The Avista Decision Support System

Better Operations and Planning Using Avista's New Optimization/Simulation Technology – A Presentation Focused On Hydropower Capability

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Today's Topics

- Introduction to Avista
- What is the Avista Decision Support System (ADSS)
- ADSS Implementations (where has it been used)
- Case Studies (how has it been used)
- What's Next

Introduction to Avista

135 Year Company History

- 1889: Washington Water Power
- **1890: Hydroelectric**
- 1958: Natural gas
- 1983: Biomass
- 1999: Became Avista Corporation
- 2009: Smart Grid Demonstration Project
- 2012: Wind
- **2014: ADSS in Production**
- 2015: Solar and Vanadium Flow Battery
- 2019: Smart Meters

Resource Mix

- **48% hydroelectric**
- 33% natural gas
- 8% coal
- 9% wind
- 2% biomass

The Numbers

- Revenue: $1.75 billion
- Net Income: $171 million
- Employees: 1,858
- Electric Customers: 413,669
- Natural Gas Customers: 389,456
- States Served: Idaho, Oregon, Washington
- Population Served: 1,700,000
- Electric Transmission: 2,800 miles
- Electric Distribution: 19,700 miles
- Natural Gas Distribution: 8,200 miles
- Hydroelectric Facilities: Eight (8) @ 1,025 MW
- Thermal Facilities: Seven (7) Plants @ 1,858 MW

 (Source: *2024 Quick Facts*)

About the Avista Decision Support System (ADSS)
Extensible to Any Power System Portfolio Worldwide

Recognizing large gaps in commercial co-optimized power system operations software, in 2012 Avista began developing its “Avista Decision Support System” or “ADSS”

Using Mixed-Integer Programming, ADSS software creates a co-optimized power system **digital twin** representing loads, generation, transmission, storage, transportation (fuels and electricity) and markets (electricity, fuel, ancillary services, emissions)

ADSS’ power system **digital twin** for portfolio-wide simulation and optimization can be used to support trading (including ISO/RTO bidding), risk management, valuation, retrospective look-backs, training, and various planning efforts (long-term operations, maintenance, integrated resource planning)

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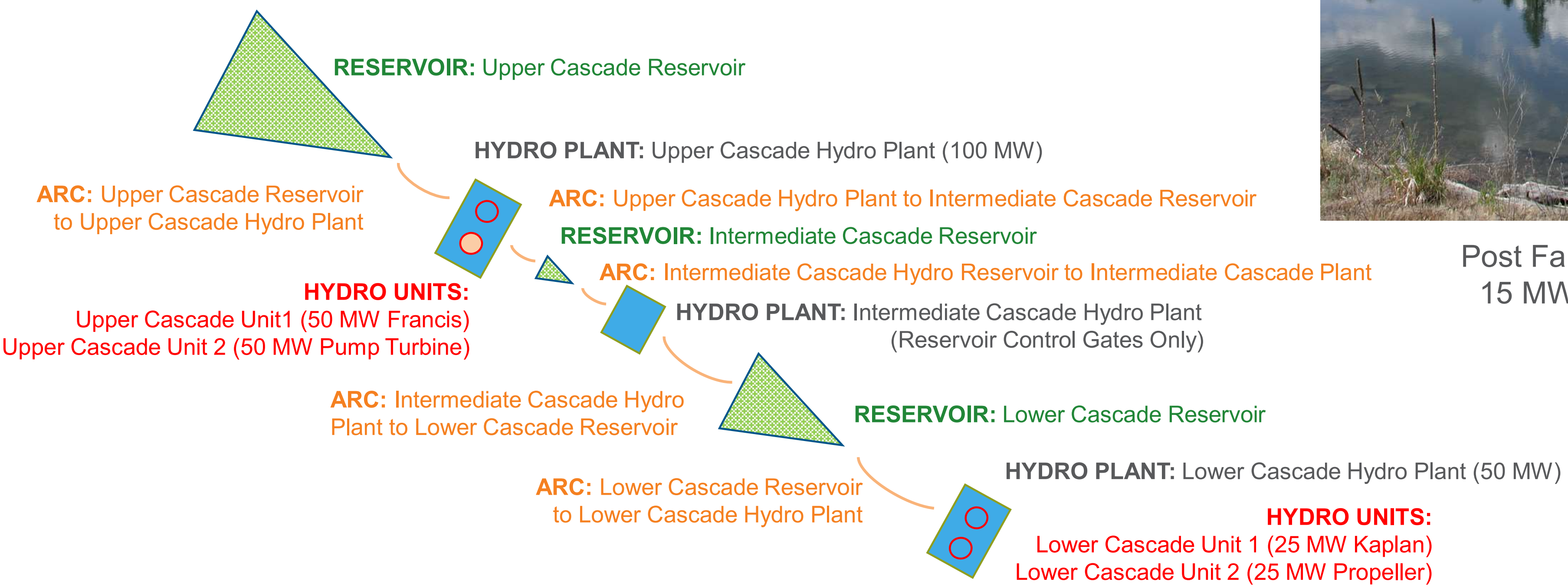
ADSS – Hydro Modeling Strengths
Sample of Capabilities

