Utility-Scale Battery Storage

NE Wind & Solar Conference

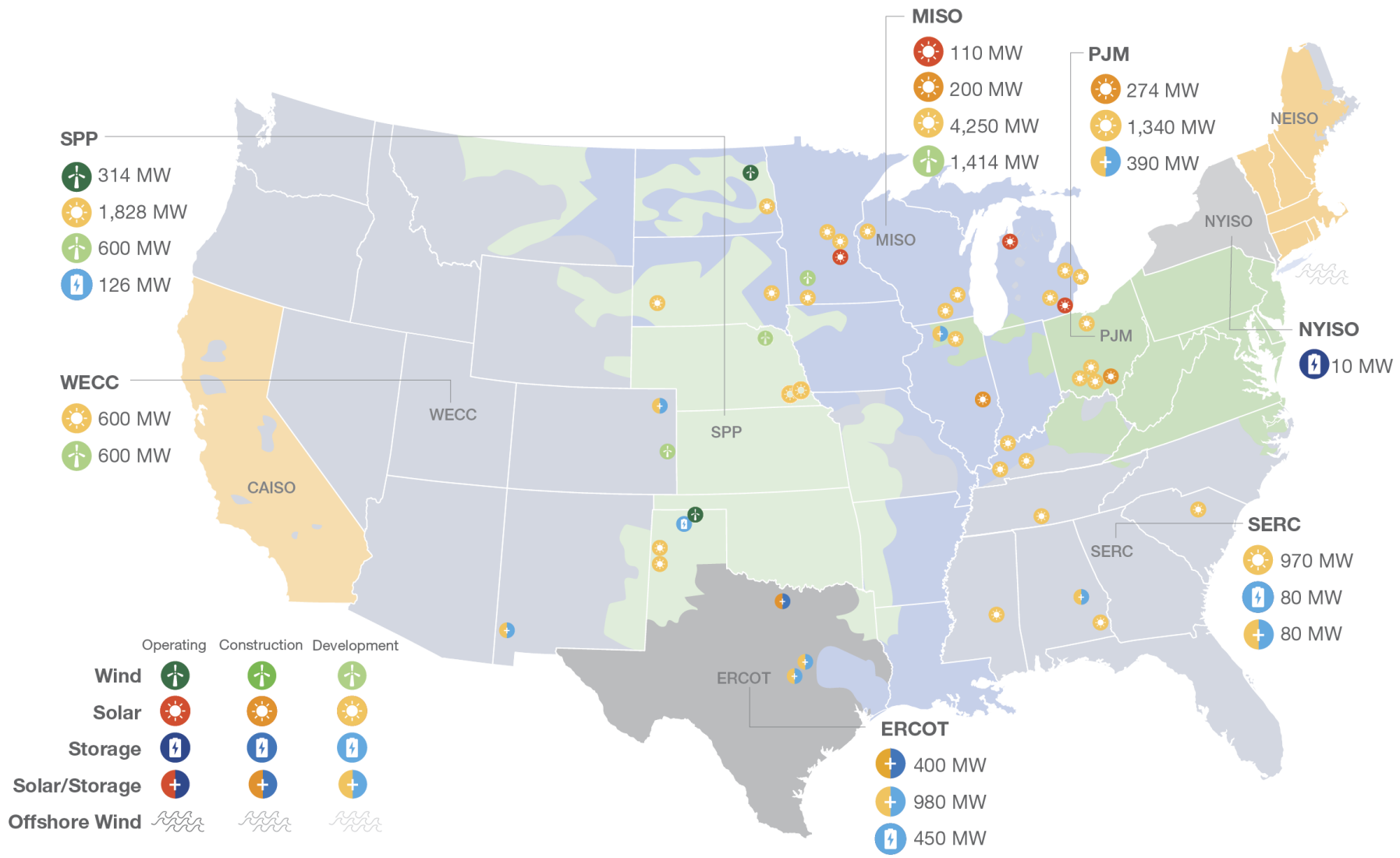
November 8, 2021

Leading U.S. Renewable Energy Company

- National Grid Renewables develops, owns and operates large-scale renewable energy assets across the United States, including solar, wind and energy storage.
- National Grid Renewables includes the renewable energy development company formerly known as Geronimo Energy, whose team has successfully developed over 3,000 megawatts (MW) of wind and solar projects that are currently in operation or under construction
- We are experts in renewable energy project development, construction and operations
- The robust National Grid Renewables pipeline stretches across the United States, including projects in advanced development phases


Farmer friendly. Community focused.
We do the right thing, and we make it happen.

