NATIONAL COUNCIL
ON ELECTRICITY POLICY

Welcomes

Argonne National Laboratory

Thursday, April 9, 2020

Virtual Meeting

NATIONAL COUNCIL ON ELECTRICITY POLICY

Argonne National Laboratory

Agenda

- Overview of Argonne National Labs
- Overview of Energy Zones Mapping Tool (EZMT)
- Update on (forthcoming) Valuation Guidance and Techno-Economic Studies for Pumped Storage Hydropower
- Other projects
- Q&A

Kerry Worthington

kworthington@naruc.org

Welcome

During the webinar:

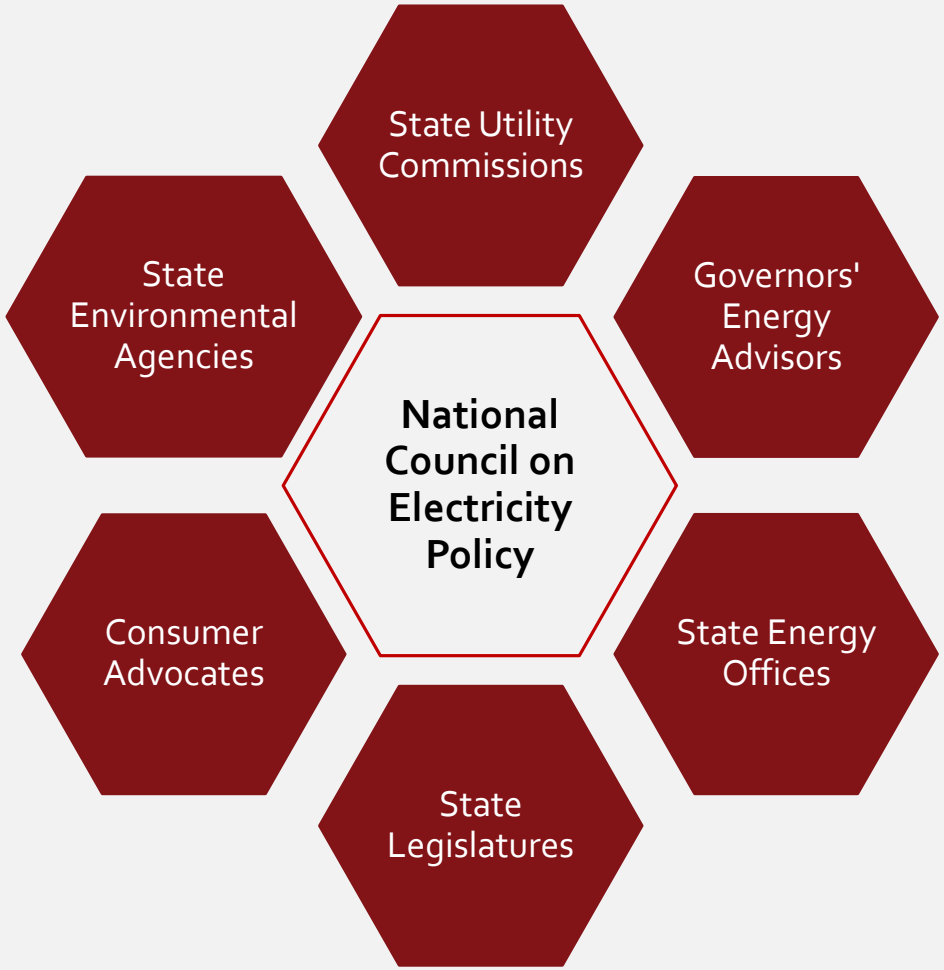
- This webinar is being recorded.
- Ask questions through the chat function in the GoToWebinar application.
  - Relevant clarifying questions will be asked immediately.
  - Other questions will wait for the discussion at the end.
  - Type in your questions anytime.

After the webinar:

- Presentation and recording posted on www.electricitypolicy.org.
- Unanswered questions will be sent to panelists with contact information (unless you prefer to remain anonymous and staff will liaison).
- Join our listserv by checking off NCEP as an interest area in your MYNARUC account at www.naruc.org/mynaruc/ or e-mail Kerry Worthington at Kworthington@naruc.org after your profile has been created.

The National Council on Electricity Policy (NCEP)

- NCEP is a peer-learning platform to examine the ways new technologies, policies, regulations, and markets impact state resources and the bulk power system.
- NCEP is currently exploring the evolving interface between the transmission and distribution systems as the resource mix on the grid changes (planning, operations, and markets).
- NCEP thanks the U.S. Department of Energy for its ongoing support. NCEP is administered by NARUC. **All NCEP resources are available at www.electricitypolicy.org.**



The Honorable Ted Thomas

Arkansas Public Service Commission

Webinar Moderator

Argonne National Laboratory Panelists

Vladimir Koritarov

Jim Kuiper

OVERVIEW OF ARGONNE

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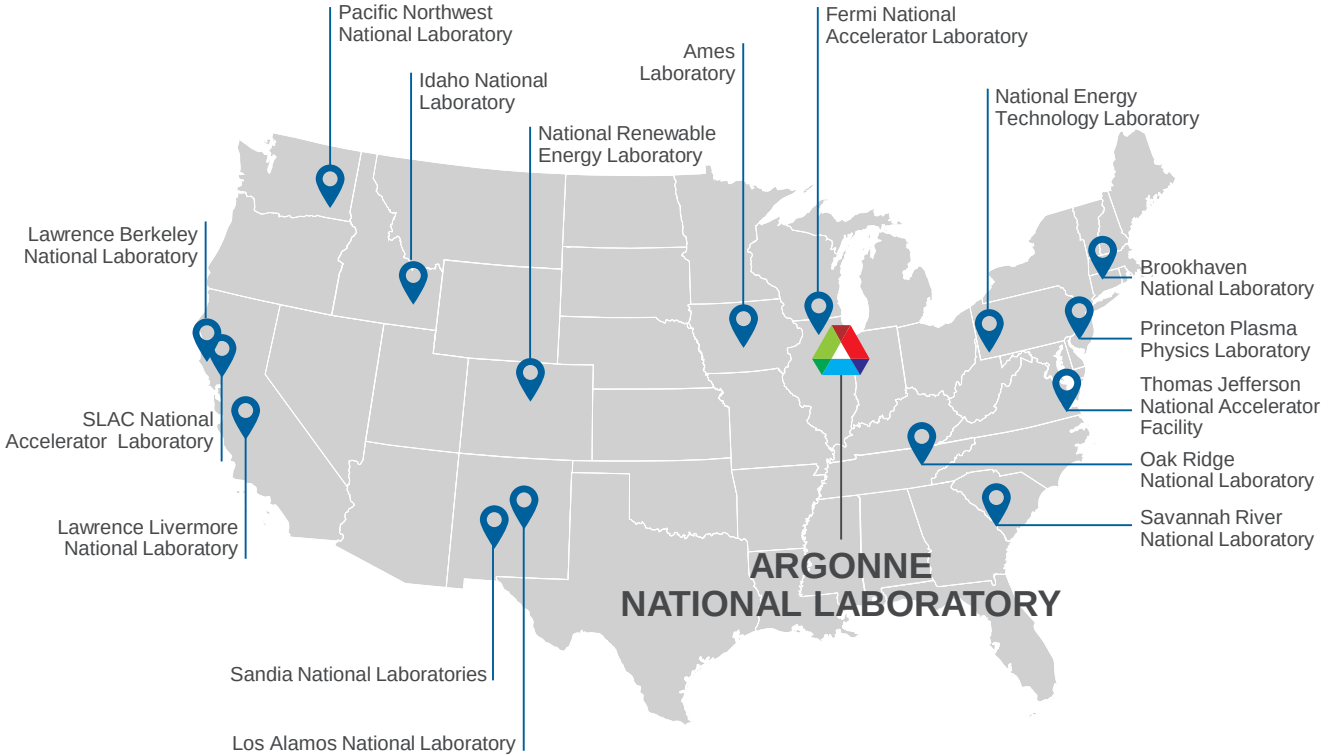
NCEP Webinar
April 9, 2020

A VITAL PART OF THE DEPARTMENT OF ENERGY NATIONAL LABORATORY SYSTEM



Argonne NATIONAL LABORATORY

DIVERSIFIED RESEARCH PORTFOLIO

$1.02 Billion in FY2020

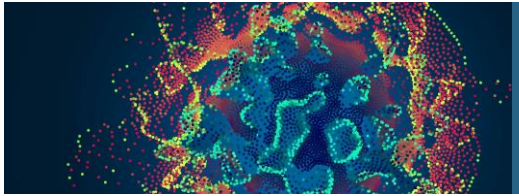
End-to-end, from discovery to application

User facilities integrated with our research

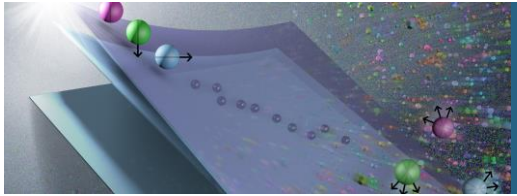
Collaborations within and outside Argonne