- “Engineering level” representations
- Object-oriented structure
  - upstream “Project A” modifications do not require revisiting downstream “Project B”
- Cascading hydro
  - time-lagged flow
  - reservoirs
  - encroachment
- Pumped hydro
- Full power curve modeling
- Flow limitations
  - ramping rates
  - minimums/maximums
  - in-stream flow limits
  - dissolved gas, temperatures
- Plant head
  - impacts of flow on head (“live” tailrace)
  - in-plant head losses
  - impacts of head on efficiency curves

- Co-optimization of entire system
  - energy and ancillary services
  - loads, markets and transmission
  - units level representation
  - commitment and dispatch
  - rivers and reservoirs
- Operating considerations
  - min/max up/down times
  - must run
  - dispatch and merit order
  - motoring/condensing
  - AGC control
  - start-up/shut-down costs
  - min/max turbine/generator limits
  - rough zones, thermal limits
  - flash boards, Obermeyer gates
  - equal wear cycling
  - unit steady states
  - elevation targets
  - water right limits

Coyote Springs 2
combined-cycle gas
320 MW

ADSS Demonstration Portfolio
Upper and Lower Cascade Hydro (150 MW)



Post Falls
15 MW

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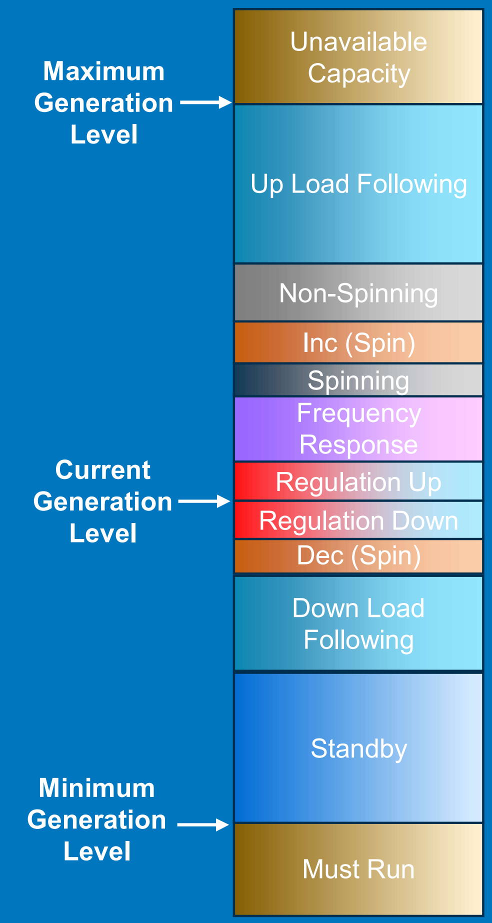
ADSS Ancillary and Reserve Services
Fully customizable products

- Fast Frequency Response (<1 second)
- Frequency Response (<1 minute)
- Regulation (<1 minute)
- Spinning (<10 minute)
- Non-Spinning (<10 minute)
- Inc (<10 minute)
- Dec (<10 minute)
- Load Following/Flex (10-60 minute)
- Standby (thru next trading day, with energy)



.ADSS can model most any ancillary service and it associated attributes (e.g., response time requirement)