Project Portfolio



Storage 101

What is Battery Energy Storage?

- Battery Energy Storage is a type of power plant that uses rechargeable batteries to store and provide electricity when it's needed most – much like a fridge that stores food, prevents waste, and enables consumption at a later date
- **The batteries charge when sun and wind power are creating more electricity than can be used**
- When the sun stops shining and the wind stops blowing, the batteries provide electricity to power homes and businesses
- Battery Energy Storage is a game-changer for the US power sector

17 GW

Large-scale battery storage capacity will grow from 1 GW in 2019 to 17 GW in 2050, according to EIA

1,736

US battery storage jumped from 59 MW in 2010 to 1,736 MW in 2021

89%

Lithium-ion battery pack prices have fallen 89% from above $1,100/kWh in 2010 to $137/kWh in 2020

Sources: EIA; cleanpower.org; BNEF

How Do Battery Energy Storage Systems Work?

Renewable energy storage systems basically do 3 things:

1. **CHARGE:** When the wind is blowing and/or the sun is shining, the battery is collects and stores the clean electrons

2. **OPTIMIZE:** Intelligent battery software uses algorithms to coordinate energy production and computerized control systems are used to decide when to store the energy and/or release it to the grid

3. **DISCHARGE:** Energy is released from the battery storage system during times of peak demand, keeping costs down and electricity flowing

Source: EIA: nationalgrid.com

Types of Battery Energy Storage

Storage requires low-cost technologies that **have long lives** – charging and discharging thousands of times – **are safe** and **can store enough energy** cost effectively to match demand

Lithium-Ion

Overview:

- By far, the most popular battery storage option today (~80% of the global grid battery storage market)
- Originally used for small-scale consumer items such as cellphones; now common in rural electrification
- **High energy density** and are **lightweight**
- New innovations (graphite replace for increased capacity) are making LIONs more competitive for longer-term storage.

Compressed Air

Overview:

- Air is pumped underground during off-peak hours; When energy is needed, the underground air is released into a facility, where it is heated; the resulting expansion turns an electricity generator.
- Natural gas is required for heating, but **compressed air storage triples the energy output of the plant**

Mechanical Gravity

Overview:

- Energy is used to lift a heavy material (eg water, concrete blocks) to higher elevation during off-peak hours; When the energy is needed or prices are high, the material is lowered back down, generating electricity using the pull of gravity
- Comparatively cheaper, especially for very large capacity storage

Flow

Overview:

- An alternative to lithium-ion batteries, but much less popular (~5% of the market)
- Essentially rechargeable fuel cells: chemical energy is dissolved in liquids and separated by a membrane
- Relatively **low energy densities** and have **long life cycles – well-suited for longer duration**

Sources: nationalgrid.com, essi.org

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RANGER POWER

Nebraska Wind and Solar Conference

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Ranger Power

- Solar development company specializing in utility-scale solar and storage projects, ranging in size from 75 to 600 MW
- Midwestern US portfolio of nearly 7 GW comprised of 50 solar and storage projects in 10 states
- Led by an experienced team of developers with a proven track record of community-supported solar
- Ranger's core team has successfully developed over 2 GW of operating clean energy projects in the United States

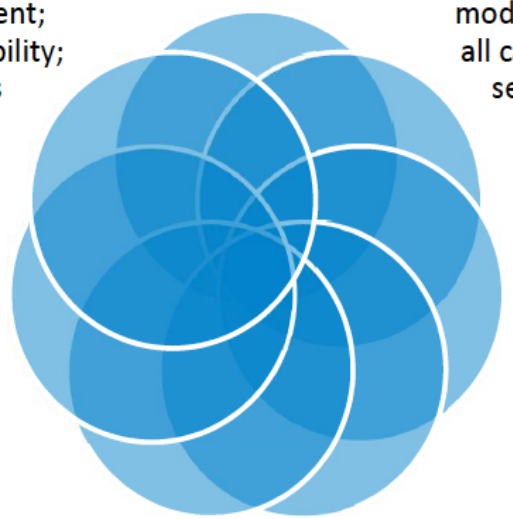
Ranger takes pride in community engagement, transparency, and responsible solar development

