April 5, 2016

MEMORANDUM

TO: **Council members**

FROM: **Brian Dekiep Montana Staff**

SUBJECT: **Gordon Butte Pump Hydro**

Presenter: **Carl Borgquist, President Absaroka Energy**

Background:

Montana-based Absaroka Energy, LLC is developing the Gordon Butte Pumped Storage Hydro Project. The project will be located on private land in Meagher County, Montana, three miles west of the small town of Martinsdale in central Montana. The project is designed to take advantage of the unique geological features of Gordon Butte to create a new closed-loop pumped storage hydro facility. This facility will provide ancillary and balancing capabilities, as well as, provide multiple services to facilitate stability, reliability, growth and longevity to existing energy infrastructure and resources in the state and region.

The Gordon Butte Hydro Pumped Storage Facility will consist of upper and lower closed-loop reservoirs connected by an underground concrete and steel-lined hydraulic shaft. The pumped storage hydro project will be an off-stream facility, constructed out of any existing watersheds thereby minimizing impacts to the local watersheds and riparian ecosystems. Each reservoir will be approximately 4,000 feet long and 1,000 feet wide with depths of 50 to 75 feet. As currently designed, an underground powerhouse with four

turbine-generators would be located at the bottom reservoir. These generators would provide an installed capacity of 400 megawatts, allowing for an estimated annual energy generation of 1,300 gigawatt hours. The project would be built in proximity to the 500 kv Colstrip Transmission lines.

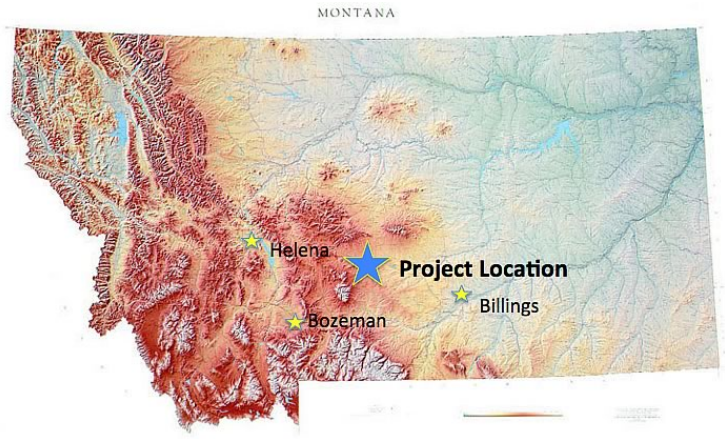
GB Energy Park has received a preliminary permit from the Federal Energy Regulatory Commission to begin a multi-year licensing process. GB Energy Park is currently in consultations with state and federal agencies, local landowners, environmental groups, and other interested stakeholders to identify, study and mitigate important issues related to the construction of this project.

Highlights:

Gordon Butte Briefing Document: http://gordonbuttepumpedstorage.com/wp-content/uploads/2014/12/Gordon-Butte-Briefing-Document-final-12102014-.pdf

http://gordonbuttepumpedstorage.com/

- FERC P-13642
- Estimated Average Annual Energy: 1300 GWh
- Estimated Installed Capacity: 400 MW
- Number of Proposed Turbine Generators: 4
- Reservoirs sized at approximately 4,000 acre-feet
- Head (Height between Reservoirs) 1,025 feet



CARL BORGQUIST BIO:

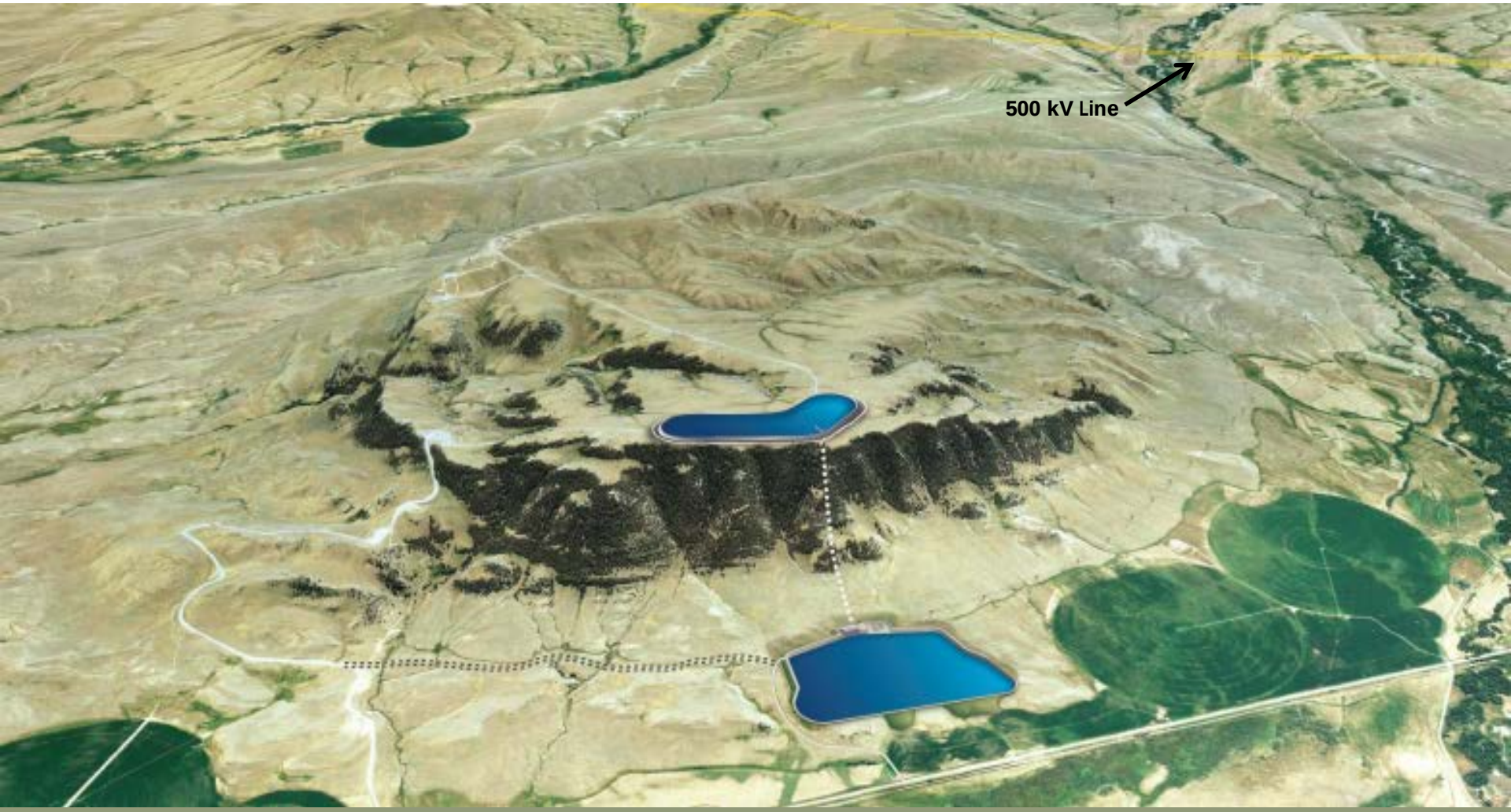
Mr. Borgquist is responsible for Absaroka Energy's corporate strategy, management and operations. As a founding partner of Absaroka Energy, he is focused on harnessing Montana's abundant alternative energy resources as well as the skilled and talented work force to bring to fruition the significant economic potential of wind energy.

