# UltraBattery Utility-Scale Solutions

**Energy Transformed Flagship**

**Peter Coppin**

**SKA Workshop April 2011**

www.csiro.au

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# Overview

- Grid-connected Storage
- Technology overview
- The UltraBattery
- Ultrabattery utility-scale trials

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# Drivers for storage applications
# The example of wind power variability

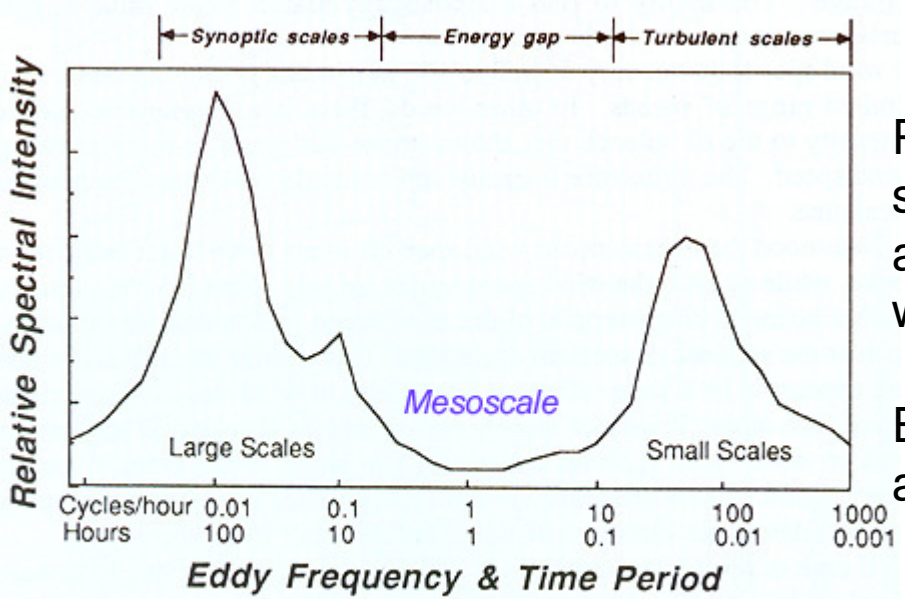



Fig. 2.2 Schematic spectrum of wind speed near the ground estimated from a study of Van der Hoven (1957).

from Stull 1988

Power spectrum shows clear separation between sub-1-hour and longer time-scale variations in wind speed

Each scale has different problems and storage solutions

# Five Categories of Grid-Related Energy Storage Applications (Sandia Report 2010-0815)

**Category 1 — Electric Supply**
1. Electric Energy Time-shift
2. Electric Supply Capacity

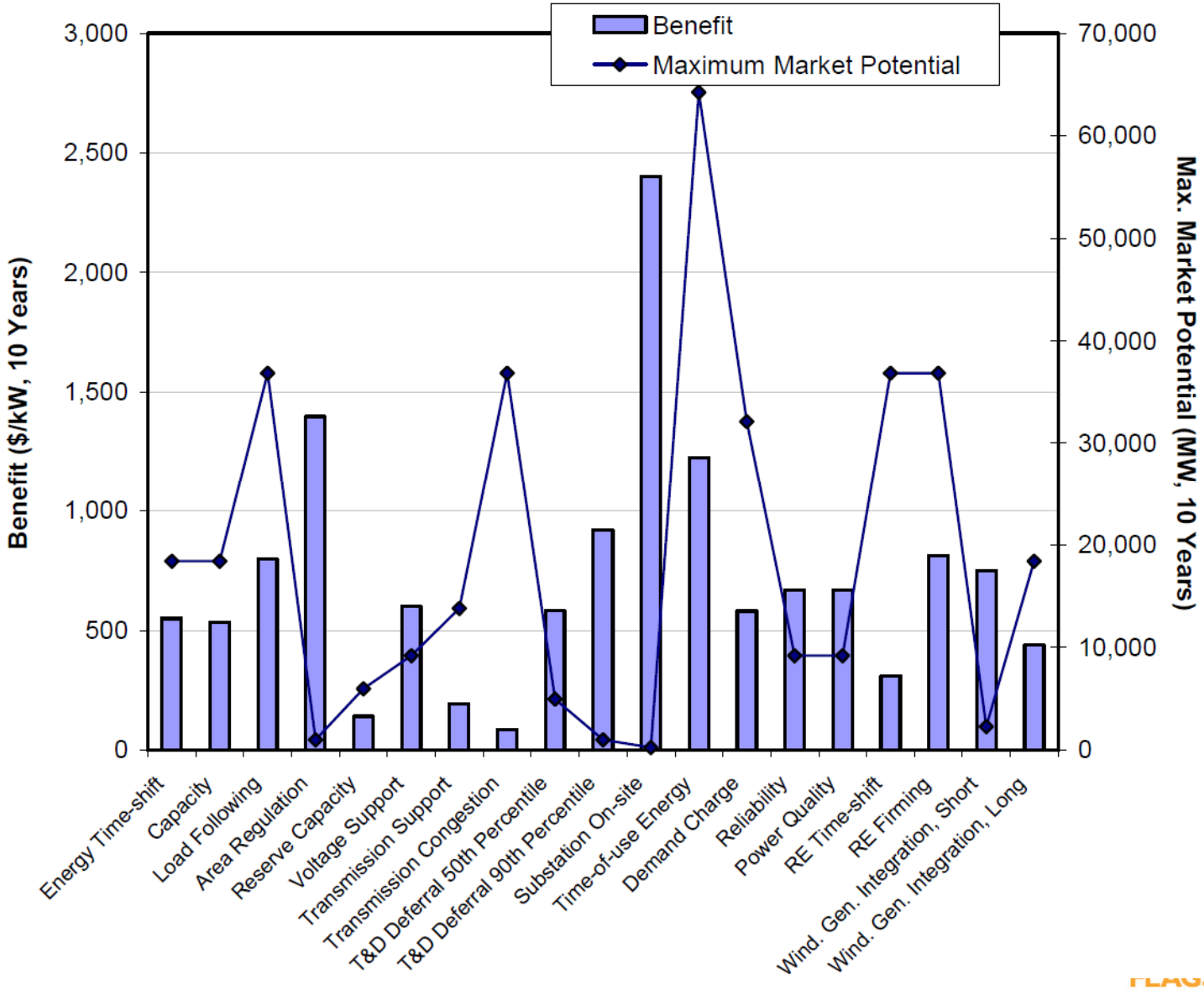
**Category 2 — Ancillary Services**
3. Load Following
4. Area Regulation
5. Electric Supply Reserve Capacity
6. Voltage Support

**Category 3 — Grid System**
7. Transmission Support
8. Transmission Congestion Relief
9. Transmission & Distribution (T&D) Upgrade Deferral
10. Substation On-site Power

**Category 4 — End User/Utility Customer**
11. Time-of-use (TOU) Energy Cost Management
12. Demand Charge Management
13. Electric Service Reliability
14. Electric Service Power Quality

**Category 5 — Renewables Integration**
15. Renewables Energy Time-shift
16. Renewables Capacity Firming
17. Wind Generation Grid Integration

