Transformation of the Electric Industry: A Primer on Battery Energy Storage

APA Annual Meeting

August 22, 2019

Tom Binet
Sr. Economist, Power, Energy and Water
CoBank's Knowledge Exchange Division

Proud Member of the Farm Credit System

Executive Summary

The Value of BESS

- While batteries can fulfill a wide array of needs, an individual BESS is typically designed and used for just 1 - 3 tasks on a system;
- As the technology matures and costs decline, batteries will likely displace traditional resources in many geographies.
- Cost declines of Li-ion batteries are non-linear due to volatility in materials, etc.;
- International EV demand drives battery prices and tech. advancements; and
- Li-ion batteries dominate the market, but are not the only solution.

Risks in Context

- Technology risk is real, widespread, and includes balance of plant elements; and
- Such risk can generally be mitigated from the outset with skilled input from your legal and financial resources.

Alaskans Leading

- Many utilities in AK are proving to the world what is possible in remote microgrids;
- Their customers are benefitting from their leadership through improved reliability, less environmental harm, and even net cost savings in some areas.

Over time, the value of BESS nationwide are *generally* expected to rise as the costs and risks diminish.

CoBANK

Today

Rising Benefits

Enables a few GW of RE resources to be semi-dispatchable.

+

RE + batteries to be the cheapest dispatchable resource in most markets.

+

Utilities won't have to balance supply and demand simultaneously.

+

> 40% of U.S. power to come from low-cost RE + storage?

Falling costs & risks

Installed battery costs remain above those of traditional gen. in some markets.

+

The technology is partially reliant on federal and state policies.

+

Risk of using a relatively untested technology.

+

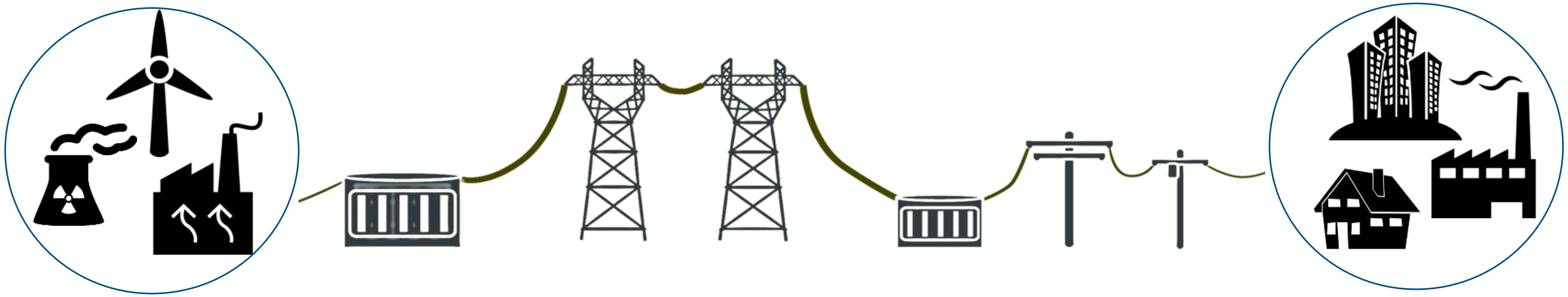
Possible supply chain disruption, preventing further battery deployment.

2030s?

Where We are Today

(*aside* from Juneau)

While BESS' have a broad range of potential uses, they are usually designed to provide 1-3 services consistently.



Generation

- Renewable Smoothing, Time Shifting, Backup
- Replace Gas Peaker Plants
- Energy Market Arbitrage
- Frequency Regulation
- Spinning/Non-spinning Reserves
- Voltage Support
- Black Start

Transmission

- Peak Efficiency Operation
- Congestion Relief
- Deferral / Avoidance of Transmission Infrastructure Investment

Distribution

Front-of-Meter

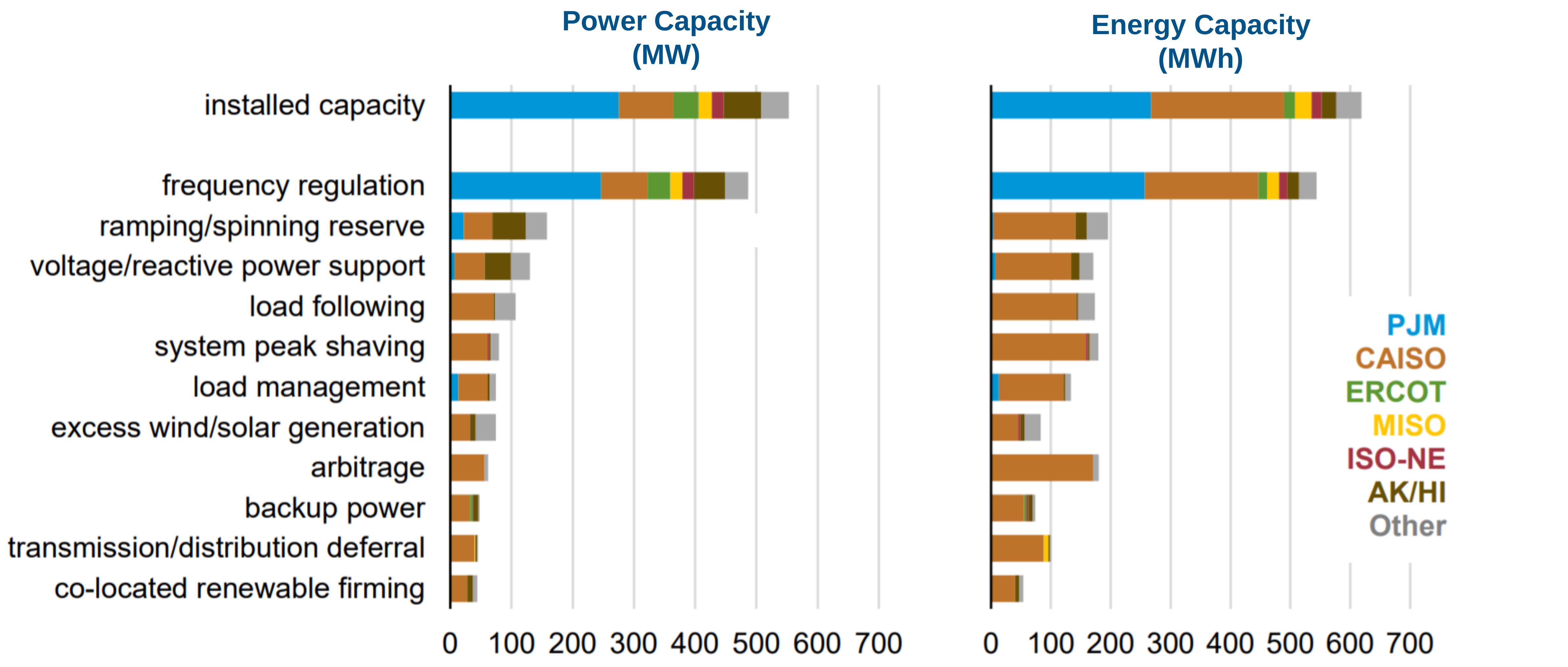
- Infrastructure Deferral and Avoidance
- Demand Management
- Managing Two-Way Current Flow

Behind-the-Meter

- Demand Charge Reduction
- Demand Response
- PV Mgmt.
- Virtual Power Plants
- Back-up Power
- Customized Micro-grid Services

Historically, U.S. front-of-the meter BESS' have mainly helped with frequency regulation in PJM and California.

Applications Served by U.S. Large-Scale Battery Storage (2016)



Source: EIA, Knowledge Exchange Division, CoBank, ACB (confidential and proprietary)

BESS has come to dominate the storage market among electric utilities, C&I facilities, and residential customers.