Mr. Borgquist is actively engaged in the renewable energy community nationally, regionally and locally. With long-term experience in capital markets, finance and renewable energy development, he is a sought after presenter and leader contributing to infrastructure development and our national energy policy. Locally, Mr. Borgquist has served his community as Board President for the Gallatin Valley Humane Society, a founding member of the YMCA, serving as a Board Member for the Bozeman Deaconess Foundation Board, and as an elected trustee of the State Bar of Montana.

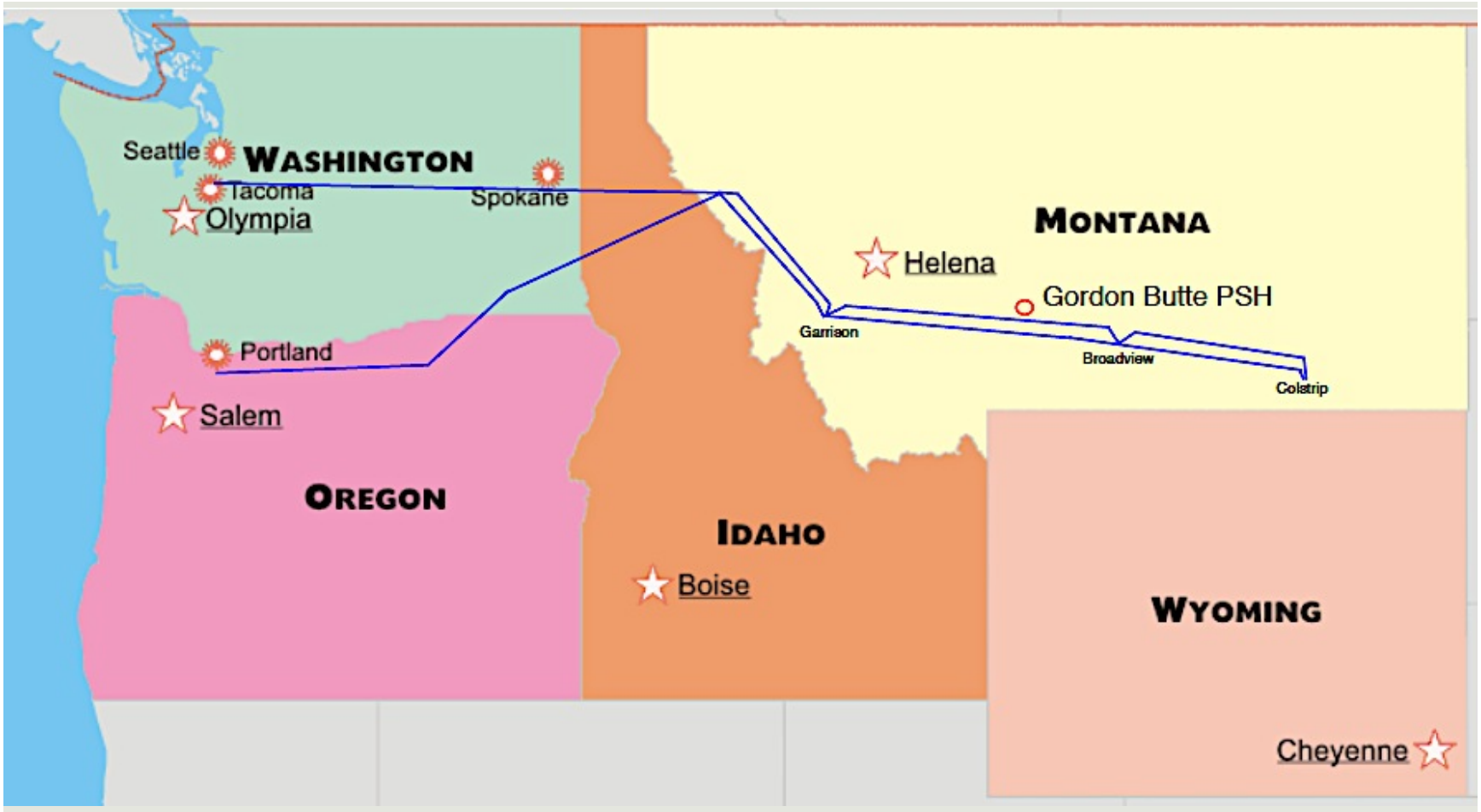
Mr. Borgquist previously served as a District Attorney for Alameda County, in the US Navy as a Naval Judge Advocate, as an Assistant United States Attorney, and with the Davison Companies and Davidson Trust Company as Director of Wealth Management. He has been heavily involved in wind power development since 2005. He holds a Bachelor of Arts in Political Science and Public Administration from California State University and a law degree from the University of San Francisco. In 2015, Montana Governor Steve Bullock presented Mr. Borqquist with the Innovator Award for the Gordon Butte project and Bridger Brewing Company of Bozeman brewed a unique "Innovator Ale" for the event.