# Application-specific 10-year benefit and maximum market potential estimates for the U.S



# The Technolgies

# Custom Built Pumped Hydro
# Taum Sauk – Missouri - 450MW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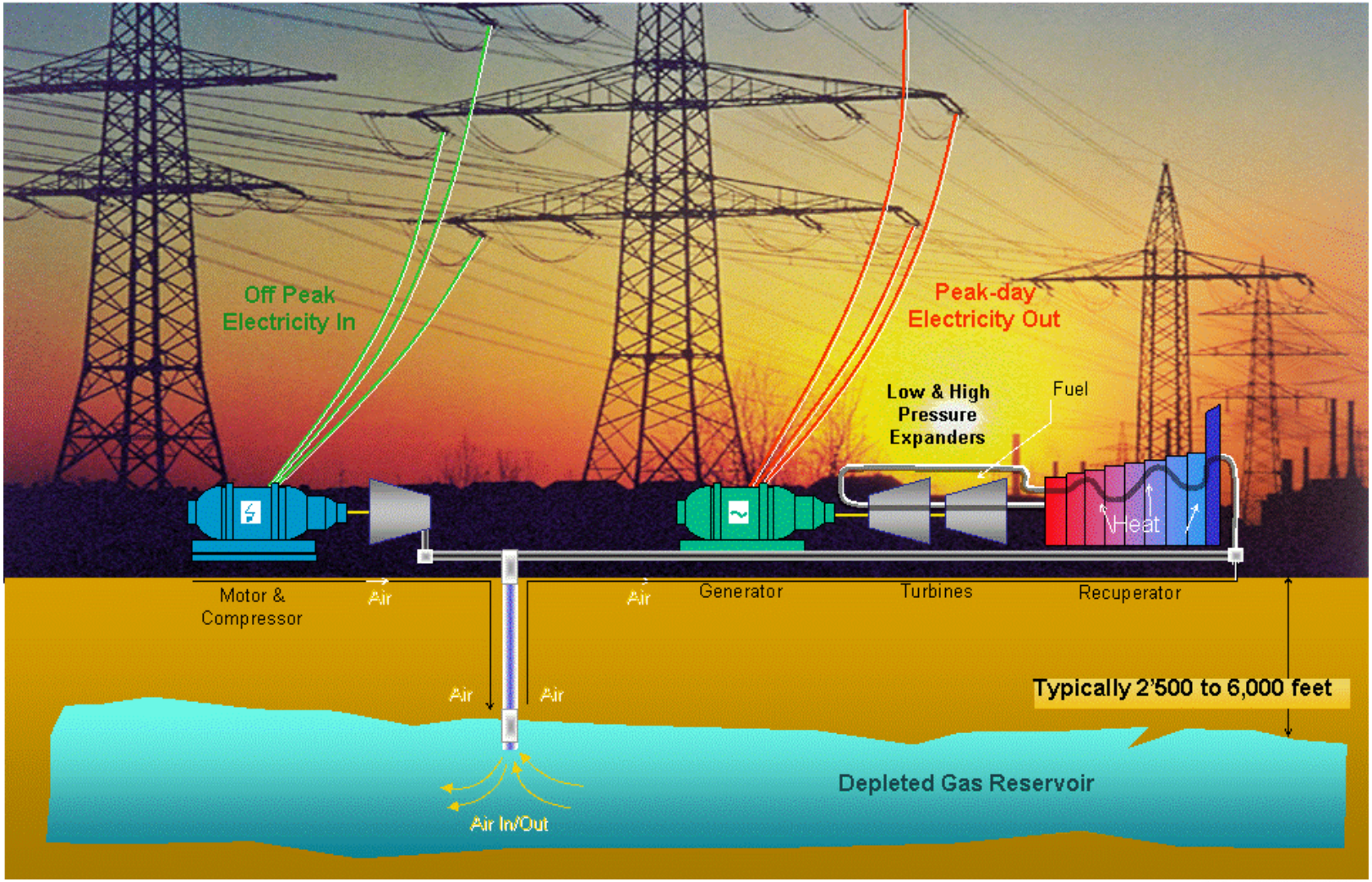
# Compressed Air Storage

**Huntdorf, Germany (290 MW) & McIntosh, Alabama. (110 MW)**

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# NaS and Lithium-Ion - Shorter Time-scales


NGK 1.2MW/ 7.2 MWhr

substation (upgrade deferral) system

(6 hrs storage)

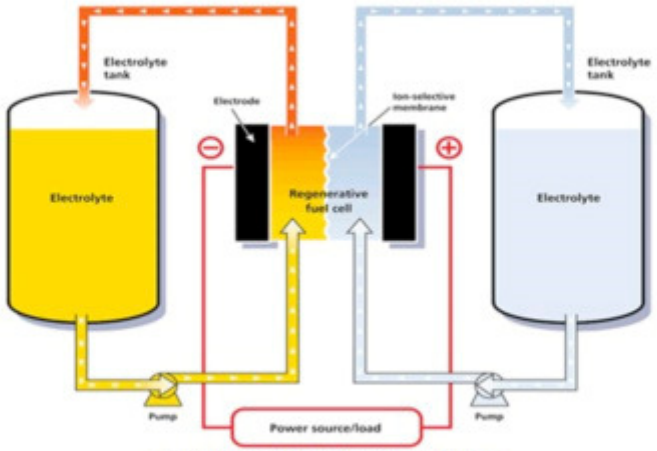
A123

2MW/ 0.5 MWhr

Multi-purpose system

(15 min storage)

# Vanadium Redox Flow Battery
## King Island Tasmania – Renewable Energy Integration



*Concept of a Redox Flow Battery System*

VRB Power Systems
200kW/ 800 kWhr
(4 hrs storage)

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# Flywheel - Regulation Services
# New York State

Beacon Power
20MW / 5MWhr
(15 min storage)

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# UltraBattery (modified Lead-Acid) Regulation Services - Pennsylvania

East Penn Manufacturing Co.

3.6MW / 3MWhr - East Penn UltraBatteries

(1 hour storage)

ecoult
smart energy storage

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# Ecoult / East Penn UltraBattery Renewable Storage Concept


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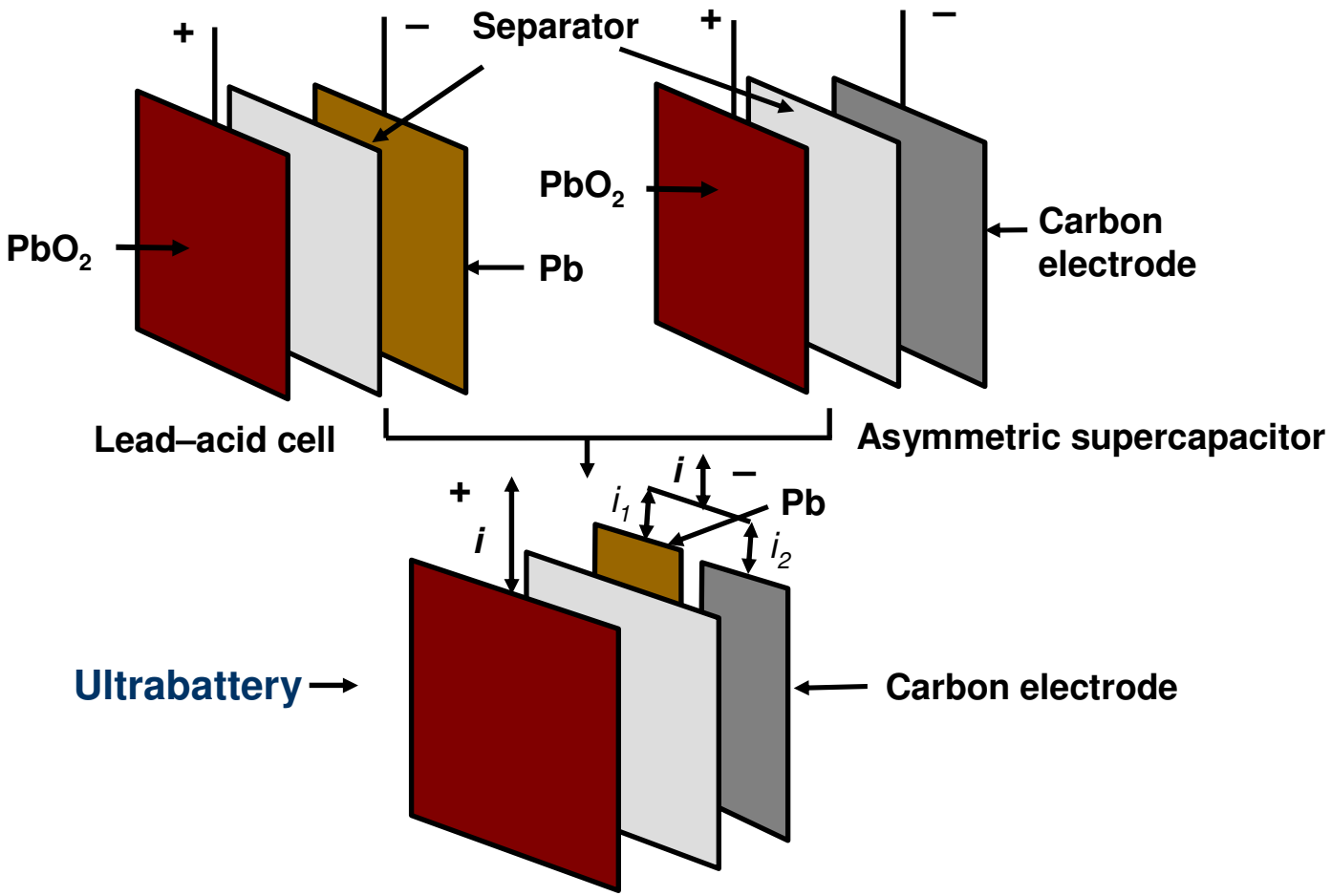
# The UltraBattery