ARGONNE IS FOCUSED ON SOLVING BIG PROBLEMS IN SCIENCE AND ENGINEERING

EMERGING INITIATIVES



Artificial Intelligence for Science

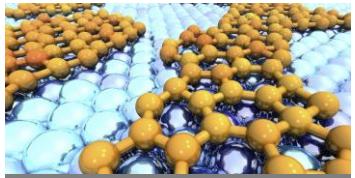


Quantum Information Science

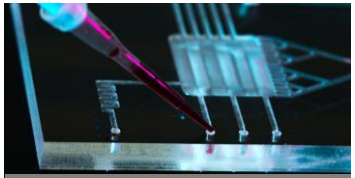
MAJOR INITIATIVES

Hard X-ray Science

Advanced Computing



Materials and Chemistry



Manufacturing Science & Engineering

Universe as Our Lab

ARGONNE'S RESEARCHERS AND DISCOVERIES ARE WIDELY RECOGNIZED

~120 R&D 100 Awards

Thousands of inventions recorded and patents issued

700+ national and international awards and honors

Numerous DOE commendations, including Secretary's Awards
4 in 2018

THREE NOBEL PRIZES

Enrico **FERMI**

Maria **GOEPPERT MAYER**

Alexei **ABRIKOSOV**

ARGONNE FOSTERS A DIVERSE, WORLD-CLASS COMMUNITY OF TALENT

1,330+ S&T Staff

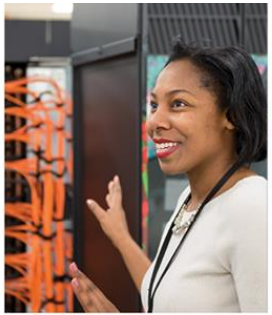
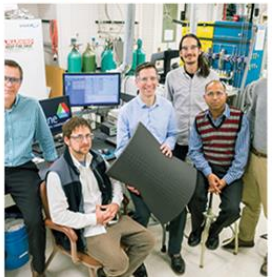
7,900+
Facility Users

790+ Visiting Researchers

3,200+ Employees

340+ Joint Faculty

590+ Students




Argonne NATIONAL LABORATORY

ARGONNE'S PARTNERSHIPS SPAN SECTORS FROM START-UPS TO FORTUNE 500'S

MANUFACTURING

P&G, Ford, Toyota, General Motors, GlobalFoundries, inpria, CAT, Boeing, Cummins, PPG, 3M, MDC, Cabot, ADSC Area Detector Systems Corporation, SEMATECH, Dow, SCHOTT glass made of ideas, CYMER, Toyota Central R&D Labs., Inc.

ENERGY

Chevron, Exelon, Schneider Electric, GE, Black Pak inc., NuScale Power, SunPower, AMBRI, Baldor, AutoGrid, EaglePicher Technologies, LLC, NuScale Power, Arkansas Power Electronics International

INFORMATION TECHNOLOGY

intel, EMC², Cisco, EY, AXSUN a Volcano company, IBM, Honeywell, Samsung, hp, TE connectivity, Panoramic Technology, Hitachi, Electronic Materials, ASML, Shin-Etsu, UES Excellence in Science & Technology

PHARMACEUTICALS

Abbott, Lilly, Pfizer, Amgen, MedImmune, AstraZeneca, Merck, Calithera, Novartis, Emerald Biostructures, MannKind Corporation, CrownBio, élan, Celgene, GlaxoSmithKline, Takeda, Zenobia Therapeutics, Array BioPharma, Plexxikon

Argonne NATIONAL LABORATORY

THANK YOU!

Energy Zones Mapping Tool (EZMT)

National Council on Electricity Policy Meeting
April 9, 2020

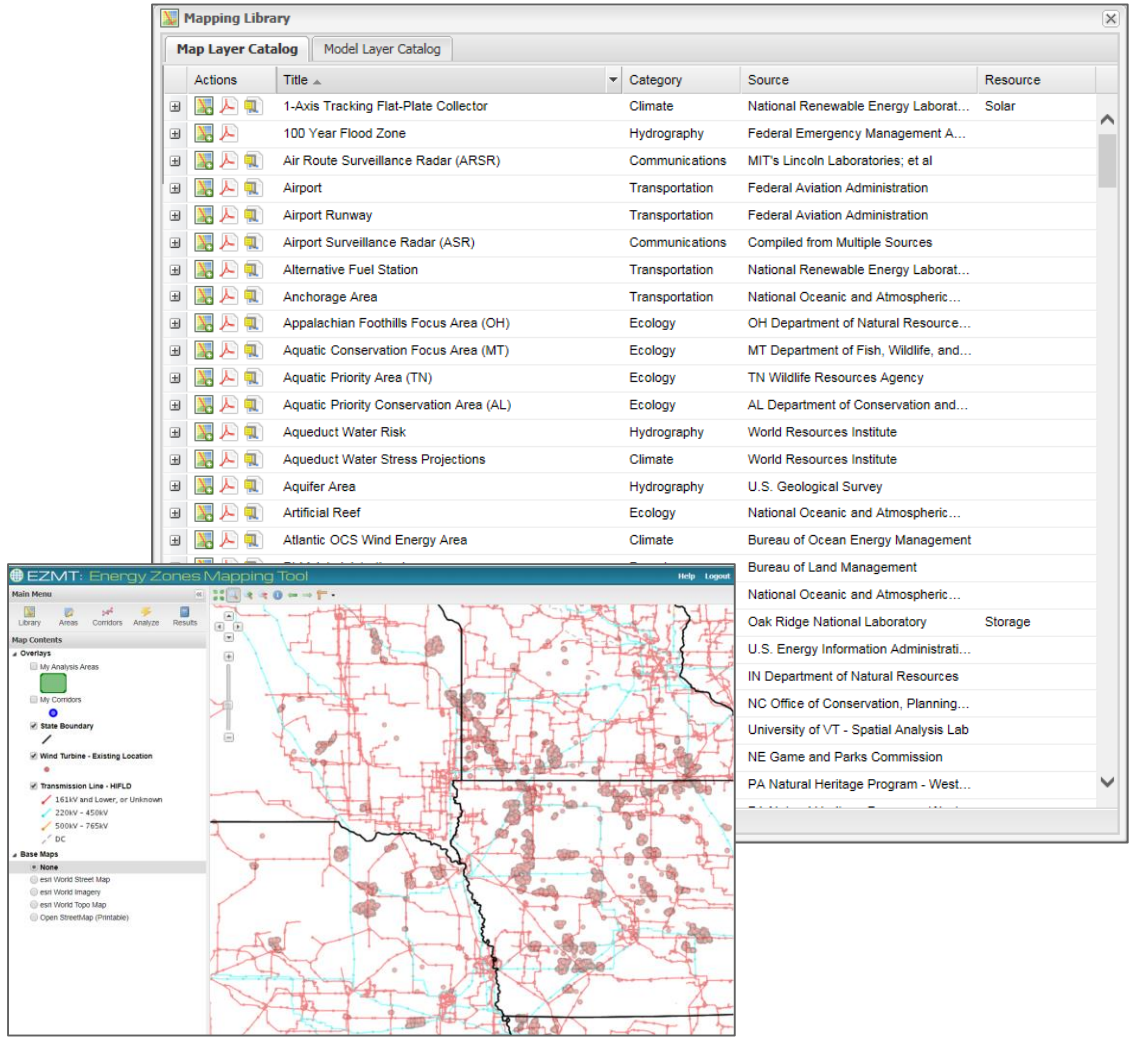
Jim Kuiper
Principal Geospatial Engineer
Argonne National Laboratory

Energy Z

- Initiated by EISPC request as part of the technical support from Argonne, NREL, and Oak Ridge
- Funded by DOE Office of Electricity
- Launched in 2013
- Publicly available web-based mapping tool for energy analysis
  - Large geospatial data library (over 320 mapping layers)
  - Suitability modeling and analysis to map
    - Areas highly suitable for energy development
    - Potential energy corridor paths
  - Location-specific reports dynamically generated from database

The EZMT Has an Extensive GIS Data Library

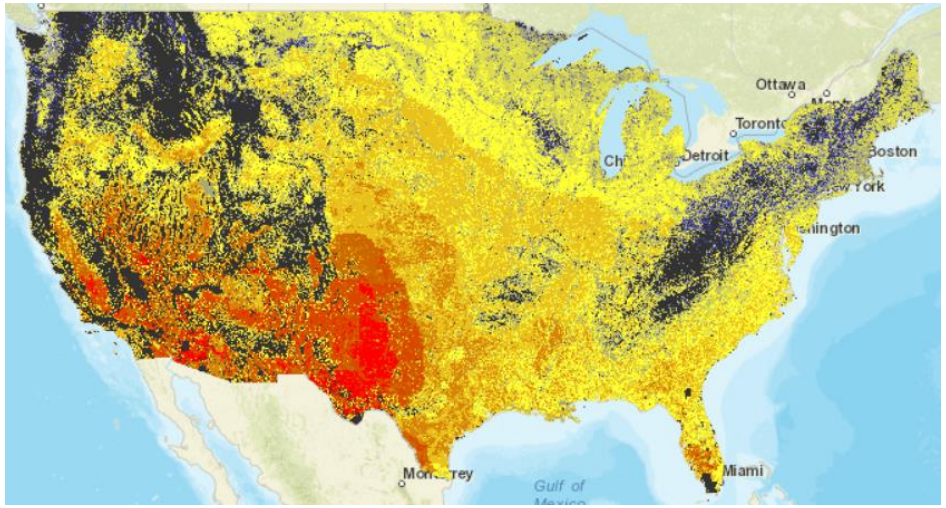
- Over 320 GIS mapping layers:
  - Energy resources (wind, solar, biomass, etc.)
  - Energy infrastructure
  - Siting factors
  - Reference layers
  - Environmental
- Detailed metadata for all layers
- Downloadable GIS data for most layers
- Actively maintained and updated