Absaroka Energy

GORDON BUTTE PUMPED STORAGE HYDRO PROJECT



PROJECT LOCATION



PROJECT MILESTONES

- LAND AGREEMENT IN PLACE FOR PROJECT AND EASEMENTS
- WATER RIGHT PERMIT OBTAINED
- 401 WATER QUALITY CERTIFICATE WAIVED – NO WATER DISCHARGE
- STATE HISTORICAL PRESERVATION OFFICE SIGNOFF – NO CULTURAL OR ARCHEOLOGICAL ISSUES
- NO ENDANGER SPECIES (ESA) ISSUES
- BOARD OF CONSULTANTS INITIAL MEETING OF CONCEPTUAL DESIGN COMPLETE
- FERC **FINAL LICENSE** APPLICATION ACCEPTED – NO DEFICIENCIES

PROVEN TECHNOLOGY

KOPS 2 / Austria - Three Machine Set (Ternary Group)

Customer:

- Vorarlberger Illwerke

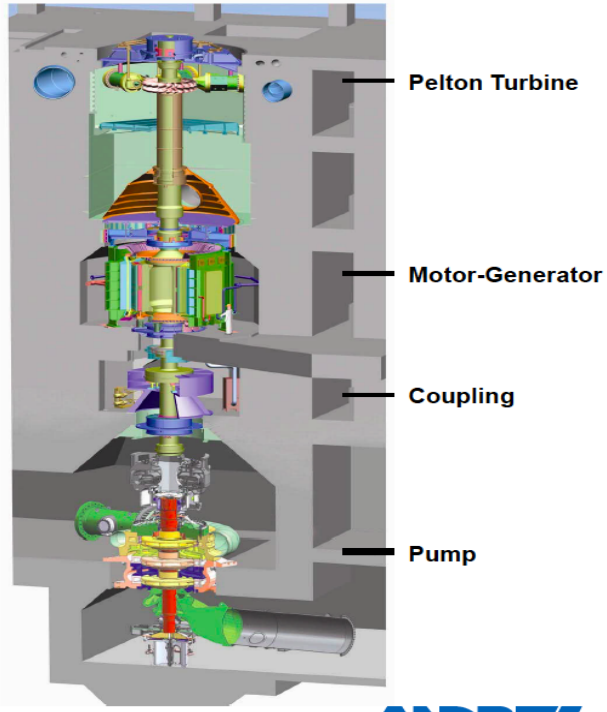
Main Equipment

- 3 x 180 MW Peltonturbines, 3-stage Pumps and 3 x 200 MVA Motorgenerators
- Net Head 808 m
- 500 rpm

Project Highlights

- Pelton units with back-pressure, positioned above the generator
- Up to 60 load changes a day
- Response time < 20 sec
- Capable of hydraulic short-circuit to achieve regulation of ± 100% power