Annual Energy Storage Additions in the U.S. by Segment and Technology: 2013–2018

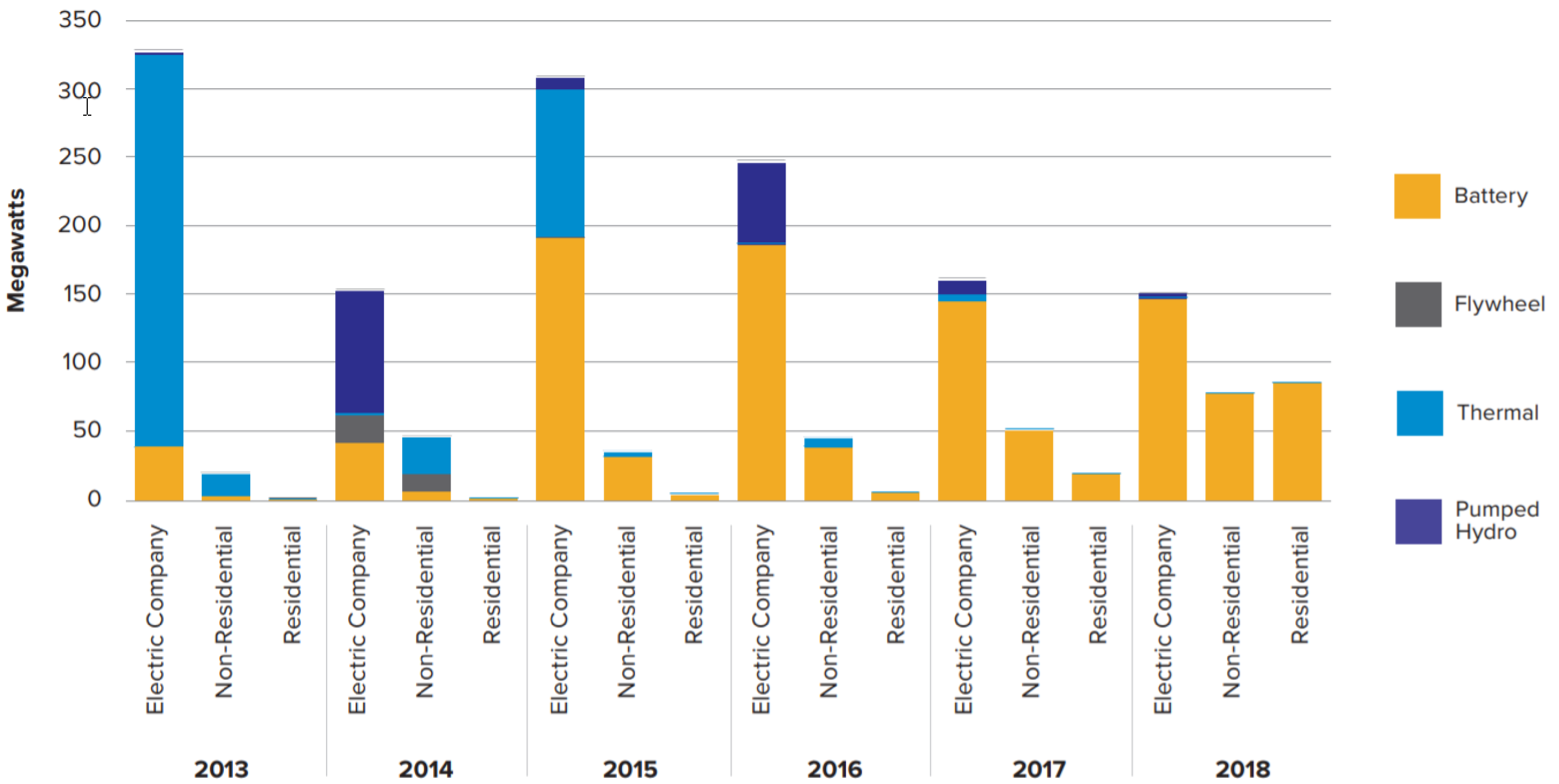
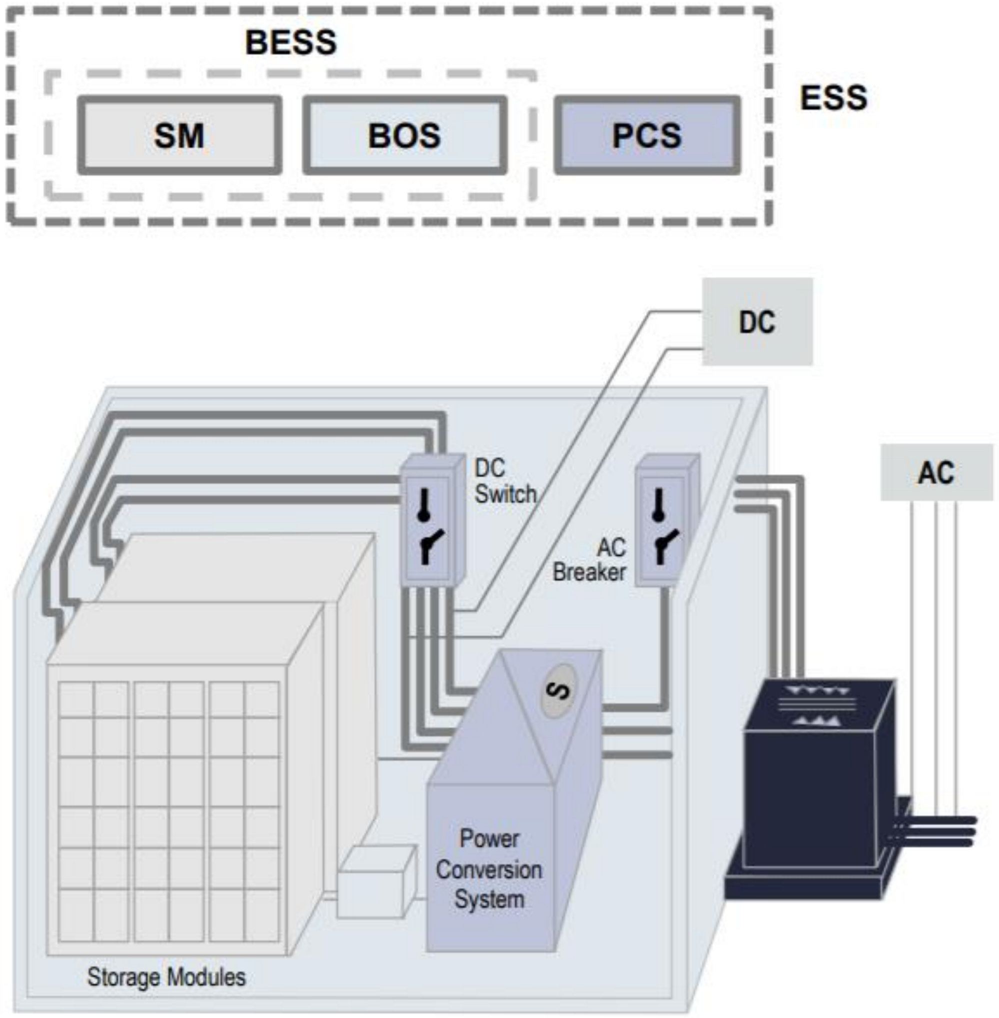


Chart source: EEI

Installed BESS costs are driven by an array of physical and non-physical inputs…

Physical Energy Storage System



System and Cost Components

System Layer		Component
SM	Storage Module	• Racking Frame/Cabinet • Battery Management System ("BMS") • Battery Modules
BOS	Balance of System	• Container • Monitors and Controls • Thermal Management • Fire Suppression
PCS	Power Conversion System	• Inverter • Protection (Switches, Breakers, etc.) • Energy Management System ("EMS")
EPC	Engineering, Procurement & Construction	• Project Management • Engineering Studies/Permitting • Site Preparation/Construction • Foundation/Mounting • Commissioning
Other (not included in analysis)		• SCADA • Shipping • Grid Integration Equipment • Metering • Land

…and the cost of each of those inputs have fallen rapidly in recent years.

Historical Decrease in BESS Component Costs ($/kWh)

