# Perspectives on Energy Storage

Northwest Energy Systems Symposium
April 30, 2014
Patrick Leslie, Emerging Technologies Program Mgr.

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# Why energy storage?

1. **Solves multiple problems:**
   - T&D peak shaving / upgrade deferral
   - System peaking capacity
   - Ancillary services (system flexibility)
   - Outage mitigation
2. **Modular & Scalable**
3. **Ease of permitting**
   - No emissions, silent
   - No water or wastewater needs
4. **Re-locatable**



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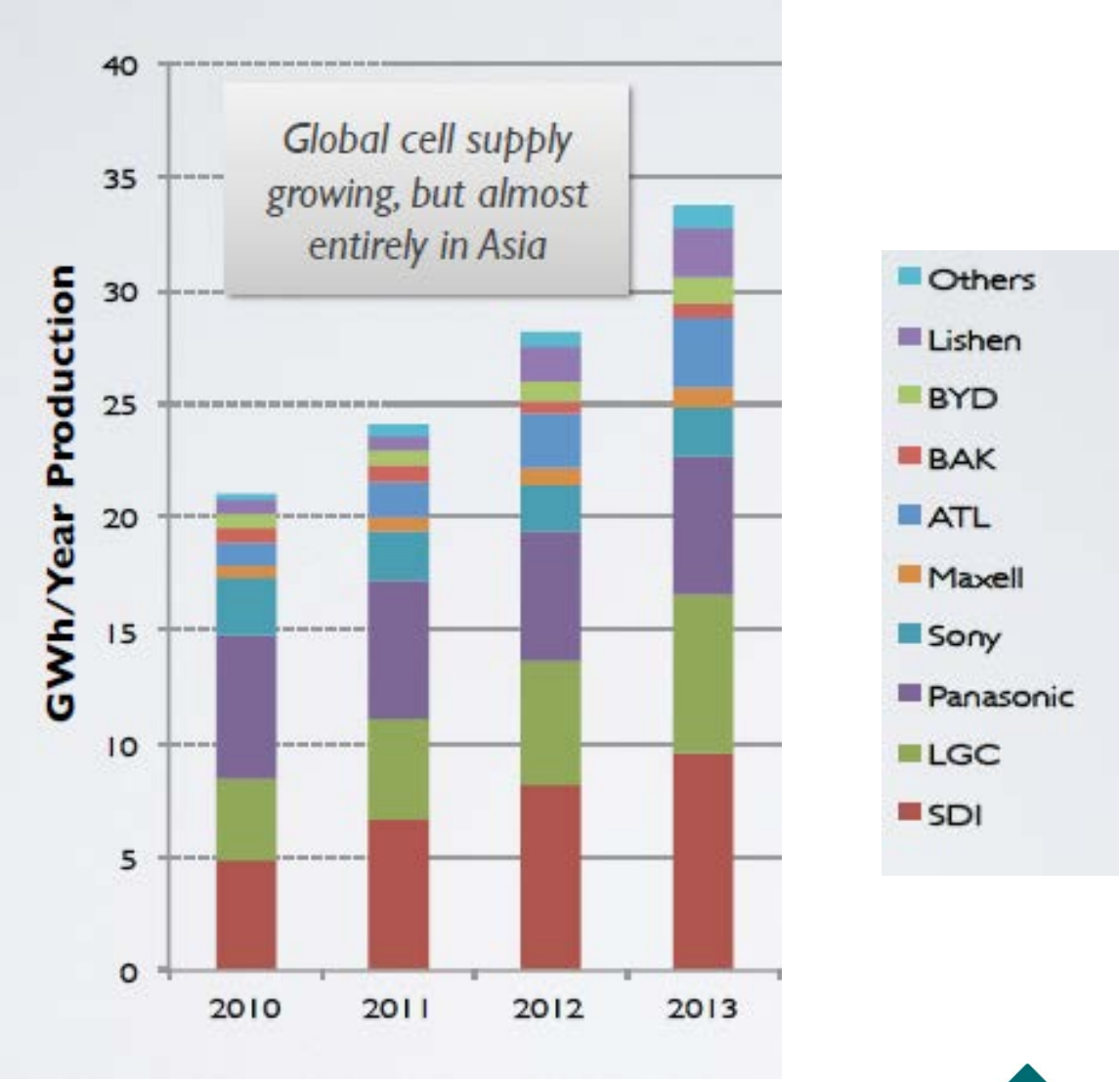
# What are the apps worth?

| Category | Landline Phone | Smartphone |
|---|---|---|
| Phone Price | $20 - $80 | $100 - $300 |
| Annual Fees | $250 - $500 | $800 - $1,500 |