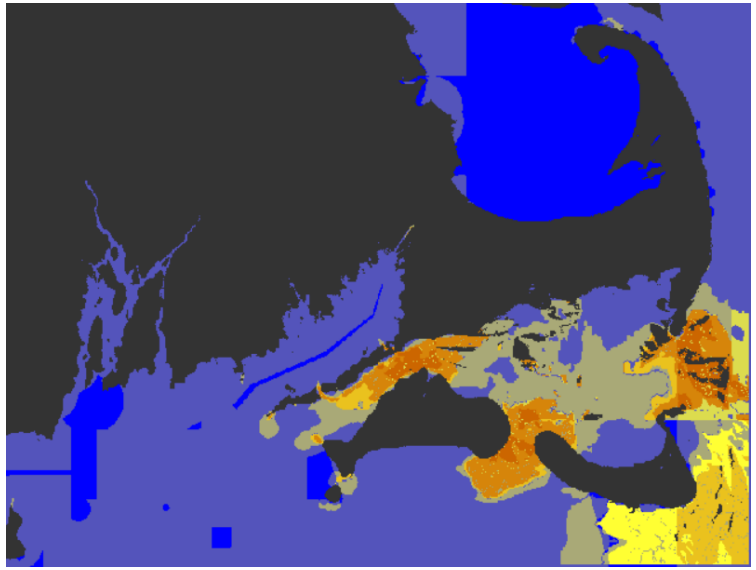
Wind turbines and electrical transmission in the plains states

EZMT Modeling – Unique and Powerful

- Nine energy resources
  - Natural gas, solar, wind, corridor, …
- Forty preconfigured models
  - Wind (land-based and offshore),100m height
  - PV solar
  - Combined-Cycle Gas Turbine
  - …
- Over ninety modeling layers
  - PV solar resource
  - Distance to >=220 kV substation
  - Habitat
  - …
- Intuitive and flexible model interface
- Can use default models, revise them for user preferences, or design new models



Utility scale photovoltaic solar

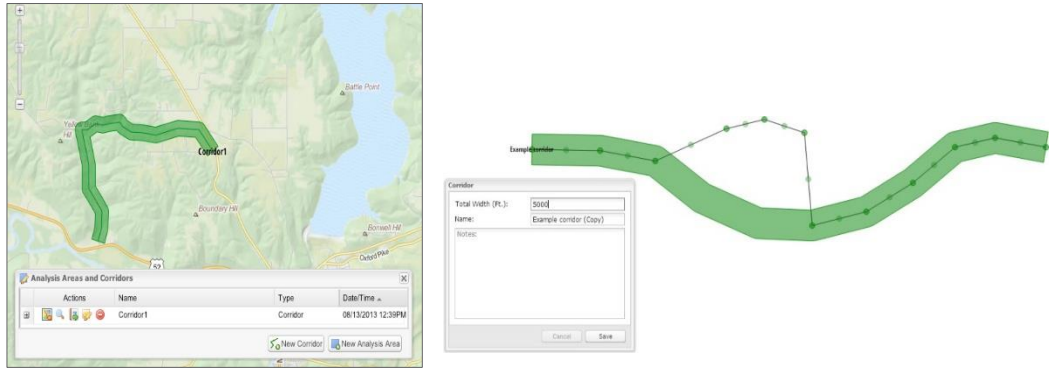


Marine tidal hydrokinetic around Cape Cod

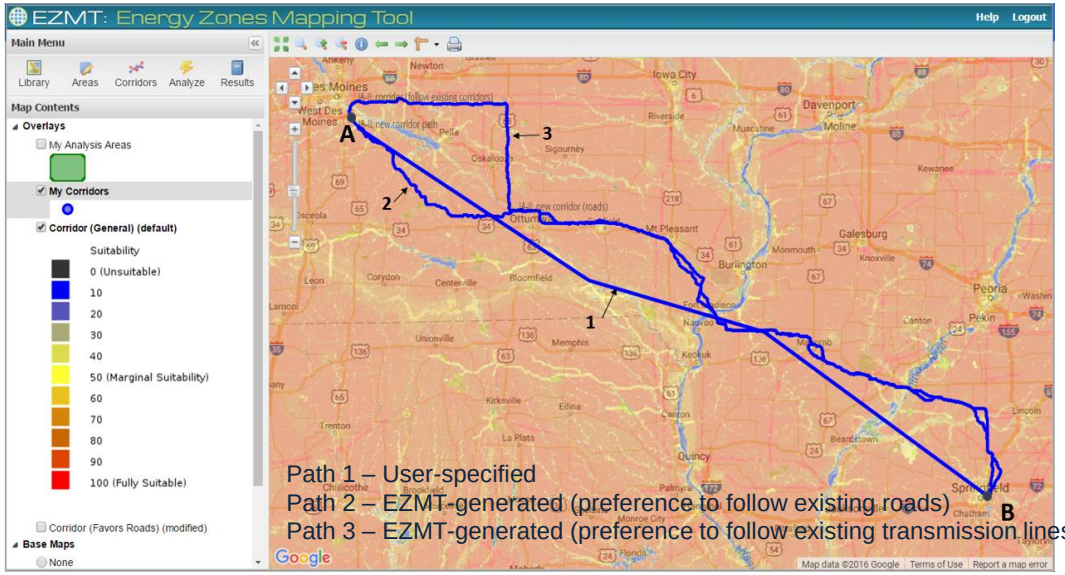
EZMT Modeling – Potential Corridor Paths

Two analytical options are available:

a) User can draw a corridor path on the map, specify a width, and run a corridor analysis report

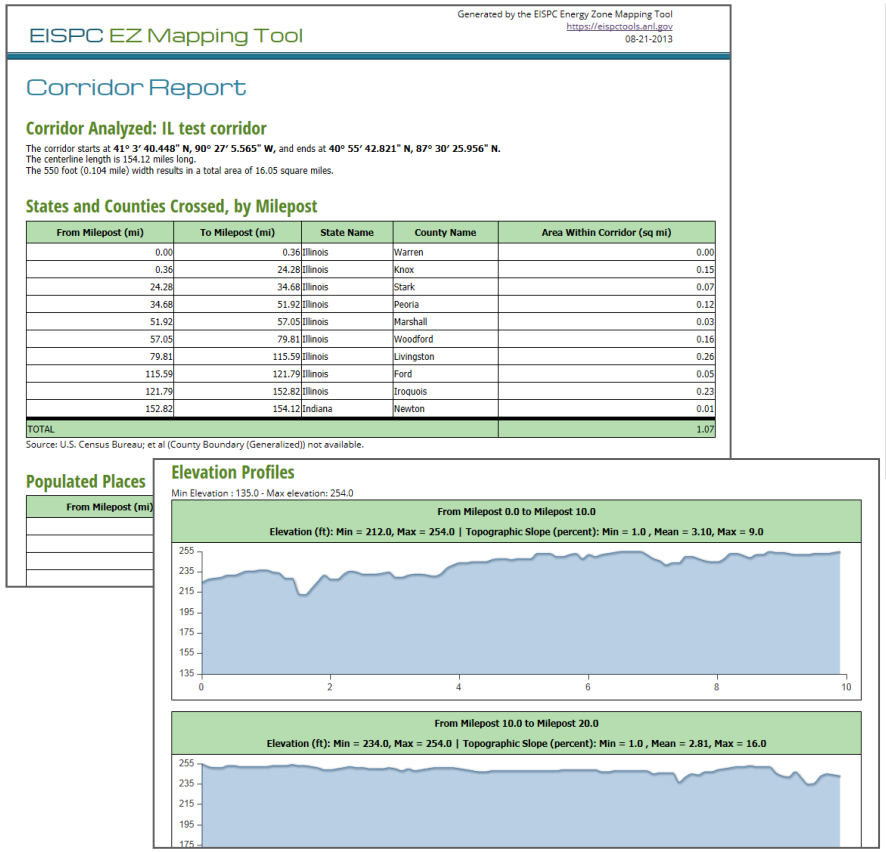


b) EZMT can model the most suitable path between points A and B, based on user-specified constraints and siting preferences



EZMT Reports – Rapid and Specific

- Sixteen report topics: Power plant, corridor, protected land, …
- Generated from current database content
- Run for user-specified map areas



EISPC EZ Mapping Tool

Generated by the EISPC Energy Zone Mapping Tool
https://eispctools.anl.gov
08-21-2013

Corridor Report

Corridor Analyzed: IL test corridor

The corridor starts at **41° 3′ 40.448″ N, 90° 27′ 5.565″ W,** and ends at **40° 55′ 42.821″ N, 87° 30′ 25.956″ N.**
The centerline length is 154.12 miles long.
The 550 foot (0.104 mile) width results in a total area of 16.05 square miles.

States and Counties Crossed, by Milepost

From Milepost (mi)	To Milepost (mi)	State Name	County Name	Area Within Corridor (sq mi)
0.00	0.36	Illinois	Warren	0.00
0.36	24.28	Illinois	Knox	0.15
24.28	34.68	Illinois	Stark	0.07
34.68	51.92	Illinois	Peoria	0.12
51.92	57.05	Illinois	Marshall	0.03
57.05	79.81	Illinois	Woodford	0.16
79.81	115.59	Illinois	Livingston	0.26
115.59	121.79	Illinois	Ford	0.05
121.79	152.82	Illinois	Iroquois	0.23
152.82	154.12	Indiana	Newton	0.01
TOTAL				1.07

Source: U.S. Census Bureau; et al (County Boundary (Generalized)) not available.