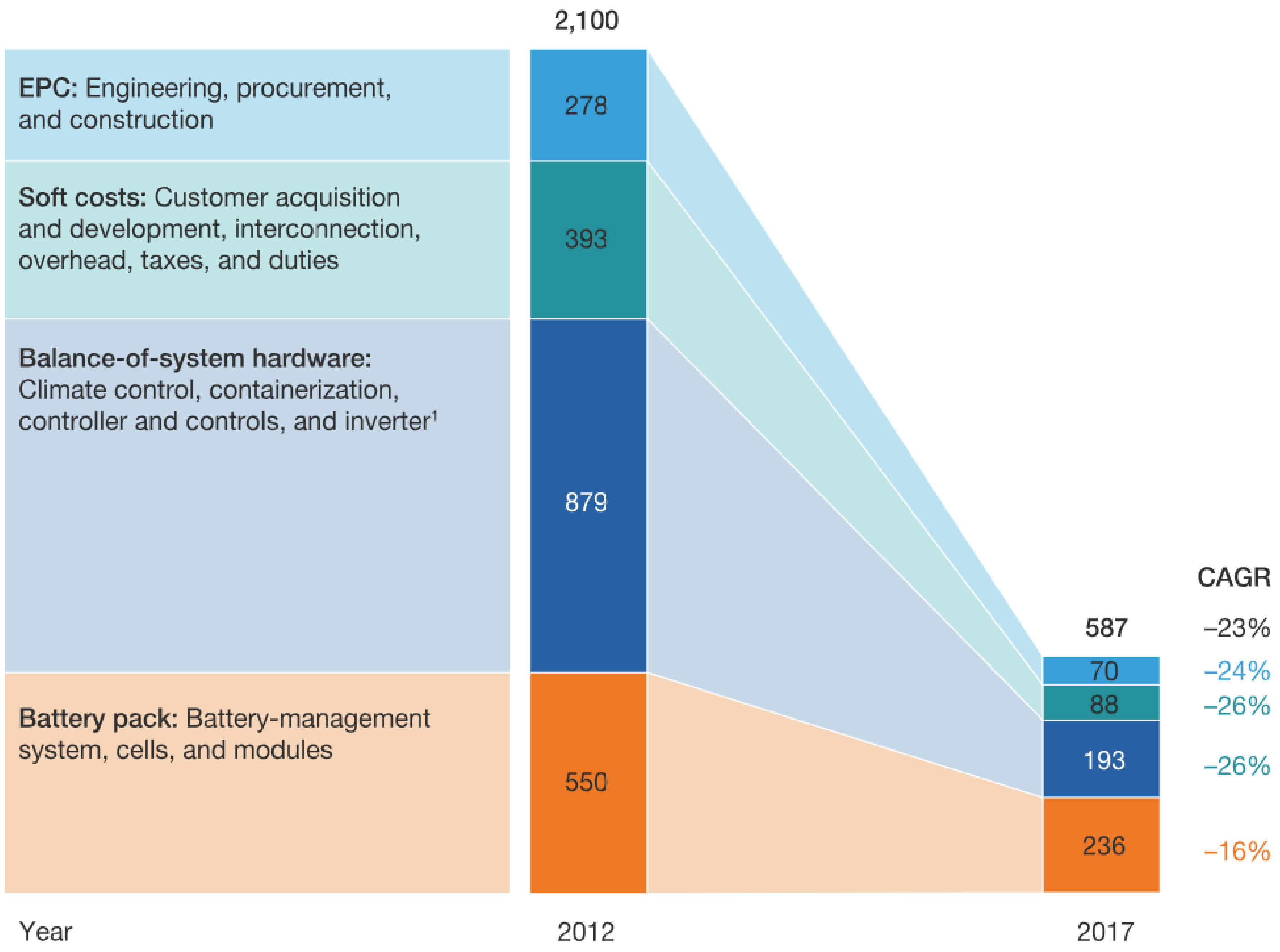
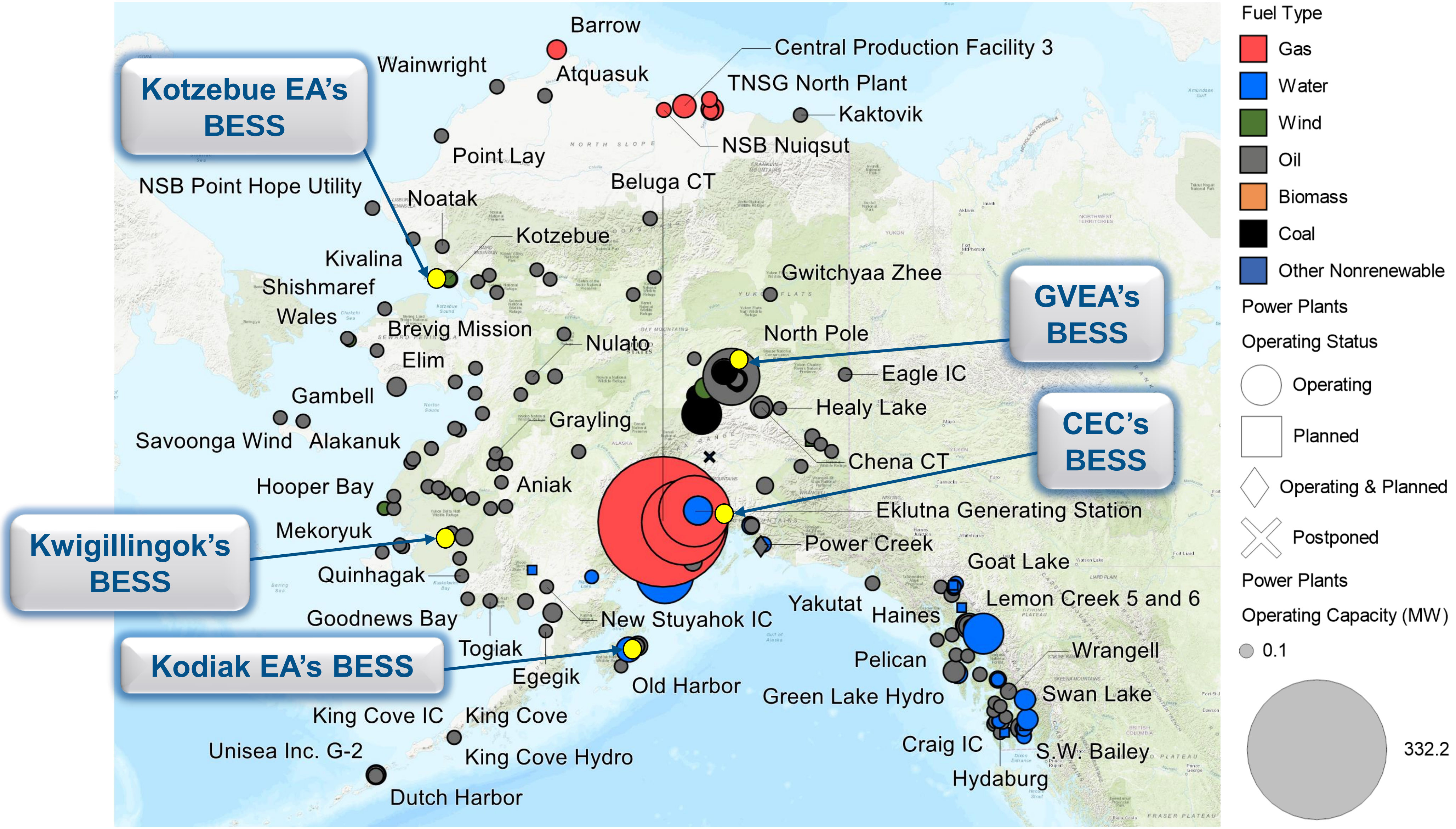


Chart source: GTM Research; McKinsey analysis

Alaska Continues to Forge its Own Path Forward

Alaska has a wide variety of installed capacity, including world-class BESS installations.



GVEA's Standalone BESS built in 2003; this was the largest BESS in the world for several years.

CoBank

Background on the Facility

- Type: Nickel-Cadmium (Ni-Cad) batteries, developed by Saft in Sweden. ABB provided the primary design and controls.
- Size: 25 MW for 15 minutes (up to 46 MW for 5 minutes).
- Purpose: Commissioned in 2003, it gives GVEA time to start local generators when there are problems with the intertie or generators in Anchorage or Fairbanks.

Facility Performance

- Reliability has been greatly improved in a cost-effective manner. The alternative solution would have cost $10 million per year.
    - **In 2018, the BESS responded to 59 events, preventing a total of 309,009 member outages.**
- The BESS is occasionally used for peaking and voltage reg.

Lessons Learned

- Understand exactly what performance characteristics you need from your BESS; have a well-written RFP that explains that need.
- Be open to working with partners; EPRI and Sandia Nat'l. Labs helped to refine the project scope and functionality.

GVEA's 25 MW BESS

Kodiak Electric's use of wind, hydro, BESS and flywheels has directly enabled the local fishing industry.

Background on the Facility

- Purpose: When Kodiak's electric crane is operating and when wind output dips, a flywheel provides instantaneous power needed while their hydroelectric facility gets up to speed. When the crane isn't operating, the Li-ion batteries bridge the gap between the wind and hydro output.
- KEA first installed lead acid batteries in 2012, but replaced those with Li-ion batteries in 2017.

Facility Performance

- The Li-ion batteries have worked beautifully in all conditions despite some initial growing pains.

Lessons Learned

- Design the system and supporting contracts around the 1-3 core uses you foresee.
- Work with highly-experienced, reliable vendors to ensure that they'll be around if/when you need them.

Kodiak Electric Association's 3 MW BESS

Sources: Darron Scott, President and CEO, Kodiak Electric Association; Image from PV-Magazine-USA.com

Cordova Electric's recently installed BESS will reduce unused hydro power while nearly paying for itself.

Background on the Facility

- Purpose: Provide what amounts to additional spinning reserve, enabling CEC to open its hydro deflectors fully, avoiding hydro spillage.

Facility Performance

- The BESS will almost pay for itself.
    - Projected annual BESS cost = $170k;
    - Projected annual avoided costs = $150k;
- After the first ten years, the BESS will provide significant net savings on fuel and other costs.
- The communications between the BESS, inverter and other critical equipment were initially troublesome.

Lessons Learned

- With the right team, BESS can be deployed and begin operating within two months.
- Understand the critical use cases.
- Know your vendors, know your technologies, and talk to those who've already installed them.

CEC's 1 MW BESS

Connexus Energy's (MN) 10 MW solar PV + 15 MW BESS facility shifts inexpensive supply to meet their peak.

Background on the Facility

- Connexus Energy is the largest member-owned utility in MN, serving ~35,000 homes and businesses.
- Purpose: Since coming online in December 2018, the two-site project has periodically delivered solar energy during the evening peak, albeit with just a few cycles per month.

Facility Performance

- The batteries, specifically, have performed better than anyone expected.
- The system's inverters have proven troublesome.
  - NextEra, the project developer, has been working diligently to address the issues.

Lessons Learned

- Work with well-established technology vendors and developers and obtain a system-wide warranty that isolates your utility and customers from any technology risk.

