Pacific Northwest NATIONAL LABORATORY

Long-Term Planning for Energy Storage

Dhruv Bhatnagar
Patrick Maloney
Saptarshi Bhattacharya
Abhishek Somani

Pacific Northwest National Laboratory

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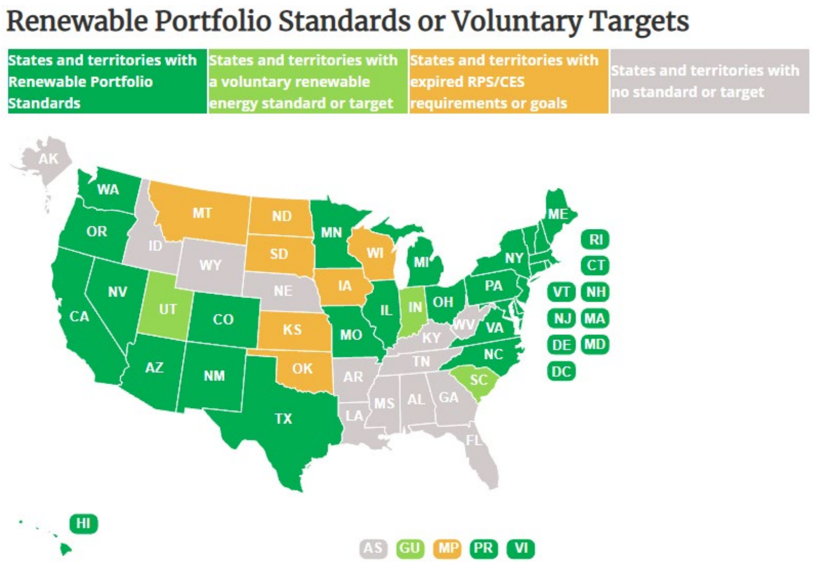
Outline

- Motivation and Need
- Modeling Approach
- Overview of FY21 Research Activities
- Case Study
- Next Steps

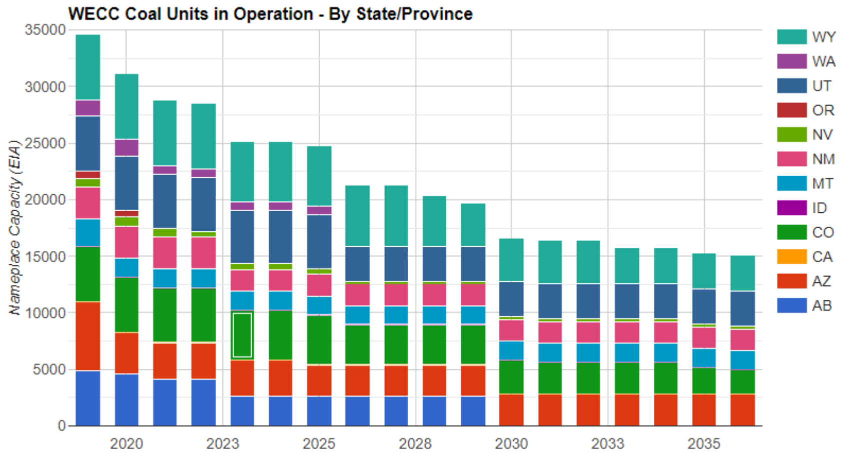
Motivation and Need

- How do we think about energy storage in the future? 2030, 2040, 2050?
  - How much storage will we need in a given system to ensure reliability as flexible generation retires and is replaced by intermittent renewables?
  - What capacity? What duration? What type of technology?
  - How do we deploy it (across time and space- where and when)?
  - What policies will ensure optimal deployment?

- What's driving the need?
  - The Biden Administration's goal to use 100% clean energy sources by 2035
  - Several states have 80% or 100% clean energy targets by 2040-2050