# UltraBattery – a modified Valve Regulated Lead Acid (VRLA) Battery

- UltraBattery characteristics
  - Solves problem of reduced life under high discharge conditions
  - originally designed for hybrid car applications
  - higher current capability
  - extended cycle lifetime
  - low string-voltage drift
  - standard production techniques


Highly successful 100,000mile trial in Honda Insight (no string balancing required)

# Principle of the UltraBattery




- Ultrabattery is a hybrid energy-storage device, which combines an asymmetric capacitor and a lead-acid battery in one unit cell, without extra electronic control

# UltraBattery applications

- New classes of applications for VRLA batteries
  - Build on high current capability
  - renewable energy smoothing of fluctuations <~60mins
  - Regulation services (phase and voltage compensation)


- Manufacturing through Furukawa in Japan and East-Penn in USA
  - Available in production quantities
  - Applications through Ecoult division of East-Penn (ecoult.com)

ecoult
smart energy storage

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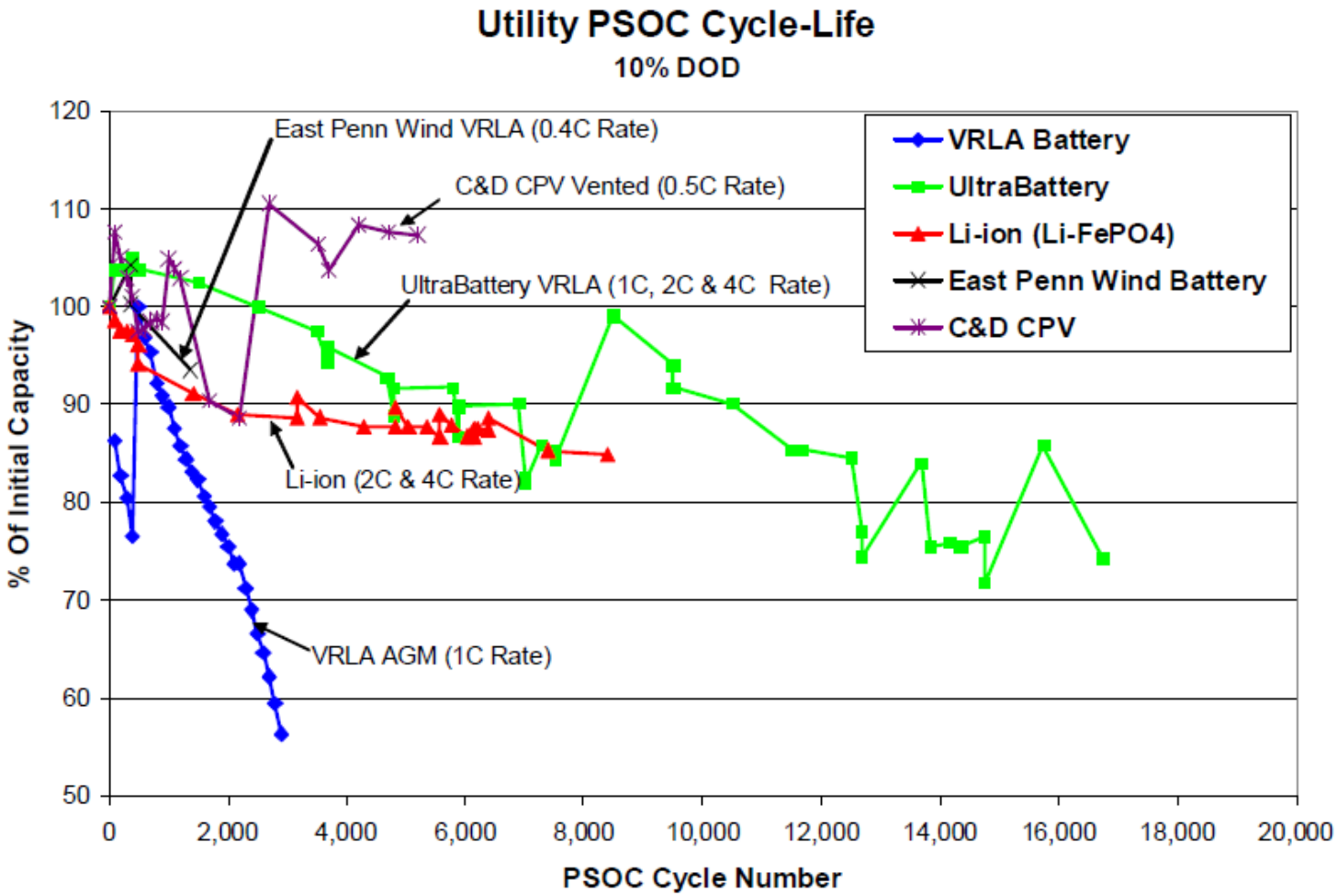
# Sandia Labs Ultrabattery Cell Testing under Regulation Services Profile (December 2008)