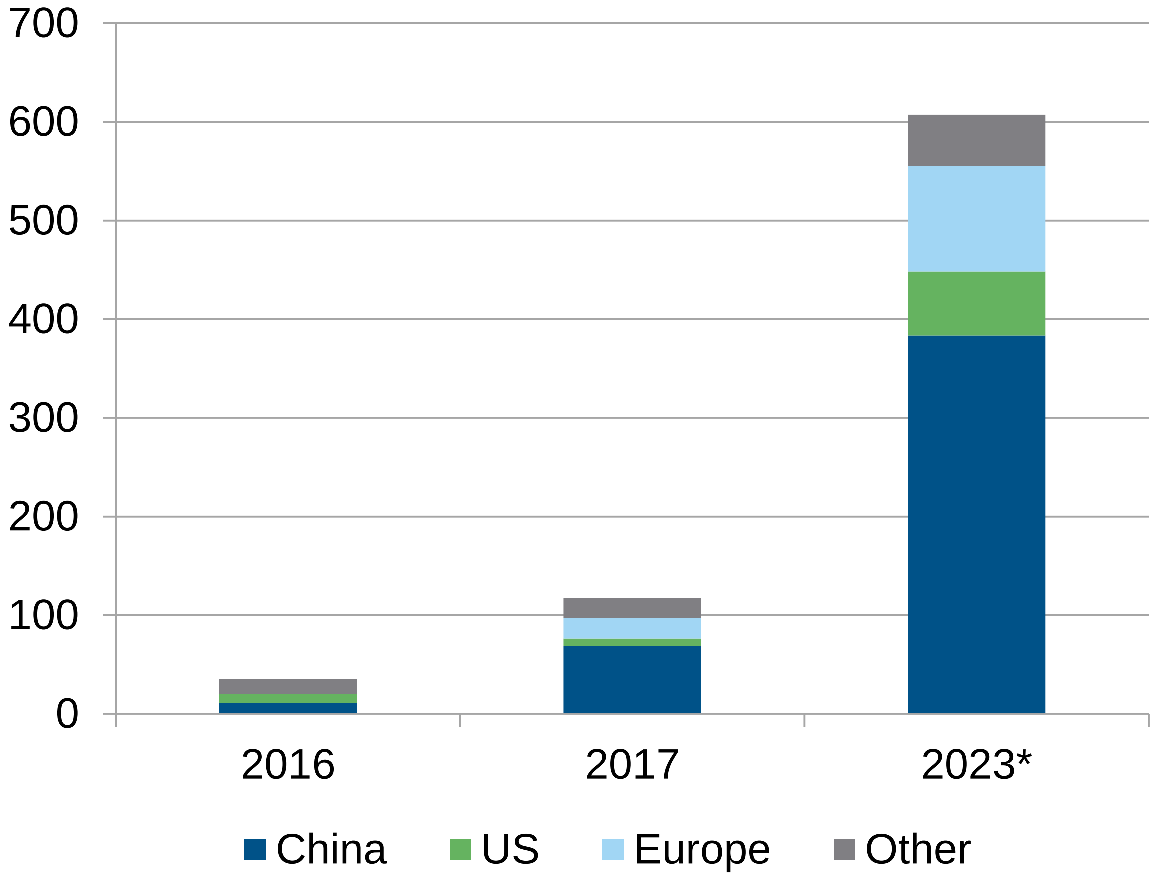
Connexus Energy's 6 MW BESS

Sources: Brian Burandt, VP of Power Supply, Connexus Energy; Image from Finance-Commerce.com

National Outlook on the Economics of BESS

Barring supply and/or trade disruption, Li-ion battery prices will fall as manufacturing capacity rises.

Li-ion Annual Battery Manufacturing Capacity (GWh)



On-going Trade Dispute with China

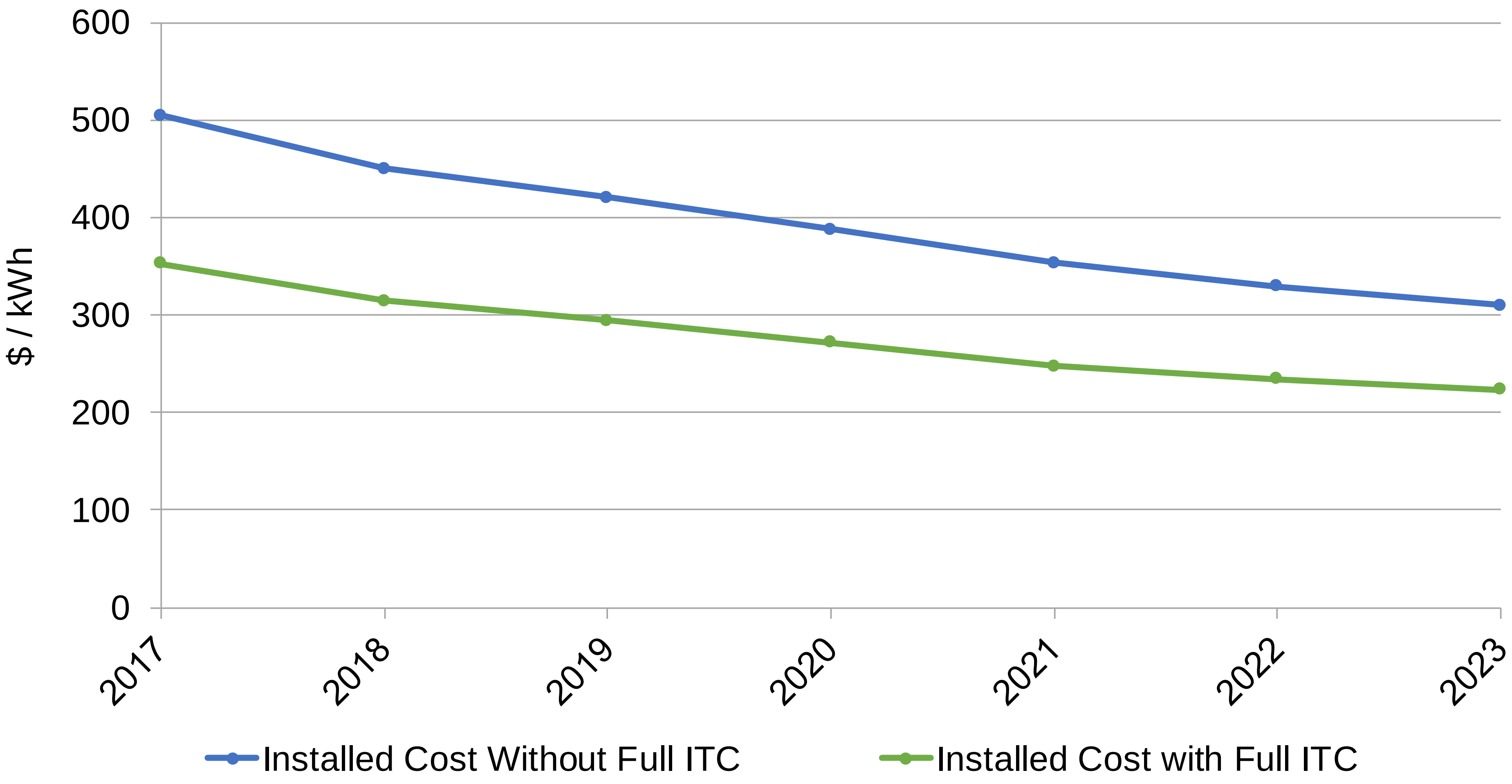
- Four tranches of tariffs under the Section 301;
- Third tranche: 10% duty from Sep 24, 2018, 25% duty from May 2019 on inverters;
- Fourth tranche would include Li-ion batteries (25% duty) – frozen on June 29, 2019 pending further discussions between US/China;
- Up to 15% price increase in 4-hour systems;
- Would offset much of the ITC's benefit, in the near term, hampering deployments of PV + BESS projects.

Sources: NREL, EIA, 2018

Average installed costs for BESS are projected to reach $310/kWh by 2023 without the ITC.

CoBank

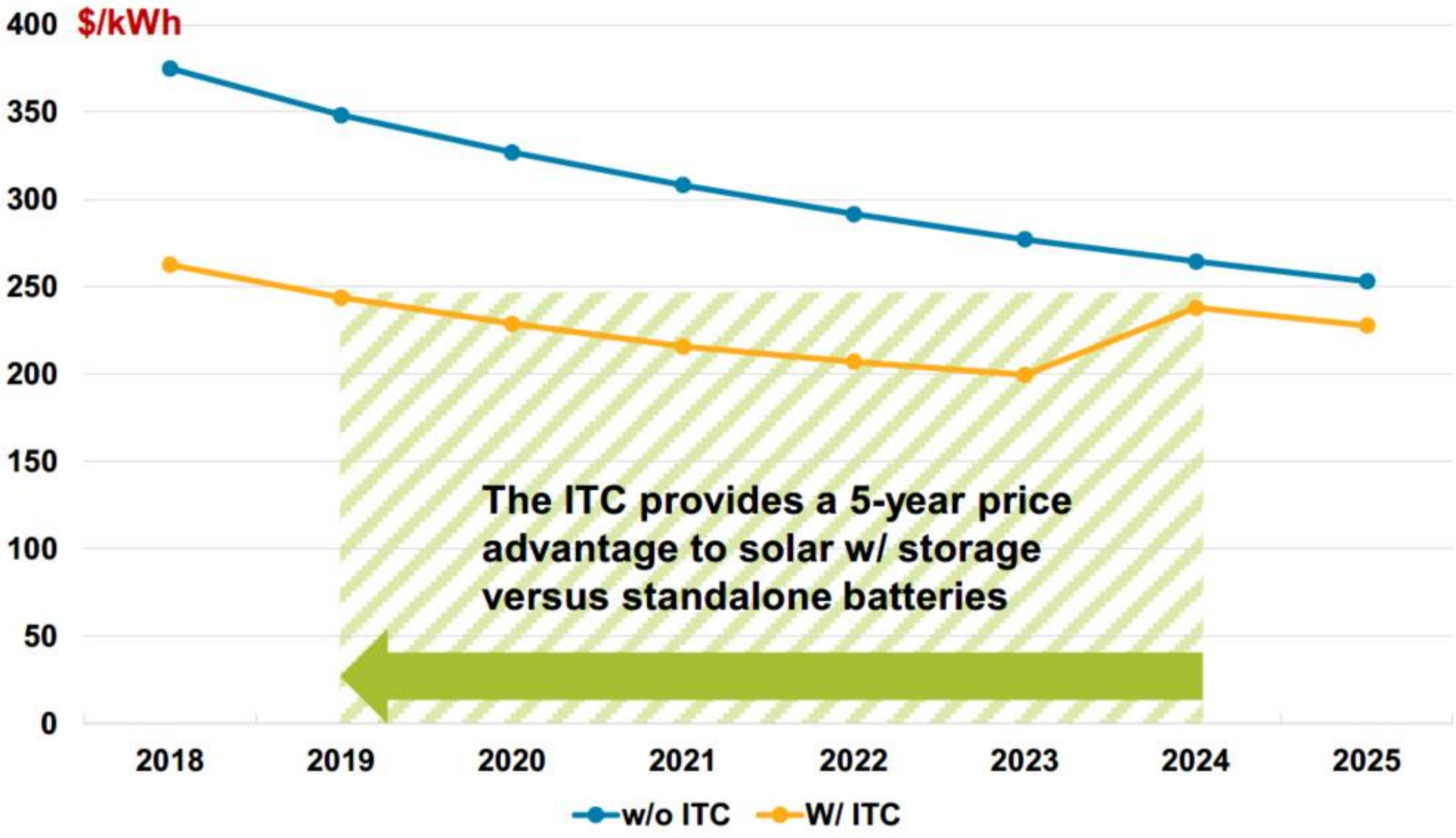
Lithium-ion BESS Installed Cost Curve: Large-scale BESS with 4-hour Duration



Source: S&P Global Platts

The ITC will provide PV + BESS with a cost advantage over standalone BESS through 2024.