FERC Order 841 – Energy Storage Resources

Establish standard definition of Electric Storage Resources (ESRs)

State of Charge management; Make-Whole payment eligibility; Metering requirements

Establish ESR market participation model for eligible ESRs to provide all capacity, energy, and ancillary services they are technically capable to provide



Sale and purchase of electric energy to ESRs must be at the wholesale locational marginal price ("LMP")

Ensure ESRs can be dispatched and can set the wholesale market clearing price as both a wholesale seller and wholesale buyer

Establish a minimum market participation size requirement not exceed 100 kW

Account for ESR's physical and operational characteristics through bidding parameters or other means

GTM Storage Deployment Forecast

Revenue Streams to Support Storage

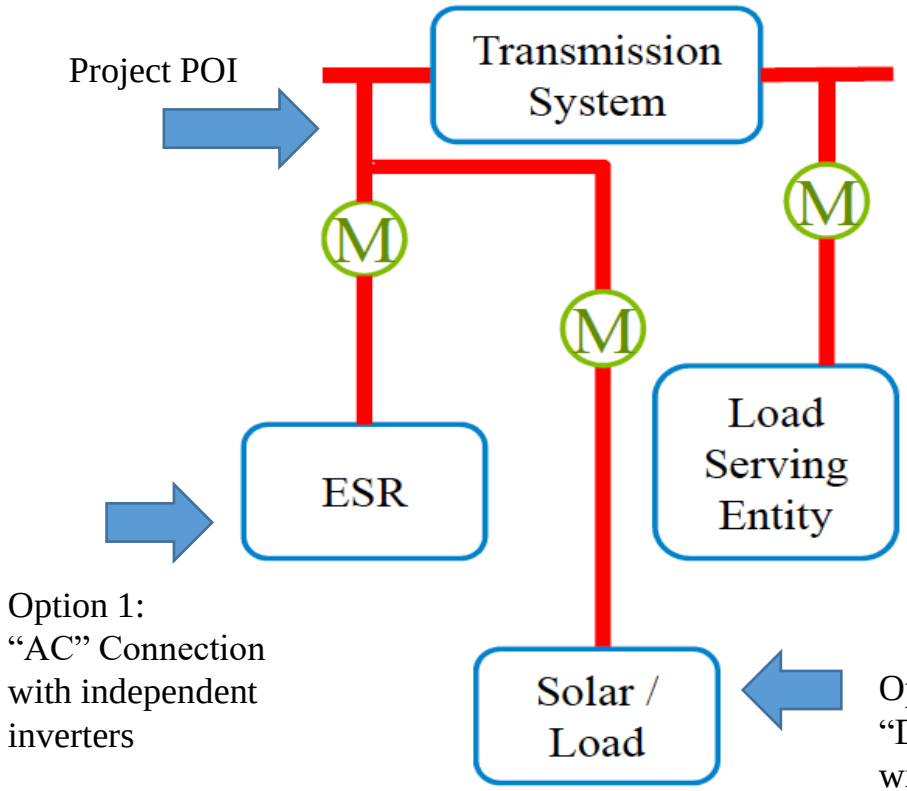
- Market Based Revenue
  - Energy (MWhr)
  - Capacity (MW-Day)
  - Ancillary Services
    - Balancing Resource
    - Spinning Reserves
    - Frequency Response
- Reliability Revenue
  - Reactive Supply and Voltage Control
  - Blackstart Resources

System Costs Go Down

Project Income Incentivizes Development

How is an energy storage system connected?

- Distributed vs. Transmission System
- Behind or in front of the meter with load
- Independent Location
- Co-located with solar or wind
  - Tied into the AC Collection
  - Tied into the DC Collection



Option 1:
"AC" Connection with independent inverters

Option 2:
"DC" Connection with shared inverters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Thank You!