- Conclusion: Smartphones not economic choice

# Lithium-ion manufacturing ramping up



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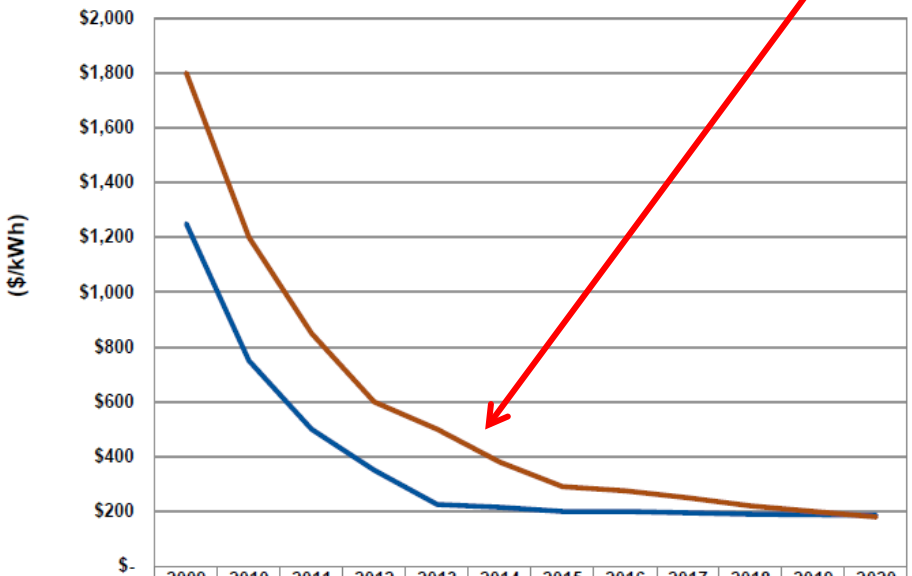
# Prices are dropping

## Lithium Ion Cell Pricing Forecast

We are here

### Lithium Ion Battery Pricing by Cell Type: 2009-2020




| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Consumer Electronics Li-ion | 1,250 | 750 | 500 | 350 | 225 | 215 | 200 | 200 | 195 | 190 | 188 | 187 |
| Large Format Li-ion | 1,800 | 1,200 | 850 | 600 | 500 | 380 | 290 | 275 | 250 | 220 | 200 | 180 |

(Source: Navigant Research)

**ACTUAL** **FORECAST**





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# Storage projects are proliferating

[partial list]

| Utility | Project | Capacity (MW) | Location | Technology | Project Start |
|---|---|---|---|---|---|
| PGE | Salem | 5.0 | Oregon | Li-ion | 2013 |
| Energy Northwest | Nine Canyon | 0.1 | Washington | Li-ion | 2013 |
| SnoPUD | MESA | 1.0 | Washington | Li-ion | 2013 |
| BC Hydro | Golden | 1.0 | British Columbia | Sodium sulfur | 2011 |
| PG&E | Various | 6.0 | California | Sodium sulfur | 2013 |
| SCE | Tehachapi | 8.0 | California | Li-ion | 2012 |
| SDG&E | San Diego | 1.5 | California | Li-ion | 2013 |
| SMUD | Sacramento | 1.0 | California | Zinc bromine | 2012 |
| Duke | Notrees | 36.0 | Texas | Advanced lead acid | 2012 |
| AES | Laurel Mountain | 30.0 | Virginia | Li-ion | 2011 |
| Dayton Power & Light | Tait Station | 40.0 | Ohio | Li-ion | 2013 |

# Storage projects are scaling-up


**AES Laurel Mountain**
Capacity: +32/-32 MW
Energy: 7.5 MWh
COD: 2011 Q4
Location: W. Virginia
Use: Frequency Regulation

**Duke Notrees**
Capacity: +36/-36 MW
Energy: 24 MWh
COD: 2012 Q4
Location: Texas
Use: Frequency Regulation



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# Storage projects are scaling-up

**AES Tait Station**
Capacity: +20/-20 MW
Energy: 10 MWh
COD: Sep 2013
Location: Ohio
Use: Frequency regulation

Bloomberg

Print Back to story

## AES Plans 100-Megawatt Northern Ireland Power-Storage Project

By Alex Morales - Apr 2, 2014

AES Corp. (AES) said it's planning to build 100 megawatts of battery capacity in Northern Ireland to store excess wind power and release it when generation is low.

The battery array would be built at the company's Kilroot power station, northeast of Belfast, AES said in a statement yesterday. The Arlington, Virginia-based company applied to the System Operator of Northern Ireland, the grid operator, to secure a connection to the transmission grid. The project could be running by the second quarter of 2015, it said.

# Behind-the-meter storage is emerging

Storage systems shave peaks, reduce demand charges, shave TOU rate blocks, and provide backup power. Installed under lease or PPA terms.

TESLA SolarCity

**Residential**


**Commercial**

**10 MW+ in development; 500+ interconnection requests submitted in CA.**

stem

**Commercial**


**15 MW+ development pipeline**

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# PSE-Primus-PNNL Pilot Project

BONNEVILLE POWER ADMINISTRATION

*Technology Innovation*

## TIP 0285
## Energy Storage: Multifaceted tool for demand management

January 2013

Pacific Northwest NATIONAL LABORATORY

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PRIMUS POWER

# Project Synopsis

**Objective:** Assess and demonstrate the benefits of energy storage on the distribution grid. Install and test a 0.5 MW x 1.0 MWh system.

