

Improving Hydropower Generation Efficiency with the Hydroplant Performance Calculator (HPC)

Paul J. Wolff, WolffWare Ltd., Norris, Tennessee
Patrick March, Hydro Performance Processes Inc., Doylestown, Pennsylvania



1

Overview of Presentation

- Components of Hydroplant Efficiency
 - Data Requirements
 - Accurate Unit Characteristics
 - Unit Dispatch Optimization (Operational Efficiency) – Meeting the plant load with the appropriate number of units at power levels that provide the plant load using the least amount of water.
 - Scheduling Optimization (Scheduling Efficiency) – Generation at plant power levels that are aligned with peak efficiency points of the plant efficiency curve
 - Efficiency improvements of 1 to 2 % are commonly available, sometimes higher.
- Hydroplant Performance Calculator (HPC)
- Automated Efficiency Analyses

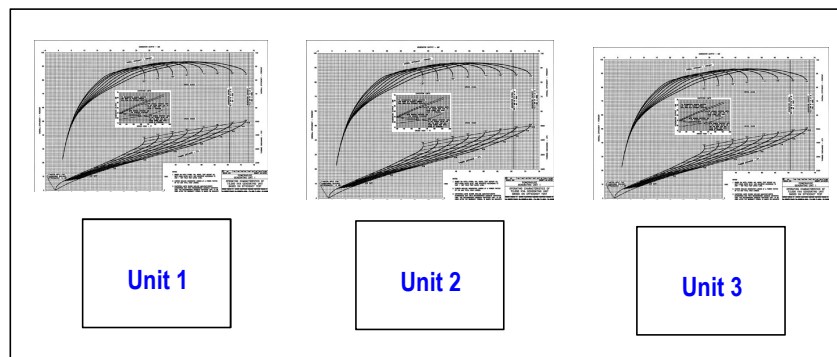
2

Data Requirements

- Sampling Frequency – Consistent with how often unit loads are changed. With tributary plants, hourly data may be adequate. For a run of river plant, higher density data is usually required.
- Unit Dispatch and Scheduling Optimization Data Requirements
 - Plant headwater and tailwater elevations
 - Unit loads
- Unit Characteristics
 - Relative or absolute online flow measurement is required for continuous evaluation of unit efficiency
- Most plants have necessary data to compute the unit dispatch and scheduling optimization analyses

3

Unit Characteristics (Unit Flow versus Unit Power and Head)



Three Unit Hydroplant

4

Unit Characteristics

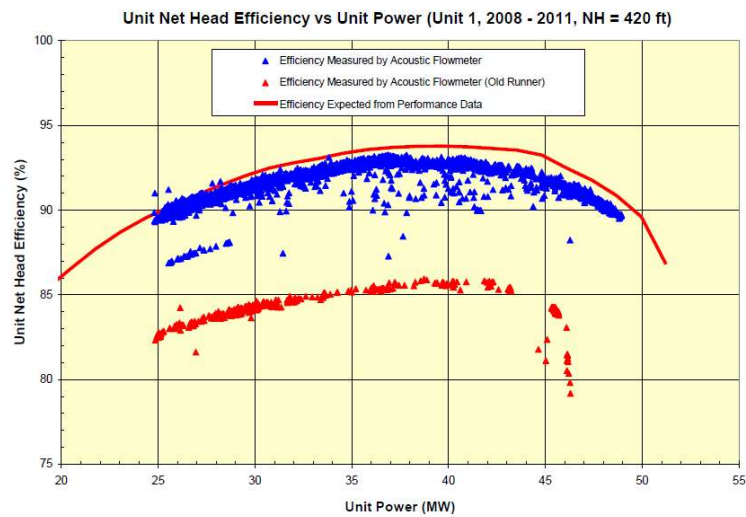
	A	B	C	D	E	F
1	Turbine Flow vs Head and Turbine Power					
2	Head (m)	Power (MW)	Flow (cms)			

- Manufacturer's Curves
 - Based on units of similar design.
 - Model Tests
- Testing
 - Index Tests – Winter-Kennedy Flow
 - Absolute Performance Tests – Current Meters, Pressure-Time, Acoustic Flow Meters
- On-Line Measurement
 - Continuous flow measurement with the Winter-Kennedy pressure differential or with acoustic flow meters can be used to continuously measure unit efficiency.