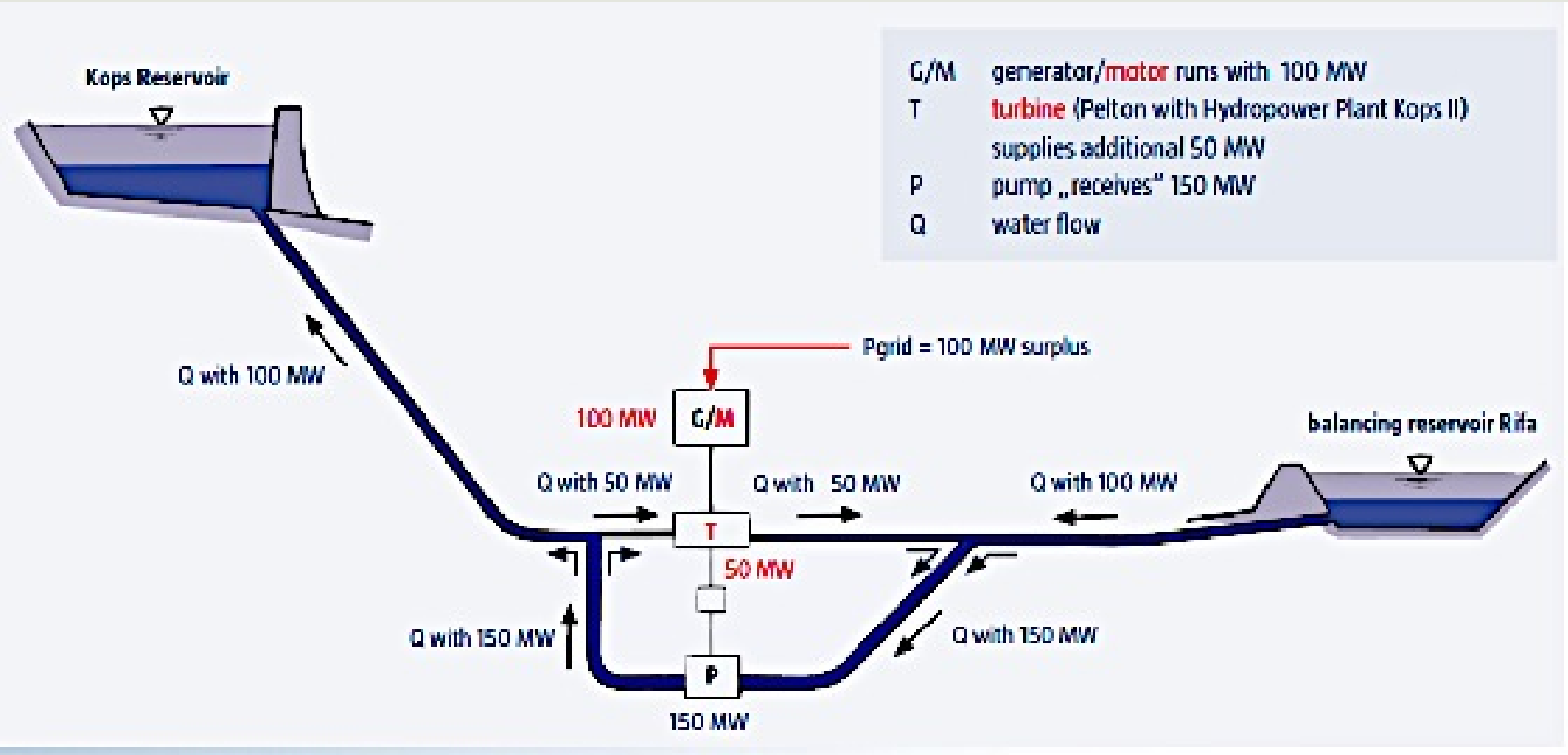
Since 2008 successful in operation



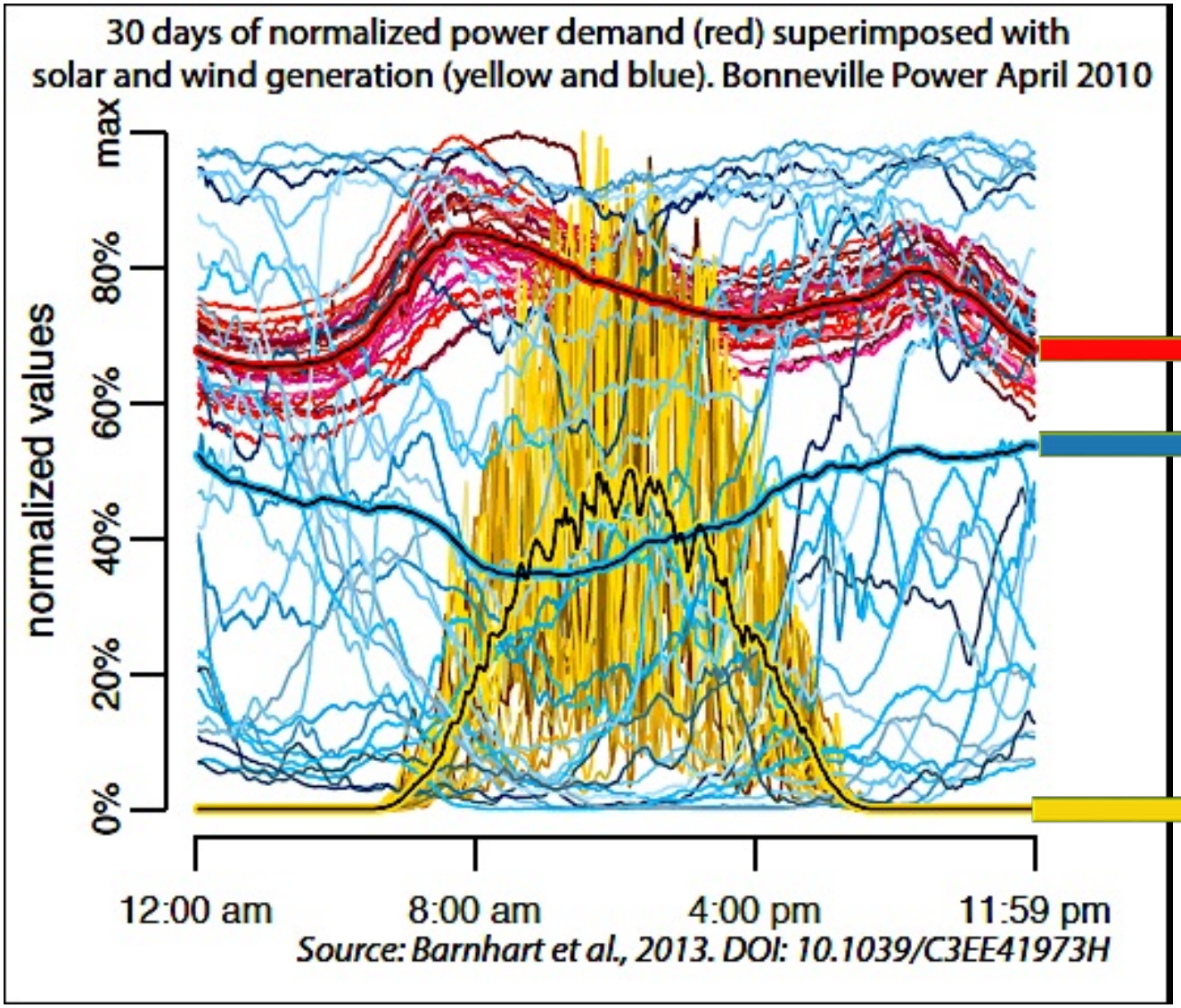
ANDRITZ Hydro

All - Energy 2010 - Aberdeen

HYDRAULIC SHORT CIRCUIT



REAL PROBLEM

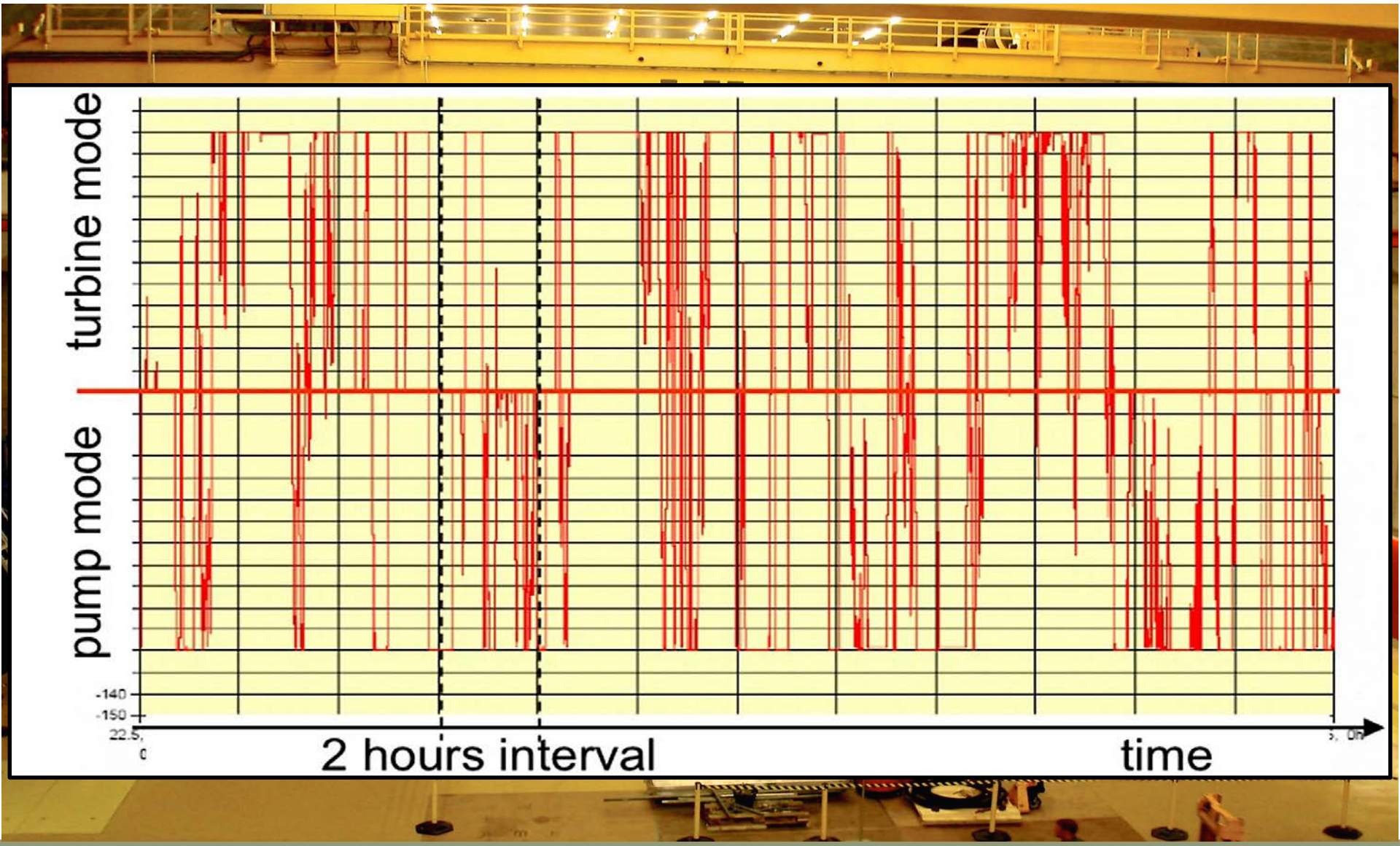