Populated Places

From Milepost (mi)

Elevation Profiles

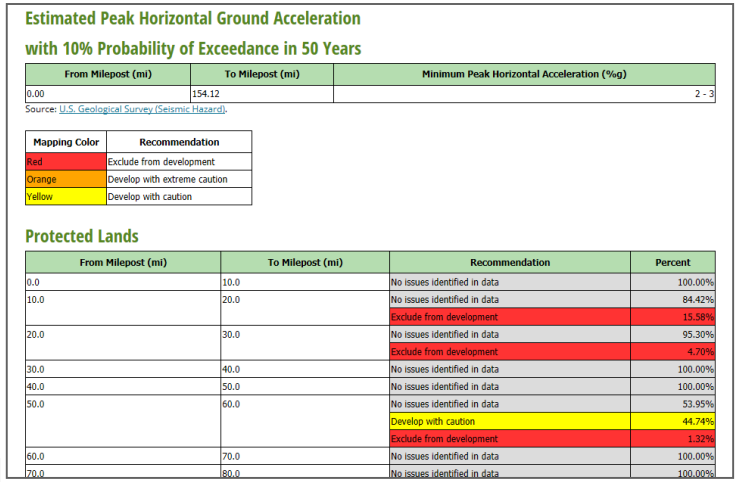
Min Elevation : 135.0 - Max elevation: 254.0

From Milepost 0.0 to Milepost 10.0

Elevation (ft): Min = 212.0, Max = 254.0 | Topographic Slope (percent): Min = 1.0 , Mean = 3.10, Max = 9.0

From Milepost 10.0 to Milepost 20.0

Elevation (ft): Min = 234.0, Max = 254.0 | Topographic Slope (percent): Min = 1.0 , Mean = 2.81, Max = 16.0



Estimated Peak Horizontal Ground Acceleration with 10% Probability of Exceedance in 50 Years

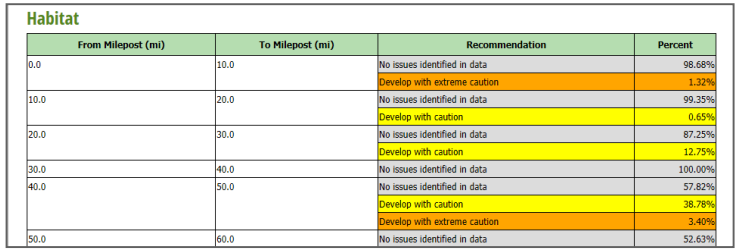
From Milepost (mi)	To Milepost (mi)	Minimum Peak Horizontal Acceleration (%g)
0.00	154.12	2 - 3

Source: U.S. Geological Survey (Seismic Hazard).

Mapping Color	Recommendation
Red	Exclude from development
Orange	Develop with extreme caution
Yellow	Develop with caution

Protected Lands

From Milepost (mi)	To Milepost (mi)	Recommendation	Percent
0.0	10.0	No issues identified in data	100.00%
10.0	20.0	No issues identified in data	84.42%
		Exclude from development	15.58%
20.0	30.0	No issues identified in data	95.30%
		Exclude from development	4.70%
30.0	40.0	No issues identified in data	100.00%
40.0	50.0	No issues identified in data	100.00%
50.0	60.0	No issues identified in data	53.95%
		Develop with caution	44.74%
		Exclude from development	1.32%
60.0	70.0	No issues identified in data	100.00%
70.0	80.0	No issues identified in data	100.00%



Habitat

From Milepost (mi)	To Milepost (mi)	Recommendation	Percent
0.0	10.0	No issues identified in data	98.68%
		Develop with extreme caution	1.32%
10.0	20.0	No issues identified in data	99.35%
		Develop with caution	0.65%
20.0	30.0	No issues identified in data	87.25%
		Develop with caution	12.75%
30.0	40.0	No issues identified in data	100.00%
40.0	50.0	No issues identified in data	57.82%
		Develop with caution	38.78%
		Develop with extreme caution	3.40%
50.0	60.0	No issues identified in data	52.63%

Corridor report excerpts

Example Use Cases

- Mapping library
  - Discover new, vetted, geospatial data and download it for internal use
  - Interactively study energy infrastructure and resources nationally or locally
- Models
  - Visualize where power plants of different types are most viable, and why
  - Examine where transmission capacity increases could be most effective
  - Find a potential corridor route that avoids many constraints
- Reports
  - Compare power generation portfolio for different regions (power plant)
  - Rapidly inventory characteristics and constraints along a potential corridor

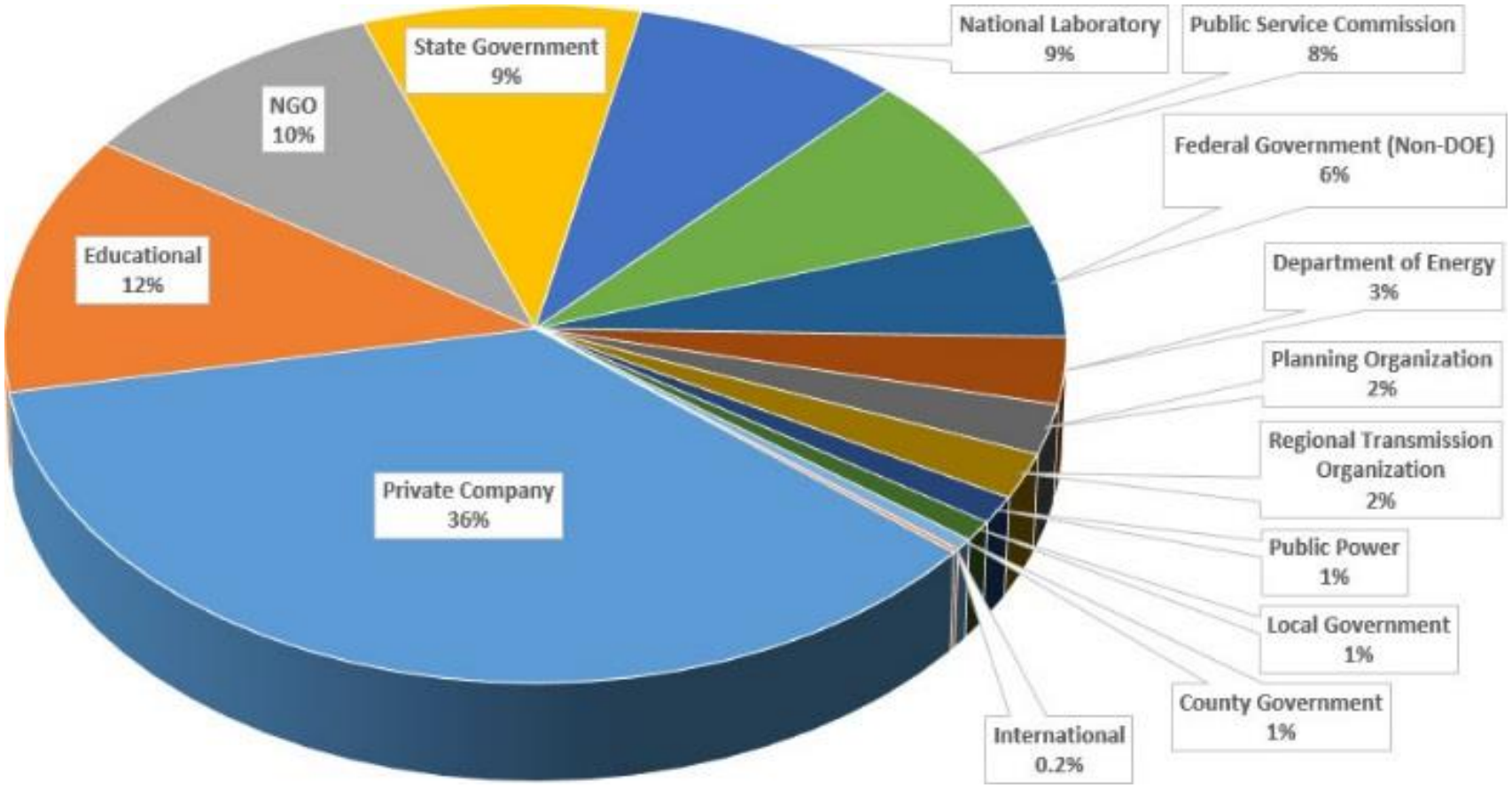
Recent Activities

- Newsletters and webinars
  (announced to users and other stakeholders)
- Added corridor/analysis area import/export tools
- Extended solar, wind, corridor models to lower 48 states
- Increased data content, such as:
  - "Sight Wind Right" data from The Nature Conservancy
  - Natural Gas Compressor Stations
  - Petroleum Refineries
  - Petroleum Product Terminals

Recent Activities

- Transitioned from Platts to HIFLD transmission data
- Updated distance to transmission modeling layers
- Added distance to substation modeling layers
- Reviewed and updated all models
- Pilot study and discussions about EZMT's potential for electric vehicle charging station planning

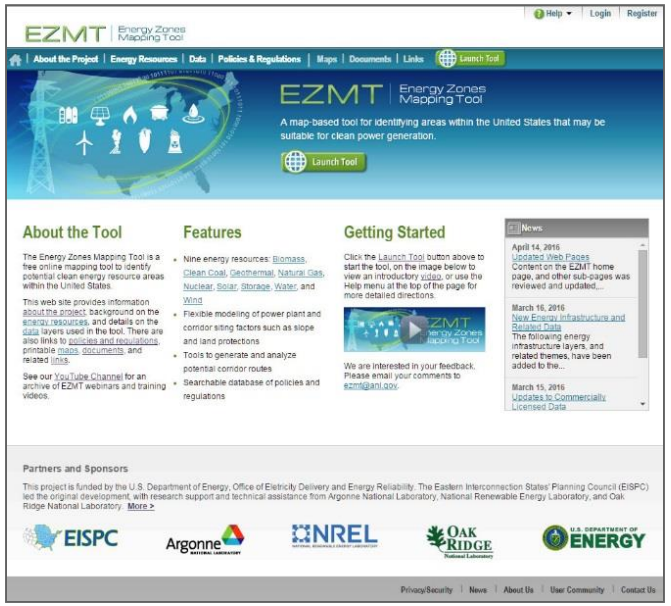
EZMT User Community



Over 2,000 users have registered.