30		35.3669088	76.61262			
31		38.4331133	82.41076			
32		41.2982551	87.72099			
33		44.3946189	93.50495			
34		46.5258823	98.45777			
35		48.5164019	103.039			
36		50.3159121	107.5266			
37		51.9545722	111.8724			
38		53.4725947	116.3316			
39		54.8769114	120.8009			
40	Turbine Flow vs Head and Power / Generator Efficiency					

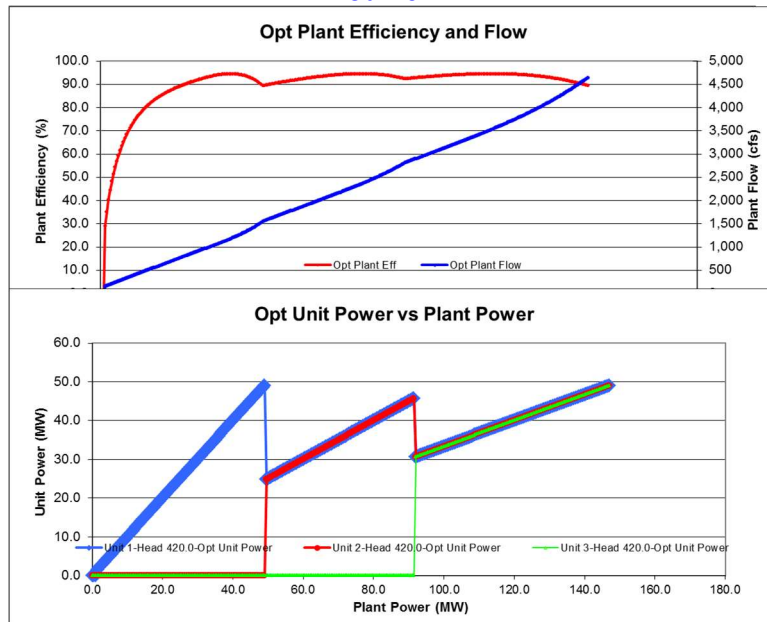
5

Unit Characteristics Tracked with On-Line Data



6

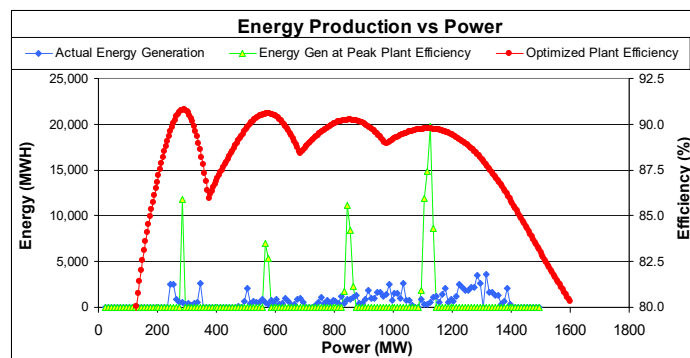
Unit Dispatch Optimization – Optimized Plant Performance Curve



7

Optimized Plant Scheduling

- Optimized plant scheduling changes plant load to align with peak plant efficiency points
- Optimized scheduling often produces a 2-3 percent improvement in plant efficiency



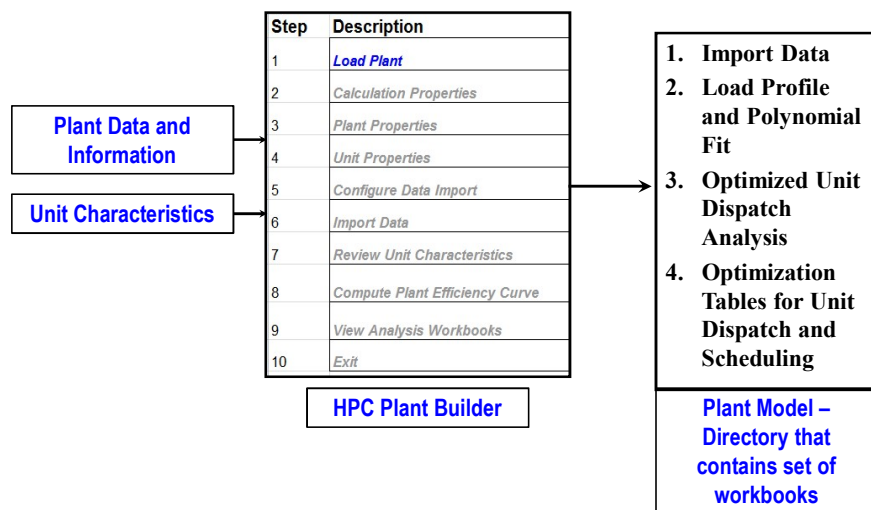
8

Overview of HPC

- HPC automates data analyses for hydro plants
 - Operational Efficiency Analysis – Unit dispatch optimization analysis
 - Scheduling Efficiency Analysis – Optimizes the plant load scheduling
 - Flow Analysis – Computes unit and plant flow from unit data
- HPC consists of two Excel-Based programs to create plant models and to automate analyses using the plant models.
 - HPC Plant Builder
 - HPC Analyzer
- Automates Analyses
 - Archival Analyses – Review plant operation to identify possible performance improvements
 - Unit Upgrade Analyses – Streamlining analyses for quantifying benefits of turbine or generator upgrades.
 - Fleetwide Analyses – Can compute analyses for an entire hydro system
- Performance Metrics
 - Quantifies possible improvements in performance metrics that can be aggregated from plant to region or system performance.