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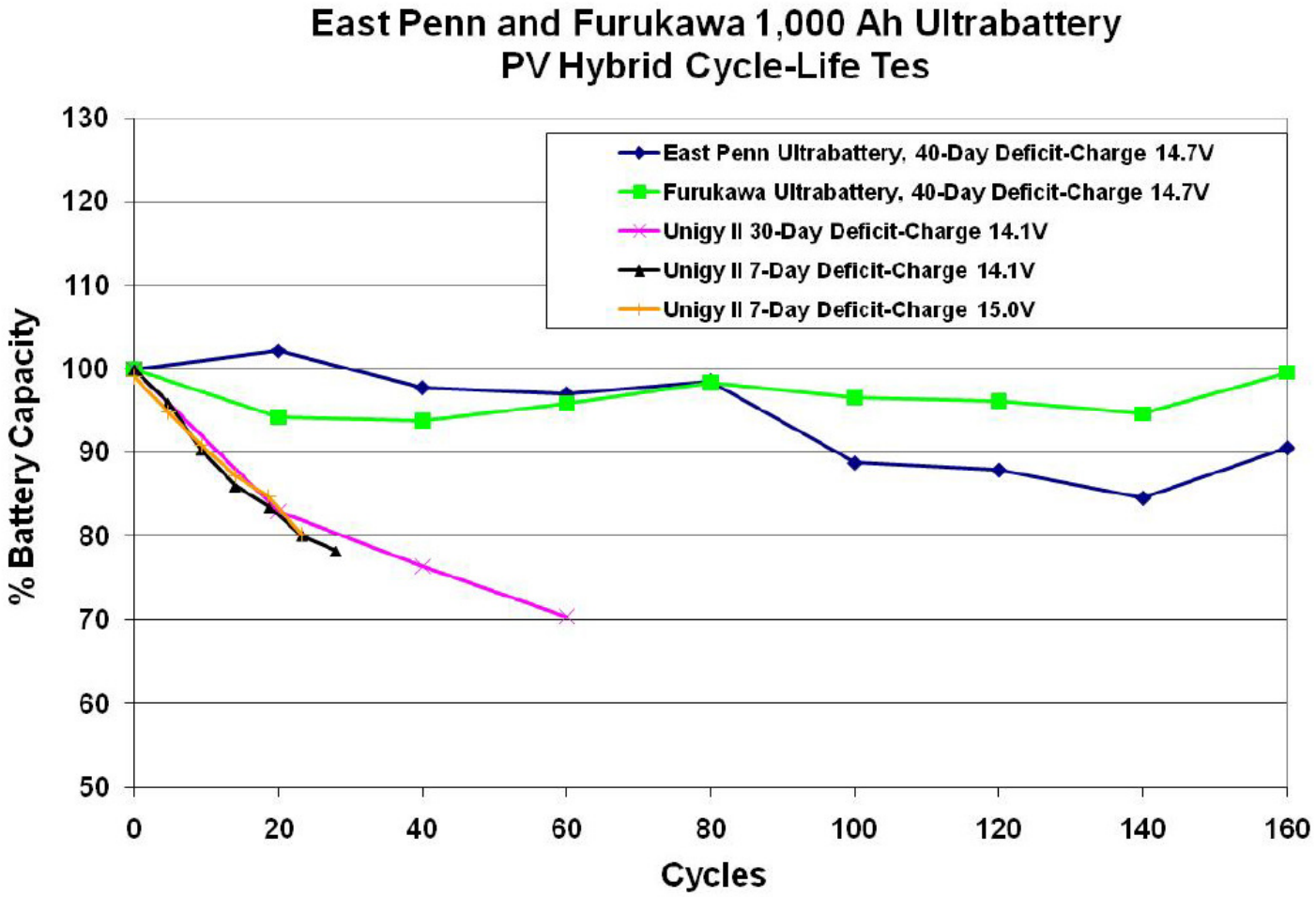
# Sandia Labs Ultrabattery String Testing under PV-Hybrid Test Profile (November 2010)




Sandia National Laboratories

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# Large-scale UltraBattery Systems

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# Demonstration Strategy - Grid Connected Wind Farm

**Hampton Wind Park**
New South Wales
Australia

2 Vestas V47-660kW turbines

Storage Systems:

Module 1 – Custom built
Module 2 – Modular building block

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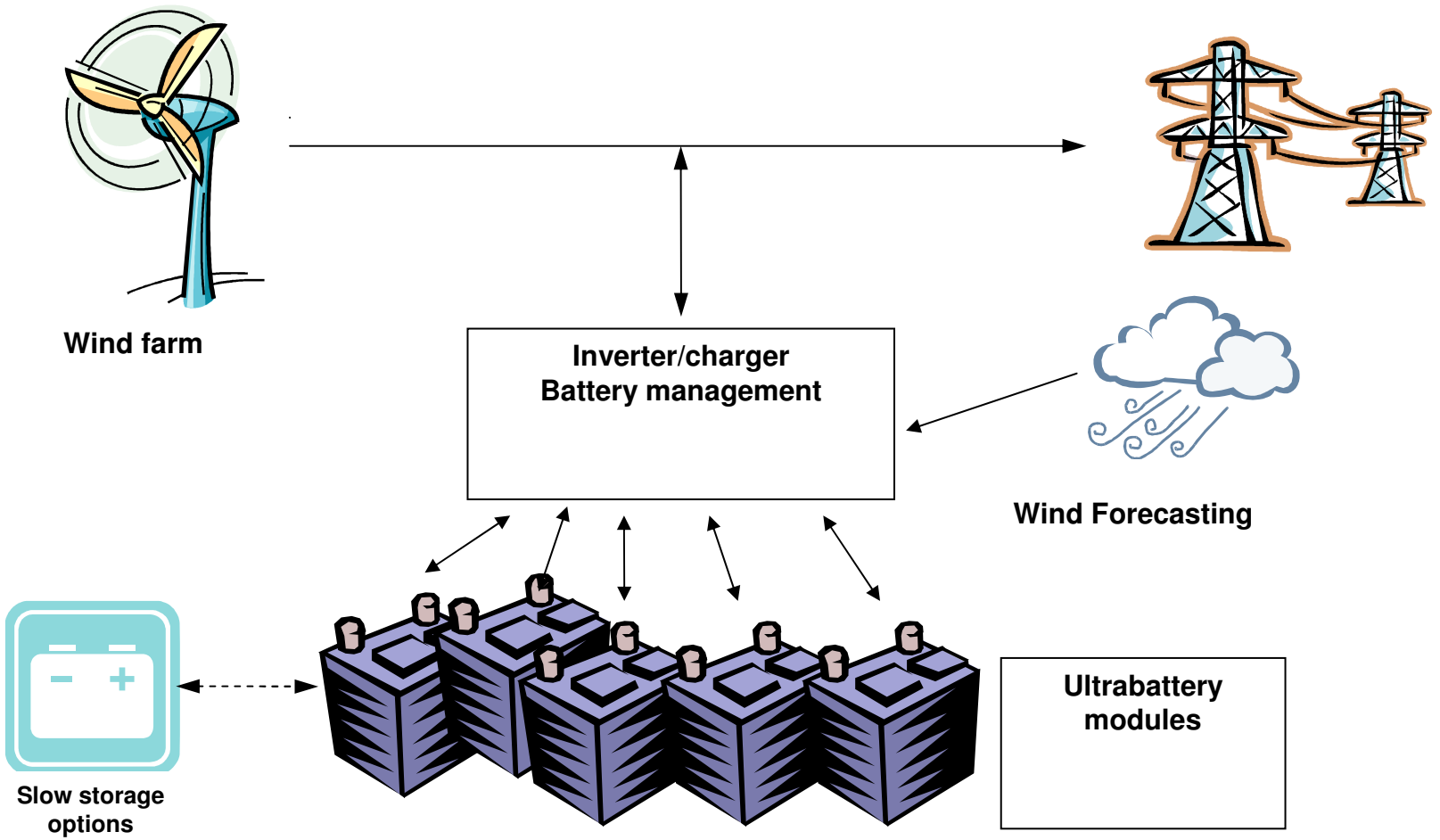
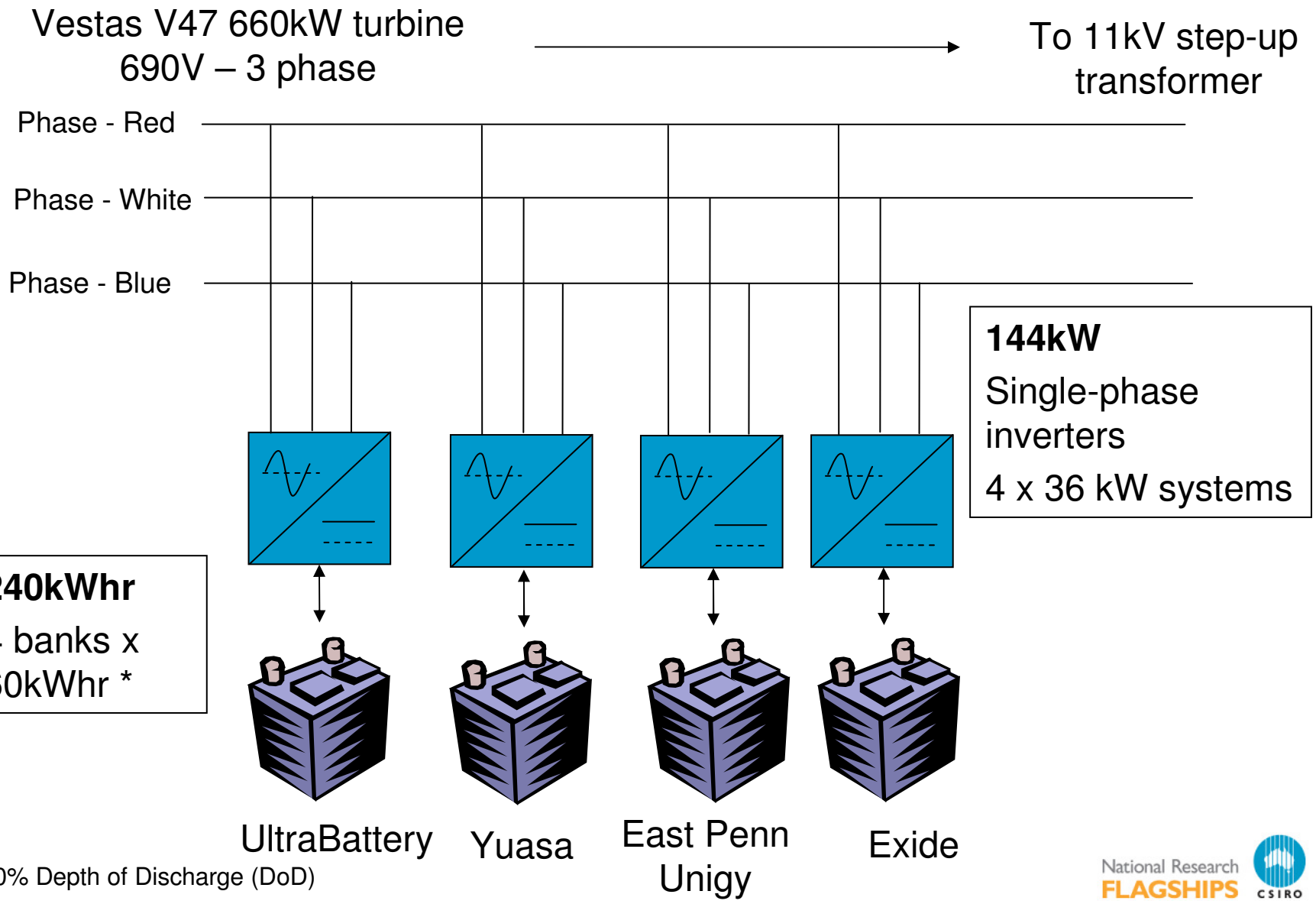
# Wind-storage example schematic