Source: https://www.ncsl.org/research/energy/renewable-portfolio-standards.aspx



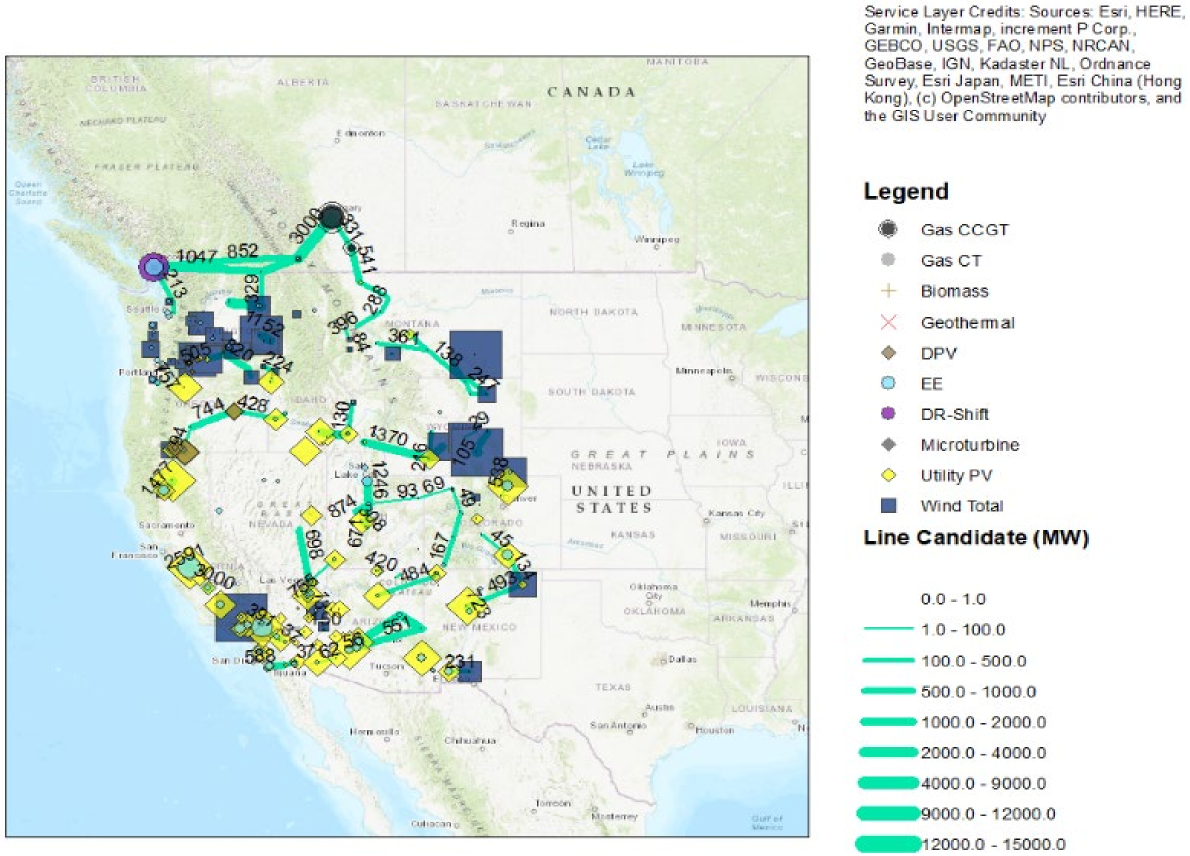
Source: https://www.nwcouncil.org/news/coal-retirements

Modeling Approach

Capacity expansion planning (CEP)

- Linear and mixed integer linear program
- Used to determining the optimal timing, size, and location of new investments (transmission and generation)
- Typical objective function: minimize cost
- Standard DC power flow

	Invested Capacity (GW) by year		
Technology	**2018**	**2024**	**2030**
Distributed PV	0.8	0.9	0.2
DR shift - New	0.0	0.0	1.5
EE - New	2.8	3.0	3.2
Gas CCGT - New	0.0	0.0	1.1
Gas CT - New	0.0	0.0	0.0
Geothermal - New	0.0	0.0	0.0
Solar PV-Distributed Utility-Fixed Tilt - New	3.7	9.5	43.1
Wind	18.6	9.4	6.2
Generation Total	25.9	22.9	55.3
Transmission	80.0	9.7	11.5



2036 cumulative generation and transmission investments

Capacity Expansion Planning

- By its nature, CEP is a complex modeling effort that requires careful consideration of trade-offs between model details and solve times

- Energy storage challenges the typical CEP formulation
  - Storage across multiple time slices (e.g. multi-day durations)
  - Multiple services (generation and transmission)

Model	Solve time	Storage representation
Intra-year time slice representation (operational setpoints per year)	Renewable capacity value implementation	End effects
Unit retirements	Representation of uncertainty	