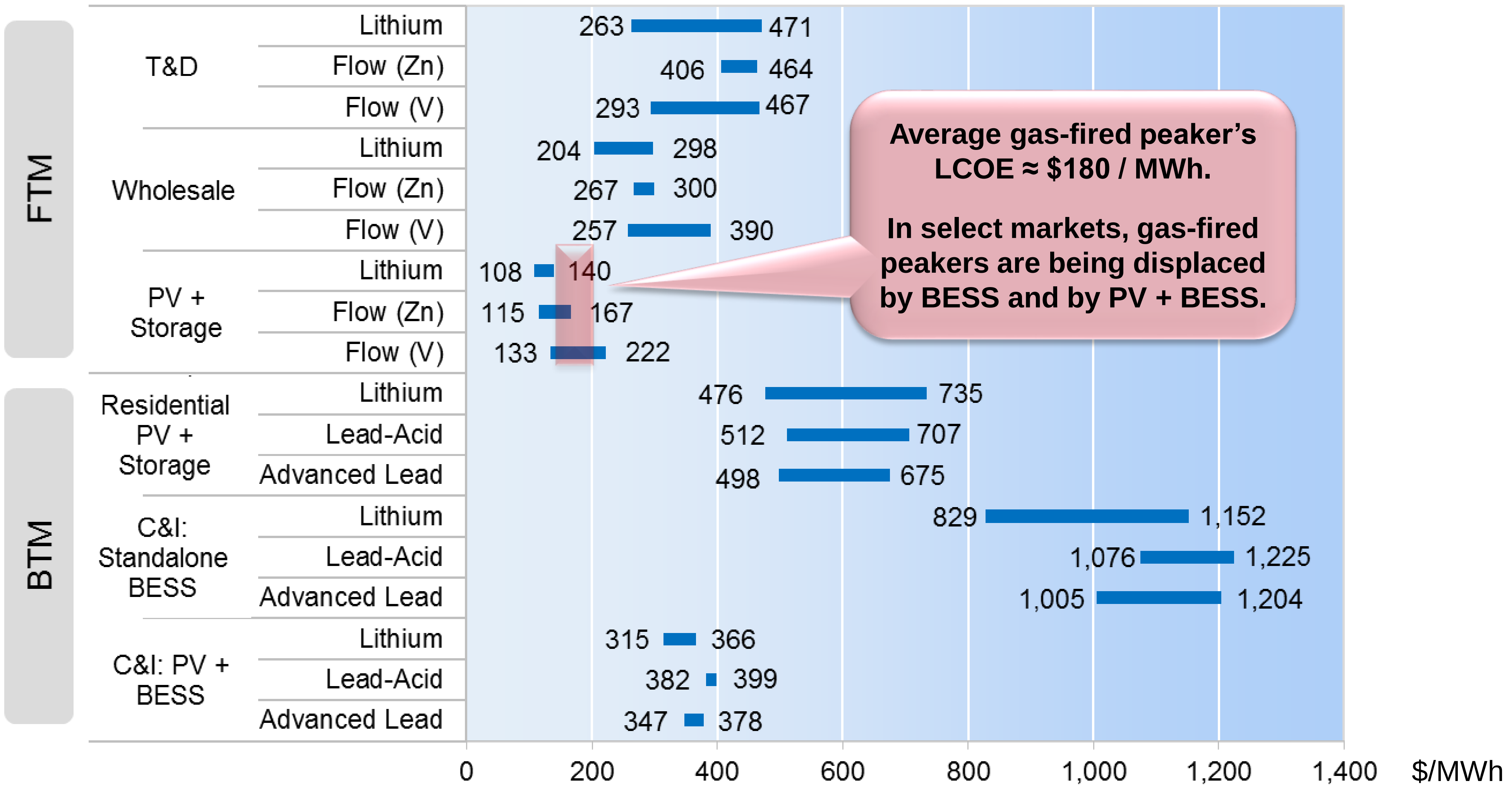
Projected Median Installed Cost of Solar PV + 4-hour BESS with / without the ITC



Sources: S&P Global Platts

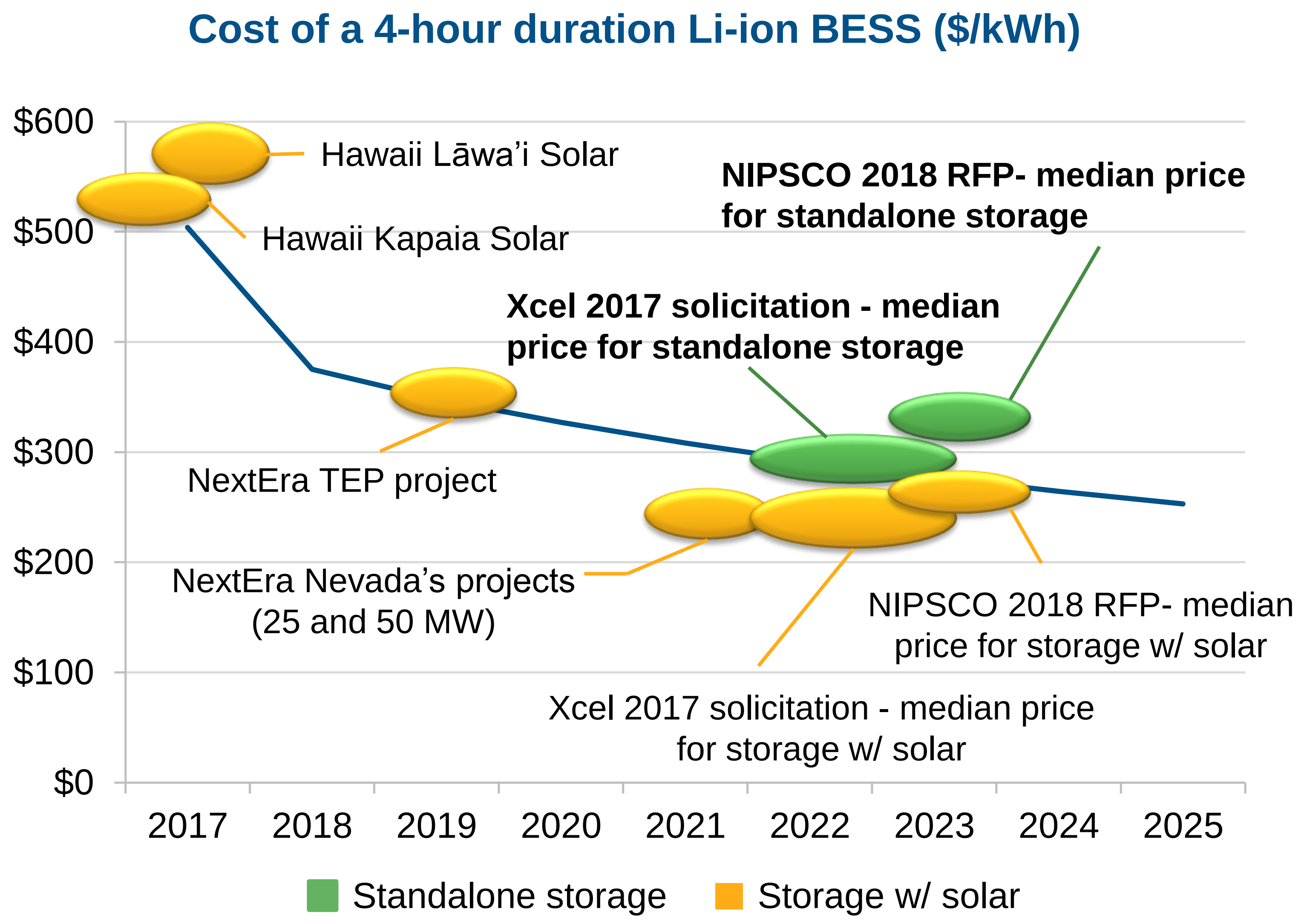
In the U.S., AUS, GER, and the U.K., the *levelized* cost of storage are falling…gas-fired peaker developers beware.

Levelized Cost of Storage: 2018 Survey of Project Developers, Integrators, and Vendors



Sources: Lazard LCOS 4.0, LCOE 12.0

Recent procurements for standalone BESS and solar PV + BESS show a decline in costs.