# Module I – prototype test system




* 50% Depth of Discharge (DoD)

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# Hampton Module 1 Control Systems


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# Hampton Module 1 Battery systems

Furukawa manufactured UltraBatteries

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# Hampton Module 1 Battery systems


Deka (East-Penn) unigy II batteries

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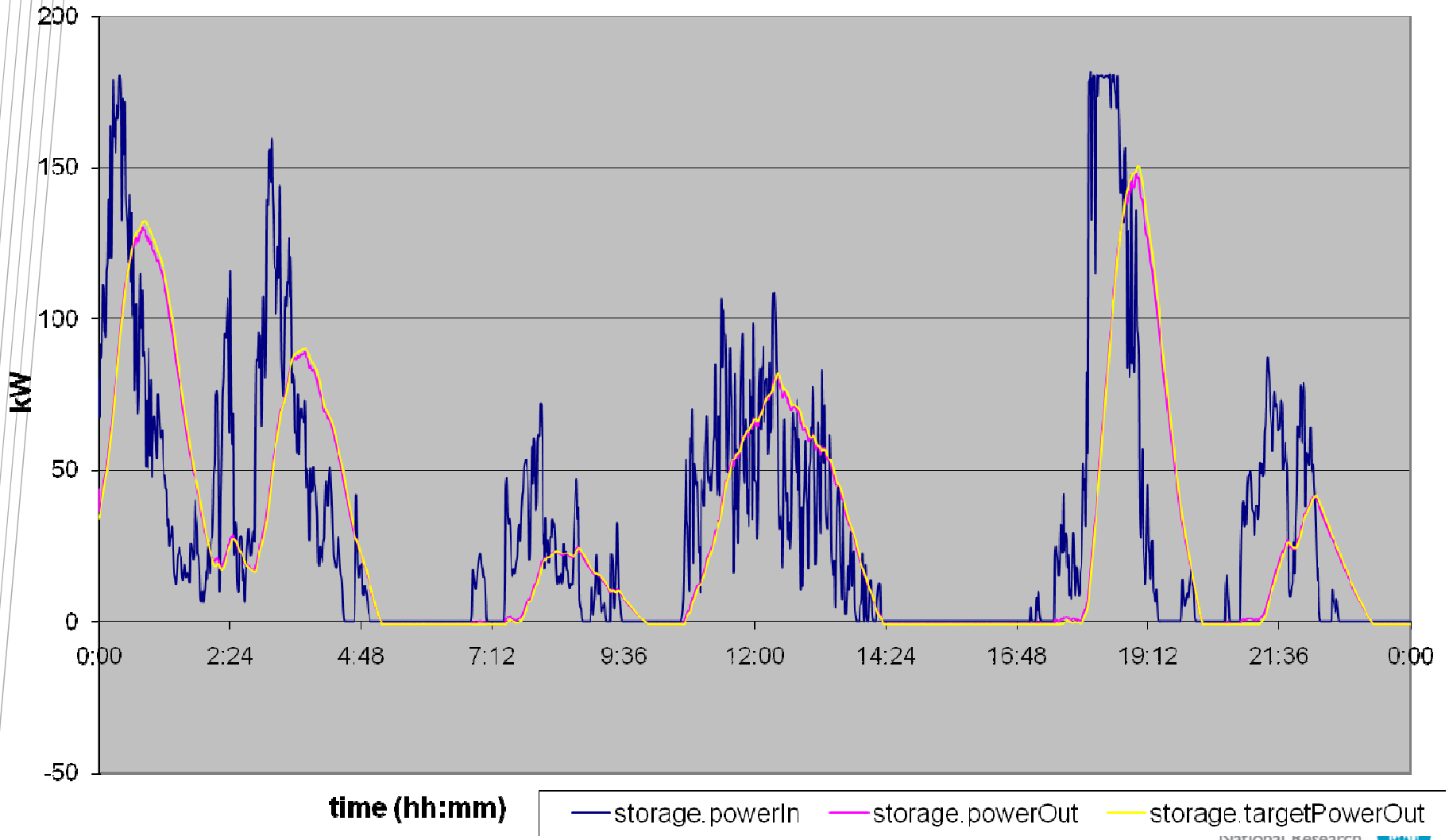
# Renewable Energy Smoothing – wind farm example 26th December 2010 – simple filtering

