2025 CU Boulder Hydropower Collegiate Competition Team

Conceptual Design and Testing

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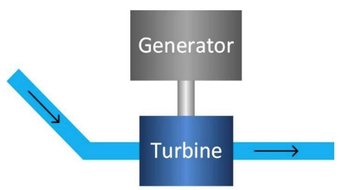
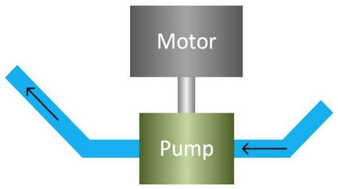
U.S. DEPARTMENT OF ENERGY

Motivation and Background





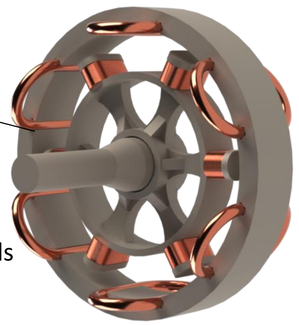
Generation	
Duration	8 Hours
Average Flowrate	2.8 m/s
Number of Turbines	4
Best Efficiency Point	91%
Energy Produced	3.84 GWh

Pumping	
Duration	16 Hours
Average Flowrate	1.4 m/s
Number of Pumps	4
Maximum Efficiency	93%
Volume Pumped	4.4 Billion Liters

Critical Powerhouse Components

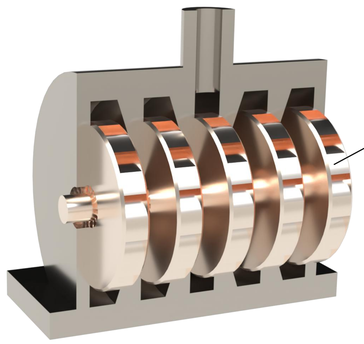
Pelton Turbine

- 4.32-meter diameter
- Produces 119 MW
- Selected based on power specific speed
- Controlled by Oil Pressure Governor
- Must operate above maximum water line



Salient Pole Synchronous Generator

- 6 poles, 1,200 RPM
- Rated for 146 MVA
- Stator generates 3 phase voltage
- Rated to handle turbine runaway speeds



Multi-stage Centrifugal Pump

- Diffuser Guide Vanes
- Shrouded impellers
- 3 stages, double suction
- Operates 10 feet below minimum water line

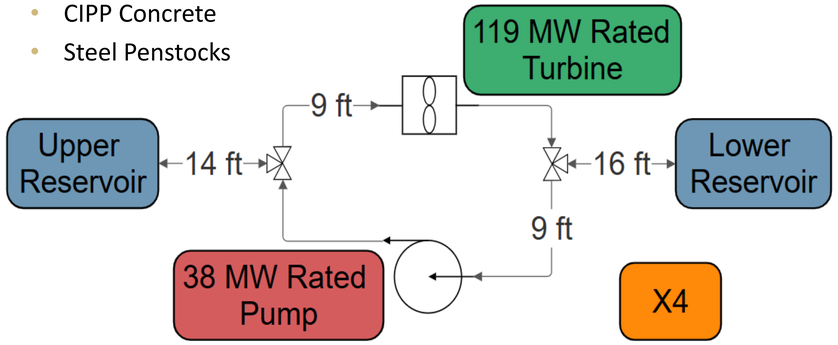
Piping Design

Major & Minor Losses

- Reduction in valve count
- Favored lower roughness in pipe
  - CIPP Concrete
  - Steel Penstocks

Service & Security

- Controls water movement can be stopped anywhere



Building and Testing

Testing Goals

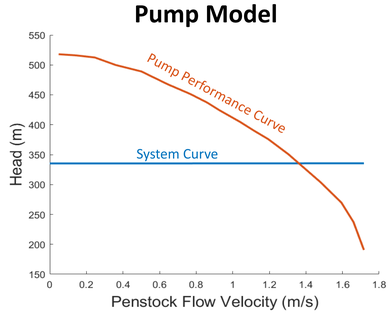
- Analysis of local factors
  - Scaling and corrosion
- Validation of theoretical model
- Repeated testing of physical full-scale model
- Application to overall theoretical design from testing results

Site Water Analysis

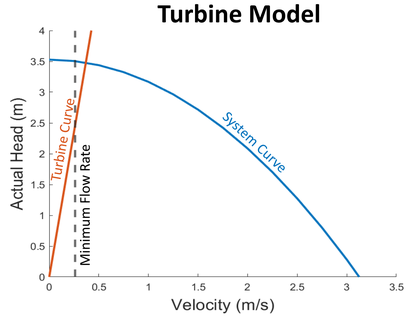
Test	Value	Unit
pH	8.03	
Turbidity	1.83	NTU
Conductivity	749.8	uS/cm
Ammonia	0.000	mg/L NH3
Nitrate	0.245	mg/L NO3-
Nitrite	0.000	mg/L NO2-
Alkalinity	187	mg/L CaCO3
TOC	2.53	ppm
DIC	44.2	ppm

