Technical and Economic Feasibility Assessment of Small Hydropower Development in the Deschutes River Basin

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Introduction

- **Purpose:** identify and assess opportunities for new small hydropower development in Deschutes Basin, along with technology needed to develop selected sites and economic feasibility of developing sites.

- **Three likely scenarios for additional hydropower generation:**
  - add new generators at non-powered dams (NPDs) and diversion structures;
  - add new generators in existing irrigation canals and conduits; and
  - increase generation at existing hydropower facilities.

- **Focus:** developing new projects, so assessment includes only adding new generators at (1) NPDs and diversion structures and (2) existing irrigation canals and conduits.
Introduction

- Today: brief overview of assessment methodology and results for Deschutes Basin.

- In March: more detailed written report on assessment methodology and results for Deschutes Basin.

- After March: more detailed documentation on ORNL Hydropower Energy and Economic Assessment (HEEA) Tool, including availability for use in assessing other sites and basins in United States.
Recent Assessments: NPDs

- National Hydropower Asset Assessment Program (NHAAP) database lists 64 NPDs/diversions in Upper and Middle Deschutes and Crooked basins. Three have potential capacity > 3 MW: North Unit Diversion Dam (4.65 MW), Wickiup Dam (3.95 MW), and Bowman Dam (3.393 MW).

- Reclamation (2011) *Hydropower Resource Assessment at Existing Reclamation Facilities* also models Wickiup with potential capacity of 3.95 MW and Bowman with potential capacity of 3.29 MW.

- *Reclamation 2011* ranks hydropower sites at Reclamation dams in Pacific Northwest based on benefit/cost ratio (BCR) (with green incentives) > 0.75. Bowman ranks highest in Pacific Northwest with BCR of 1.90 and internal rate of return (IRR) of 11.2 percent.

- Two other Deschutes Basin dams had BCRs > 0.75 in *Reclamation 2011*: Wickiup (0.98) and Haystack Canal (0.85). Three others (Crane Prairie, Lytle Creek, and Ochoco), did not meet 0.75 BCR threshold.
Recent Assessments: NPDs

Two NPDs have moved past assessment stage:

- Symbiotics, LLC: FERC license application for Wickiup Dam Hydroelectric Project (installed capacity 7.15 MW and average annual energy production 21.15 GWh).

- Portland General Electric: FERC preliminary application document for Crooked River Hydroelectric Project at Bowman Dam (installed capacity 6.0 MW and average annual energy production 23.0 GWh).
Recent Assessments: Canals/Conduits

- Potential exemplified by SID’s Ponderosa Project, COID’s Juniper Ridge Project, and TSID’s Main Canal Project.

- Black Rock Consulting (2009) *Feasibility Study on Five Potential Hydroelectric Power Generation Locations in the North Unit Irrigation District*. Three sites deemed economically feasible (i.e., BCR > 1.0) with Energy Trust of Oregon (ETO) grants, investment tax credits, and low-cost equipment and construction.

Recent Assessments: Canals/Conduits

- COID and Oregon Department of Energy (ODE) (2011) *Feasibility Study for Six Central Oregon Irrigation District Potential Hydroelectric Power Generation Sites*. Two sites have estimated BCRs > 0.75.

- Reclamation (2012) *Site Inventory and Hydropower Energy Assessment of Reclamation Owned Conduits* assesses 393 sites in 13 states and ranks by potential annual energy and potential installed capacity.

- *Reclamation 2012* includes 39 NUID sites along North Unit Main Canal; four of top 25 sites in all 13 states are NUID sites.
ORNL Assessment Methodology

- Used ORNL *Hydropower Energy and Economic Assessment (HEEA) Tool* (Version 1.0) being developed by Qin Fen (Katherine) Zhang and Rocio Martinez.

- Site-specific information (including available flow data) from recent NPD and canal/conduit assessments and from multiple data sources.

- Energy/economic assessment differentiates between economically feasible and infeasible sites. Ranks sites by BCR and IRR based on site-specific conditions and green incentives.