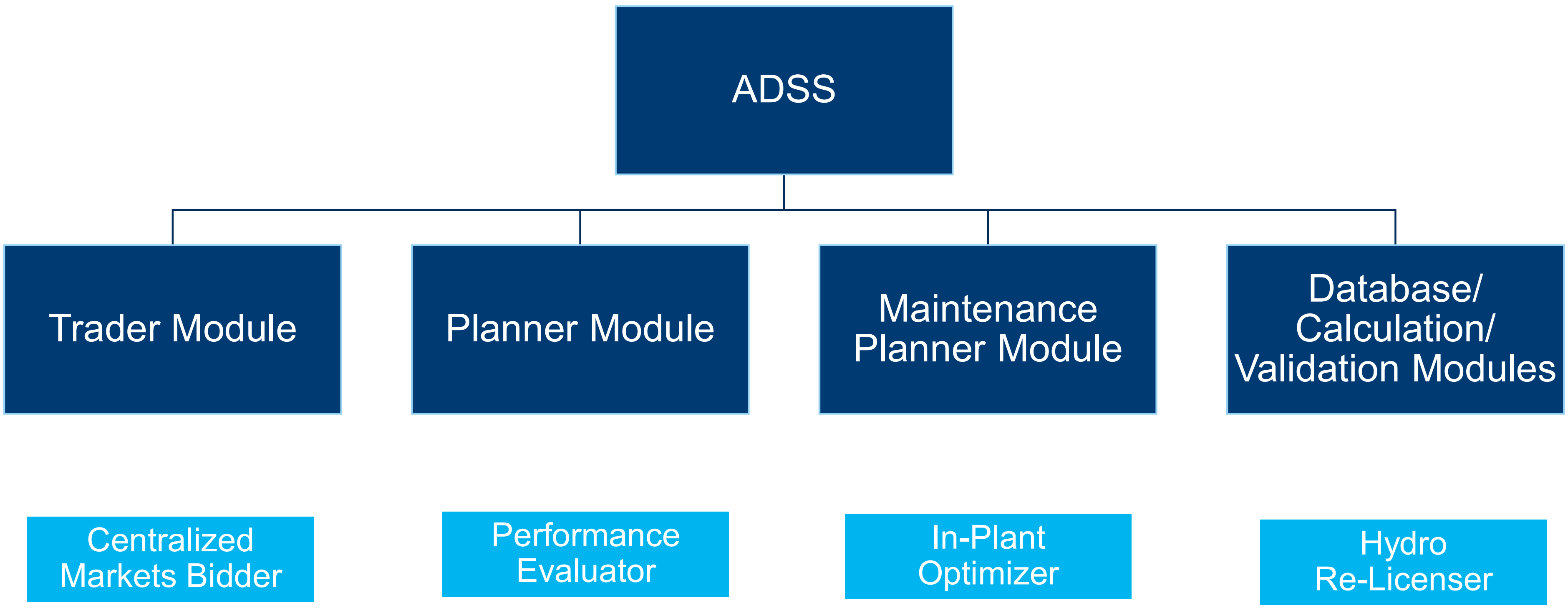
The Avista Decision Support System (ADSS)

Decision Flow

Optimizes	Including	Constrained by	Used by	Integrated With
Power supply decisions	Hydropower	Operational limits	Planners	Forecasts (load, VER, prices, inflows, markets, transport, etc.)
2 forms of math models	Thermal power	Regulations	Traders	15+ internal and external data sources/ consumers
About 30 integrated sub-models	Wind and solar power	User desires	Operators	
	Batteries		Internal IT systems	
	Etc.			

The Avista Decision Support System (ADSS)

Key Solutions



The Avista Decision Support System (ADSS)

Two powerful solutions

Arc-Node Model

Inputs

- Plants
- Reservoirs
- Loads
- Markets / prices
- Inflows
- Transmission
- Pipelines
- Operational limits
- Rules to follow

Outputs

- Unit generation levels
- Unit ancillary service levels
- Transmission use
- Pipeline use
- Fuel use
- Reservoir levels
- Outflows
- Buy and sell
- System cost