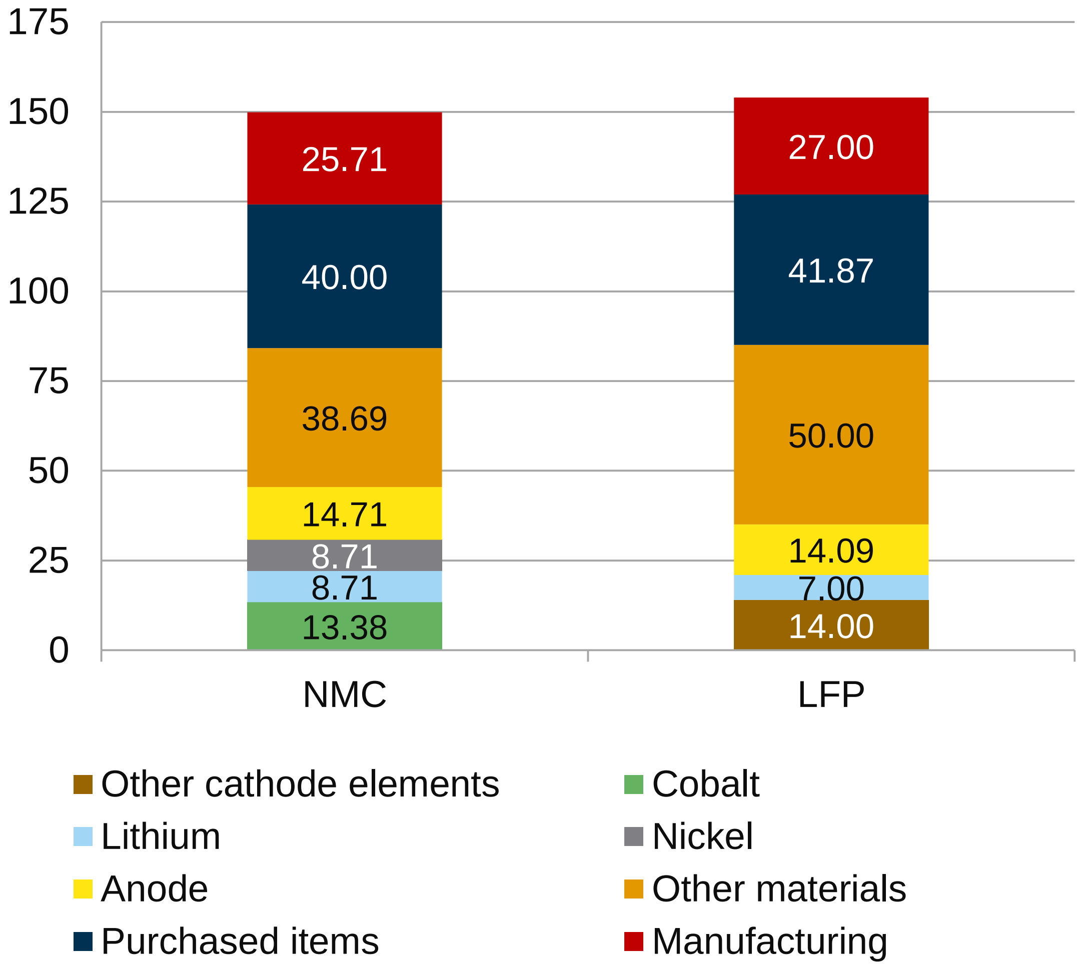


Sources: S&P Global Platts

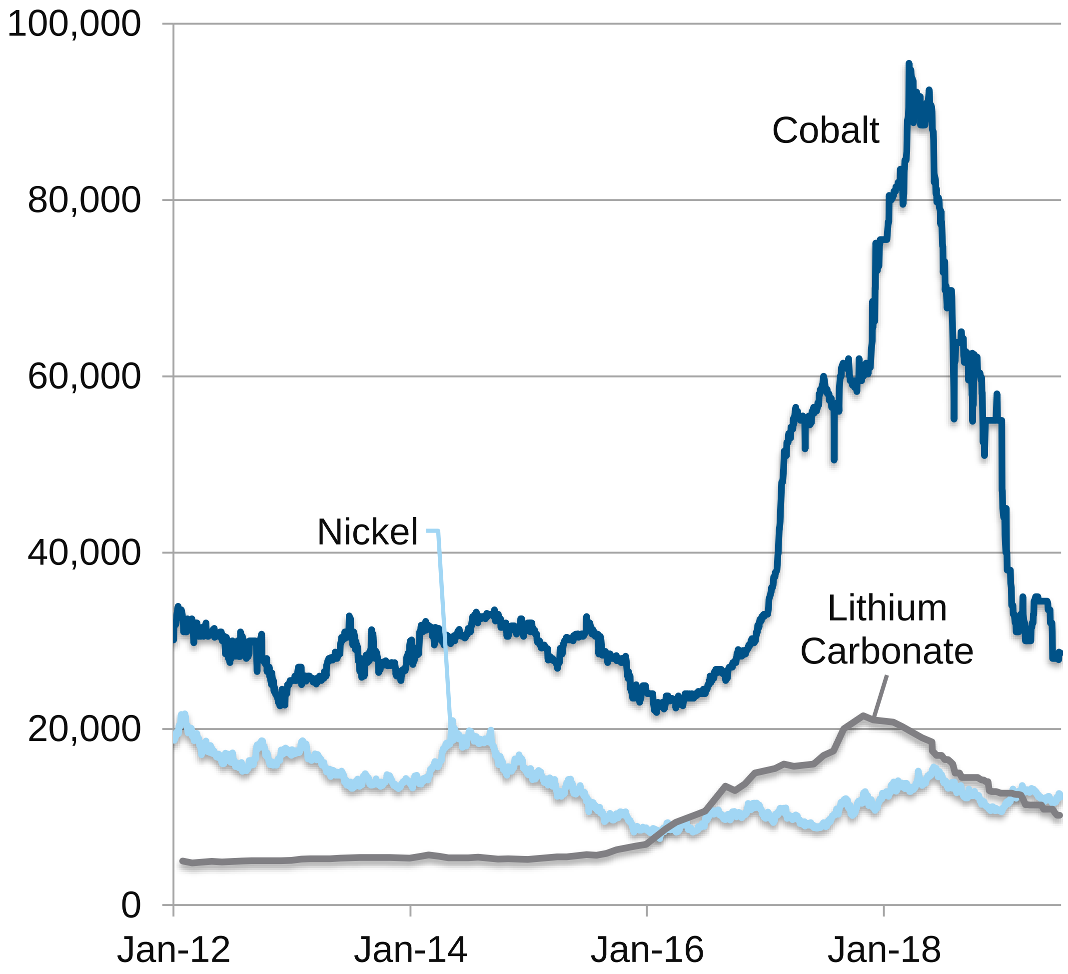
Putting the Potential Risks of BESS in Context

With key materials equal to ~10% of a Li-ion battery's cost, supply/demand imbalance could hamper deployment.

Battery module price breakdown ($/kWh)



Pricing of Key Li-Ion Battery Metals ($/lb)



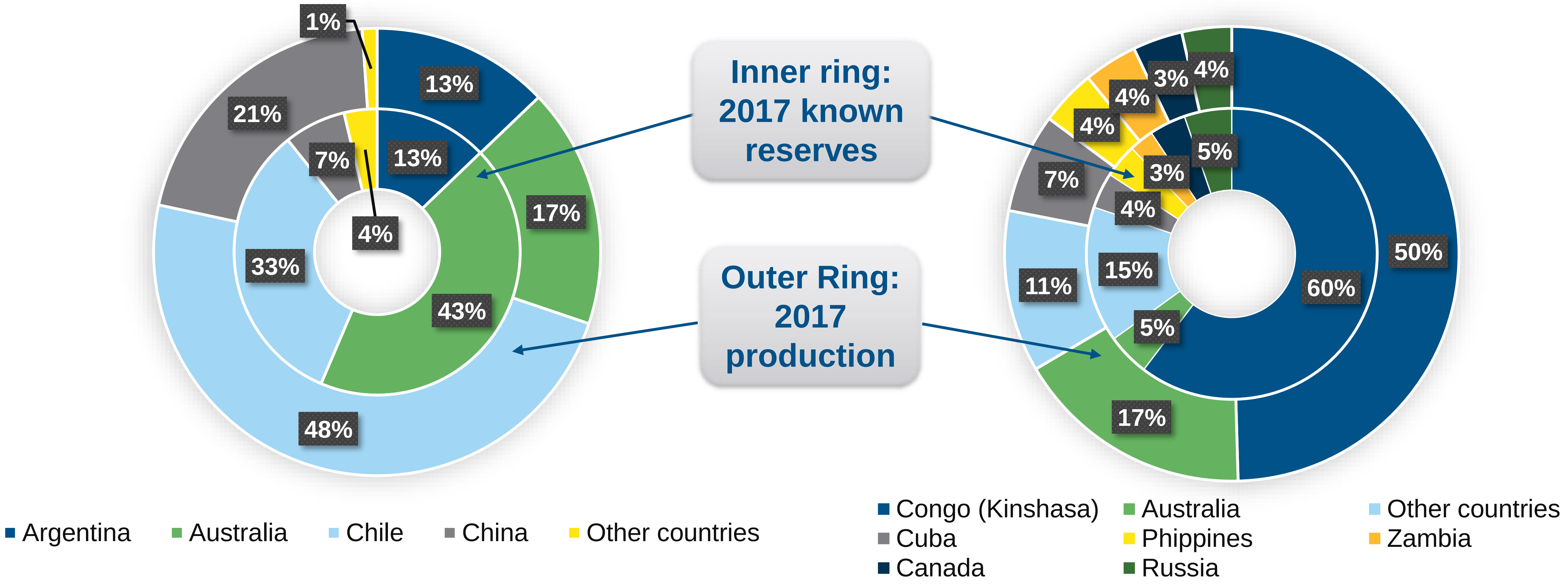
Sources: Platts

Over the long term, Li and cobalt supply risk stems mainly from potential geopolitical and humanitarian concerns.

- **As of 2017, we had mined < 5% of the known lithium reserves and < 10% of the known cobalt reserves.**
- Lithium supply disruption could arise from environmental concerns in Chile related to mining practices.
- Cobalt supply disruption could arise from humanitarian concerns in the Democratic Republic of Congo.