**Project phases:**


| | | | |
|---|---|---|---|
| **Objective** | Feasibility & cost-benefit analysis, PNNL report | Permit, construct, interconnect, commission | Test, monitor, evaluate. PNNL report. |
| **Timeline** | Feb – Sept 2013 | Oct '13 – Sep '14 | Oct '14 – Dec '15 |

**Budget**

| | Primus | U.S. Dept. of Energy | PSE | BPA | Total Cost |
|---|---|---|---|---|---|
| **Phase 1** | $ 30,600 | $ 80,000 | $ 11,700 | $ 122,300 | $ 244,600 |
| **Phase 2** | $ 698,700 | $ 59,800 | $ 1,376,015 | $ 675,800 | $ 2,810,315 |
| **Phase 3** | $ 51,300 | $ 114,500 | $ 16,100 | $ 181,900 | $ 363,800 |
| **TOTAL** | **$ 780,600** | **$ 254,300** | **$ 1,403,815** | **$ 980,000** | **$ 3,418,715** |

# EnergyPod®: grid-scale, rechargeable batteries


**A distributed storage technology that can simultaneously deliver:**

**Power Density**

Fits inside a substation

**Safety**

Non-flammable electrolyte & zero emissions

**Long Life**

Can be recharged for 20 years

**Mobility**

Can be moved to meet system needs

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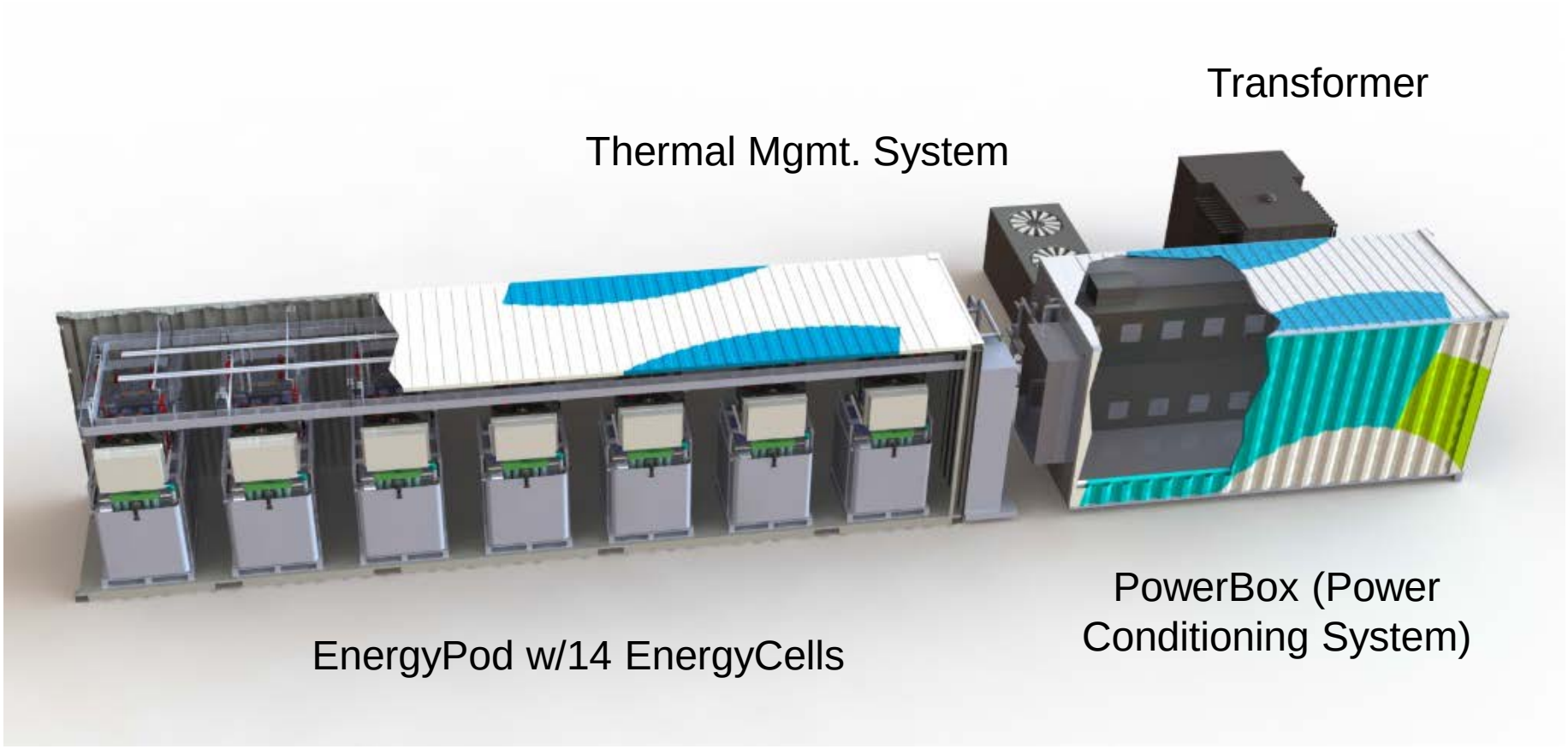
# What's inside an EnergyPod®?