Final Design, Testing Method, and Models

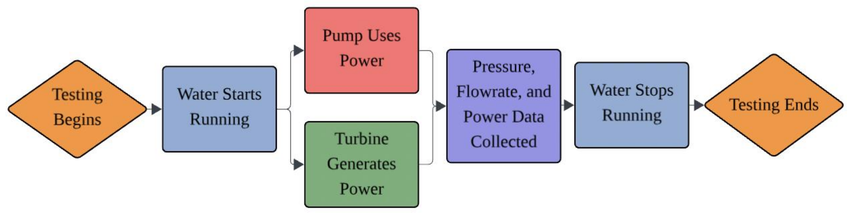
Pump Model



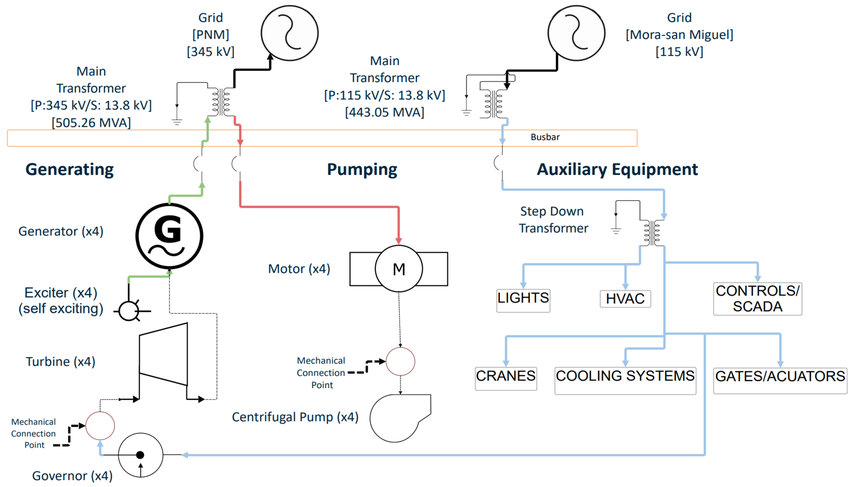
Turbine Model



Testing Process Diagram

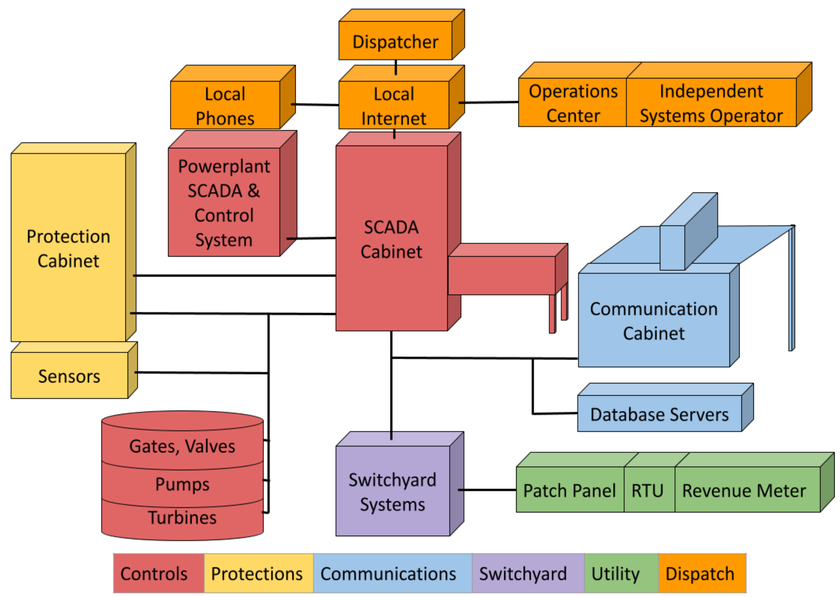


Electrical Design



Main Component Loads and Voltages	
Generator	131 MW/13.8 kV
Motor	91.5 MW/13.8 kV
Facility Auxiliary	10.8 kW/120 V
Equipment Auxiliary	410 kW/480 V

Cybersecurity and Controls



Key Considerations

- Facility availability and communication integrity prioritized
- Redundancies in digital systems and defenses provide security
- Sensors and logging alert operators of unexpected activity

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