Outage Model

Inputs

- Events
- Resources needed
- Rules to follow

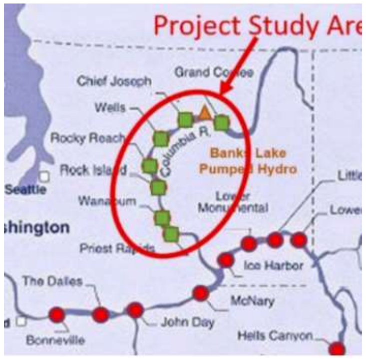
Outputs

- Outage schedule
- Resources used
- Costs

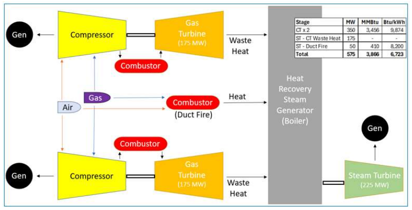
ADSS Implementations
Avista continues to demonstrate success across industry

- Grand Coulee In-Plant Optimization (2013 pre-production version)
- Avista System (2014-present)
- Tacoma Power (2015)
- Swan Lake Pumped Hydro Valuation (2018)
- Seattle City Light (2020-21)
- Middle-Columbia PUD Coordination Study (2022)
- ADSS Demo Portfolio (2025)
- U.S. DOE-Funded Coordination Study (2026-28, forthcoming)
  - Middle-Columbia cascading hydro project coordination—Grand Coulee to Priest Rapids
  - 1/3 of Northwest U.S. states' hydro capacity (~11,000 MW)
  - Broad participant list: Avista Utilities, US Bureau of Reclamation, US Army Corp of Engineers, Bonneville Power Administration, Douglas, Chelan, and Grant PUDs, Columbia Basin Irrigators' Banks Lake Pumped Hydro, Pacific NW National Labs, Washington State Univ., Lloyd Reed Consulting, Abremod Consulting