- Feasible = BCR ≥ 1.0 and IRR > 5.9% (Weighted Average Cost of Capital).

- Also investigated sensitivity of BCR and IRR to different turbine types from domestic and international suppliers.
ORNL HEEA Tool

- Can be incorporated into Deschutes Basin-Scale Water Management Model by:
  - collecting basic project and site information as input to Basin-Scale Model;
  - accepting flow and head data input from various flow scenarios simulated in Basin-Scale Model, and;
  - producing site-specific energy and economic assessment results as input to Basin-Scale Model

- Targeted application in Deschutes Basin is small hydro (100 kW to 10 MW), but can assess projects from 10 kW to 50 MW.
Methods for Design Flow & Turbine Type

- ORNL HEEA Tool automatically selects turbine type based on ranges of rated net head and design unit flow.

- Develops matrix of turbine types by referencing multiple sources (ESHA 2004; ASME-HPTC 1996; etc.).

- Matrix turbine flow ranges from 0.7 cfs to 2500 cfs, and head ranges from 6.6 ft to 3000 ft.
# Turbine Type Selection Matrix

| Flow (cfs) | 0.7 | 10 | 15 | 20 | 30 | 40 | 50 | 80 | 90 | 100 | 150 | 200 | 250 | 300 | 400 | 500 | 600 | 700 | 800 | 1000 | 1200 | 1400 | 1600 | 1800 | 2000 | 2500 |
|-----------|-----|----|----|----|----|----|----|----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|------|------|------|
| Head (m)  |     |    |    |    |    |    |    |    |    |     |     |     |     |     |     |     |     |     |     |      |      |      |      |      |      |      |      |
| 0.02      |     |    |    |    |    |    |    |    |    |     |     |     |     |     |     |     |     |     |     |      |      |      |      |      |      |      |      |
| 0.03      |     |    |    |    |    |    |    |    |    |     |     |     |     |     |     |     |     |     |     |      |      |      |      |      |      |      |      |
| 0.04      |     |    |    |    |    |    |    |    |    |     |     |     |     |     |     |     |     |     |     |      |      |      |      |      |      |      |      |
| 0.05      |     |    |    |    |    |    |    |    |    |     |     |     |     |     |     |     |     |     |     |      |      |      |      |      |      |      |      |
| 0.06      |     |    |    |    |    |    |    |    |    |     |     |     |     |     |     |     |     |     |     |      |      |      |      |      |      |      |      |
| 0.07      |     |    |    |    |    |    |    |    |    |     |     |     |     |     |     |     |     |     |     |      |      |      |      |      |      |      |      |
| 0.08      |     |    |    |    |    |    |    |    |    |     |     |     |     |     |     |     |     |     |     |      |      |      |      |      |      |      |      |
| 0.09      |     |    |    |    |    |    |    |    |    |     |     |     |     |     |     |     |     |     |     |      |      |      |      |      |      |      |      |
| 0.10      |     |    |    |    |    |    |    |    |    |     |     |     |     |     |     |     |     |     |     |      |      |      |      |      |      |      |      |
| 0.11      |     |    |    |    |    |    |    |    |    |     |     |     |     |     |     |     |     |     |     |      |      |      |      |      |      |      |      |
| 0.12      |     |    |    |    |    |    |    |    |    |     |     |     |     |     |     |     |     |     |     |      |      |      |      |      |      |      |      |
| 0.13      |     |    |    |    |    |    |    |    |    |     |     |     |     |     |     |     |     |     |     |      |      |      |      |      |      |      |      |
| 0.14      |     |    |    |    |    |    |    |    |    |     |     |     |     |     |     |     |     |     |     |      |      |      |      |      |      |      |      |
| 0.15      |     |    |    |    |    |    |    |    |    |     |     |     |     |     |     |     |     |     |     |      |      |      |      |      |      |      |      |
| 0.16      |     |    |    |    |    |    |    |    |    |     |     |     |     |     |     |     |     |     |     |      |      |      |      |      |      |      |      |
| 0.17      |     |    |    |    |    |    |    |    |    |     |     |     |     |     |     |     |     |     |     |      |      |      |      |      |      |      |      |
| 0.18      |     |    |    |    |    |    |    |    |    |     |     |     |     |     |     |     |     |     |     |      |      |      |      |      |      |      |      |
| 0.19      |     |    |    |    |    |    |    |    |    |     |     |     |     |     |     |     |     |     |     |      |      |      |      |      |      |      |      |
| 0.20      |     |    |    |    |    |    |    |    |    |     |     |     |     |     |     |     |     |     |     |      |      |      |      |      |      |      |      |

