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# EFFICIENCY MONITORING SYSTEM
# BENEFIT ANALYSIS

Accurate determination of turbine efficiency (performance) curves can lead to increased plant efficiency in multi-unit plants. The magnitude of improvement depends on how a plant is currently operated. Documented payback times for a flow-efficiency monitoring system start at 2 months, although typically the time is 12-24 months.

Experience shows that actual unit performance curves differ within multi-unit plants. Even nominally identical units vary due to prototype differences and repair work. Typically, individual curves vary by 1-3%, although 5% is not unusual.

Determining actual unit curves involves installation of a multipath flowmeter system and on-line measurement of net head and generated power over the full operating range. This is done over the range of available heads. The unit efficiency curves are easily plotted from this data and the following analysis is made:

1. The range of power (gate openings or nozzle settings) corresponding to the peak of the efficiency curves are recorded. This provides the plant engineer or operator with the preferred range of gate positions or nozzle settings.

2. The dispatch order of most efficient to least unit is made (for each head).

3. The shapes of the curves are evaluated for determining how many (and which) units should be used for each power generation requirement. For example, as the load requirement increases; thresholds based on performance curves can be established as to when two units become more efficient than one, when three units become more efficient than two, and so on. Spinning reserve requirements can be factored into these guidelines.

4. Similar curve evaluation can be undertaken to determine dispatch of individual unit nozzles, in the case of multi-nozzle Pelton units.

The table below provides the annual savings for each 1% increase in plant efficiency (3 or more units) using a 35% utilization rate.

| **Average Cost** | **Nominal Plant Output (MW)** | | | |
|---|---|---|---|---|
| **per MW hour** | **10** | **50** | **100** | **200** |
| $15. | $4,600. | $23,000. | $46,000. | $92,000. |
| 30. | $9,200. | $46,000. | $92,000. | $184,000. |
| 45. | $14,000. | $70,000. | $140,000. | $280,000. |
| 60. | $18,500 | $92,000. | $184,000. | $368,000. |

Table 1. Annual value of 1% increase in plant efficiency based on a 35% utilization rate.

Our experience is that significant improvements (1-4%) in plant operating efficiency can be achieved from this type of program.

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Increases in hydro plant operating efficiencies have been documented in several papers presented at Waterpower Conferences, and published in Hydro Review and EPRI publications, as summarized below;

1. *Grand River Dam Authority; WaterPower '87*
   Pensacola Dam, Contact: Joel Webb (918) 782-3382
   6 units, 16 MW each; $22/MWhr avoided cost
   Increase in plant efficiency 1.5%
   Annual avoided cost =
   (.015 X 96MW) X 24 hours X 365 days X 35% utilization X $22/MWhr =
   **$98,000.**

2. *Washington Water Power; WaterPower '89*
   Cabinet Gorge, Contact: Scott Hamilton (509) 489-0500
   4 units, 50MW each; $15 /MWhr avoided cost
   Increase in plant efficiency 6%
   Annual avoided cost =
   (.06 X 200MW) X 24 hours X 365 days X 46% utilization X $15/MWhr =
   **$730,000.**

3. *Seattle City Light; HydroReview August 1987, EPRI:RP2038-2*
   Gorge Power Station, Contact: Mitch Yamagiwa (206) 684-3618
   4 units, 3 at 38MW, 1 at 66MW; $22/MWhr avoided cost
   Increase in plant efficiency 0.8%
   Annual avoided cost =
   (0.008 x 180MW) X 24 hours X 365 days X 29% utilization X $22/MWhr =
   **$80,000**

The cost of a standard 4-path flowmeter system for a 4-unit plant is approximately $75,000. Installation costs are approximately $30,000. The additional cost for on-line efficiency measurement for four units is approximately $30,000.

## SEATTLE CITY LIGHT

## GORGE POWERHOUSE

Power Generation

| Condition | | Total Flow | Unit 21 (MW) | Unit 22 (MW) | Unit 22 (MW) | Unit 22 (MW) | Total (MW) | Percent Improvement |
|---|---|---|---|---|---|---|---|---|
| 1. | Actual | | 30.0 | 30.0 | 30.0 | 62.1 | 152.1 | |
| | Optimized | 5860 | 32.3 | 29.7 | 31.1 | 59.3 | 152.4 | 0.20 |
| 2. | Actual | | 28.1 | 28.0 | 28.1 | 59.0 | 143.2 | |
| | Optimized | 5842 | 32.8 | 30.2 | 22.0 | 59.1 | 144.1 | 0.63 |
| 3. | Actual | | 27.9 | 26.1 | 27.0 | 56.1 | 127.1 | |
| | Optimized | 5200 | 35.2 | 0 | 33.8 | 70.4 | 139.4 | 1.67 |
| 4. | Actual | | 30.0 | 29.0 | 0 | 65.1 | 124.1 | |
| | Optimized | 4606 | 34.4 | 31.7 | 0 | 58.7 | 124.8 | 0.56 |
| 5. | Actual | | 18.1 | 0 | 25.1 | 55.1 | 98.3 | |
| | Optimized | 3702 | 3.55 | 33.0 | 34.0 | 0 | 102.9 | 4.68 |
| 6. | Actual | | 32.0 | 32.0 | 32.0 | 0 | 96.0 | |
| | Optimized | 3420 | 36.1 | 33.4 | 27.1 | 0 | 96.0 | 0.62 |
| 7. | Actual | | 0 | 0 | 0 | 80.0 | 80.0 | |
| | Optimized | 2836 | 40.6 | 40.3 | 0 | 0 | 80.9 | 1.12 |
| 8. | Actual | | 0 | 0 | 0 | 70.0 | 70.0 | |
| | Optimized | 2465 | 37.5 | 34.4 | 0 | 0 | 71.90 | 2.71 |

Notes: cfs - cubic feet per seconds
Mw - megawatts

Table 1. Optimization results