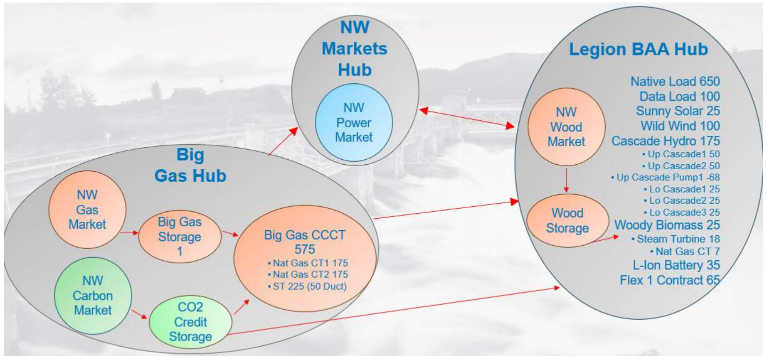
Mid-C Study Area



2x1 Gas CCCT

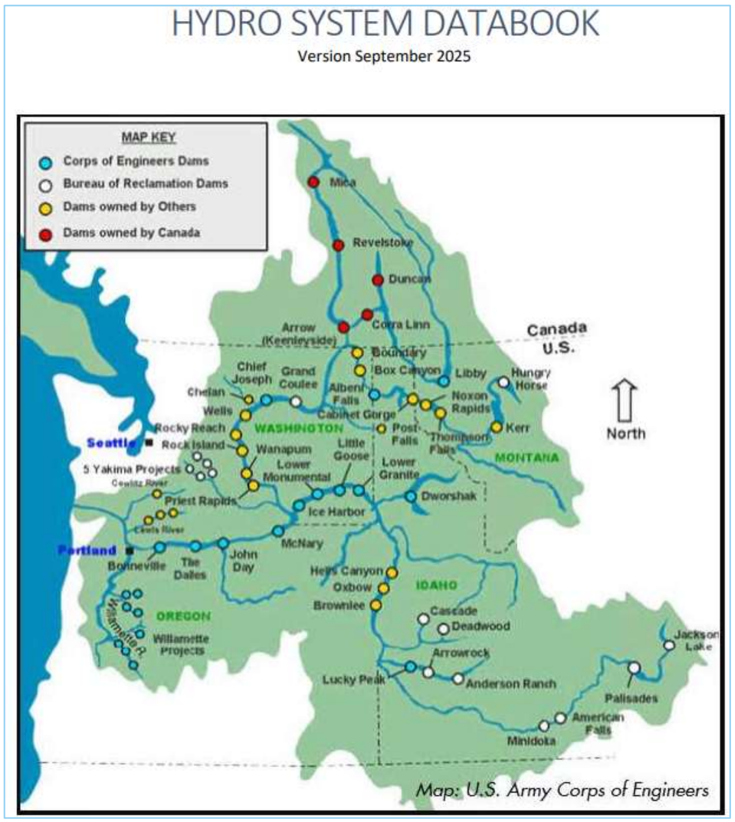


ADSS-Demo Instance

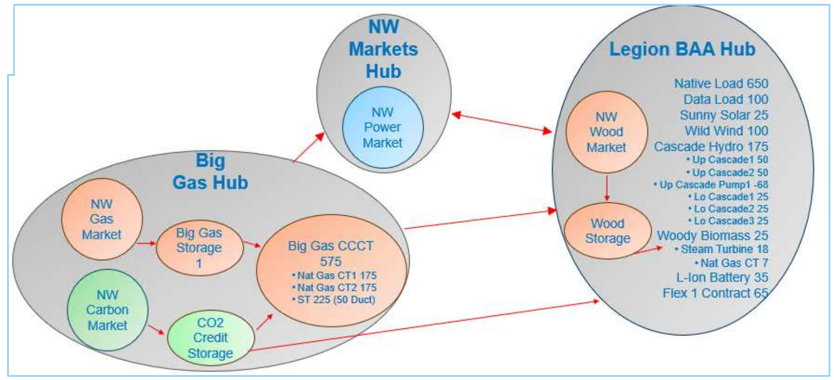


ADSS Instance Examples

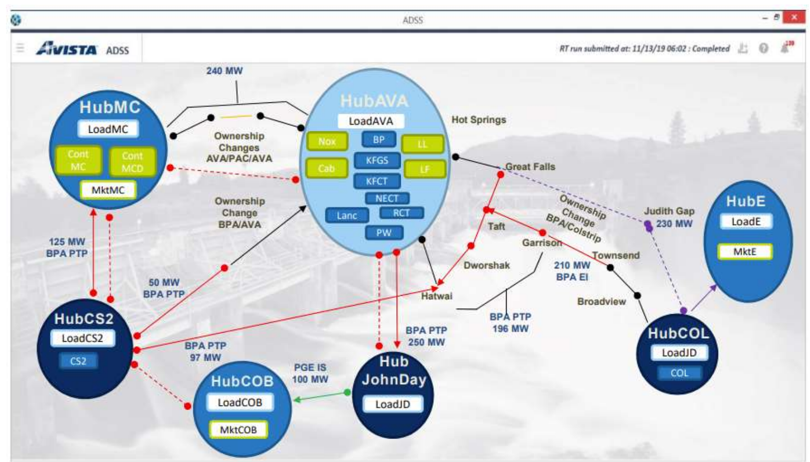
ADSS-Northwest



ADSS-Demonstration



ADSS-Avista



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ADSS Case Studies

1. Ancillary Services
2. Emergency Maintenance: Kaplan Failure
3. Emergency Maintenance: Trash Rack
4. Generation Upgrades
5. Hydro Relicensing
6. New Resource: Lithium Ion Battery
7. New Resource: Pumped Hydro Addition
8. In-Plant Optimization

Palouse Wind, 105 MW

Avista Boulder Park Reciprocating Engines, 25 MW

Case Study 1 – Ancillary Services

Utility generation assets are options providing various capacity services. Energy is the most prevalent and best understood. Other services, including regulation, load following, and operating reserves are more difficult to quantify. Even in organized markets, where price discovery is available both for energy and ancillary services, determining the incremental costs of providing ancillary services is difficult, if not impossible.

- Problem: evaluate increased regulation service request from wind owner
- Expectation: higher purchase volume lowers per-kW price
- ADSS Analysis: value portfolio under varying market & hydro conditions
- Learning: higher sales volume increased per-kW cost
- Outcome: no sale

Case Study 2 – Emergency Maintenance

Managing forced outages and unexpected maintenance needs continually challenge utility operators and traders. Either event can impact system reliability and economics. Though utility staff are near powerless to prevent forced outages and unexpected maintenance events, responses can be managed better. Correct decisions can reduce costs by tens of thousands, even millions of dollars.