Contact Information

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BRIGHT Battery Project

Courtney Kennedy, Manager – Alternative Energy Program

BRIGHT Grant & Project Scoping

Battery Research Innovation Guided by High-Potential Technologies (BRIGHT)

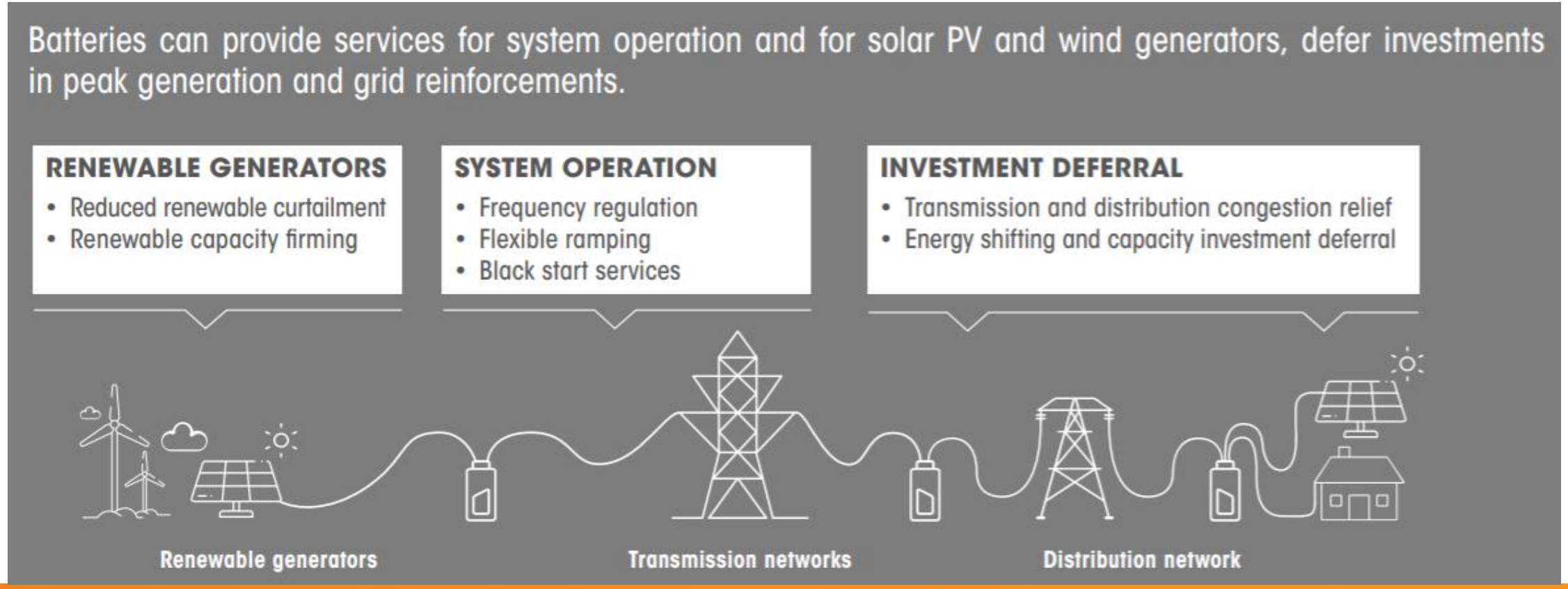
- Nebraska Environmental Trust (NET) Air Quality Category
  - OPPD submitted application in September 2019
  - NET approved funds in June 2020
  - Grant project funding: $600,000

- Project to facilitate OPPD technology and operational learning
  - Allows OPPD to learn about interconnection, permitting, engineering, construction, operations, and safety requirements

- Project specifics based on grant application
  - Size will be ~1MW
  - Location to be at OPPD substation in Cass County
  - Grant application did not specify technology

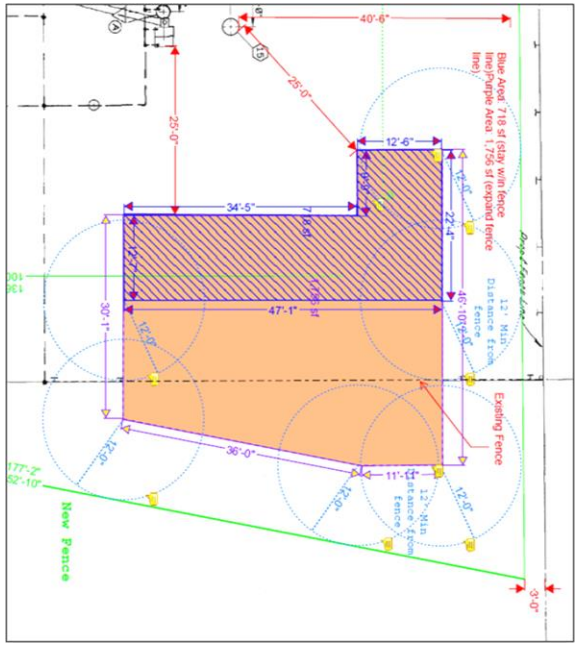
Project Analysis

- Considerations: cost, grant requirements, timeline, location, organizational learning
- Analyses conducted: Site, Feeder, and Technoeconomic



