

TO: APPLICATION FOR PERMIT REVIEW

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SUBJECT: HYDRO POWER EVALUATION

The applicant supplied all the basic information requested in Administrative Memo 24. The applicant showed that have completed a hydropower affidavit. They have contacted the Federal Energy Regulatory Commission. The application shows in remarks that they are seeking 15 Kw of power, which fits within the guidelines of 10 to 15 Kw for a total electric home in Administrative Memo 24. The application also states a Pelton Wheel type generator will be used. The application map shows that there is a 160 ft elevation or head differential between the point of diversion and the generator. The application also asks for 2.00 cfs of flow to generate the 15 Kw of power needed.

Using the worksheet formula in Administrative Memo 24, I ran a couple of calculation to determine if the application was reasonable. The base formula is $P \text{ (power)} = [Q \text{ (cfs)} \times H \text{ (head)} \times e \text{ (efficiency 0.50 for Pelton Wheel)}] / 11.8$. I first used this base formula to determine if the 2.00 cfs requested in the permit was excessive using the following variation of the formula $Q = [P(11.8)] / H_e$. Please see below for the results:

$Q = (15 \text{ Kw})(11.8)/(160 \text{ ft head})(0.50 \text{ eff.}) = 2.25 \text{ cfs}$ required to attain 15 Kw of electricity.

This seems reasonable, since this is a very basic estimation of the efficiency of the generator. Whereas there was a small difference in the diversion rate, I wanted to determine how much power could be generated using the 2.00 cfs rate using the base formula shown above. My calculations are shown below:

$P = (2.00 \text{ cfs})(160 \text{ Ft Head})(0.50 \text{ eff.})/11.8 = 13.6 \text{ Kw}$ electricity that can be produced by this system

Using this calculation, I determined that this facility could provide the 10 to 15 Kw needed to supply the total electric needs for a home. Therefore, I believe this application can go forward with processing.

ATTACHMENT C

INDIVIDUAL HYDROPOWER PRODUCTION

The following is an acceptable means of evaluating water requirements for planning a small scale hydropower facility. This method is general and intended to provide approximate results for use in filing a water right permit application for development of such a facility. Sizing and selection of equipment for installation is much more complicated and should not be attempted without proper technical guidance. Any one of the following four variables can be determined by mathematical or graphical methods providing the other three are known or assumed: (See Figure 1).

- 1) Power (kilowatts)
- 2) Gross Head (feet)
- 3) Design Flow (cubic feet per second)
- 4) Efficiency

Definition and Explanation of Terms

For turbines, pelton wheels and overshot water wheels, the above variables are defined as follows:

A) Power (P)

System power production capability or system capacity is the amount of electrical power that can be generated by the hydropower system. Power demand is the amount of electrical power that is required by the user to supply electrical appliances. In order to have an operational system, power production capability must be greater than or equal to power demand. Power is commonly measured in kilowatts.

Maximum power demand can be estimated by summing the demand of all electrical appliances that may reasonably be in use at one time. The demand requirements of individual electrical appliances can usually be obtained from power suppliers or are listed on the appliances. An estimate of normal household demand can also be obtained from the following table:

Table 1: Maximum Household Power Demand

Electrical Power Use	Demand (Watts/ft ²)
Lighting and refrigeration only	2
Lighting, refrigeration, water heating, cooking and clothes drying	4-7
Total electric home	10-15

15 KW
OK.
DAN

Maximum power demand in watts can be computed by multiplying demand in watts per square foot by the home size in square feet. Divide by 1000 to convert watts to kilowatts.

B) Gross Head (H)

1) Pelton Wheel or Hydraulic Turbine

Gross head for a pelton wheel or hydraulic turbine is the total vertical elevation difference in feet between the upper end of the penstock and the lower end of the penstock.

2) Overshot Water Wheel

Gross head for an overshot water wheel is the total vertical elevation difference in feet between the bottom of the discharge flume and the water surface of the tail-water.

C) Design Flow (Q)

The flow in cubic feet per second (cfs) at which the system is designed to operate.

D) Efficiency (e)

The fraction of total hydraulic energy available that can be converted to electrical energy and delivered to the consumer. For estimating purposes, use .50 for pelton wheels and turbines and .40 for overshot water wheels.

EXAMPLE PROBLEM

Problem Statement

A person with a 2000 ft² total electric home has a stream near his house which flows a minimum of 15 cfs and has a vertical drop of 400 ft. in the mile upstream from his house. The person desires to supply all of the electrical requirements of his home with a hydro-power generating system. How much water does he need?

Solution

This will be a graphical solution using Figure 1 and assuming the use of a pelton wheel or hydraulic turbine system.

1) Determine home electrical power demand.

Using Table 1

$$\begin{aligned}\text{Maximum Demand} &= 2000 \text{ ft}^2 (15 \text{ watts/ft}^2) \\ &= 30,000 \text{ watts} = 30 \text{ kw}\end{aligned}$$

2) Assume System Efficiency

Since power is assumed to be generated by a pelton wheel or hydraulic turbine, a reasonable system efficiency might be 50%. Assume $e = .5$.

3) Determine $H \times Q$ Requirement to Produce the Desired Power

Enter the graph (Figure 1) at 30 kw. Cross to the 50% efficiency line and proceed down to the lower axis and find $H \times Q = 708$.

4) Select a Head and Solve for the Flow

$H \times Q = 708$; therefore

$$Q = \frac{708}{H}$$

If $H = 400$ ft.; $Q = \frac{708}{400} = 1.8$ cfs

If $H = 200$ ft.; $Q = 3.5$ cfs

If $H = 50$ ft.; $Q = 14.2$ cfs

(It should be noted that there are an infinite number of possible solutions for $H \times Q = 708$ that provide 30 kw of power.)

$$1 \text{ hp} = 746 \text{ W} = .746 \text{ kW}$$

$$1 \text{ kW} = 1000 \text{ W} = 1.34 \text{ hp} = .001 \text{ MW}$$

$$1 \text{ MW} = 1,000,000 \text{ watts} = 1,000 \text{ kW}$$

FIGURE 1: GRAPHICAL SOLUTION OF HYDRO POWER PROBLEMS

