



# **Painesville Municipal Electric Power Vanadium Redox Battery Demonstration Project**

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# Briefing Overview

- Painesville Municipal Electric Power Plant Project Synopsis
- Vanadium Redox Flow Battery Technology
- City of Painesville Municipal Electric Plant History
- Project Multiple Objectives and Additional Detail
- Project Risk Analysis presented at previous Peer Review
- Project to date progress
- Cost Distribution
- Summary/Conclusions
- Future Tasks
- Questions

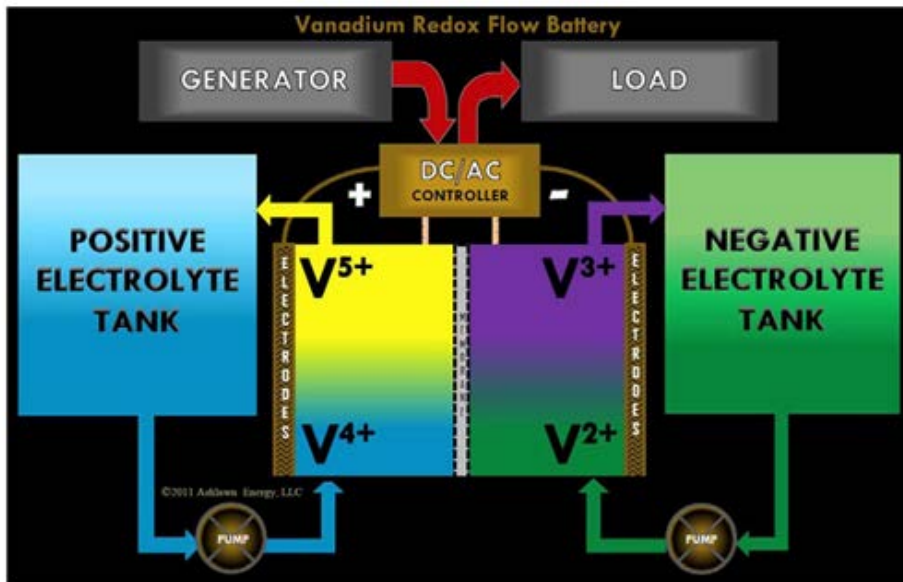


# US Produced Vanadium Redox Flow Battery for Bulk Storage, Peak Shaving

- 8 MW Hour redox flow battery (1MW 8 hours)
- To be installed at Painesville Municipal Electric Plant (PMEP), a 32 MW coal fired facility
- Most efficient PMEP operation is steady state at 26 MW (lowest emissions, lowest operating cost)
- Nominal PMEP power demand ranges from 19 MW to 37 MW
- 8 MW Hour battery to demonstrate benefits of energy storage at PMEP

## What is VanCharg™?

- Ashlawn Energy's vanadium redox flow battery
- Electricity storage system
- Made in the USA



## Advantages:

- Power and Energy Storage are independent
- It is a closed loop system that doesn't need refueling
- Systems last 30 years
- Operationally safe
- Operates in wide temperature ranges
- Low maintenance
- Interfaces with SCADA through software
- FLEXIBLE FOR MANY USES
  - Frequency Regulation
  - < 50 millisecond response
    - Black Start
    - UPS
  - Incorporating wind & solar
  - Peak shaving
- AFFORDABLE

# Vanadium Redox Flow Battery

- Power is not tied to energy storage capacity
- Construction is modular
- Safe
- Extended deep cycle life (>5,000 cycles)
- Affordable

# Modular Design

*Stack Modules-Higher Power*

**Painesville building block – 10kw stack**  
**1 Module below of 160 kw is made up of 16, 10kw stacks**

**Continuous Discharge Rate  
(kW)**

**1 Module (160 kW)**



**2 Modules (320 kW)**



**8 Modules (1.28 MW)**



# Modular Design

*Vanadium Electrolyte Modules-Higher Molarity*

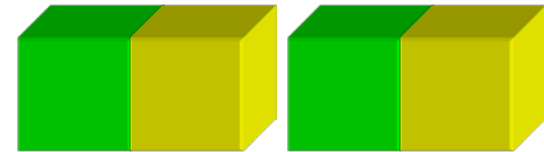
**Painesville Storage time**  
**The amount of Vanadium Electrolyte dictates storage time in hours**

**Capacity (kWh)**

**320 kWh = 3,300 G**



**640 kWh = 6,600 G**



**1.28 MWh = 13,200 G**



# History of Painesville Power



**1885** - Established by the Globe Electric Company, the Painesville Council contracted for street lights at \$6 per light per month.