Energy Zones Mapping Tool

- **Register for and access the tool here: http://ezmt.anl.gov**
- **Questions/comments at any time to: ezmt@anl.gov**



U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Valuation of Pumped Storage Hydropower (PSH)

Presented by: Vladimir Koritarov, PI
Argonne National Laboratory

National Council on Electricity Policy (NCEP) Webinar
April 9, 2020

Valuation Guidance and Techno-Economic Studies for PSH

Project Background and Overview:

- Study funded by Department of Energy's (DOE's) Water Power Technologies Office (WPTO)

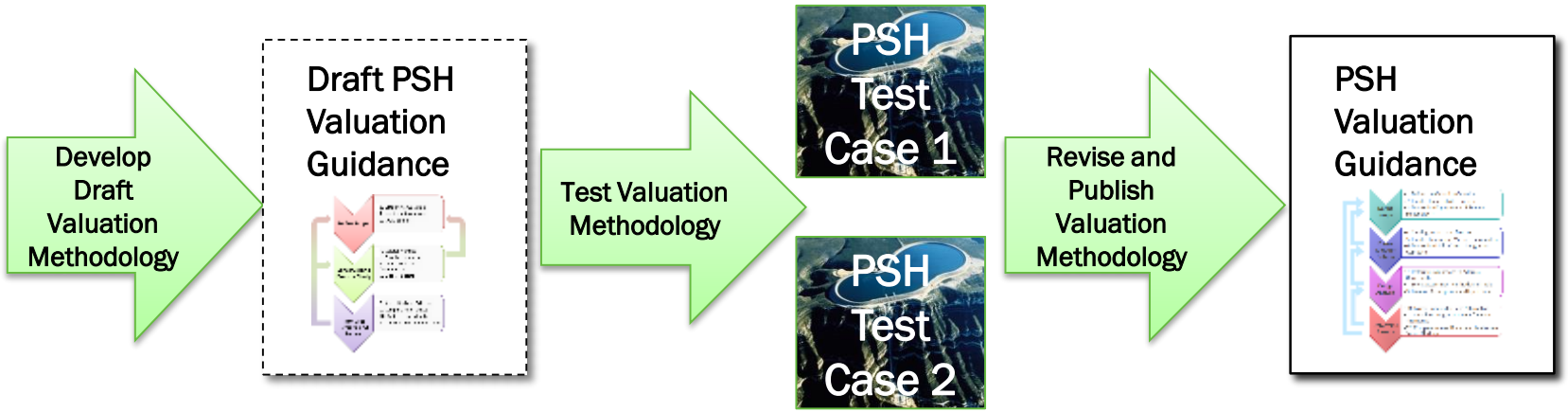
- Carried out under the WPTO HydroWIRES initiative by a collaborative comprised of five DOE National Laboratories

Project Goals and Objectives

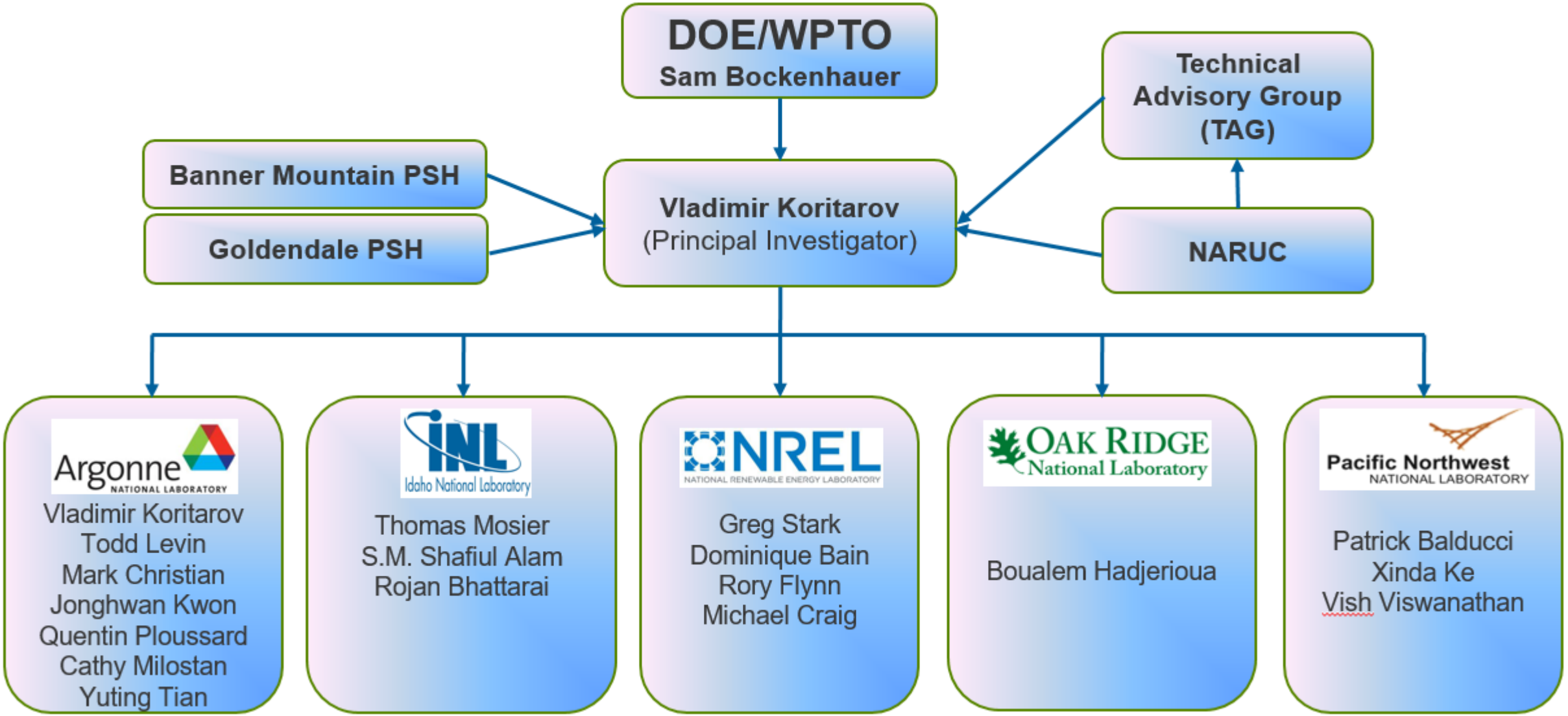
Objective: Advance the state of the art in the assessment of value of PSH plants and their role and contributions to the power system

Specific goals:

1. Develop a comprehensive and transparent valuation guidance that will allow for consistent valuation assessments and comparisons of PSH projects
2. Test the PSH valuation methodology by applying it to two selected PSH projects
3. Transfer and disseminate the PSH valuation guidance to the hydropower industry, PSH developers, and other stakeholders



Project Team and Organization



The Project Team is Collaborating with Two Industry Partners

Absaroka Energy

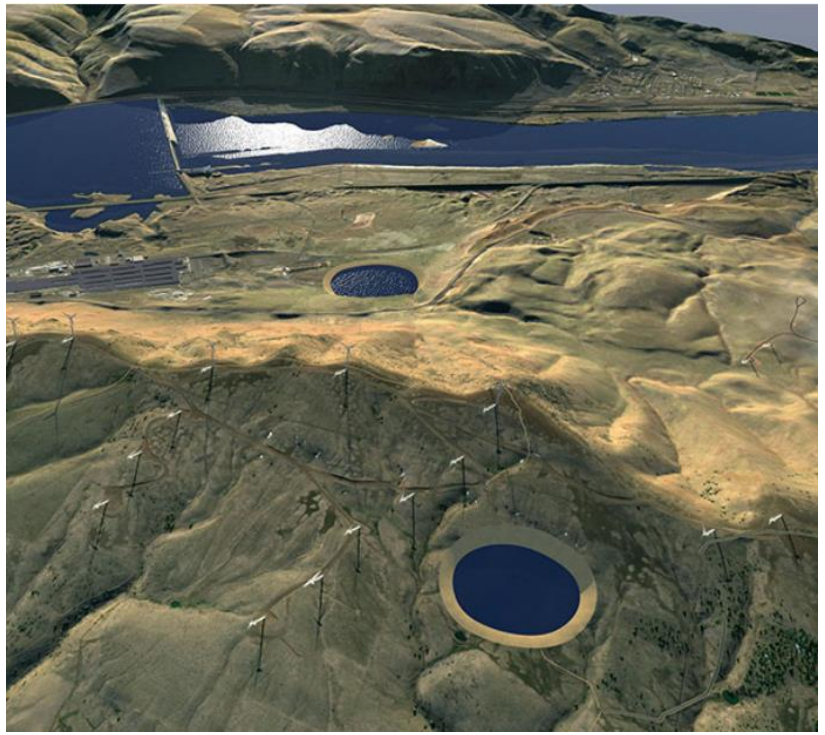
Banner Mountain PSH

- 400 MW, quaternary technology
- Closed loop
- Site near Casper, WY

National Grid & Rye Development

Goldendale Energy Storage Project

- 1,200 MW, adjustable speed technology
- Closed loop
- Site just north of OR/WA border



Collaboration with Technical Advisory Group (TAG) and NARUC

Technical Advisory Group:

Denis Bergeron	Maine PUC
Norman Bishop	Knight Piesold
Brent Buffington	SCE – Southern California Edison
Wei Dang	PSE – Puget Sound Energy
Peter Donalek	Stantec
Christine Ericson	Illinois Commerce Commission
Don Erpenbeck	Stantec
Robert Fick	LADWP
Scott Flake	Scott Flake Consulting
Levi Gilbert	PG&E – Pacific Gas & Electric

Edward Hansen	PG&E – Pacific Gas & Electric
Elaine Hart	PGE – Portland General Electric
Udi Helman	Helman Analytics
Michael Manwaring	McMillen Jacobs Associates
Jay Mearns	PG&E – Pacific Gas & Electric
Denis Obiang	LADWP
Aidan Tuohy	EPRI
Bruno Trouille	Mott McDonald
Robert Williams	PSE – Puget Sound Energy

NARUC (National Association of Regulatory Utility Commissioners) is assisting the Project Team in coordinating TAG activities and in industry outreach.