*Example Site Layout for large single EnergyPod + Inverter and ancillaries*
*End to End Length of Pod + PCS is 47.5 ft*



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# Four specific sites evaluated

| Location | Issues | Application |
|---|---|---|
| **Bainbridge** | Capacity constraint, reliability | Shave peak load on WIN and/or MUR substations. Island customers during outages. |
| **Baker River #24** | Reliability (radial feeder with frequent outages due to vegetation) | Install storage at feeder mid-point to island customers during outages |
| **Chico #12** | Reliability, capacity constraint | Multiple systems with sectionalizing switches to island customers during outages. |
| **Crystal Mountain** | Reliability | Increase supply at generator during feeder outages. |

# Energy Storage Applications

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| Num. | Application | Value Derived from Energy Storage |
|---|---|---|
| 1 | Capacity | Value based on incremental cost of peaker; alternative method based on avoided incremental cost of firm transmission from Mid-C |
| 2 | Distribution Upgrade Deferral | Deferred costs of proposed distribution upgrades |
| 3 | Outage Mitigation | Reduced outages to end-use customers assuming no foreknowledge and perfect foreknowledge |
| 4 | Balancing Services | AURORA and a PSE internal mixed integer linear programming (MILP) model used to determine the inc. and dec. balancing service price |
| 5 | Arbitrage | AURORA model used to determine energy price differentials (peak vs. off-peak) minus efficiency losses |

# 24-hour energy storage schedule for Bainbridge Island

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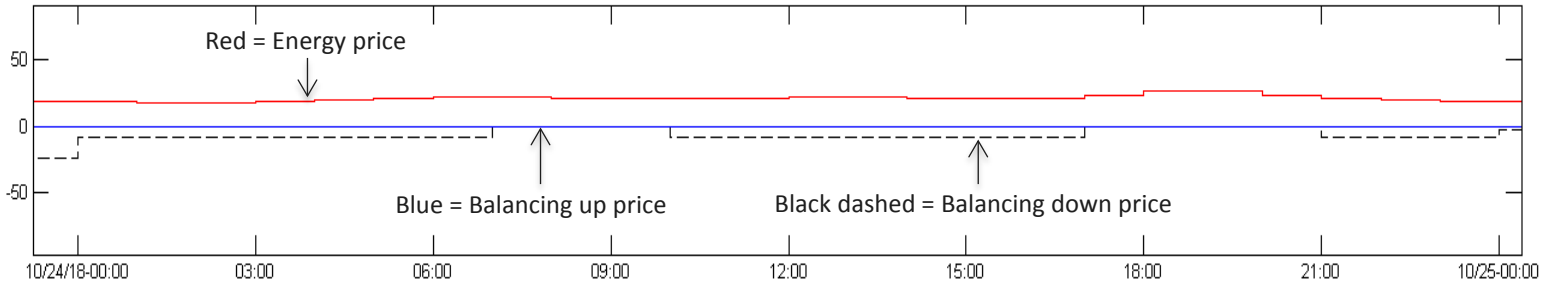
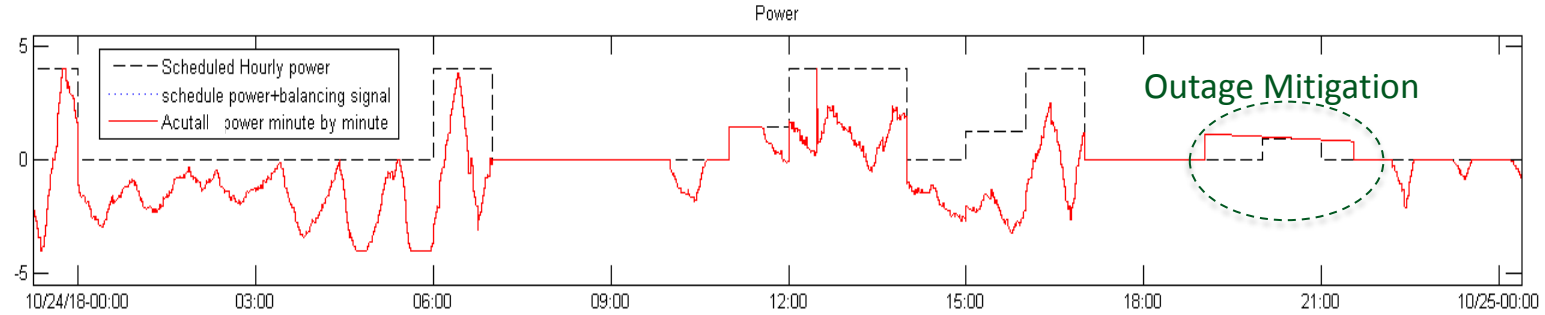
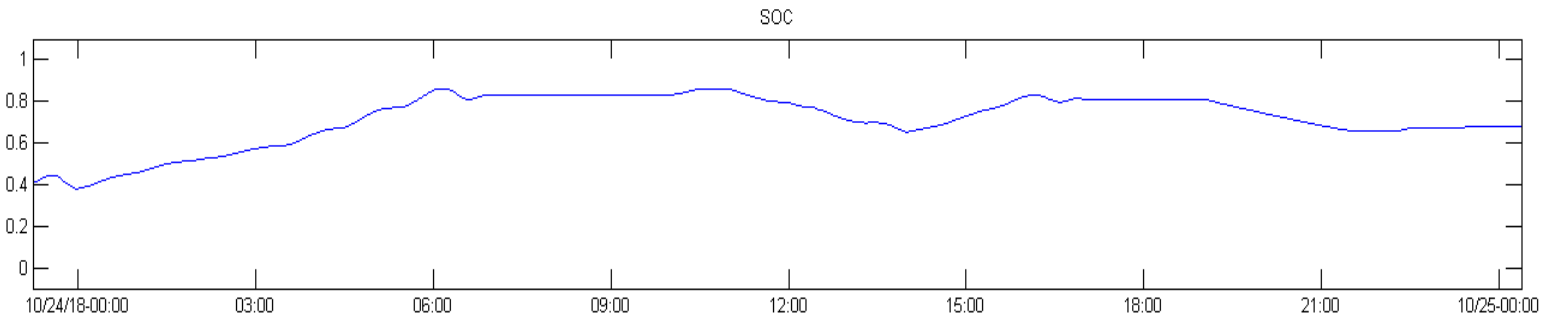
Energy and Balancing Prices $/MWh