Site Selection & Analysis

- OPPD's 69 kV Substation
  - Distribution interconnection (13.8 kV)
- Near Weeping Water, NE
- Advantageous characteristics of the substation
  - Impacted during local transmission outages
  - Allows for more flexibility of transmission maintenance outages
  - Loading of substation is conducive to peak shaving
  - Limited options regarding voltage control and support
  - Will enable testing of multiple operational use cases
  - Potential for future substation expansion
  - Configuration and existing equipment make it a low cost interconnection and low cost installation



Use Cases for BRIGHT Battery Project

Applied Use Cases

- Energy Shifting
  - Peak Load Reduction
  - Energy Arbitrage
- Voltage Support

Project Benefits

- Enhanced Reliability
- Increased Operational Development
- Community Education
- Safety Awareness

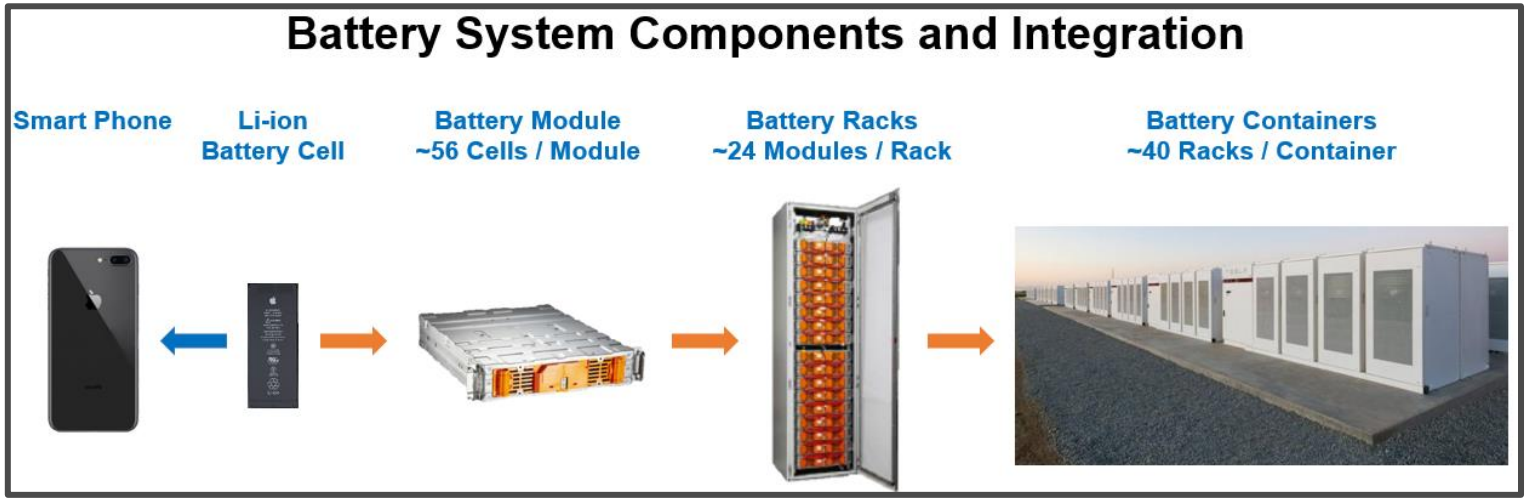
Additional Opportunities

- Market Participation
  - 10-minute Spinning Reserve
  - Regulation
- Energy Shifting
  - Intra-Hour Arbitrage

Lithium-ion (Li-ion) Batteries

- High round trip efficiency (90-95%)
- High energy density
- Falling costs
- Satisfies short duration need
- Design life
- Several battery designs
- Modular systems

Example of 1 MW, 2hr (2 MWh) battery



Capacity, Duration, & Cycling

Capacity – the measure of the energy stored in the battery in megawatts (MW)

- Grant application defines 1MW capacity

Duration – the run time of the battery on a full charge measured in hours (hrs)

