculate the value of 1 foot of head for the hypothetical project, using the givens in exhibit 2 and assuming the selling price to a utility is $.05 per kWh, as follows (note that relocation distance is measured by the amount of vertical change in feet):

Annual Value:

$$\frac{(.70 \text{ eff})(20 \text{ ft3/s})(1 \text{ ft})(24 \text{ h/d})(30.5 \text{ d/mo})(10 \text{ mo/yr})(\$.05/\text{kWh})}{11.8}$$

= $434.24/year for 1-foot change in head.

Consider this change in project benefits along with other changes in costs due to changes in penstock length or size of generating equipment, ease of construction, and changes in volume of diversion flow.

The present worth (PW) of a 25-foot change in head for this project over 20 years @ 10 percent interest is:

PW = (SPWf of 10% @ 20 yrs.)($434/ft. x 25 ft.) = $92,372.

Exhibit 4

Hydroelectric Comparisons

Where:

SPWf is the uniform series present worth factor from the formula $SPWf = \frac{(1 + i)^n - 1}{i(1+i)^n}$

Where:

i = interest rate
n = number of payments
note: if n is in months, then i must be a monthly interest rate.

60-100 watts = typical light bulb.
1,000 watts = 1 kilowatt (kW).
1,000,000 watts = 1,000 kW = 1 megawatt (MW).
1,000 MW = 1 Gigawatt (GW) = 1 billion watts.
1 Kilowatt-hour (kWh) = 1,000/watt-hours (Wh) = energy consumed by a 100-watt bulb lit for 10 hours.
1 Gigawatt-hour (Gwh) = 1,000 MWh.
1.5 MW = about 2,000 horsepower.

The following information may help to put the units of generated capacity into perspective:

1. The average home in California uses 15 Kwh/day, or 5,475 Kwh per year.

2. The town of Yreka (population 5,916) consumes 12,500,000 Kwh per year (12.5 Gwh). Discounting peak energy demands, this is equivalent to the power produced annually by a 1.5 MW (1,500 KW) plant (typical small hydro project size).

3. 12.5 Gwh is equivalent to the power produced in a thermal plant burning 21,500 barrels (903,000 gallons) of crude oil per year (42 gallons equals 1 barrel).

4. At $30 per barrel, the value of 21,500 barrels of oil would be $645,000 per year.

07 - References

1. U.S. Congress, Federal Power Act, 16 U.S.C. 797 and Federal Power Commission, U.S. Government Printing Office, April 1, 1975, stock number 015-000-00324-3.

2. Code of Federal Regulations, Title 18, Chapter 1, U.S. Government Printing Office. (Contains Federal Energy Regulatory Commission rules and regulations.)

3. U.S. Department of Agriculture, Agriculture Handbook 478, National Forest Landscape Management, Volume 2, Chapter 2, "Utilities," 1975.

4. U.S. Department of Agriculture and the Interior Environmental Criteria for Electric Transmission System, 1970. U.S. Government Printing Office, Washington, D.C. 20402, stock number 404-9320-70-2.

5. U.S. Congress, Federal Land Policy and Management Act of 1976, Public Law 94-579 (90 Stat. 2743 - 2794).