Energy Output MW

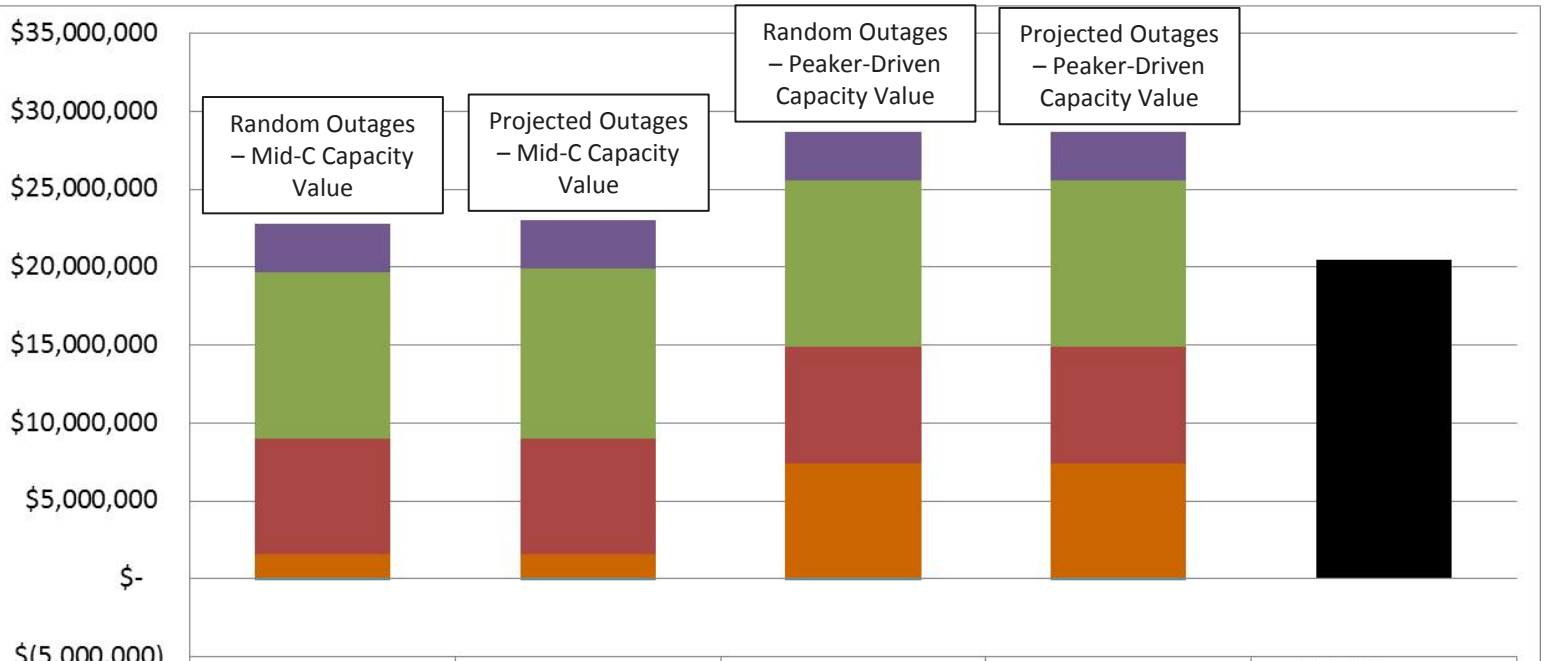



State of Charge %



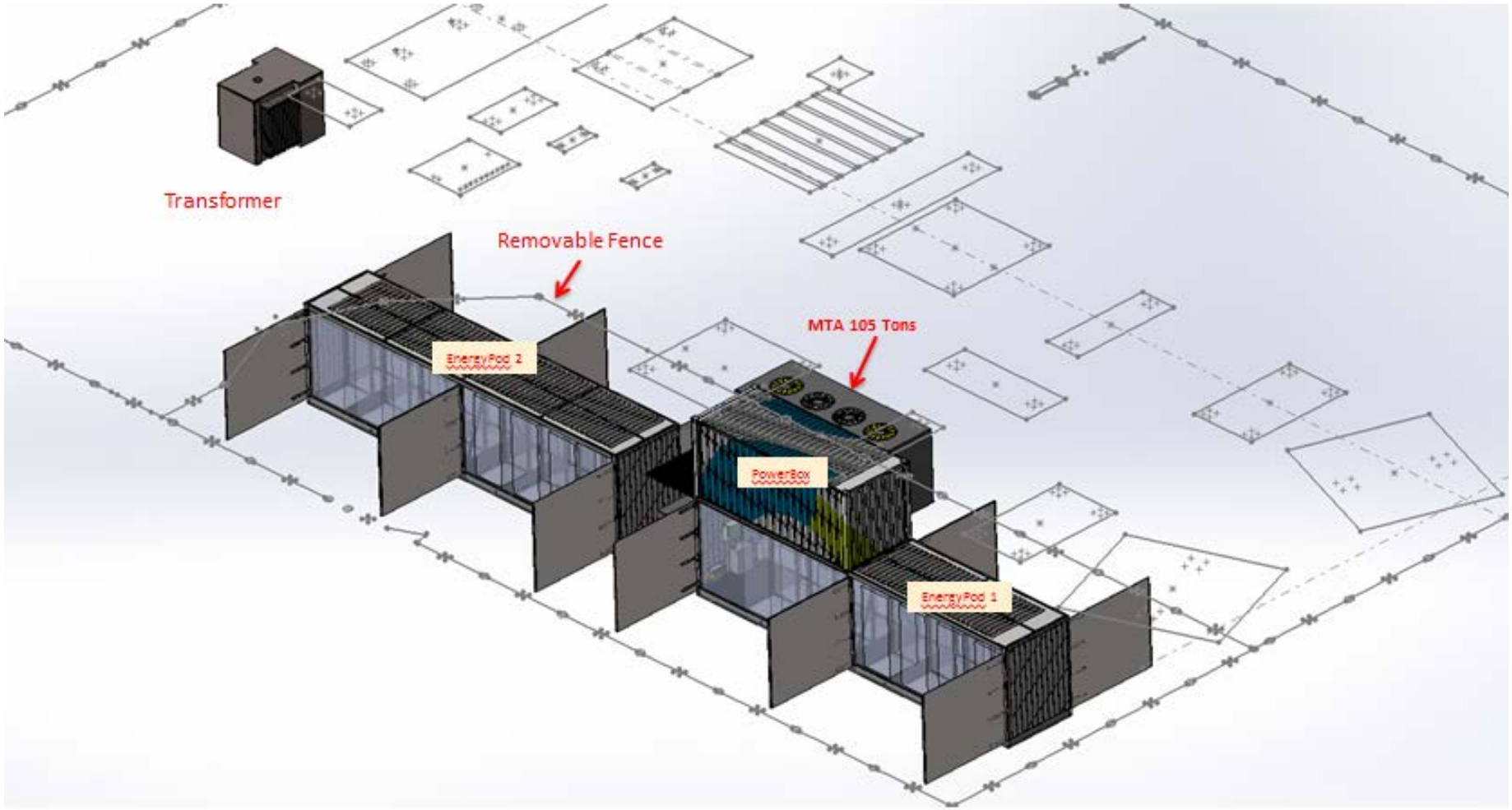
# Summary of results (NPV benefits and revenue requirements over 20-year time horizon) – Bainbridge Island






| | Scenario 1 | Scenario 2 | Scenario 3 | Scenario 4 | Total Revenue Requirements |
|---|---|---|---|---|---|
| Revenue Requirements | | | | | $20,470,000 |
| Arbitrage and Energy Costs | $(13,384) | $(23,550) | $(13,384) | $(13,384) | |
| Balancing Services | $3,104,871 | $3,100,376 | $3,104,871 | $3,104,871 | |
| Outage Mitigation | $10,632,260 | $10,864,956 | $10,632,260 | $10,632,260 | |
| Distribution Upgrade Deferral | $7,454,000 | $7,454,000 | $7,454,000 | $7,454,000 | |
| Capacity Value | $1,570,000 | $1,570,000 | $7,443,000 | $7,443,000 | |