- 2-hr and 4-hr evaluated based on supporting project use cases

Cycle – a full charge/discharge, or the equivalent, of the rated capacity

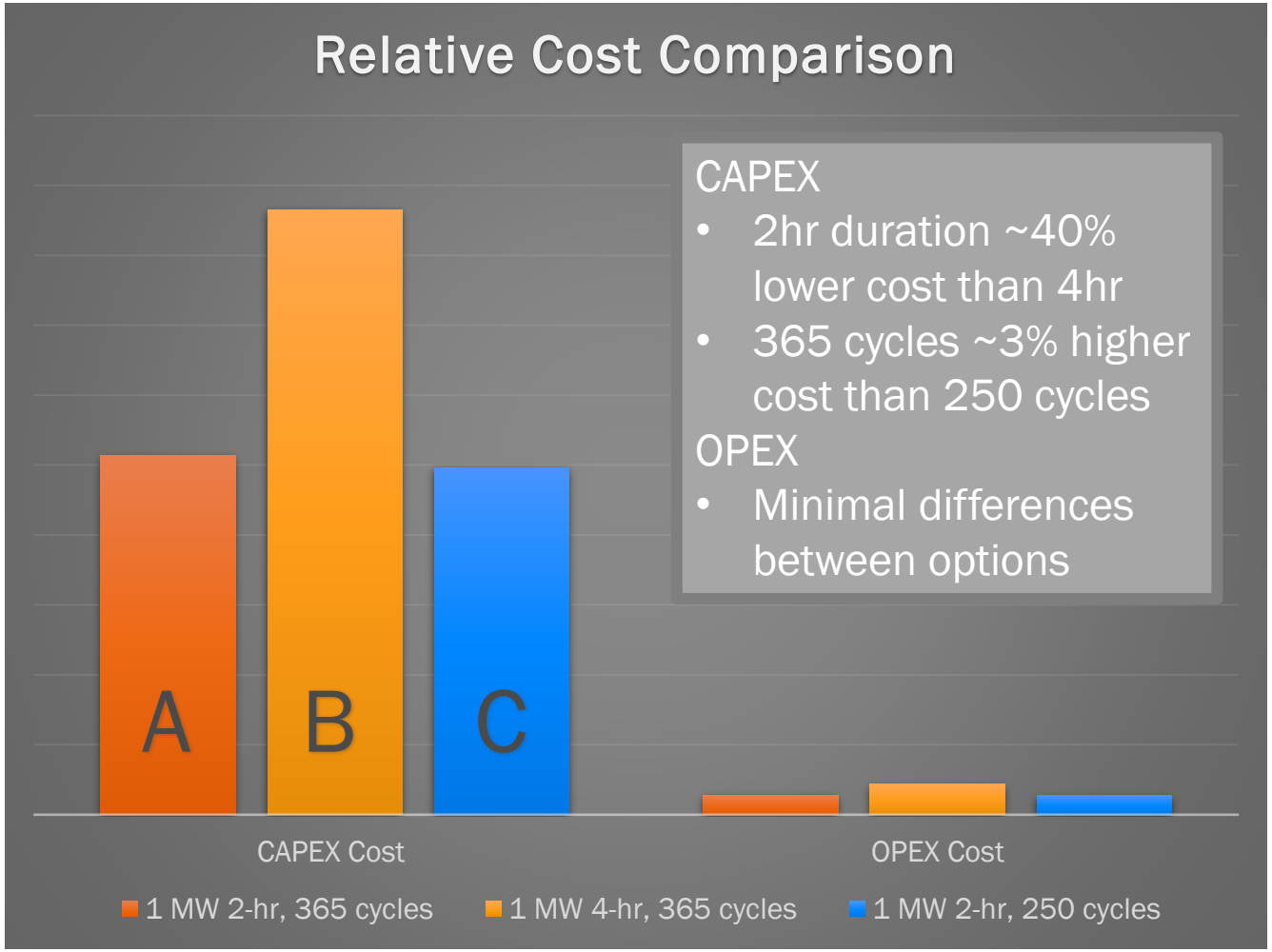
- Number of cycles defined upfront
- More cycles require larger capital cost to oversize the battery; provides increased flexibility