**1888** - Council sold bonds raising \$12,500 to erect an Electric Light Plant on N. St. Clair near Main Street in back of the old Fire and Police Station (now public parking lot). The plant continued in operation until 1908. Municipal Electric Systems in Painesville and was adopted by Resolution 223.

**1907** - Painesville Cider and Manufacturing Company property (site of present Light Plant) was purchased for \$2,250.

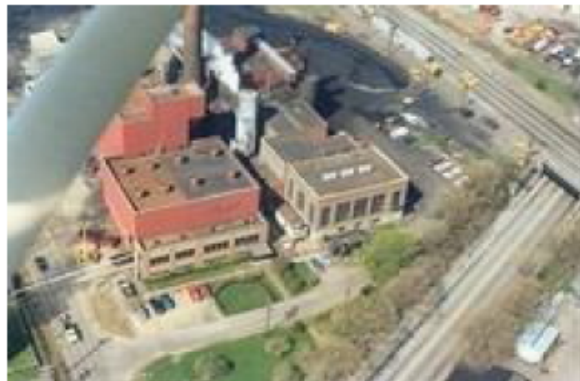
**1908** - A new plant was put into operation. The Commercial Electric Company phased itself out of operation around this time.

**1923 and again in 1928**, large general expansions of the plant facilities created by an increasing demand for electric power in the growing Painesville area.

**1923** - a 1500 kilowatt steam turbine generator manufactured by Allis-Chalmers was installed to replace the existing reciprocating engine type generators and continued in operation until the late 1950s. This was the first large steam turbine at the Light Plant.



Additional Coal fired boilers steam turbines generators and allied equipment have been added to the Light Plant over the course of the years.



The American Public Power Association's grouping of Centennial Cities and Towns lists Painesville's system as the 10th oldest in the country of those communities that still operate their systems. In addition, it is one of 14 municipally-owned electric systems in Ohio still generating, and the oldest still in continuous operation.