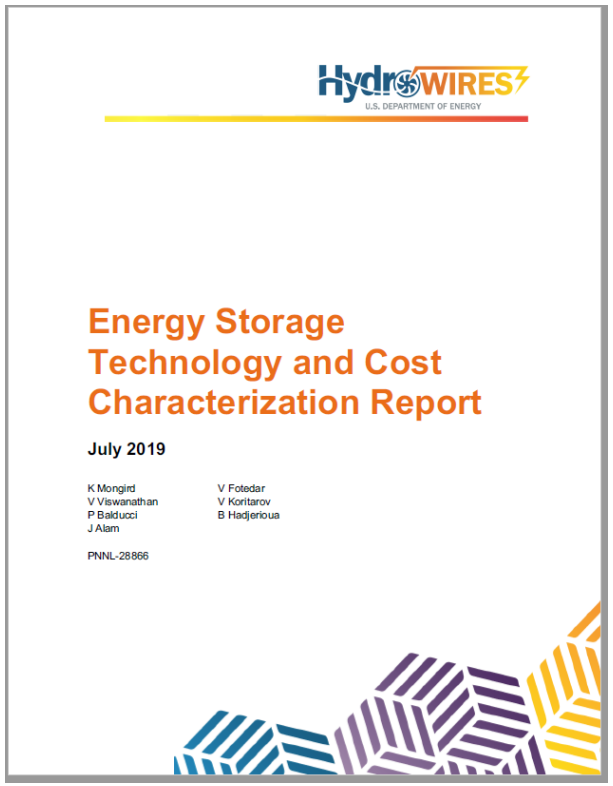
- Kerry Worthington
- Chris Villarreal (Plugged In Strategies) – Consultant to NARUC

Key Project Tasks

- ✓ Conduct valuation literature review *(Completed)*
- ✓ Perform a cost and performance comparison of PSH and competing technologies *(Completed)*
- ✓ Develop draft PSH valuation guidance *(Completed)*
- Conduct techno-economic studies for two selected PSH projects *(In progress)*
- Analyze potential market revenues of two PSH projects *(In progress)*
- Conduct two valuation case studies to test the guidance and its underlying methodology
- Revise PSH valuation guidance and document study findings

Published Energy Storage Cost and Performance Study

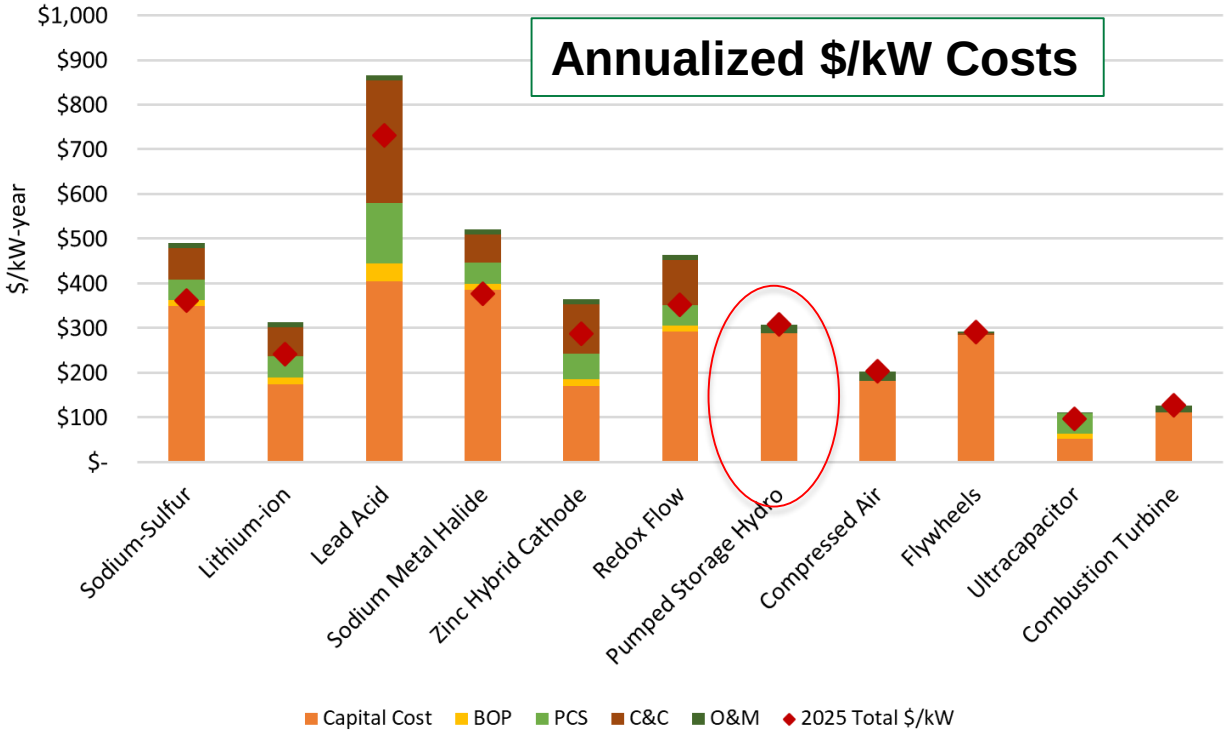
- Objective was to define and compare energy storage technology costs and to evaluate these technologies across a variety of performance parameters
  - Lithium-ion batteries
  - Lead-acid batteries
  - Redox flow batteries
  - Sodium-sulfur batteries
  - Sodium metal halide batteries
  - Zinc-hybrid cathode batteries
  - Pumped storage hydropower
  - Flywheels
  - Compressed air energy storage
  - Ultracapacitors

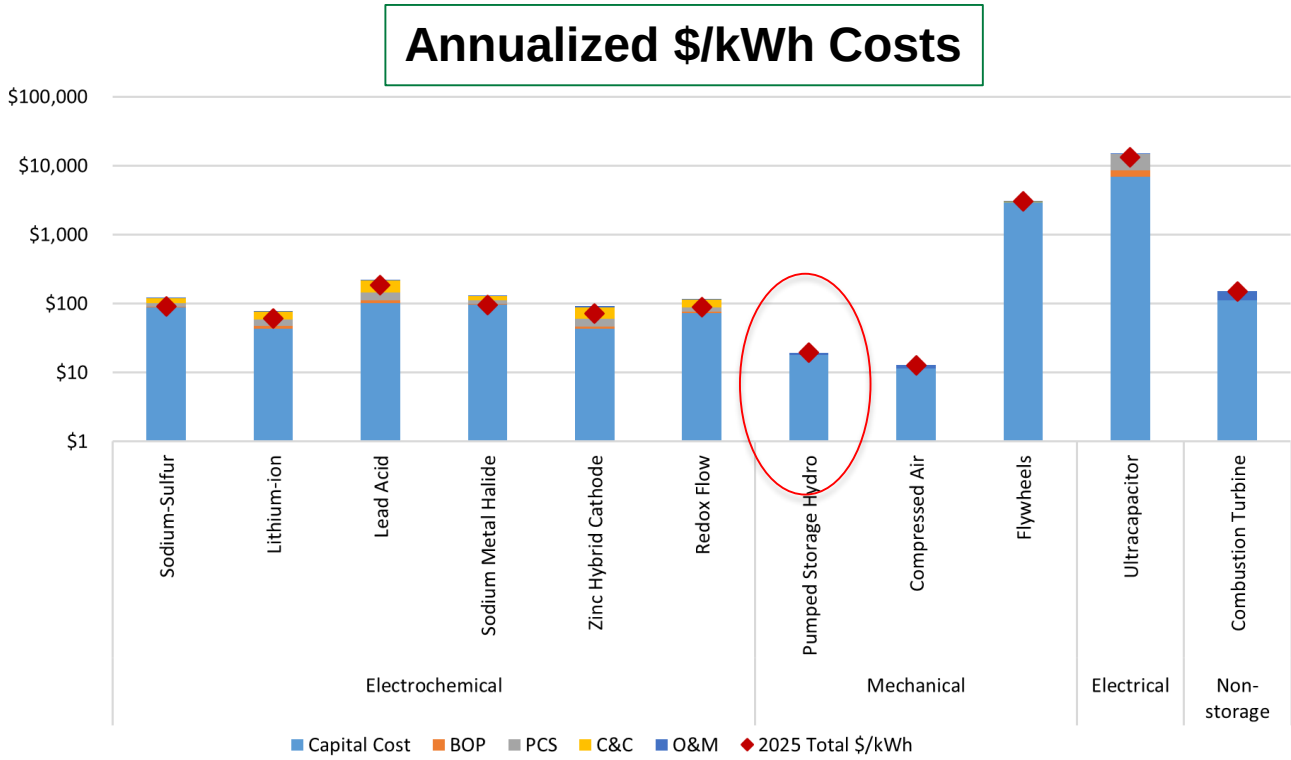


https://www.energy.gov/eere/water/hydrowires-initiative (Under Updates/Publications)

https://www.energy.gov/sites/prod/files/2019/07/f65/Storage%20Cost%20and%20Performance%20Characterization%20Report_Final.pdf

Annualized Costs by Technology





- Cost information procured for most recent year for which data are available; data procured from literature and industry survey/contacts/data.
- Base year used is 2018 and projections for 2025 are provided.