Optimizing Best Sizing & Annual Cycling Options

✓ **Option A:** 1 MW 2-hr, 365 cycles:
- ~40% lower cost than 4 hour duration

Option B: 1 MW 4-hr, 365 cycles:
- Significant cost increase for longer duration

Option C: 1 MW 2-hr, 250 cycles:
- Lowest cost given short duration and lower cycles



Additional Value Streams

ADMINISTRATIVE

- Develop processes for SPP ancillary market
- Develop favorable ESR contract terms
- Integrate into control systems
- Develop ESR success metrics
- Implentation of FERC Order 841

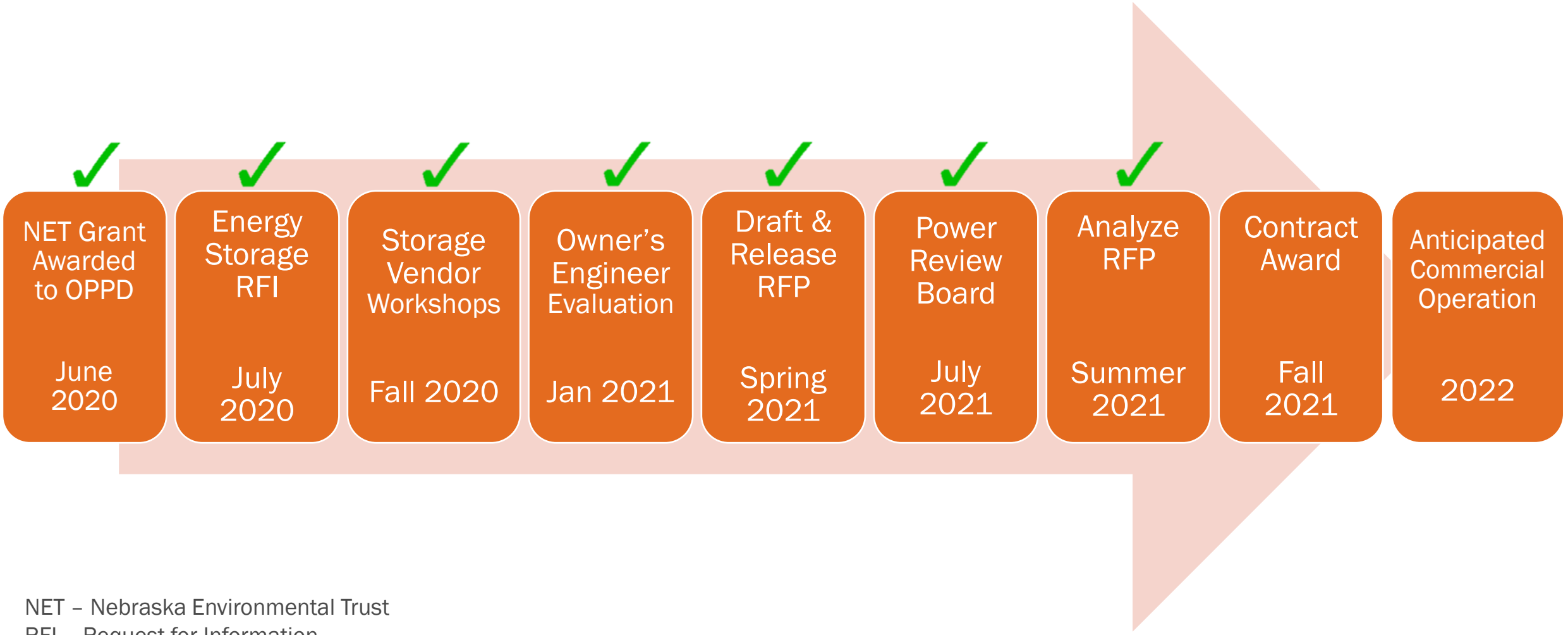
EDUCATIONAL

- Explore ownership hurdles
- State-wide educational benefit
- Develop battery storage maintenance practices
- Study ESR distribution benefits
- Operational and markets training
- Learn about battery safety
- Study greenhouse gas (GHG) reductions

OPERATIONAL

- Increased renewable integration
- Economics of distibution level ESR
- Maximize value in SPP Market
- Address reliability concerns
- Demonstrate individual and stacked services
- Explore innovative commercial approaches

BRIGHT Milestones



NET – Nebraska Environmental Trust
RFI – Request for Information
RFP – Request for Proposals

Questions