Global Sources of Lithium Supply

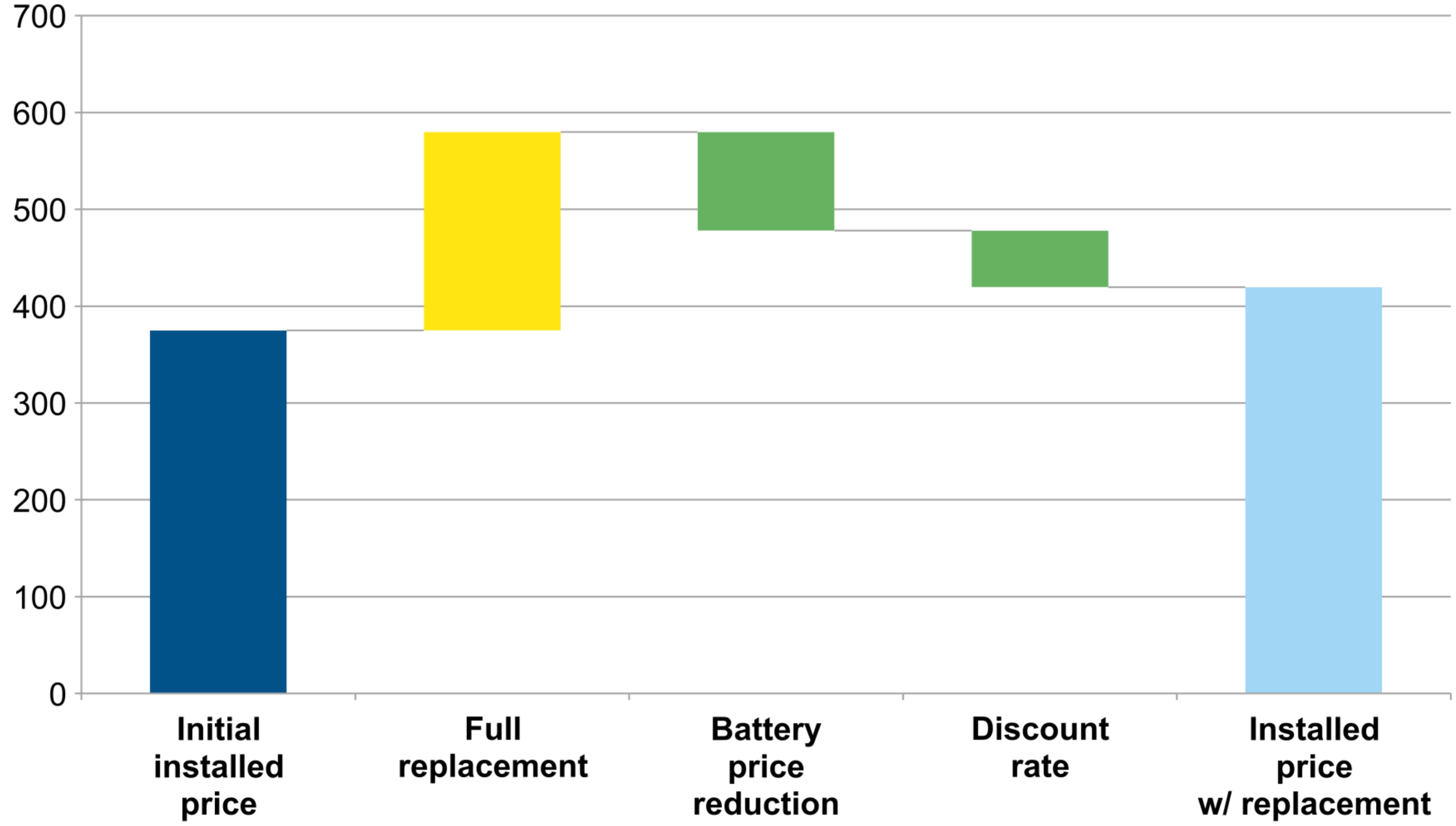
Global Sources of Cobalt Supply



Sources: U.S. Geological Survey

With proper planning, the cost of replacing a Li-ion battery after 10 years of operation can be manageable.

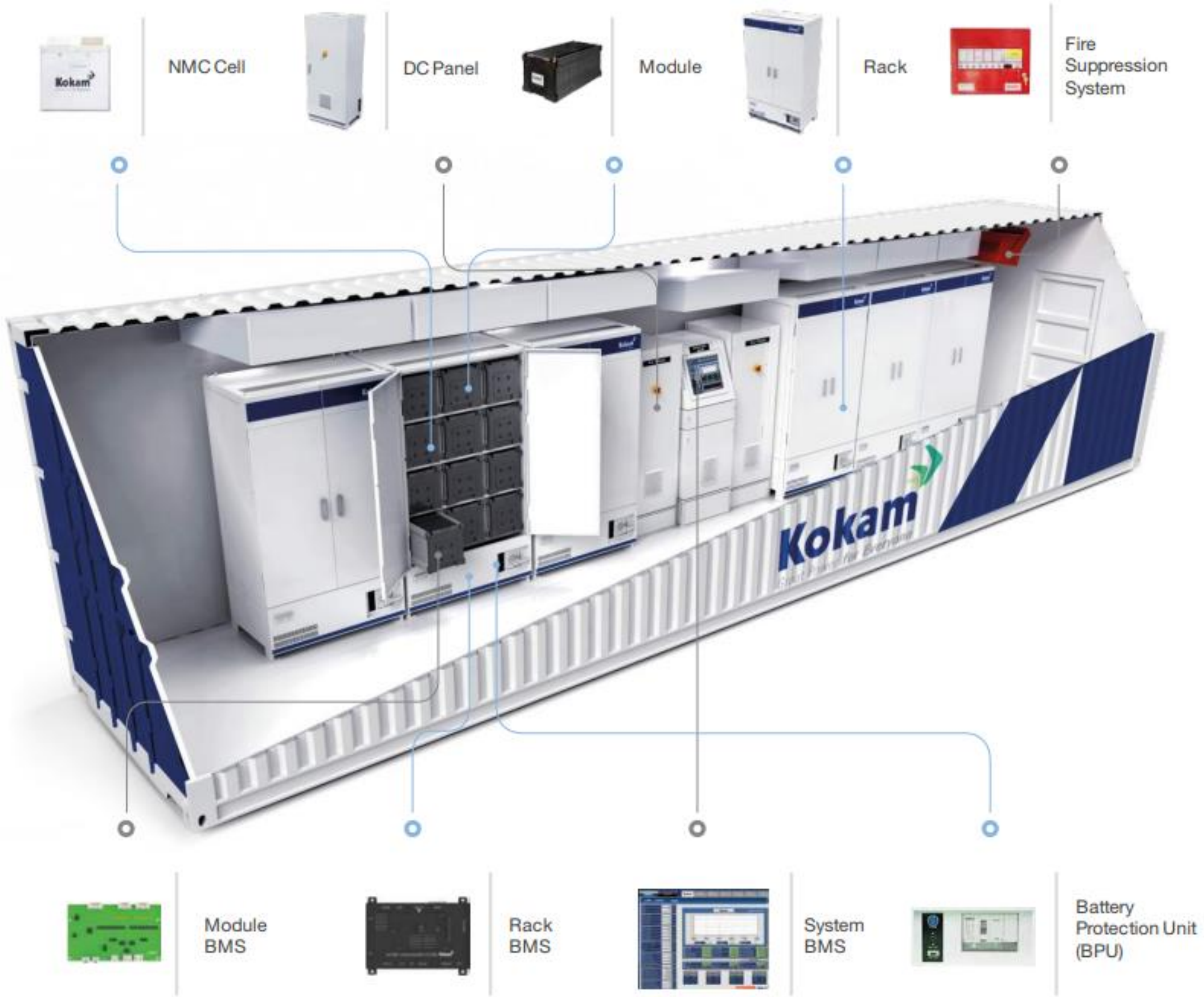
Impact of Replacement Cost on Li-Ion Batteries



Sources: S&P Global Platts

Much of the technology risk associated with BESS can be contained, both physically and contractually.

- Containerized BESS can be quickly deployed, expanded, and/or replaced.
- This capability makes BESS suitable for a variety of environments.



Sources: Kokam

Alaska's Offshore Wind Resource

The latest offshore wind resource assessment for Alaska shows an enormous resource, with caveats.