Average Power Demand

Average Wind Generation

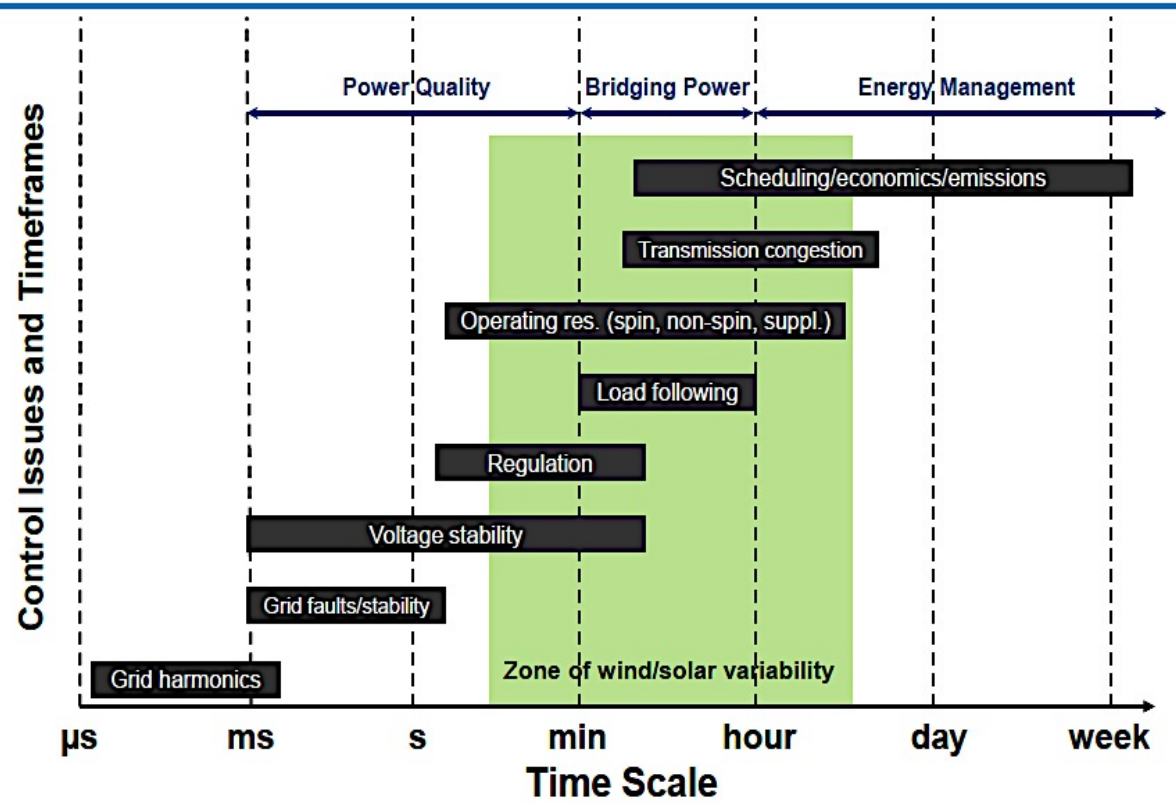
Average Solar Generation

ULTIMATE FLEXIBLE CAPACITY



FLEXIBILITY WHERE NEEDED

PSH Can Help with Many Short-Term Control Issues

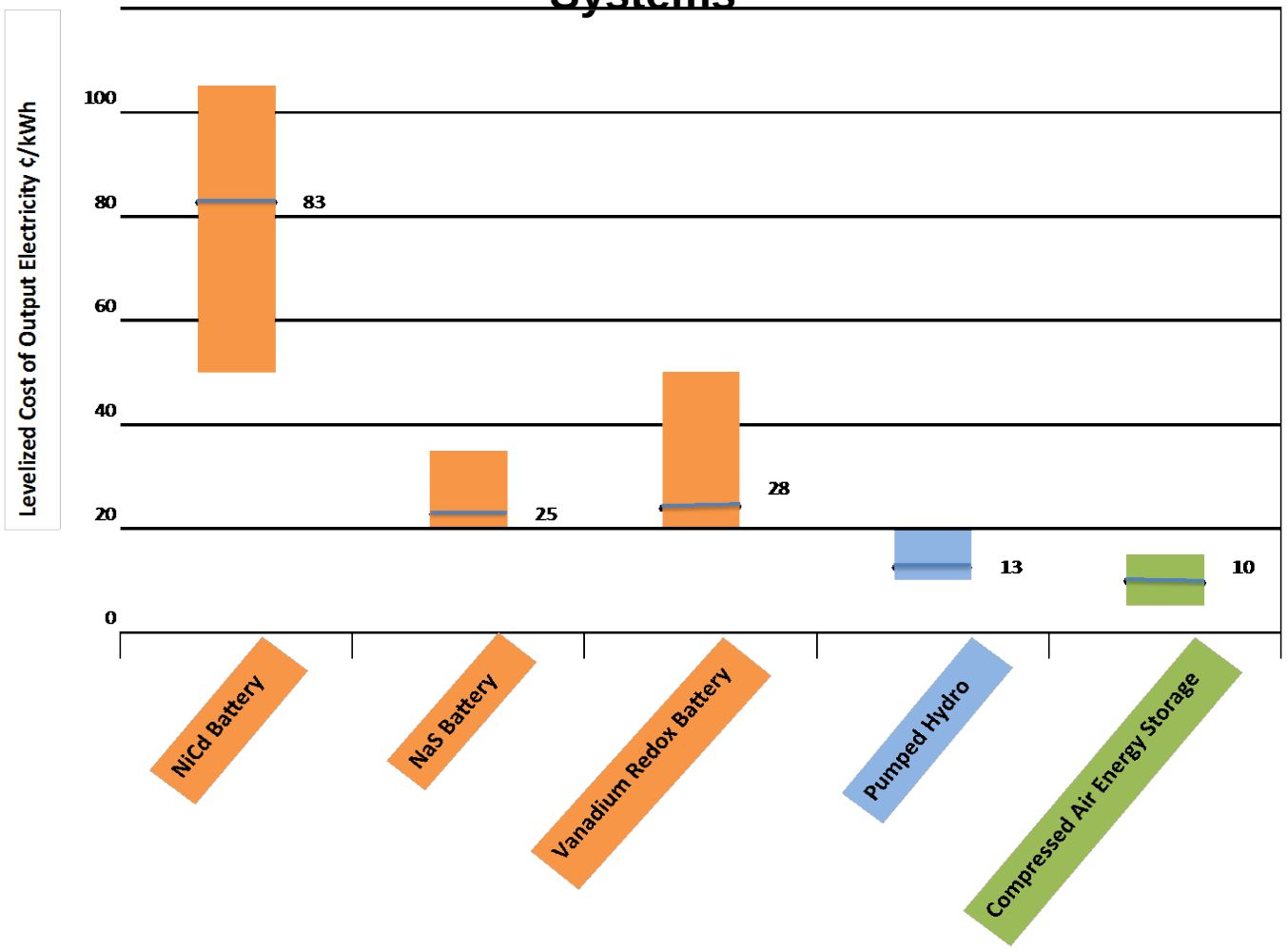