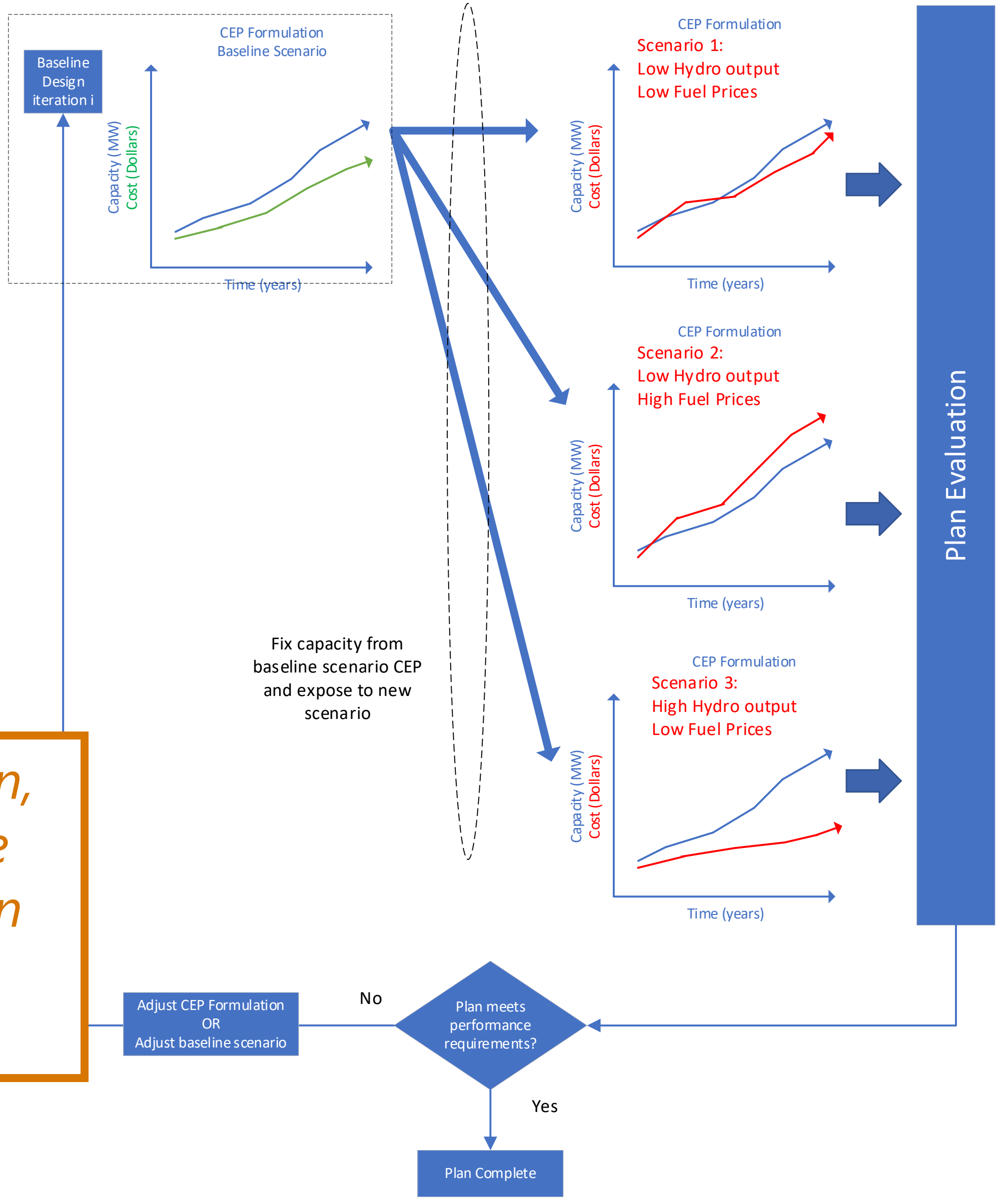
Significant CEP model features that impact investment decision such as storage

Analysis Drivers

In addition to a consideration of cost and reliability inherent in expansion modeling, we consider:

- System Resilience
- Equity of resource deployment
- Option value of resource deployment

An approach to resilience: generate plan, expose plan to uncertainties to evaluate performance, evaluate plan, and re-plan with adjusted CEP formulation or adjusted baseline scenario



Existing Efforts, Challenges and Constraints

Other expansion models have considered storage needs in a future electric system, but:

- They do not answer the question for specific jurisdictions or identify the pathway to achieve an identified future
- Existing approaches are limited by the following:
  - Inability/limited ability to model long duration storage; time horizons are too short, sometimes just several representative hours in each year (chronological order of hours is not maintained)
  - Often zonal models that identify needs only in broader regions
  - Limitations on exploration of questions beyond lowest cost objective

Comparison Across Models

Feature	ReEDS	GridPath	ISU CEP
Model	Contiguous US 134 balancing authorities 17 time slices per year Simulation years (configurable)	Three bus test system	300 buses 12 time slices per year (configurable) Simulation years (configurable)
Cited Solve Times on base model	Deterministic Low foresight: 3-5h Deterministic Perfect Foresight: 48-72h	Three bus test system solves in < 1 second	Perfect foresight deterministic < 5 mins Perfect foresight stochastic/adaptive 8 scenario: 6-8h
Storage Representation	Included	Included	Not included
Intra-year time slice representation	16 characteristic, 1 peak (hours are averaged conditions)	Extremely flexible (User configures hours and balancing horizons for storage)	11 characteristic hours 1, peak hour (hours are actual conditions)
Renewable Capacity Value Varies with Penetration	Yes	No	No
End Effects	?	Operational costs weighted more heavily in last year.	Last year of planning horizon weighted as 30 years of operations.
Existing unit retirements	Base model is exogeneous	Options for exogenous and endogenous	Exogeneous
Uncertainty Representation	No	No	Yes (stochastic programming, adaptive programming)
Linux Compatible (Required for HPC applications)	No	Yes	Yes