# Painesville Municipal Electric Power Plant



**Battery Building Site**

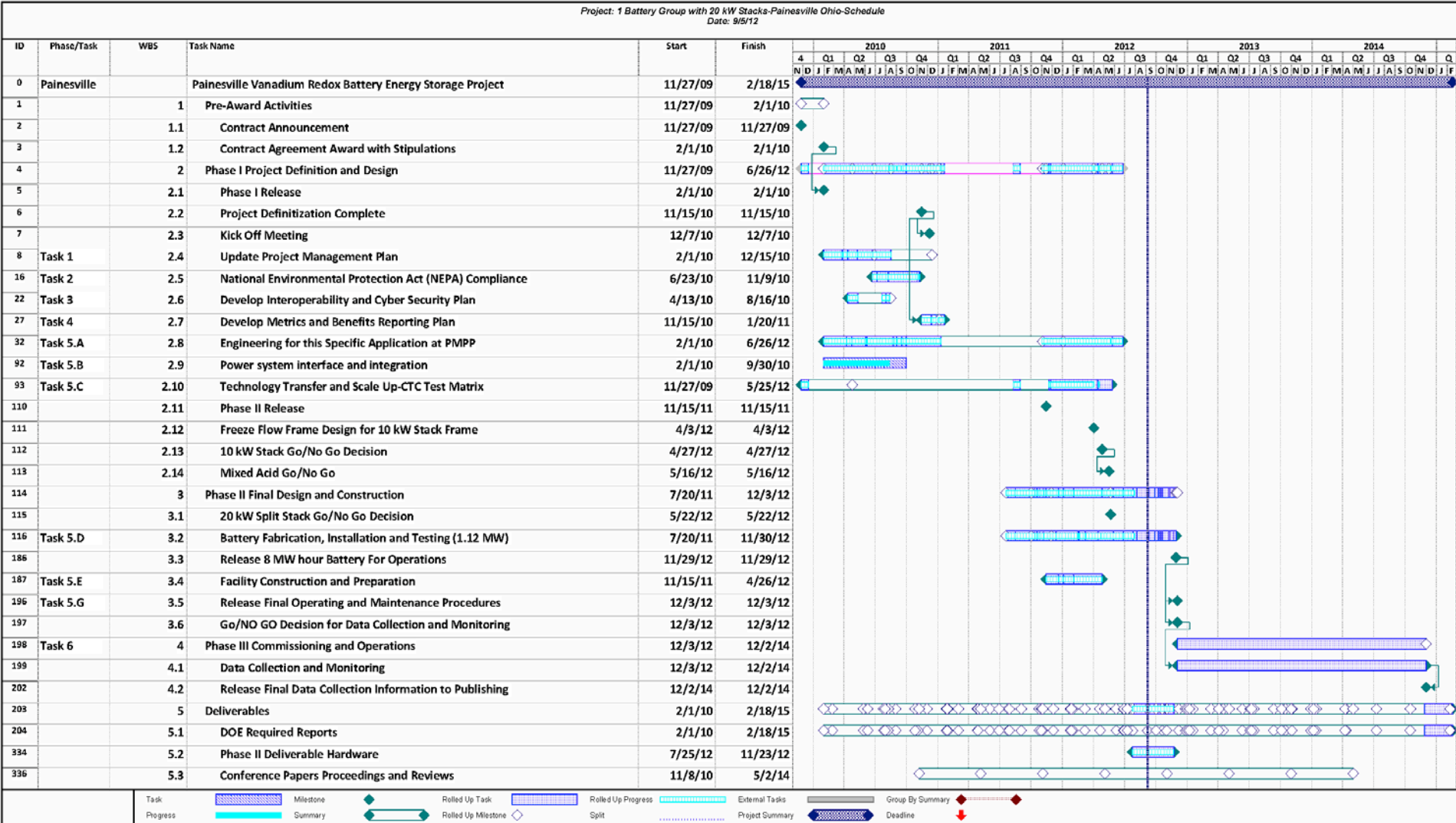
# Project has Multiple Objectives

- **Establish/Use US Manufacturing Base**
  - Stack components/stack fabrication
  - Electrolyte
  - Power Conditioning System
- **Demonstrate Efficacy/Reliability of latest Vanadium Redox Flow Battery Design**
- **Cost Reduction**
- **Platform for Commercially Viable Product**