There is a need for better modeling and simulation of PSH plants at sub-hourly time scales.

6

STORAGE COST COMPARISONS

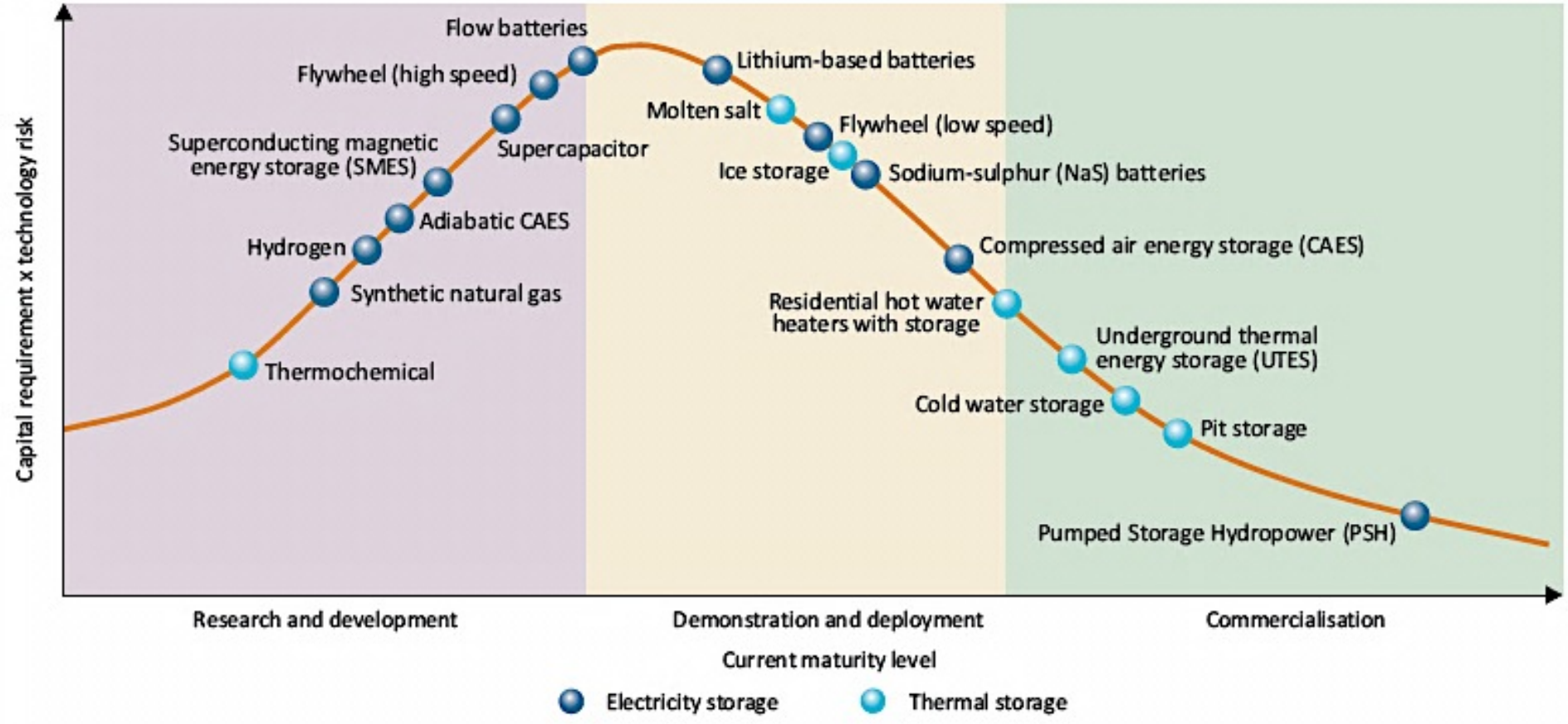
Ranges of Levelized Cost of Output Electricity from Storage Systems