- Problem: Cabinet 1 Kaplan blades stopped actuating
- Initial Decision: operate without actuation until next budget year
- ADSS Analysis: value Kaplan with and without actuation
- Learning: $1.2 million savings was 4x value of $0.3 million maintenance cost
- Outcome: initial decision reversed & repair completed in current budget year

Case Study 3 – Emergency Maintenance

Plant operators called utility schedulers at week's end, requesting a reservoir drawdown over the weekend to enable debris removal from intake trash racks on Monday morning when maintenance crews would be available without incurring more-expensive overtime hours. Scheduling staff knew that a weekend drafting exercise would generate unneeded electricity that would be sold at low prices in the wholesale marketplace and require its replacement to be made during higher-priced weekday periods.

- Problem: Valuing cost of overtime versus lost power value
- Initial Decision: draft reservoir over weekend to remove debris on Monday
- ADSS Analysis: value drawdown over weekend days vs. weekdays
- Learning: weekend drawdown reduced power sales value by $50,000
- Outcome: initial decision reversed–debris removed using weekend overtime

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Case Study 4 –Generation Upgrades

Investment decisions can remain with a firm for decades. One example is upgrading an existing generation asset. The choice can position an organization for many years of success, or a similar period of frustration. Early risks in the upgrade lifecycle are cost approvals by regulatory agencies. Longer-term risks include operational performance, and the fit of the asset within the larger generation portfolio.

- Problem: find a Post Falls configuration beating economics of “run to failure”
- Initial Decision: lack of feasible rebuild configuration prevented project
- ADSS Analysis: given turbine design limits, design powerhouse better than running to failure
- Learning: a mix of viable turbines could offer a better solution
- Outcome: Post Falls is being rebuilt

Case Study 5 – Hydro Relicensing

Hydro generation projects present many challenges to entities attempting a license renewal. Societal preferences change over the many-decade original license, and new project requirements can cost the owner tens or hundreds of millions of dollars in upfront capital investment, annual expenses, and operational changes. ADSS can be used to quantify the impacts of various in-plant and operational changes, potentially reducing annual and license-life costs by many millions of dollars. Beyond financial savings, ADSS is able to illustrate to interested parties the impacts of various desired changes, including identifying competing interests that cannot be met simultaneously.

- Problem: Interest group wanted sustained higher summertime water releases
- Concern: inability to easily demonstrate physical limitations and poor economics
- ADSS Analysis: run entire 80-year water record to demonstrate reservoir performance given other competing obligations
- Learning: higher flows could not be sustained while holding summer pool
- Outcome: interest group dropped request and operator saved millions annually

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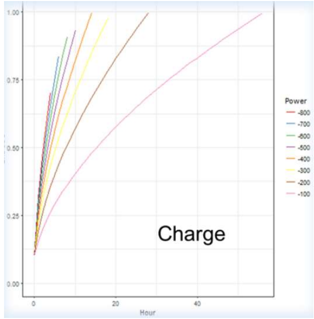
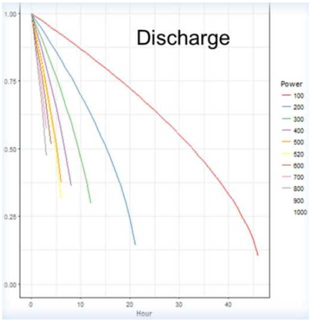
Case Study 6 – New Li-Ion Battery

ADSS is capable of representing very detailed and complex resource configurations, limited only by the data available to the modeler. For batteries the tool can represent different battery charge and discharge curves, using our optimization algorithms to distinguishing the best draw-down and refill profile given the conditions-specific needs of the power system. The valuation studies only the energy arbitrage value of moving power from low- to high-value periods, it also helps illustrate the potential for ancillary and reserve services.