Scaled wind turbine output – 165kW during initial trials

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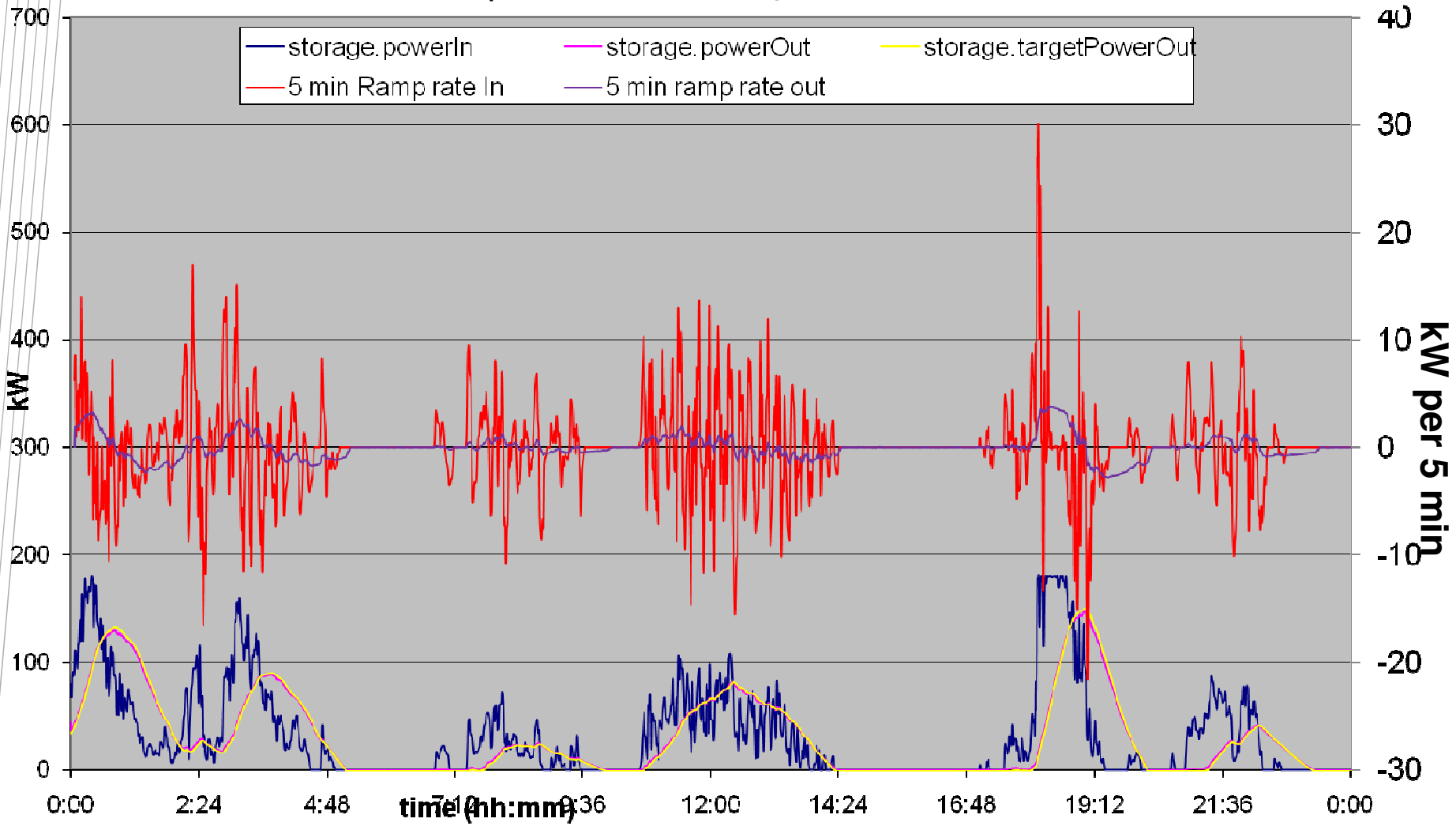
# Storage effect on power ramp rate

Scaled wind turbine output – 165kW during initial trials

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# Module 2 –1MW production system

Vestas V47 660kW turbine
690V – 3 phase

To 11kV step-up transformer

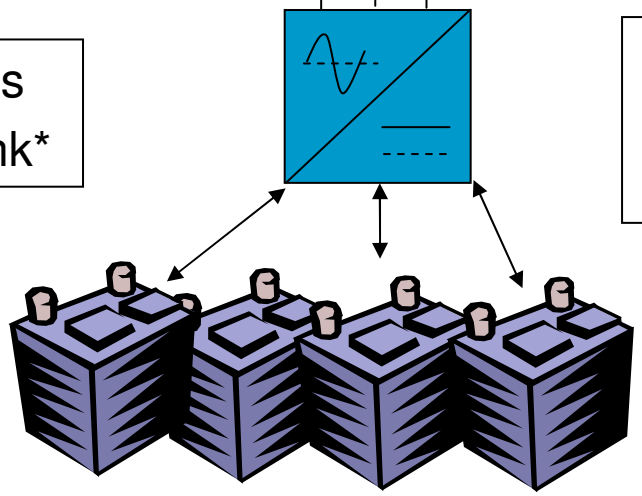
Phase - Red

Phase - White

Phase - Blue

320 high capacity cells
yields1 x **500Whr** bank*

1 x **1MWhr**
(capped 660kW)
3-phase inverter



East Penn
UltraBatteries

* 50% Depth of Discharge (DoD)