Source: NREL "Hydrogen for Energy Storage Analysis Overview" Darlene Steward, Todd Ramsden, Kevin Harrison, May 2010

STORAGE TECHNOLOGY RISK / MATURITY

Maturity of Energy Storage Technologies



Source: "Thermal Energy Storage Today" presented at the IEA Energy Storage Technology Roadmap Stakeholder Engagement Workshop, Paris, France,

TRADITIONAL VALUE PROPOSITION

Pumped Hydro provides:

- Capacity to meet peak loads
- Storage to move energy from low value to high value hours

But:

- Gas CTs provide less expensive capacity ($1,000-/kw vs. $2,000+/kw)
- Storage value not enough to offset higher capital costs

And, Pacific Northwest hydro system has historically provided abundant capacity and storage capability

NEW VALUE PROPOSITION

Pacific Northwest hydro increasingly constrained

Utilities need fast ramping, regulating reserves (up and down) to manage increasing system variability (loads and variable generation)

Cost to provide 100 MW of regulating reserves (+/- 50 MW)

Pumped Hydro : 50 MW x $2,000/kw = **$100 Million**
Gas: 150 MW* x $1,200/kw** = **$180 million**

assumes 33%* of capacity dedicated to minimum load & spare unit requirements assumes fast-ramping CTs or recips suitable for regulation Net cost of pumping energy (80% efficient) similar to “out- of-market” cost of running CTs for regulation

ACTUALLY COSTS LESS

Resource	Gordon Butte	Gordon Butte	NWE DGGS	PGE PW2	PGE 2013 IRP	PGE 2013 IRP	PSE 2015 IRP	PSE 2015 IRP
Technology	Pumped Hydro	Pumped Hydro	Aero CT	Recip	Aero CT	Recip	Aero CT	Recip
Capacity (MW)	600	400	150	220	100	110	206	220
Min Load (MW)	-600	-400	10	9	30	8	52	9
Reg. Capacity (MW)	1,200	800	105	211	70	102	154	211
Installed Cost ($MM)	$1,100	$800	$183	$249	$135	$181	$259	$352
Cost/kw of Capacity	$1,833	$2,000	$1,217	$1,451	$1,348	$1,648	$1,255	$1,600
Cost/kw of Reg Capacity	**$917**	**$1,000**	**$1,738**	**$1,513**	**$1,925**	**$1,777**	**$1,679**	**$1,668**

ADDITIONAL ISSUES
PUMPED STORAGE VS. GAS

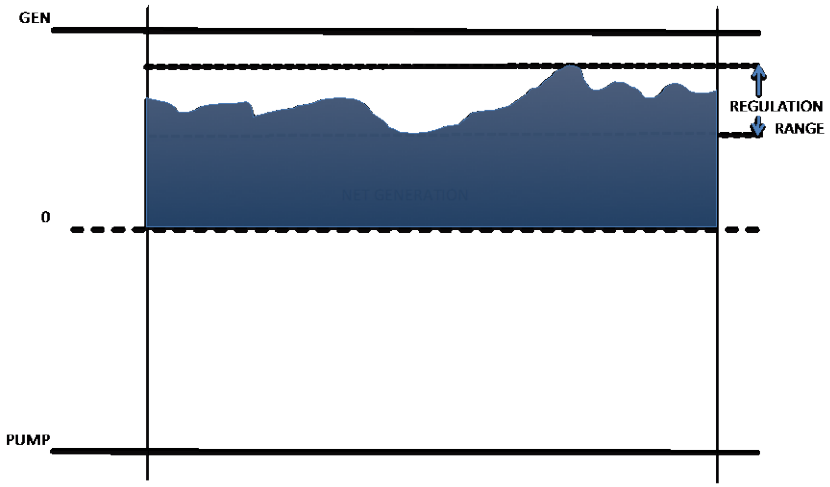
Attribute	Pumped Hydro	Gas
Cost per kw of Regulation	$1,000-	$1,500+
Energy Cost Penalty	80% efficiency	Out-of-market costs
Other Ancillary Services	+	+
Energy Storage	+	-
Transmission Congestion Relief	+	-
Fuel Price Risk	+	-
Carbon Emissions	+	-
Capacity Varies with Temperature	+	-

PUMPED HYDRO REGULATION FOR LOAD

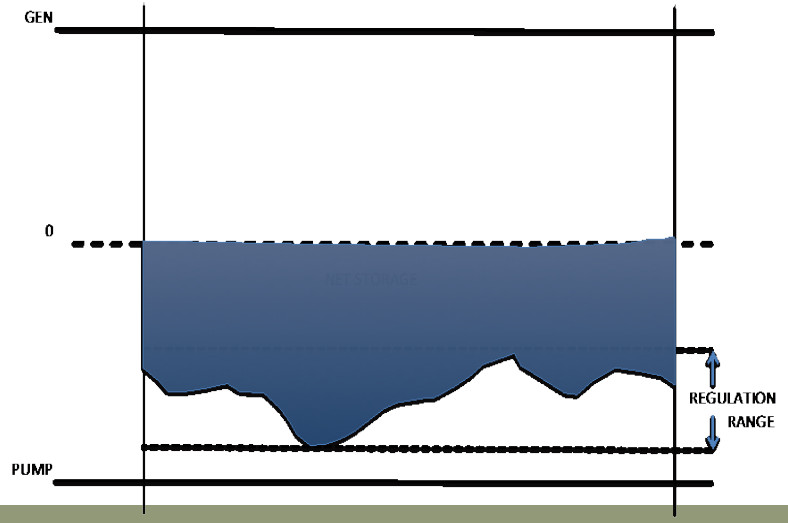
- **Ramping/regulation requirements for load are greatest during morning (up) and evening (down) ramp hours**