*Note: The table continues with more rows and columns, providing specific turbine types for different combinations of flow and head.*
Method for Benefit/Economic Evaluation

Three revenue streams considered

- Energy value: monthly generation data used, so energy value seasonality is taken into account.

- Capacity value: reflects avoided cost by utilities of buying energy through a power purchase agreement rather than producing it.

- Green incentives:
  - Renewable Electricity Production Tax Credit (PTC) or Business Energy Investment Tax Credit (ITC) included.
  - Renewable energy credits (RECs) and REC sales not included (yet).
  - State and local grants not included (yet).
Results: NPDs

- Assessed 14 NPD sites with sufficient historical flow data.
- For Wickiup, Bowman, North Unit Diversion, Crescent Lake, and Crane Prairie, used daily flow data from USGS. For all other NPD sites, used estimated monthly flow data from NHAAP database.
- Used HEEA Tool default input data and assumed 2-year construction period for projects > 3 MW and 1-year period for smaller projects.
- Initial incentive funds, length of new pipeline, and length and voltage of new transmission line from previous assessments.
Results: NPDs

- Wickiup, Bowman, North Unit Diversion, and Ochoco (ranked by potential capacity) are economically feasible.

- Wickiup, Bowman, and North Unit Diversion have BCRs > 1.0 for almost all turbine types and manufacturers considered, even without green incentives.

- Total potential power capacity at all 14 NPDs about 17.8 MW, with 70.3 GWh annual energy generation.

- Total potential power capacity at four feasible projects about 17.0 MW, with 66.6 GWh annual energy generation.
**Results: Canals/Conduits**

- Assessed 17 canal/conduit sites with some historical flow data available.

- For 45-Mile Site, used flow data from application for FERC Exemption (EBD Hydro 2010). For other sites, used flow data from previous assessments (Black Rock 2009; ETO 2010; COID and ODE 2011).

- Used HEEA Tool default input data and assumed 1-year construction period.

- Initial incentive funds, length of new pipeline, and length and voltage of new transmission line from previous assessments.
Results: Canals/Conduits

- Six sites (45-Mile, Haystack Reservoir, Columbia South Main, 58-11 Lateral, Columbia South Lateral, and 58-9 lateral) are economically feasible with green incentives.

- Without green incentives, only three (45-Mile, Haystack Reservoir, Columbia South Main) are economically feasible.

- Total potential power capacity at all 17 canal/conduit sites about 14.9 MW, with 67.6 GWh annual energy generation.

- Total potential power capacity at six feasible canal/conduit sites about 7.8 MW, with 36.6 GWh annual energy generation.
Conclusions

- Used ORNL HEEA Tool (Version 1.0) to evaluate power/energy potential and financial feasibility of adding hydropower generation to existing NPDs and irrigation canals/conduits with sufficient hydrologic data.

- Potential generation capacity across 14 NPD and 17 canal sites evaluated about 33 MW.

- With estimated lifecycle benefits/costs, only four NPD sites and six canal/conduit sites appear economically feasible.

- These 10 feasible projects could add about 25 MW of capacity, generate over 103 GWh of renewable energy each year, and avoid GHG emissions of 38,500 tonne of CO₂ equivalent each year.
Conclusions

- ORNL HEEA Tool can be incorporated into Deschutes Basin-Scale Water Management Model.

- In March: more detailed written report on assessment methodology and results for Deschutes Basin.

- After March: more detailed documentation on ORNL HEEA Tool, including availability for use in assessing other sites and basins in United States.
Thank you!