FY21 Research Activities

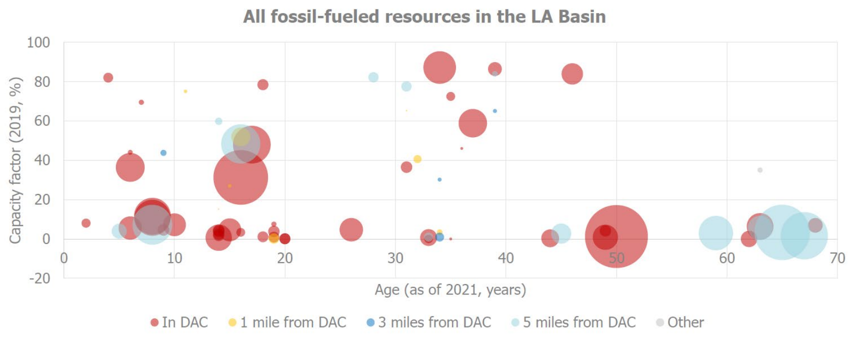
- Identified a set of available capacity expansion models, evaluating advantages, disadvantages and tradeoffs
- Developed initial datasets (toy models) to consider storage modeling parameters
- Identified real use cases for further analysis and began data and assumptions collection
  - LA Basin natural gas peaker replacement in partnership with Strategen Consulting
  - Oregon and Washington storage requirements for future clean energy needs
- Developed a *draft* Expansion Planning Methodology Report that lays out analyses and variables of interest and a path forward

Case Study: Energy Storage to Replace Peaker Plants in Disadvantaged Communities

- The LA Basin has a unique opportunity for storage
  - California has ambitious energy and environmental goals that will require reduced dependence on fossil infrastructure
  - The Los Angeles Basin currently relies on 7.5 GW of low-capacity factor fossil peaking resources that could be replaced by storage
  - Due to other emergent issues, the CPUC is not able to study this opportunity unless there is a credible case for fossil fuel plant replacement

Inputs & Assumptions

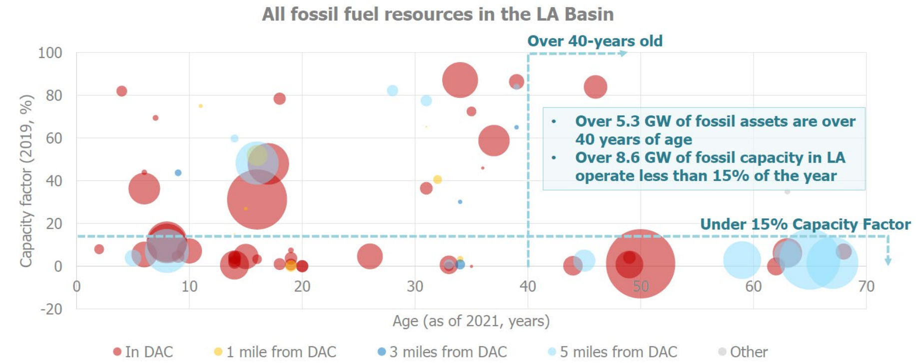
Nearly all of the fossil assets in the LA Basin are within 5 miles of a disadvantaged community



99.5% of the installed capacity within the LA Basin is at least 5 miles away from a DAC

Inputs & Assumptions

Over 8.8 GW of capacity could be retired due to age or capacity factor



8.8 GW fulfill at least one of these criteria, 5.1 GW fulfill both criteria

Next Steps

- Continue to develop expansion planning capabilities for modeling the deployment of energy storage; incorporating
  - Inputs from Joint Global Climate Change Research Institute's GCAM (Global Climate Adaptation Model) multi-sectoral market equilibrium model
  - PNNL research on offshore wind, marine energy, electric vehicle integration, hydropower transmission planning
- Support system studies of storage deployment
  - LA Basin Peaker replacement
  - Oregon and Washington storage needs to meet clean energy targets
- Evaluate alternative approaches to identifying future storage needs

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Mission – to ensure a resilient, reliable, and flexible electricity system through research, partnerships, facilitation, modeling and analytics, and emergency preparedness.

https://www.energy.gov/oe/activities/technology-development/energy-storage

Thank You

Dhruv Bhatnagar
dhruv.bhatnagar@pnnl.gov

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