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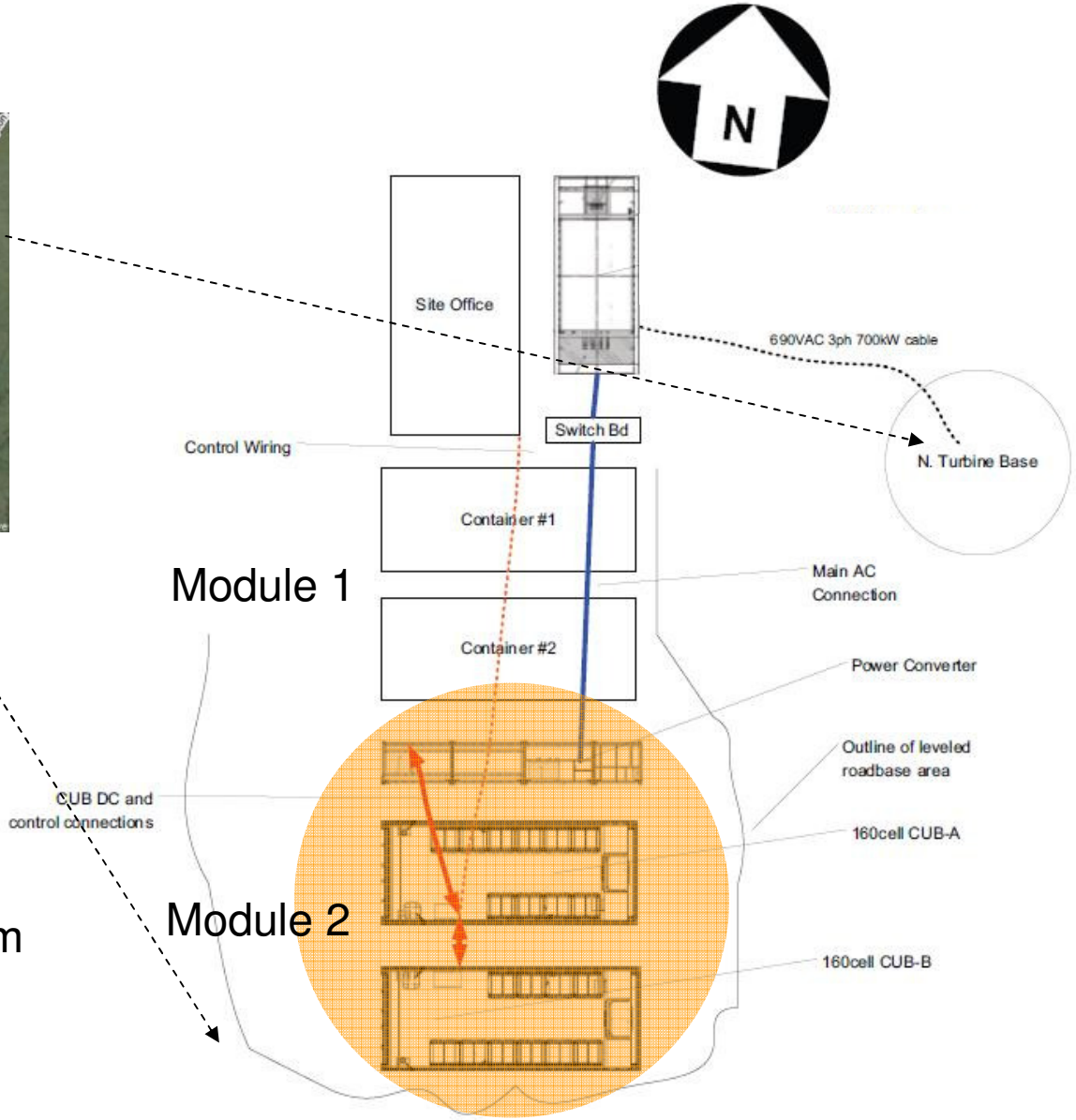
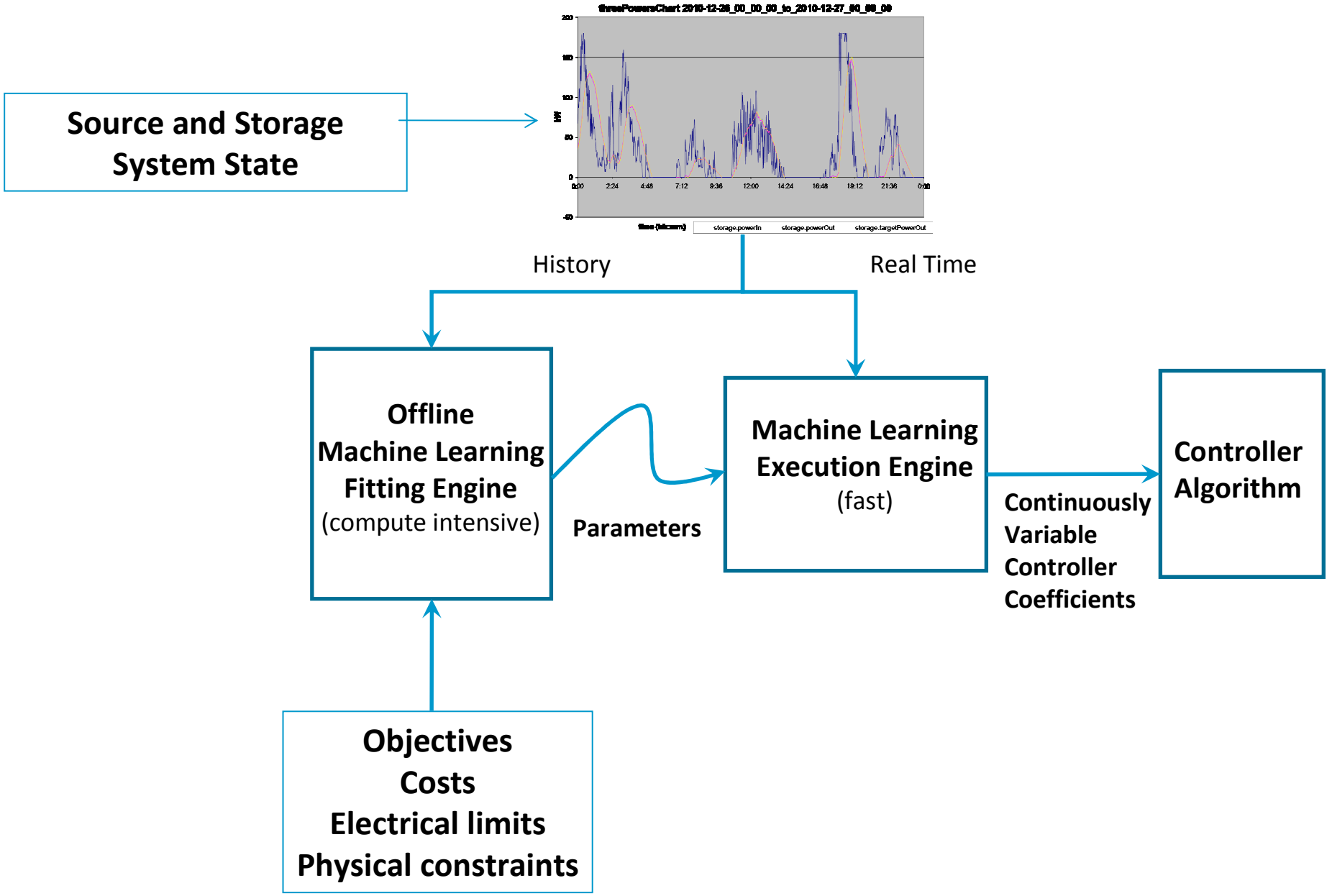
# Hampton Site – module locations


- Trial of production system
- Modular platform
- 1MW PCS building block
- Containerized Battery System
- 500kWhr storage module

# Adaptive Controller Design



# Ecoult Grid Regulation Services Trial

## System located at East Penn Campus, Pennsylvania:

- US DOE funding – Energy Storage Demonstrations
- Regulation services for PJM (Regional Transmission Organization)
- **3.6MW and 3MWhr*** - 1920 East Penn UltraBatteries
- Install though 2011

*(50% Depth of Discharge)