# Proposed Layout



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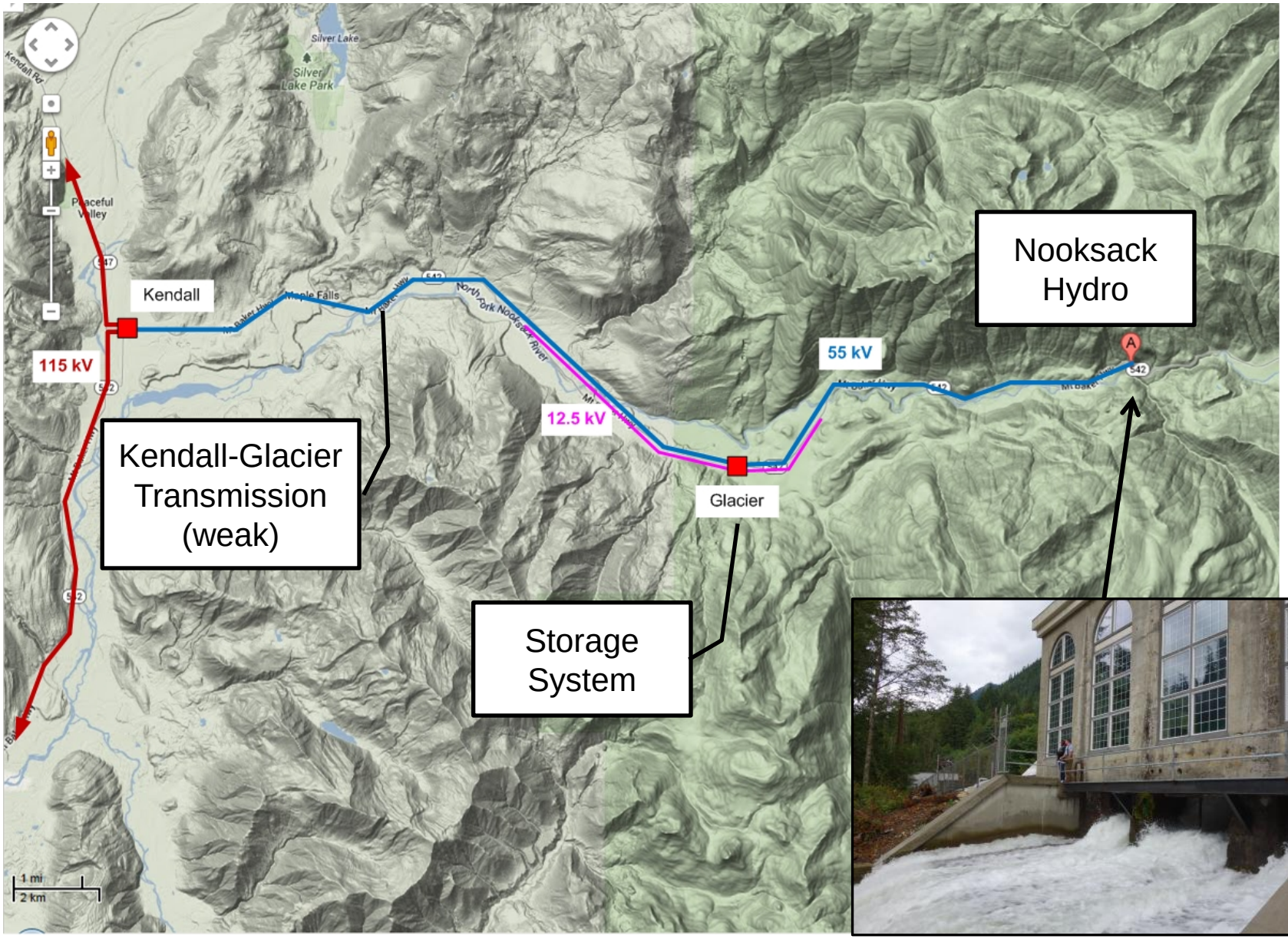
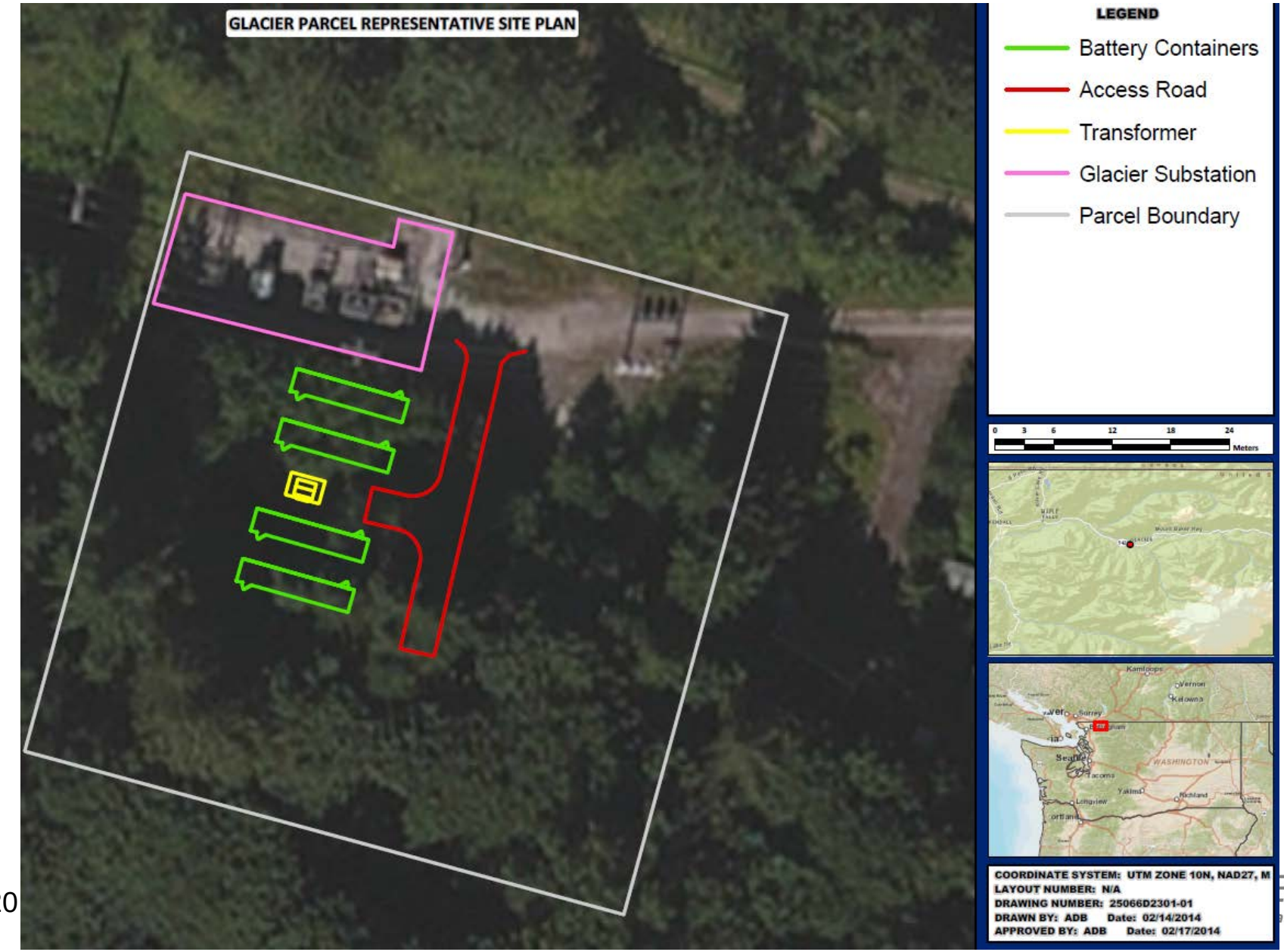
# Proposed Glacier Microgrid Concept