PSH Valuation Guidance Development Goals

- **Objective** and **comprehensive** methodology
- **Consistent** and **repeatable** valuation approach
- **Transparent** valuation process and results
- Can be applied to **different types and sizes** of PSH plants
- Accounts for **various services and contributions** that PSH plants provide to the grid
- Considers PSH **benefits and costs over time**
- Applies to both **traditional and restructured market environments**
- Can be used by **stakeholders with different perspectives**
- **Publicly available** for use by hydropower industry and stakeholders

Development of PSH Valuation Guidance

Leveraging numerous current and past efforts in this area

- **DOE-funded Grid Modernization Laboratory Consortium (GMLC) projects:**
  - GMLC 1.2.4: Valuation Framework
  - GMLC 1.1: Metrics Analysis
- **EPRI: The Integrated Grid – A Benefit-Cost Framework for DER**
- **EPRI: Guidebook for C/B Analysis of Smart Grid Demonstration Projects**
- **Argonne: The Role and Value of Advanced Pumped-Storage Hydropower in the United States**
- **Other valuation studies (e.g., solar, wind, storage, etc.)**

PSH Valuation Guidance
Detailed step-by-step methodology for valuation assessment of PSH projects

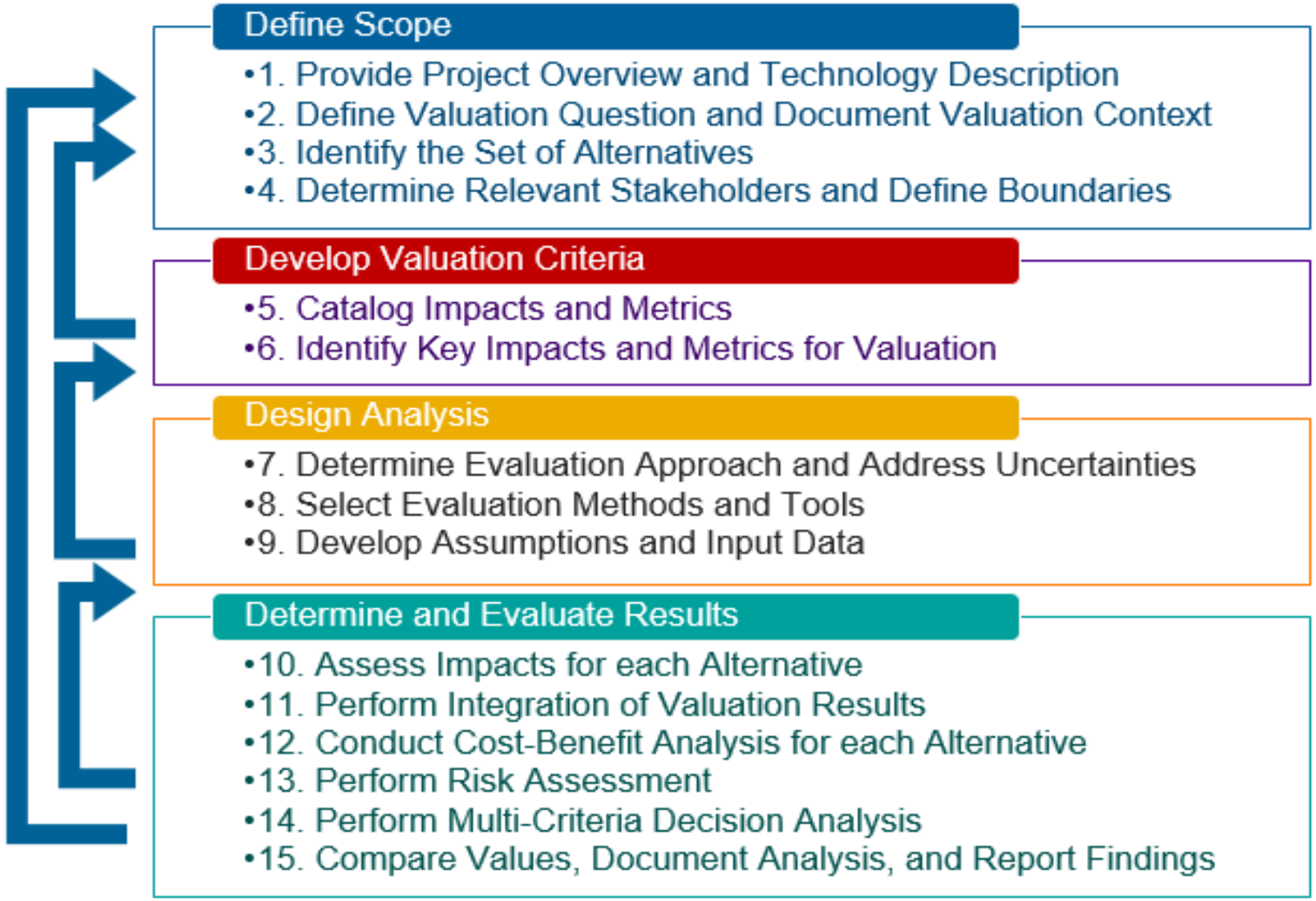
Techno-Economic Studies for Banner Mountain and Goldendale

A variety of analyses are carried out to assess the costs and benefits of various PSH services and contributions to the grid:

- ANL: Capacity valuation using AURORA model
- ANL: Historical electricity market analysis (PMAT)
- ANL: Black start service valuation (developing own model)
- NREL: Value of PSH ancillary services: regulation service, contingency reserves, and flexibility reserves (PLEXOS)
- INL: Power system stability services: inertial response, governor response (primary frequency control), transient and small signal stability, voltage support (PSSE)
- NREL: PSH impacts on power system cycling and ramping costs (PLEXOS)
- ORNL: Potential cost and performance impacts of increased PSH cycling and ramping operations (e.g., increased wear and tear of PSH units)
- NREL: Other system-wide effects of PSH operations (e.g., PSH impacts on system production costs, integration of variable energy resources, power system emissions) (PLEXOS)
- PNNL: PSH transmission benefits (congestion relief, transmission investments deferral) (PSSE)
- ORNL: PSH non-energy services (e.g., water management, socioeconomic benefits, and env. impacts)

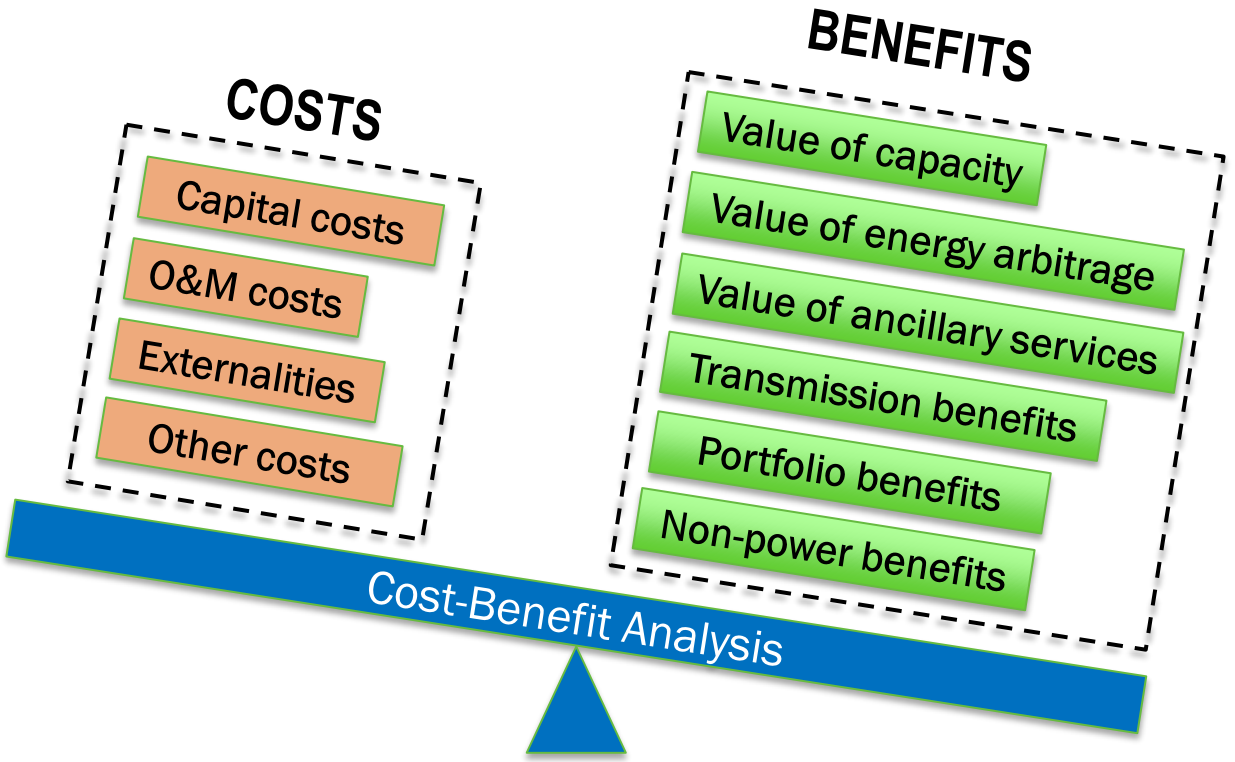
Proposed PSH Valuation Process

A Cost-Benefit and Decision Analysis Valuation Framework



PSH Valuation Framework – Cost-Benefit Analysis

The results of various techno-economic studies will provide inputs for Cost-Benefit Analysis (CBA)