- Problem: Identify values beyond energy arbitrage to support battery economics
- Initial Problem: energy arbitrage would not support batteries
- ADSS Analysis: operate a hypothetical battery within Avista's portfolio
- Learning: Non-energy values increased value by ~ 50%
- Outcome: Total value (energy, other services) still below battery costs





Battery Capacity (MW)	Annual Value	Value $/kw-year
35	$1,201,590	$ 34.33
30	$1,024,569	$ 34.15
25	$ 923,291	$ 36.93
10	$ 381,407	$ 38.14
5	$ 189,000	$ 37.80
1	$ 36,862	$ 36.86

Value Stream	Incremental Value	Value Contribution
Energy Arbitrage	$ 629,082	64.2%
Load Following	$ 276,032	28.2%
Operating Reserves	$ 49,824	5.1%
Regulation(AGC)	$ 24,320	2.5%

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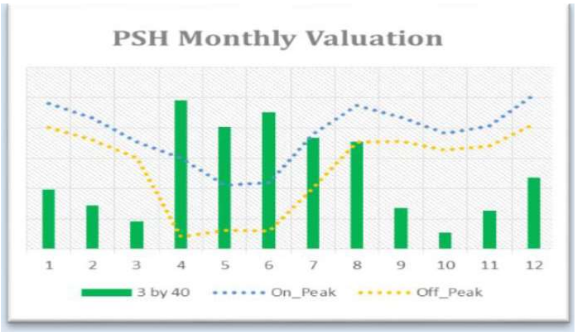
Case Study 7 – New Pumped Hydro

Working with a leading pumped hydro storage developer, Avista used its Avista Decision Support System (ADSS) to conduct a comprehensive valuation for their project. Working to closely translate the many facets of the three-unit, 1,200 megawatt project into ADSS, including pump turbine units, generators, transformers and reservoirs, was an essential aspect of the work.

- Problem: Identify values beyond energy arbitrage for Swan Lake pumped hydro project
- Initial Problem: energy arbitrage would not support pumped hydro development
- ADSS Analysis: integrated Swan Lake Pump Hydro Project in Avista’s portfolio
- Learning 1: Non-energy values increased value by up to 100%
- Learning 2: For hydro utilities extra cost of equipment for fast reserves was not justified
- Outcome: Total value (energy, other services) still below costs



Case Study 8 – In-Plant Optimization

Working with the United States Bureau of Reclamation, Avista used its Avista Decision Support System (ADSS) to measure the its potential to increase the economic efficiency of the 6,800 MW Grand Coulee Dam.

- Problem: Existing solution wasn't responsive to system changes
- Challenge of Study: Model 24 hydro units at real-time (~2 second) SCADA speeds
- ADSS Analysis: Using 2 years of 2-second data on BPA energy and capacity requests, project inflows, unit availability, and operating limits, define incremental value associated with adopting ADSS optimization
- Learning 1: ADSS could optimize complex plant operations at intra-minute granularity
- Learning 2: Potential for >2% gain ($25 million annually)
- Outcome: Funding issues prevented next steps

What's Next for ADSS Software

- More Functionality/Features
  - Greater detail in accounting for carbon and similar regulations
  - Enhancing maintenance planning capabilities
  - Adding Monte Carlo simulation features
  - Develop mathematically-simplified module emulating Aurora/Plexos use cases (sacrifice accuracy for speed)

- Making ADSS available for other utilities and entities
  - Get the word out
  - Offer zero-cost access to Demo Portfolio Instance of ADSS
  - Define a technology market offering
    - establish low-cost solution through a cooperative of users?
    - partner with established software vendor?

Avista Upper Falls/Monroe Street, 26 MW

Q&A

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Clint Kalich ADSS-Focused Biography

Born and raised in the electric utility business, Clint Kalich began his career with a multi-disciplinary utility consulting firm in 1991. He worked for Tacoma Power from 1995 to 2000 in resource development, procurement, and optimization, hydroelectric operations and re-licensing, contract negotiations, and system operations. At Tacoma Clint led development of, and ultimately managed, its industrial market access program serving one-quarter of retail load. In 2000 he joined Avista Utilities, assisting in resource analyses, dispatch modeling, resource procurement, integrated resource planning, and expert witness testimony in various regulatory proceedings before the Idaho and Washington State public utilities commissions. In recent years Clint has led many aspects of Avista's integration into the CAISO EIM and EDAM markets, and the company's response to new environmental laws in Oregon and Washington State (e.g., CPP, CEIP, CCA) affecting its electric and natural gas business lines. The Avista Decision Support System (ADSS) is the culmination of Clint's broad power supply experience; he has led its development since 2012.

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