BUILDING A BORLD OF DIFFERENCE

HYDROPOWER FOR MUNICIPAL WATER SYSTEMS

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WHY CONSIDER HYDRAULIC POWER RECOVERY

- Reduced energy costs
- Increased energy efficiency
- Public perception



Actual power bill after energy recovery started in December.

AGENDA

- Opportunities
- Technology
- Challenges
- Case Study
- Q&A Period





Municipal Hydropower is not large dams and civil works projects.



- **Existing pressure reduction** facilities
- Locations with hydraulic grade drop

- **Predictable flow rate**
- Relief in the system (changes in elevation)
- Area available for turbine







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Most sites not currently viable due to low power production and varying flows.

8

MWS HYDROPOWER TECHNOLOGY AND TERMINOLOGY



To communicate effectively we all must speak the same language.

SMALL HYDRO IMPLEMENTATION



3 TRADITIONAL TYPES OF TURBINES AVAILABLE

• Pelton

- For high head applications
- 250' to 2500'
- Impulse type turbine

• Francis

- For intermediate head applications
- 50' to 500'
- Reaction type turbine
- Propeller / Kaplan
 - For low head applications
 - 15' to 130'
 - Reaction type turbine



PELTON



FRANCIS



APPLICATION DIAGRAM



MWS HYDRO TECHNOLOGY

12



NATEL ENERGY SLH GRAPHIC



RITZ-ATRO HYDRODYNAMIC SCREV



TECHNOLOGY FOR MWS HYDRAULIC POWER RECOVERY INNOVATIVE TECHNOLOGIES

- Hydrodynamic screw (Archimedes screw in reverse)
- VLH "gate" turbine
- Schneider Linear Hydroengine (SLH)
- Siphon turbine
- All low head < 20 ft (6 m)

Appropriate technology depends on specific site conditions.

SCHNEIDER LINEAR HYDROENGINE (SLH) NATEL ENERGY

- Hydrofoils bound by chain drive
- Flow impacts foil to create movement
- Can operate in submerged condition
- Full scale testing recently complete in Buckeye, AZ



SLH" installation with parallel by-passichute

Ideal for wastewater effluent or low head outfalls and irrigation channels.

NEW TECHNOLOGY POWER RECOVERY AND PRESSURE CONTROL

- Introduced to market in 2010
- Still under testing



- Pressure reduction helical rotary lobe
- Uses "off the shelf" components
- Utilizes AFD and induction motor to generate power
- AFD converts power and adjusts unit speed
- Capable of pressure control

Applicable for pressure reduction stations within distribution systems or between zones.

OLD TECHNOLOGY IN NEW APPLICATIONS

- Unregulated centrifugal pumping units
- No wickets gates = simplified operation
- Standard production items means lower unit cost
- Slight loss in efficiency
- Best for fixed flow rates
- Suitable for residual discharge pressure (forcemain applications)

Applicable for pressure reduction stations with atmospheric discharge.



CORNELL PUMP COMPANY UNREGULATED MICRO TURBINE OTHER ARRANGEMENTS AVAILABLE

MWS HYDRO EVALUATION PROCESS



HEAD AND FLOW RELATIONSHIP

Head and flow alone do not guarantee generation capability. Project specific constraints must be evaluated on a case-by-case basis.

IDEAL CONDITIONS

- Zone 1 high equipment costs
- Zone 2 situations vary greatly
- Zone 3 lower cost higher return



Equipment costs are generally flow driven as flow dictates equipment passage size.

PRELIMINARY EVALUATION PITFALLS

• Flow variations not properly accounted

- Flow variations also impact head
- Efficiency varies with flow and head
- Annual average often too optimistic
- Get as accurate flow and head data as possible
- More flow data is useful to properly size equipment
- Use conservative availability assumption when estimating production

Without accurate data equipment sizing and project planning can be a risky gamble.





HYDROPOWER PERMITTING

- Federal Energy Regulatory Commission (FERC) regulates the nation's non-federal hydropower resources (under the Federal Power Act)
- Three basic types of development authorizations:
 - Conduit Exemptions (up to 15 MW, no EA or EIS)
 - Less than 5-MW Exemptions (must own all real property)
 - Full License
- FERC/Colorado MOU signed in 2010 outlines a path for streamlined permitting process
- Start early!



Most MWS Hydro would fall under the Conduit exemption.