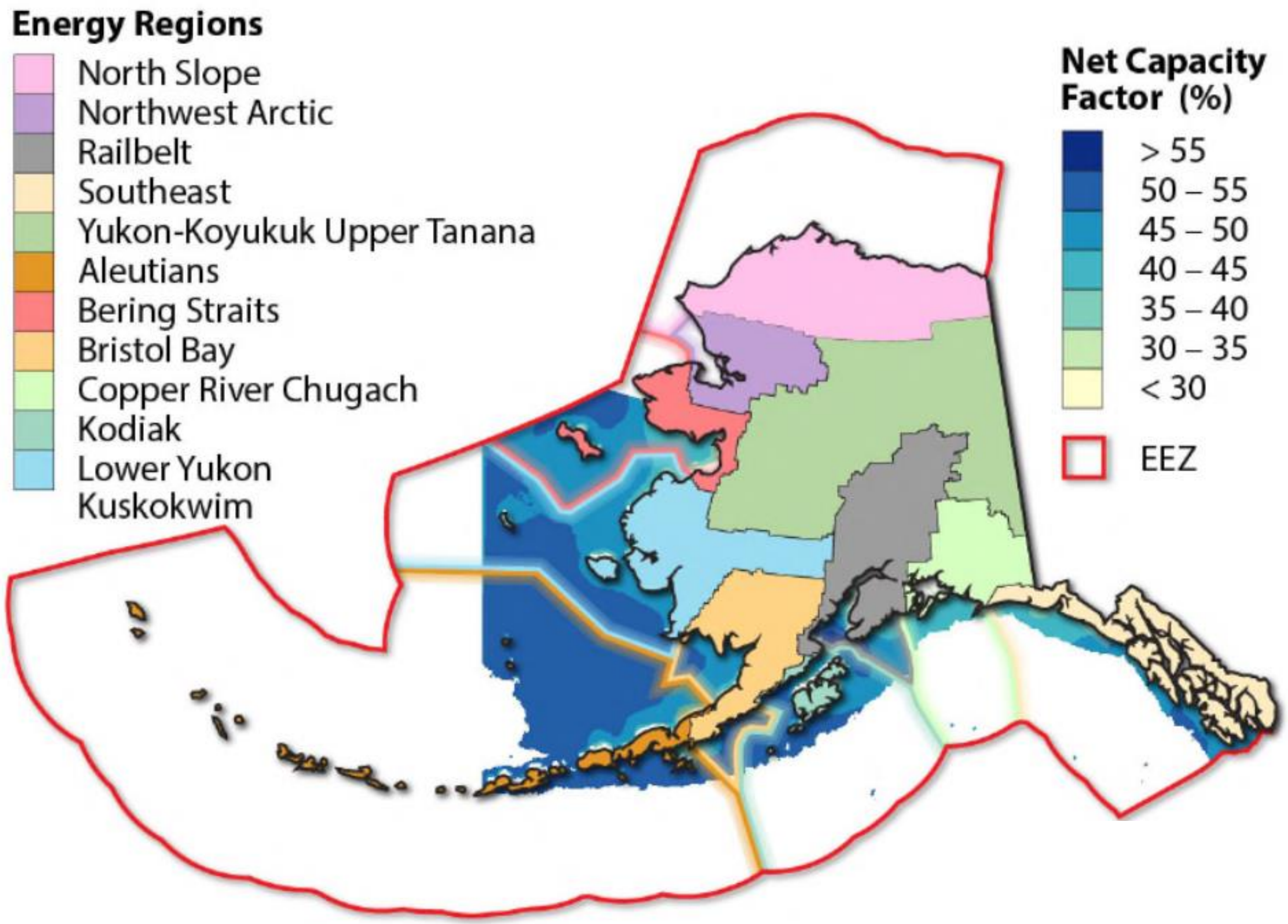
Takeaways from NREL's Report

*"The technical offshore wind resource area in Alaska is **larger than the technical offshore resource area of all other coastal U.S. states combined.**"*

"Alaska has a net offshore wind energy potential that is 68% higher than that of all other states combined."

*"Despite the abundant wind resource available, **significant challenges inhibit large-scale offshore wind deployment in Alaska,** such as the remoteness of the resource, its distance from load centers, and the wealth of land available for onshore wind development."*

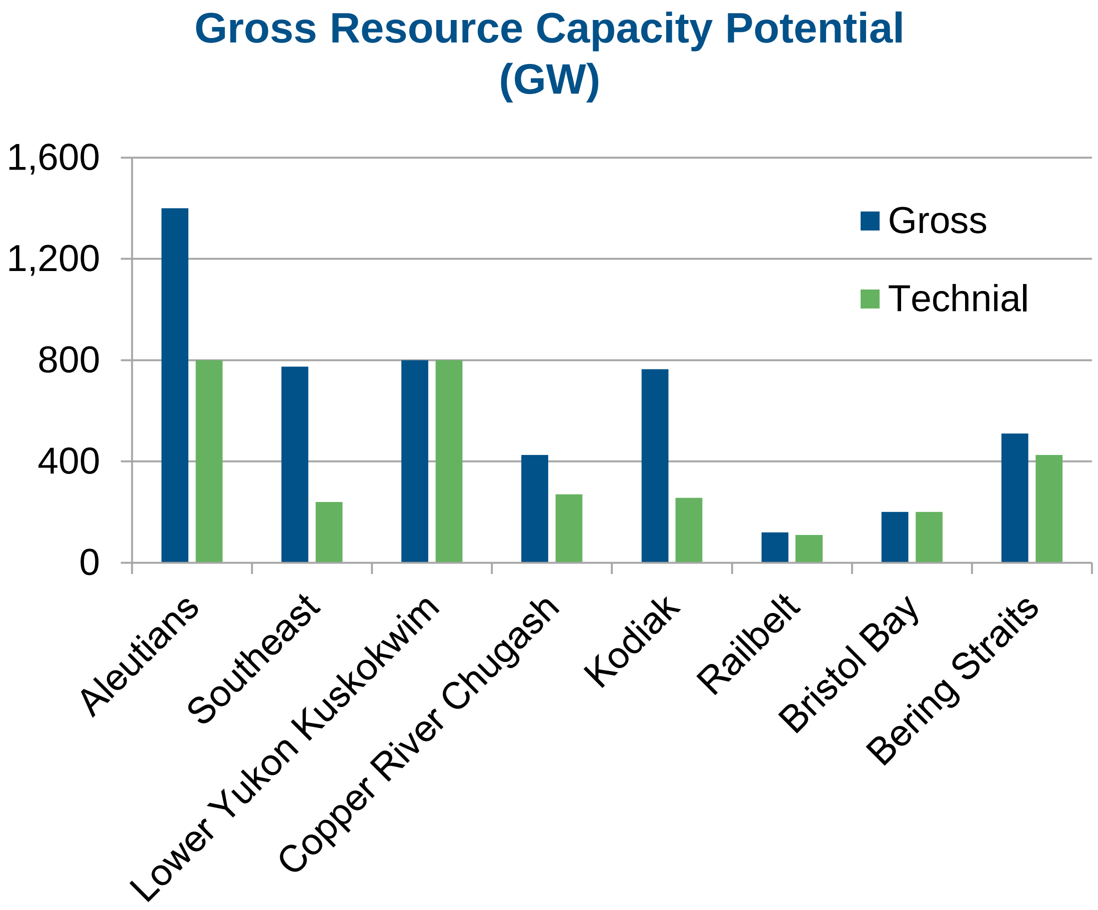
AK's Offshore Wind Resource at 100 Meters Hub Height

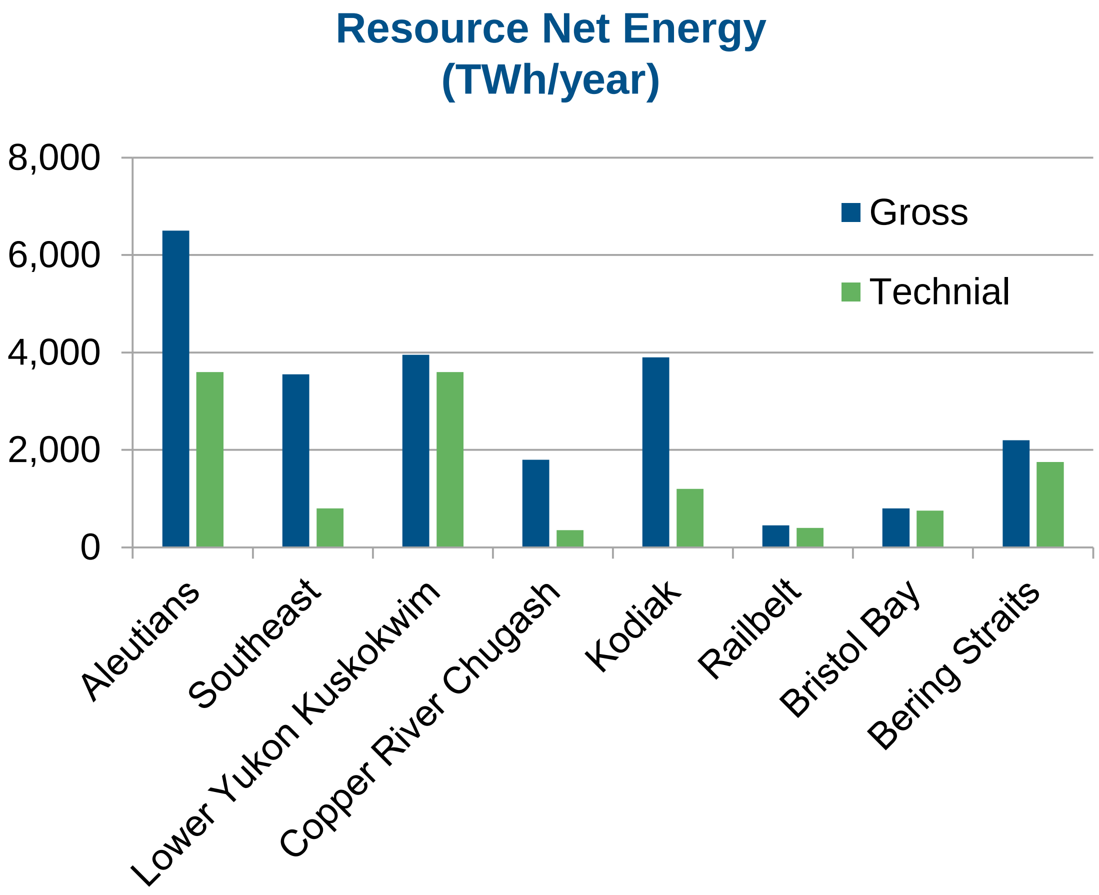


Sources: NREL, *Offshore Wind Energy Resource Assessment for Alaska*

Even after accounting for various physical constraints, Alaska's offshore wind resource is still massive.

The authors derived technical offshore wind resource potential by accounting for ocean depth (< 1,000 m), average wind speed (> 7 m/s), sea ice concentration (< 90%).





Sources: NREL, *Offshore Wind Energy Resource Assessment for Alaska*

Thank you!

Any questions?