- **During other hours, ramping/regulation requirements for load are less. Pumped hydro operation can be biased to result in:**
  - **Net energy storage at night**
  - **Net energy generation during the day**

Typical Daytime Hour



Typical Nighttime Hour



PSH VALUE PROPOSITIONS

Alternative #1 – WA/OR Wind + Gas Peakers

Component	Resource	Nameplate Capacity (MW)	Unit Cost ($/kw)	Total Cost ($MM)
600 MW Capacity	Gas Aero CTs	600	$1,200	$720
500 aMW Energy	Wind @ 30% CF	1,667	$2,000	$3,334
Total				**$4,054**

PSH VALUE PROPOSITIONS

Alternative #2 – MT Wind + Pumped Hydro

Component	Resource	Nameplate Capacity (MW)	Unit Cost ($/kw)	Total Cost ($MM)
600 MW Capacity	Pumped Hydro	600	$1,800	$1,080
500 aMW Energy	Wind @ 45% CF	1,111	$2,000	$2,222
550 MW Transmission*	BV-GR Upgrades			$73
Total				**$3,375**

* With these upgrades and pumped hydro 99.5+% of MT wind energy can be delivered to WA/OR without upgrades to BPA main grid transmission.

FUTURE OF COLSTRIP 1&2

- Units 1 & 2 Aging Infrastructure
- Talen Energy Asset Valuation Write Down
- Competing Resources (Wind, Solar, Gas)
- EPA Clean Power Plan (111d)
- Washington State Senate Bill 6248 Established Colstrip Retirement Fund
- Oregon State Senate Bill 1547 No Imported Coal Generation
- Colstrip Transmission System Stranded Asset

CONCLUSION

Pumped Hydro:

- More Cost Effective Than Gas CTs
- More Flexible Ancillary Services and Integration
- Gordon Butte PSH – Locational Advantage

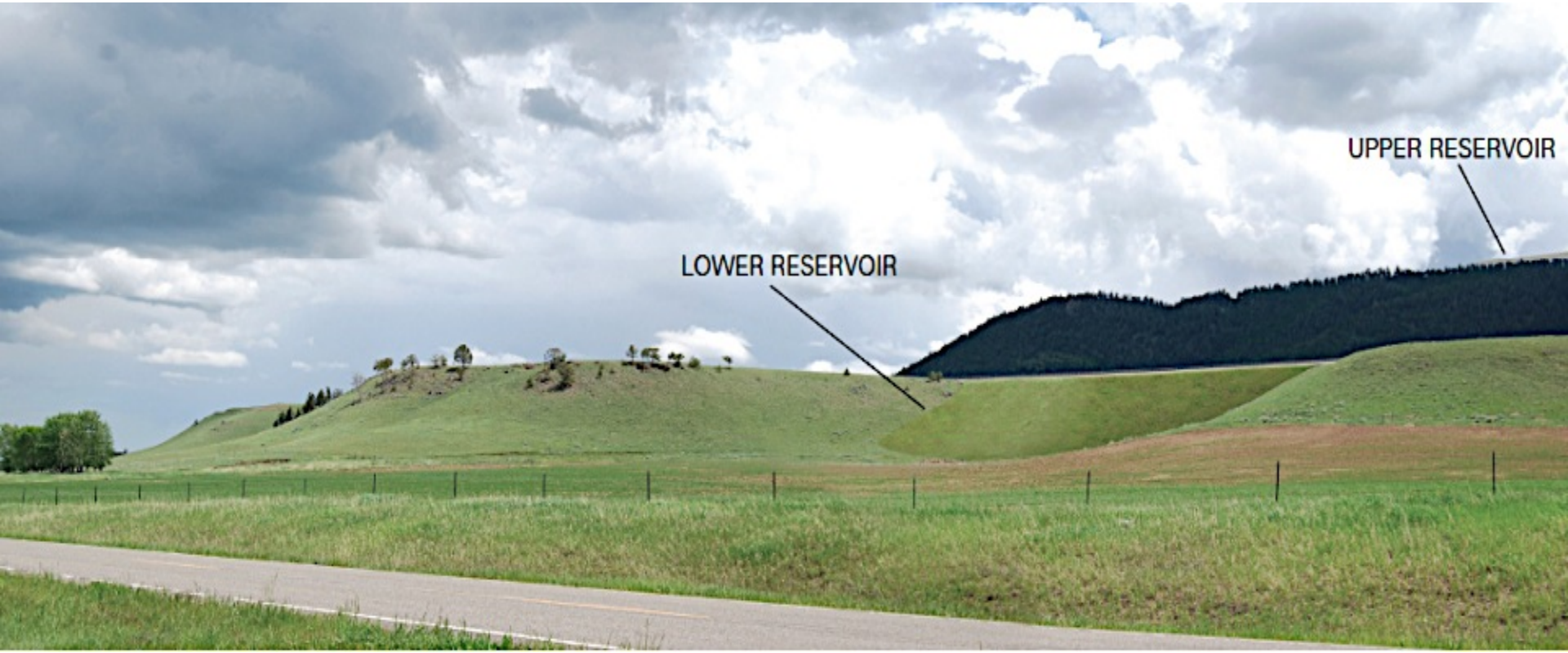
Montana Wind

- Higher Capacity Factor
- Output Aligned with Demand
- Economic Offset of Colstrip Retirements

Montana Wind and PSH

- Dispatchable Renewable Energy

THANK YOU



www.gordonbuttepumpedstorage.com

Carl Borgquist / President
Rhett Hurless / Sr. Vice President