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CHANGES NEEDED TO CONTINUE TO DEVELOP MUNICIPAL WATER SYSTEM HYDROPOWER

Regulatory modifications

- Reduce cost and time associated with permitting
- Simplify permitting process for small conduit projects
- HR 795 Small Hydropower Improvement Act
- Equipment
 - Improved controls for pressure regulation
 - More competition for reduced costs
- Outside Factors
 - Develop consistent renewable portfolio standards
 - Realize the real value of electricity and water resources

PROJECT 7 WATER AUTHORITY

Case Study

PROJECT 7 WATER AUTHORITY

- P7 treats raw water for 6 entities on the west slope of Colorado
 - City of Montrose
 - Tri-County Water
 Conservation District
 - City of Delta
 - Town of Olathe
 - Menoken Water District
 - Chipeta Water District
- Source Water Gunnison River
- Formed in 1977
 - Owns and operates
 Water Treatment Plant
 - Owns and operates 30 miles of Treated Water Distribution Piping



PROJECT 7 WATER AUTHORITY

- WTP designed in 1967 capacity of 7 MGD with two filters
- Treatment plant upgraded in 1978 – design capacity of 26 MGD
- Raw water delivery 19 MGD
 - Two parallel gravity lines, 18-inch dia.
 & 24-inch dia.
- Demands reached 19 MGD in 2006, earlier than expected
- Plant upgrade required
 - Target capacity 27 mgd



PROJECT 7 WTP – RAW WATER DELIVERY SYSTEM

- Fairview Reservoir, designed to serve the P7 Water Treatment Plant alone.
 - Static Head Differential – 163 ft (70.6 psi)
 - Approximately 7,000 ft delivery pipeline
- Existing valve house located below the reservoir
 - Intermediate head break-tank
 - Upstream flow control
 - Raw water conduit designed for full head of reservoir
 - Raw water conduit not operating at full capacity





PROJECT 7 WTP – 2009 PROJECT OVERVIEW

- Increase overall plant capacity
 - New Filters
 - New Disinfection Facilities
 - Increase Raw Water Delivery
- Relocate flow control to the plant
 - Better control of raw water into WTP
- Convert 24-inch raw water pipeline to pressure pipe
 - Calculated delivery approximately 20 mgd
 - Excess Head during average flows (10 mgd = 47 psi)
 - Pressure reducing valves required

PROJECT 7 WTP – 2009 PROJECT OVERVIEW

• Project 7 initiated MWS Hydro Project

- P7 considered alternative location for new hydro units (Treated Water)
- Contracted directly with Canyon Hydro (Deming, Washington)

• Design-Build Delivery

- Flexibility during construction
- Flexibility during permitting
- Last minute design issues
- Alternative to Procurement



PROJECT 7 WTP – 2009 PROJECT OVERVIEW

• P7 - Hydro Design Issues

- Unregulated Francis Turbines (Reverse Pumps)
- Flow Variability 5 to 15 MGD
- Head Variability 87 to 132 ft.
- Discharge into operating WTP
- Surge analysis surge protection required
- Electrical Design
 - Power routed through existing plant meter
 - Net-metering agreement with Delta-Montrose Electric Association (DMEA)
 - No power sold directly to the grid



FLOW CONTROL STRUCTURE

- Raw Water Flow
 - Flowmeter
 - Pressure Reducing Valves
 - Flow Control Valve
- Flow Through Hydro-Turbines
 - 6TRI = 75 kW
 - 10TRI = 110 kW
- Surge Relief Valves



PROJECT 7 PERMITTING

- FERC regulates the nation's non-federal hydropower resources (under the Federal Power Act).
 - P7 reviewed all three types of development authorizations:
 - Conduit Exemptions, 5-MW Exemptions, Licenses
- Project 7 was permitted through FERC, via a 5 MW or less exemption
- FERC signed MOU with State of Colorado to facilitate MWS hydropower



PROJECT 7 WATER AUTHORITY

Project Results

Average Monthly Electrical Costs



32

PROJECT RESULTS – COMPOUND PAY-BACK PERIOD

- Capital Costs:
 - \$200,000 (Hydro Units)
 - \$100,000 (15% FCS costs)
- O&M R&R \$4,000 per year
- Present Worth of Capital + O&M/R&R
 - \$300,000 + \$4,000(P/A, 3.5%, 20)
 - Present Worth = \$357,000
- Revenue \$35,000 to \$50,000 Annual Electrical Cost Savings
- Compound Project Pay-Back (assuming 3.5% cost of money) - 10 years
- Compound-Compound Project Pay Back-
 - Electrical costs increase 8% O&M Costs increase 4% 7 years



BENEFITS OF MWS HYDRO

- Limited ecological impact since water is already in treatment system
- Offsets power consumption
- Creates revenue stream
- Generates a renewable source of energy
- Creates jobs
- Balances other renewable energy asse
- Widely available



Triple Bottom Line

Not one size fits all. Proper evaluation required to determine viability.

Building a world of difference. Together

