MASS CEC WORKSHOP

ENERGY MODELING

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THE ESSEX PARTNERSHIP

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%)

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Basics of Energy Modeling

- Sufficient period of hydrological record
  - (greater than 30 yrs.)
- Hydropower equation
  - Power (kW) = Flow (cfs) X Head (Ft) X 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

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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

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Model 3 Scenarios

1. Original plant

2. Calibrate to existing plant

3. Changed Case

SAMPLE PROBLEM

1. Assemble hydrologic record
   - USGS gage: *(73.5 mi^2, record 1932 – present)*
   - Adjust flows to dam, *(96 mi^2)*
   - 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*

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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*

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Sample Problem

5. Revise Model to reflect changed conditions
   - See Model: *3 Upgraded Plant*
     - Efficiency & flows of new Kaplan
     - Revise generator efficiency
     - Revise forced outage factor

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

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Q&A