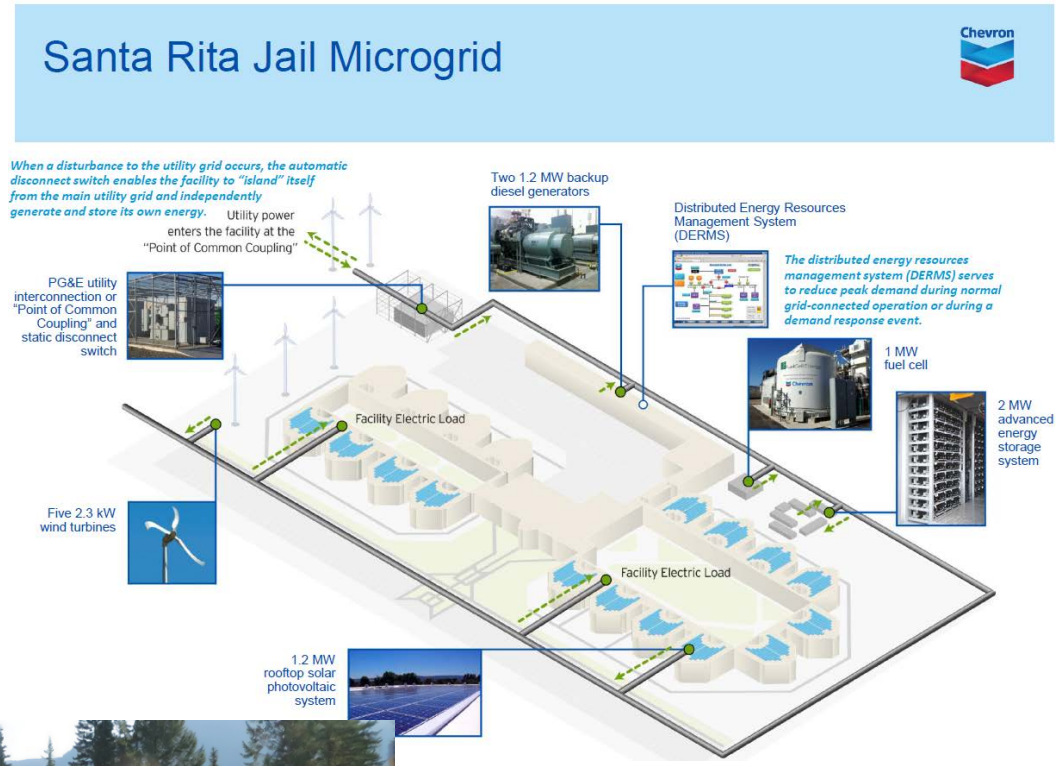


# Potential Glacier Layout



# Similar Projects

- Santa Rita Prison microgrid




- BC Hydro



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