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smart energy storage

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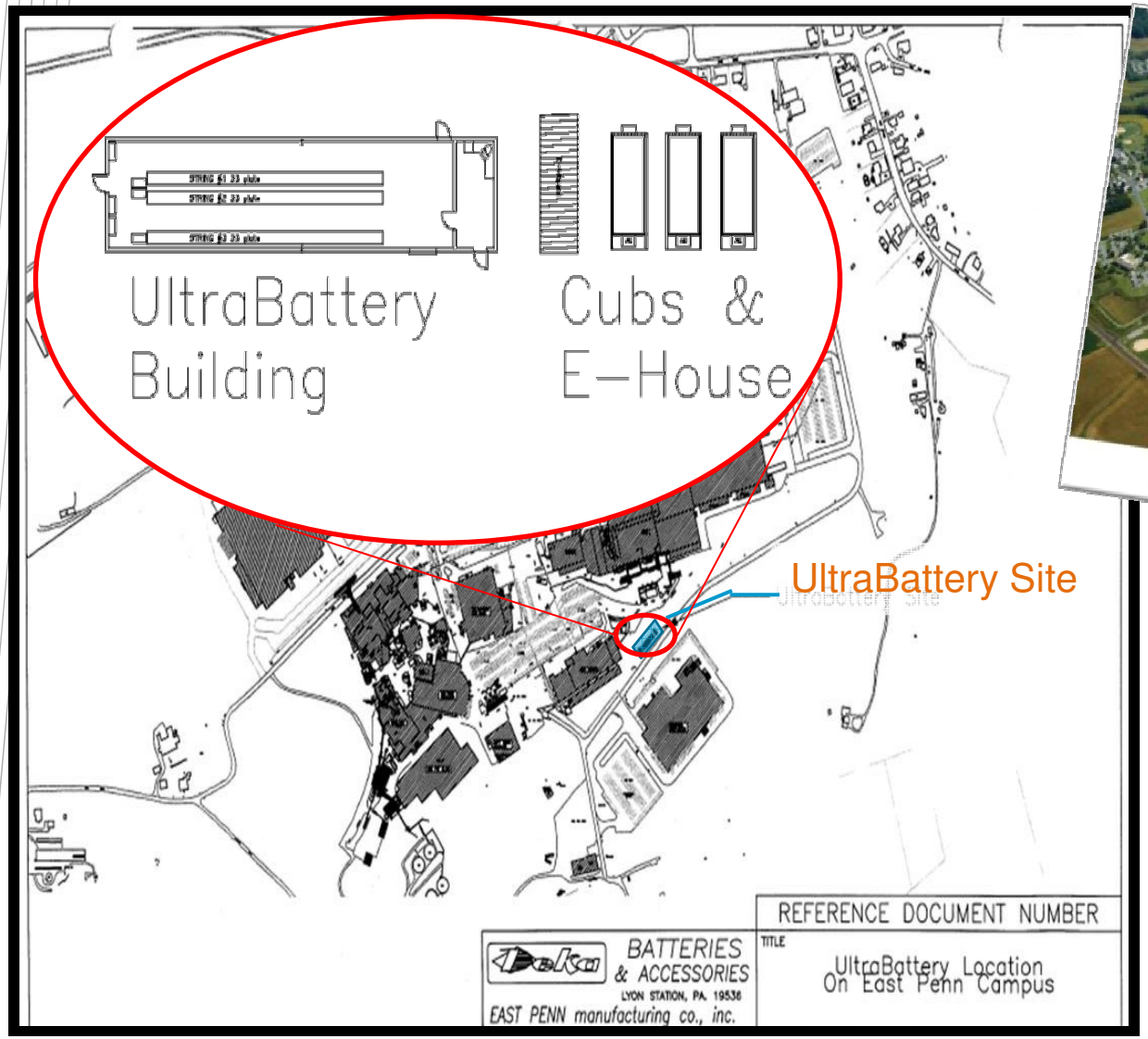
# Ecoult / East Penn 3.6MW Energy Store





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# PV UltraBattery systems

- Public Service Corporation of New Mexico (PNM) “Prosperity PV storage project” - PV plus battery for simultaneous voltage smoothing and peak shifting
  - DOE funding
  - **500kW PV**
  - **500kW / 500kWhr smoothing system**
  - **250kW / 1000kWhr shifting system**

- Australian Government “Solar Flagships”
  - ~150MW PV + 150MW CST – construction from 2012
  - Compulsory Education Infrastructure requirement
  - Proposed solar monitoring, forecasting and storage components

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# Solar Flagships PV Storage System Layout

**150MW PV array**
**HV substn connection**
**Isolator and protection**

**33kV feeder segment**

3MW | 3MW | 125kW | 125kW

Isolator & protection | Isolator & protection | Isolator & protection | Isolator & protection

33kV step-up Txfmr | 33kV step-up Txfmr | 33kV step-up Txfmr | 33kV step-up Txfmr

Sensing from solar array | Sensing from solar array | Sensing from solar array

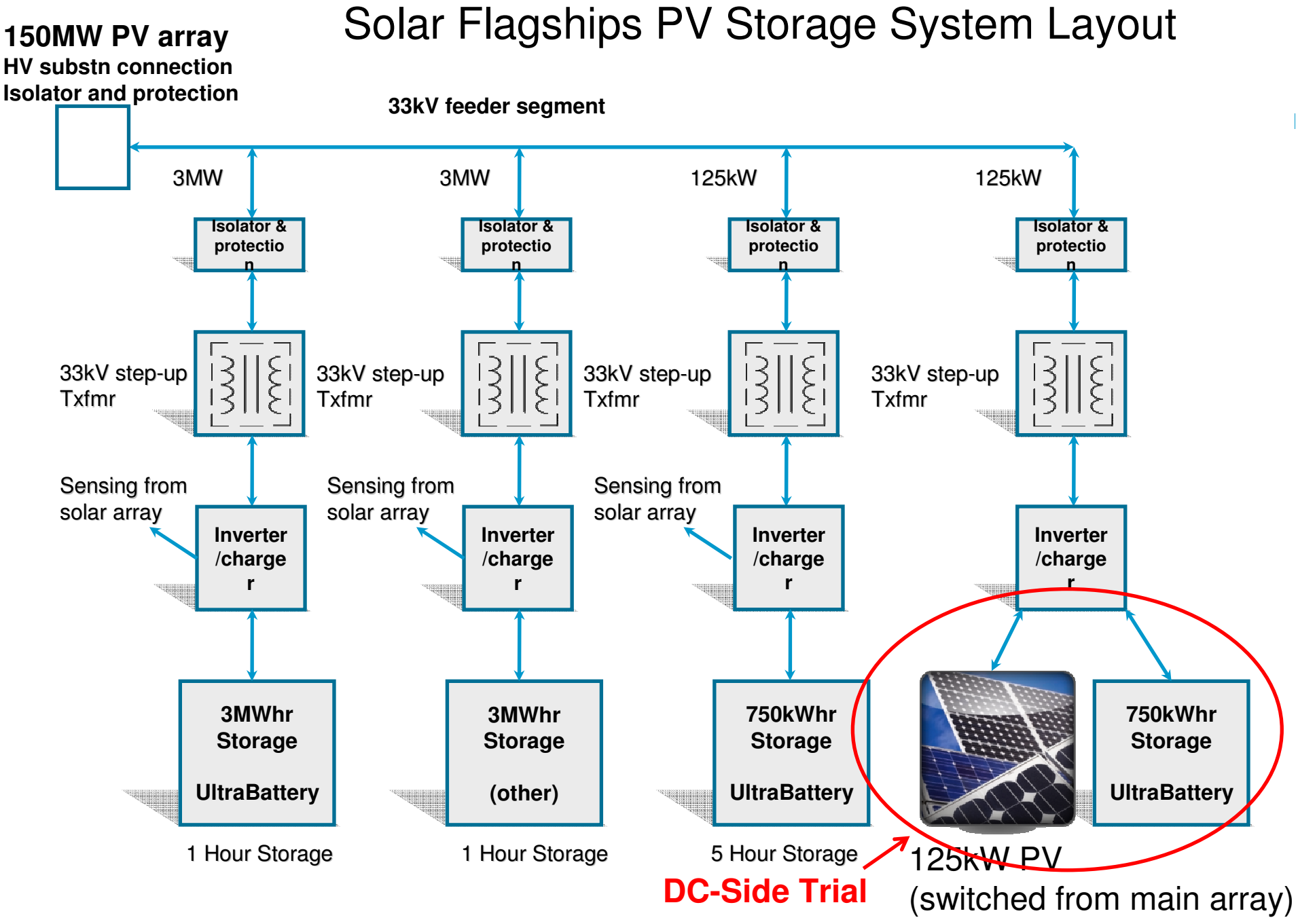
Inverter /charger | Inverter /charger | Inverter /charger | Inverter /charger

3MWhr Storage UltraBattery | 3MWhr Storage (other) | 750kWhr Storage UltraBattery | 750kWhr Storage UltraBattery

1 Hour Storage | 1 Hour Storage | 5 Hour Storage

125kW PV
(switched from main array)

# Solar Flagships PV Storage System Layout



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# Thank you

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