MASS CEC WORKSHOP

ENERGY MODELING

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CASE STUDIES

1. Assuming constant turbine efficiency (~15%)
2. Compared 10 years of historic generation to an “engineers study” over 25 years earlier (~25%)
3. Replacement turbine – without knowing efficiency & flows of existing turbine (~20%)
4. Assuming HW & TW constant (~10-15%)
5. Short period of hydrologic record (~20%)
BASICS OF ENERGY MODELING

– Sufficient period of hydrological record
  • (greater than 30 yrs.)

– Hydropower equation
  • Power (kW) = Flow (cfs) \times Head (Ft) \times Eff (%) / 11.81

– Model existing plant conditions
  • Existing: flows, head & equipment efficiencies
  • Tip: focus on parameters that will change

– Calibrate model using historic generation
  • Typically generation record is shorter than hydrologic
BASICS OF ENERGY MODELING (2)

– Model Long-Term generation of existing plant
  • Baseline conditions

– Model L.T. generation for changed plant
  • Change in head, flows or efficiency due to:
    – Intake improvements, new trashracks, rake, etc.
    – New or refurbished equipment
    – Operations & Control systems
    – New license conditions

– Compare changed conditions to baseline
Sample Problem

• 220 kW hydro plant, built by utility in 1978
  – Single, ‘fixed blade’ unit, 30-ft gross head
• 1980’s sold to an IPP
  – Did minimal maintenance, License expires in 2018
• You buy the project in 2013
  – Submitted license application in 2016
  – Plan to install new Kaplan unit
  – Apply to Mass CEC for a grant
  – Need good estimate of increase in generation
SAMPLE PROBLEM

Model 3 Scenarios

1. Original plant

2. Calibrate to existing plant

3. Changed Case
SAMPLE PROBLEM

1. Assemble hydrologic record
   – USGS gage: (73.5 mi², record 1932 – present)
   – Adjust flows to dam, (96 mi²)
   – Create fields for Year, Month & Day
   – Only use complete years of data

2. If conduit project
   – Use historic conduit flow data

• See: Hydrology spreadsheet
SAMPLE PROBLEM

2. Build a model for existing conditions
   • Flows
     – River flows, license conditions & turbine flows
   • Head
     – HW, TW, headlosses (for entire hydraulic conveyance system), license conditions
   • Efficiencies
     – Turbine, speed increaser, generator, transformer

   • See Model: 1 Un-calibrated original plant
SAMPLE PROBLEM

3. Calibrate model to historic generation
   • Compare model results to historic
   • Often record of historic gen less hydrologic
     – I like at least 10 historic data points
       • Approximate range of hydrologic flows
   • Only have 1 or 2 years of historic gen data
     – Consider calibrating to monthly totals
   • Summary sheet, col’s. D-F
3. Calibration cont’d.

- Recall: modeled plant “As-New”
- Review of plant logs 2006-2015
  - Output (kW) decreased by >10%
  - Outages increased ~ 5%
- See Model: 2 Calibrated existing plant
  - TrbnPerf, Energy & Summary sheets
SAMPLE PROBLEM

4. Model existing plant over hydrologic period
   • Establishes Long-Term baseline generation

   • Per Model: 2 Calibrated existing plant
     – L.T. average annual generation
       • 1932 -2015 (84-yrs): 834 MWH (Baseline)
       • 2006 – 2015 (10-yrs): 1077 MWH (Calibration per.)
     – Illustrates danger of too short a period of record
5. Revise Model to reflect changed conditions

- See Model: 3 *Upgraded Plant*
  - Efficiency & flows of new Kaplan
  - Revise generator efficiency
  - Revise forced outage factor
SAMPLE PROBLEM

6. Revise Model for new license conditions
   • Seasonally adjusted min flows

   • See Models:
     – 2a Existing plant New License
     – 3a Upgraded plant New License
Wrap-Up

Elements of a sound energy study

1. Assemble Long-Term hydrologic data
2. Build an energy model for existing conditions
3. Calibrate the model to historic generation
4. Establish Long-Term baseline generation
5. Model changed conditions for Long-Term period
Q&A