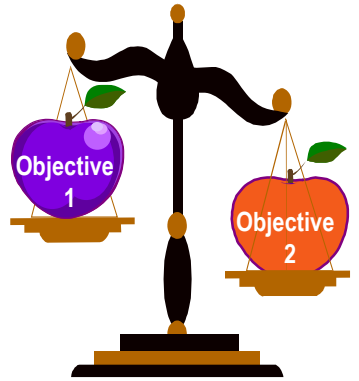


CBA will be used to calculate the net present value (NPV), benefit-cost (B/C) ratio, etc.

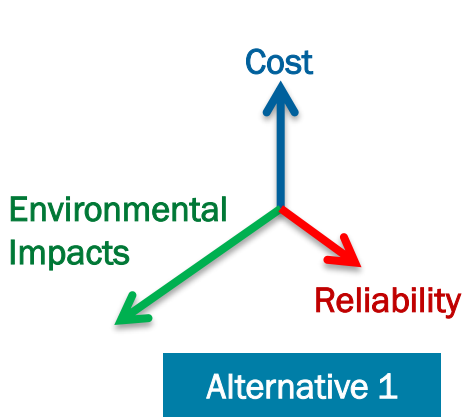
PSH Valuation Framework – Multi-Criteria Decision Analysis

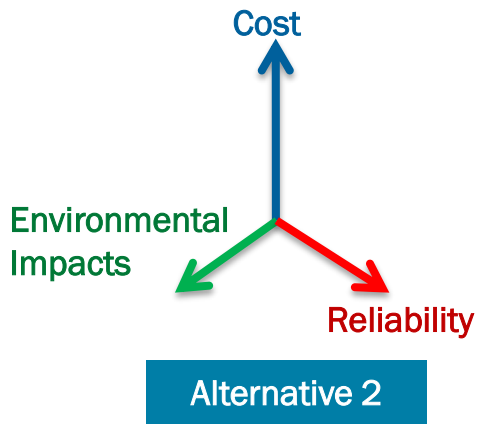
Choosing among different alternatives with multiple attributes

- Many PSH impacts are not easily monetized and have to be expressed in physical units or qualitatively
- How to compare different alternatives that are described by both monetized and non-monetized impacts?
- A decision-support system can help decision-makers choose among different alternatives defined by multiple attributes



Tradeoffs Among Objectives





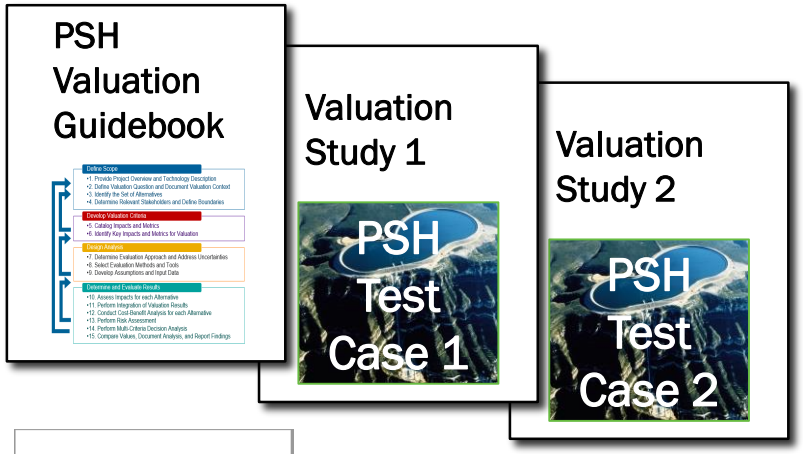
Which alternative is better?

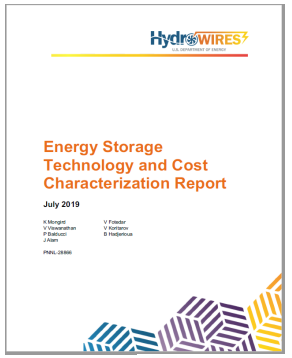
Key Products of the PSH Valuation Project

- PSH Valuation Guidebook
- Two technical reports illustrating the application of Guidebook methodology for valuation of actual PSH projects

- Energy storage cost and performance study

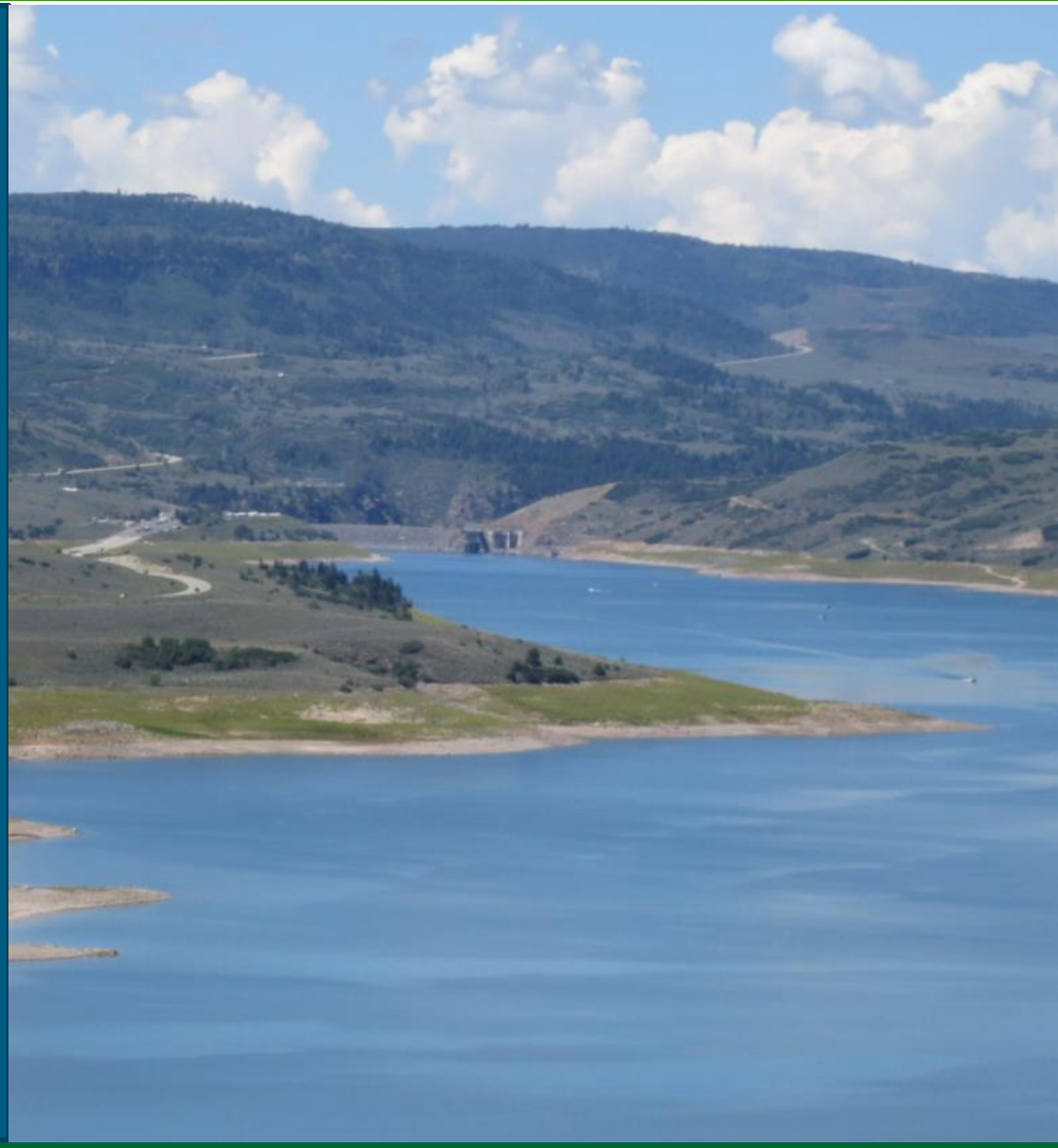
- PSH valuation tool helping the users navigate the PSH valuation process





Main Project Outcomes

- A comprehensive, transparent, consistent, and repeatable valuation methodology
- A cost-benefit and decision analysis framework that allows for valuation of both monetized and non-monetized PSH services and contributions
- Increased understanding of PSH grid value among various stakeholders (utilities and power market operators, PSH developers, regulators, etc.)
- A valuation framework which can easily be generalized and adapted for valuation of other energy storage technologies



Thank you! Questions?

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