9

Overview of HPC – Plant Builder



10

Overview of HPC – Analyzer

Plant Model

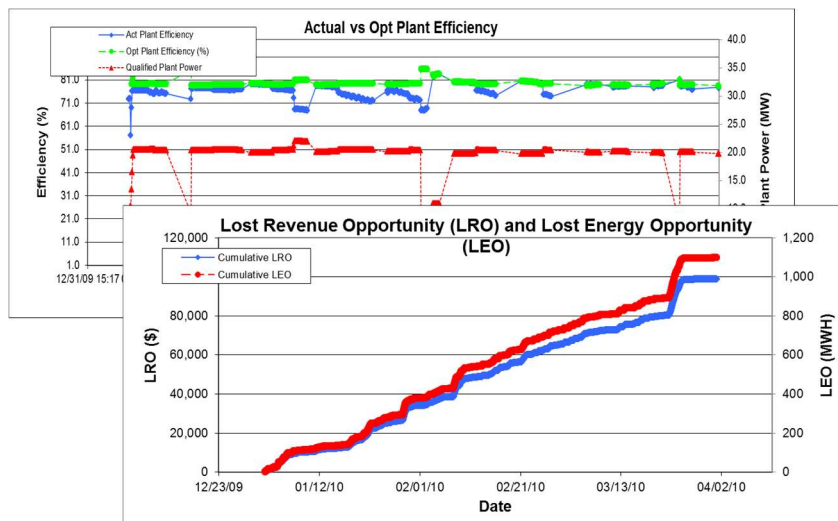
Plant Data

	A	B	C	D
1	Compute This Analysis Set	Compute All Analysis Sets		
2				
3				
4	Analysis Name	Analysis Root Directory	Case Files	Data Files
5	RPB 2014	C:\My Documents\	C:\My Documents\RPB Plant Model.xls	C:\My Documents\RPB 2014 Data.xls
6	RPB 2015	C:\My Documents\	C:\My Documents\RPB Plant Model.xls	C:\My Documents\RPB 2015 Data.xls
7	VRK 2014	C:\My Documents\	C:\My Documents\VRK Plant Model.xls	C:\My Documents\VRK 2014 Data.xls
8	VRK 2015	C:\My Documents\	C:\My Documents\VRK Plant Model.xls	C:\My Documents\VRK 2015 Data.xls

- **Analysis Results in Excel Workbooks**
 - Operational Efficiency Analysis – Unit Dispatch Optimization
 - Scheduling Efficiency Analysis

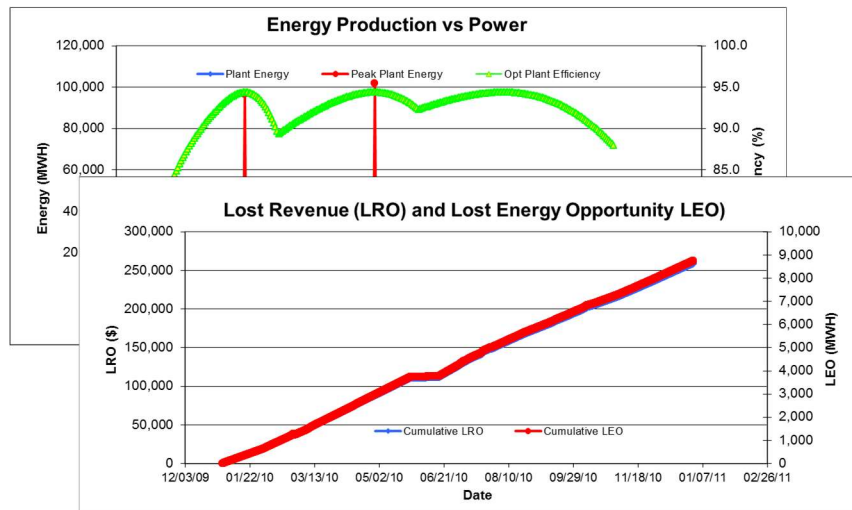
11

HPC Analyses – Operational Efficiency Results



12

Scheduling Efficiency Results



13

Key Points

- Most plants have sufficient data to compute operational and scheduling efficiencies for multiple years of operation.
- HPC automates these analyses and is available through ORNL.
- Cost effective method for improving plant and system efficiency.

14

Thank you for your attention.

Paul Wolff, WolffWare Ltd., pjwolff@wolffwareltd.com

Patrick March, Hydro Performance Processes Inc., pamarch@hydroppi.com

