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1. Micro Hydro-Turbine Tutorial

2. Evaluation Approach for Estimating Annual Energy Recovery

3. Impacts from Variabilities and D/S Flow Control
Basic Concept – Energy Recovery in Water Distribution Systems

- Pressure from sources is too high and must be reduced
- Typically done with pressure reducing valves (PRVs)
- By using a turbine, part of energy is converted to power
- Power Output (kW) = (Flow, gpm)(TDH, ft)(0.746 kW/hp)(100)(Eff)

3,960
Case Study: TVWD Center St. Generator Station

- Identify energy recovery opportunities
- Evaluate alternatives for retrofit or replacement of existing turbine
- Determine annual energy recovery and project payback periods
- Sustainability evaluation (CO₂ emission offset)
TVWD Distribution System

Center St. Generator Station

Figure 1.2
SYSTEM SCHEMATIC
WATER MASTER PLAN UPDATE
TUALATIN VALLEY WATER DISTRICT
Center St. Generator Station

Worthington Turbine (112 kW)

14” BFV

Generator
Evaluation Approach

- Identify evaluation period and future system changes
- Develop hourly flow & pressure projections for evaluation period
  - Capture diurnal and seasonal variabilities
  - Future system growth and changes
- Calculate generator kW for each hour during evaluation period
- Determine project cost and construction/retrofit feasibility for alternatives
- Compare alternatives:
  - Determine project payback period (assume $0.05/kWh)
  - Calculate carbon offset for each alternative (1 kWh = 1 lb CO2)
Center St. Generator Station - ΔPressure vs. Flow

Existing turbine H/Q (Estimated)

Pressure too low to run turbine

Net Generator Station Flow & Turbine Flow, gpm

Generator Station Pressure Drop, psi

Center St. Generator Station - ∆Pressure vs. Flow

- Center St Data
- Turbine curve
Center St. Generator Station - ΔPressure vs. Flow

Available pressure converted to energy

Pressure too low to run turbine

Bypass needed in this area

- Center St Data
- Turbine curve
Center St. Generator Station - ΔPressure vs. Flow

- Flow too low; need PRV to use turbine
- Pressure too low to run turbine
- Bypass needed in this area

Available pressure converted to energy

- Pressure too low to run turbine

Center St Data

Turbine curve
Center St. Generator Station - \( \Delta \)Pressure vs. Flow

- **Generator Station Pressure Drop, psi**
- **Net Generator Station Flow & Turbine Flow, gpm**

- **Turbine curve**
- **Turbine kW**

- **Center St Data**

- Points labeled 112, 68, and 15
Analysis Approach: Center St Generator Station

- Calculate hourly kW through 2016
- Identify and evaluate alternatives:
  - Existing 112 kW turbine (baseline scenario)
  - Existing turbine with D/S PRV
  - Replacement of existing turbine with Cornell 44, 50, 83, and 96 kW turbines (w/ and w/o D/S PRV)
Center St. PRV Station
Flow and Pressure

Summer: High flows; lower pressure

Generator Station Flow (gpm)
Generator Station Pressure Drop (psi)
Generator Station kW
Center St. Flow and Pressure Projections

![Graph showing flow and pressure drop projections from 2007 to 2017.]
Alternative 2: 6TR1 (96kW)
Alternative 3: 6TR2 (50kW)
Alternative 4: 5TR1A (44kW)
Alternative 5: 10TR2 (83kW)
Center St. Turbine Alternatives

- Existing Turbine
- Cornell Turbine 6TR1
- Cornell Turbine 6TR2
- Cornell Turbine 5TR1A
- Cornell Turbine 10TR2

Station Pressure Drop (psi) vs. Flow (gpm)

- 2007 Data
- 2016 Data
Flow control D/S of turbine was found to have major impact on energy recovery results.
Estimated 2009-16 Energy Recovery: 810 MWh (~$40,000 or ~$5,700/yr)

2007 Energy Recovery: 28,500 kWh (~$1,430)
Center St Generator Station
Modeled Generator kW: Existing Turbine (w/PRV)

Theoretical (Modeled) kW
Actual kW
Generator Station Flow (gpm)

Estimated 2009-16 Energy Recovery:
1680 MWh (~$84,000 or ~$12,000/yr)
Recommendations for Center St

- Flow control is more beneficial than replacement of the existing turbine
- Modify existing D/S 14” BFV and integrate with SCADA for automatic remote modulation/throttling of flow
Turbine Evaluation Sensitivity

Considering diurnal and seasonal variabilities significantly impacts outcome of energy recovery estimates.
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