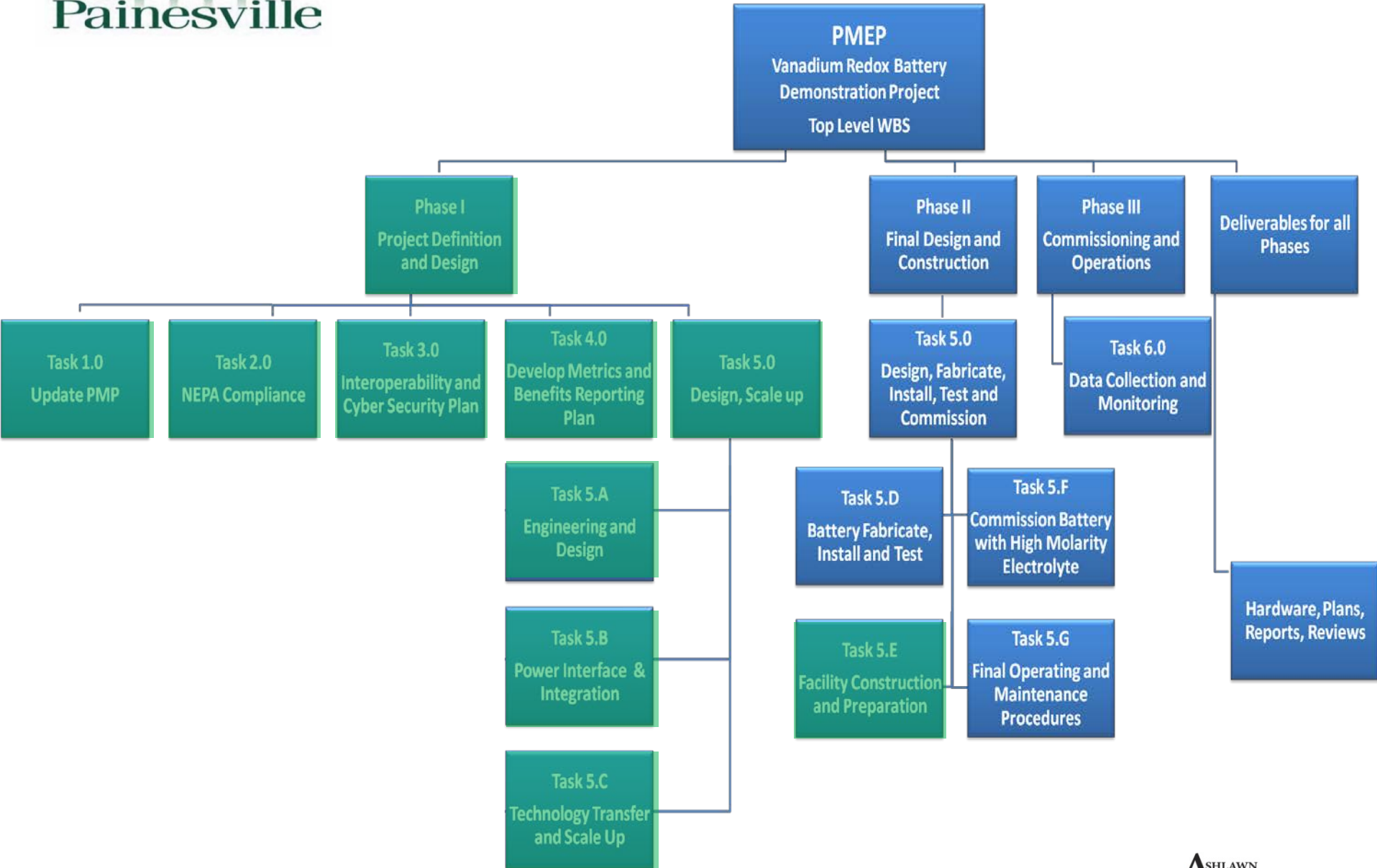


# Current Overall Schedule

Project: 1 Battery Group with 20 kW Stacks-Painesville Ohio-Schedule  
Date: 9/5/12



# Top Level WBS



*Green shading denotes complete*

# Project Risk Analysis

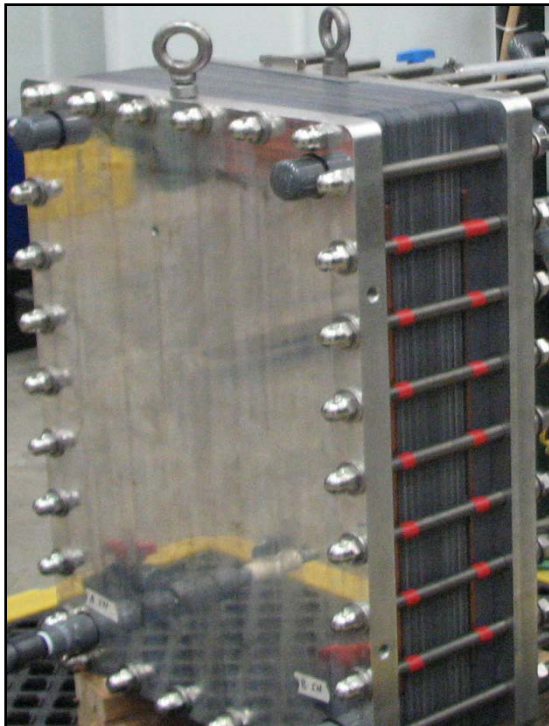
## Reported at Previous Peer Review

- 10 kW stack prove out and electrolyte pricing are key to meeting cost targets
- Process design schedule confirmation is key to meeting building schedule
- Higher molarity electrolyte is key to storage time target
- Process design changes will demonstrate round trip efficiency improvements

# Current Progress

- **Stack Design**

- Performance Capability of 10 kW Milestone Stack Verified
- New, All Composite Stack (not shown) being tested
  - Lower Weight/Lower Cost/Improved Sealing/Faster Assembly Time



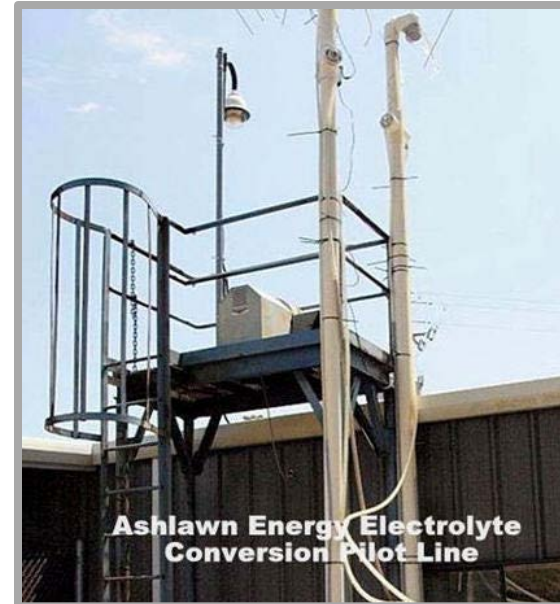
- 20 kW Stack Design Concept Confirmed

# Current Progress

(Continued)

- **Domestic Production and Testing Capability**

- Battery Test Bed System upgraded to confirm full scale pumping rates, shunt current levels, new SOC measurement methodology



- Electrolyte from 2 producers validated thereby establishing US production capability (two additional producers products in test)
- Various Low Cost Membranes, Bi-Polar Plates and Felt Approved for use
- Flow Frame Mold Steel at Mold Supplier, awaiting final flow frame design

# Current Progress

(Continued)

- Dedication of Ashlawn Battery Stack Assembly Building in Painesville





# Current Progress

(Continued)

- Ashlawn Battery Stack Assembly Building in Painesville



# Current Progress

(Continued)

- Battery Building Completed at Painesville Municipal Electric Plant



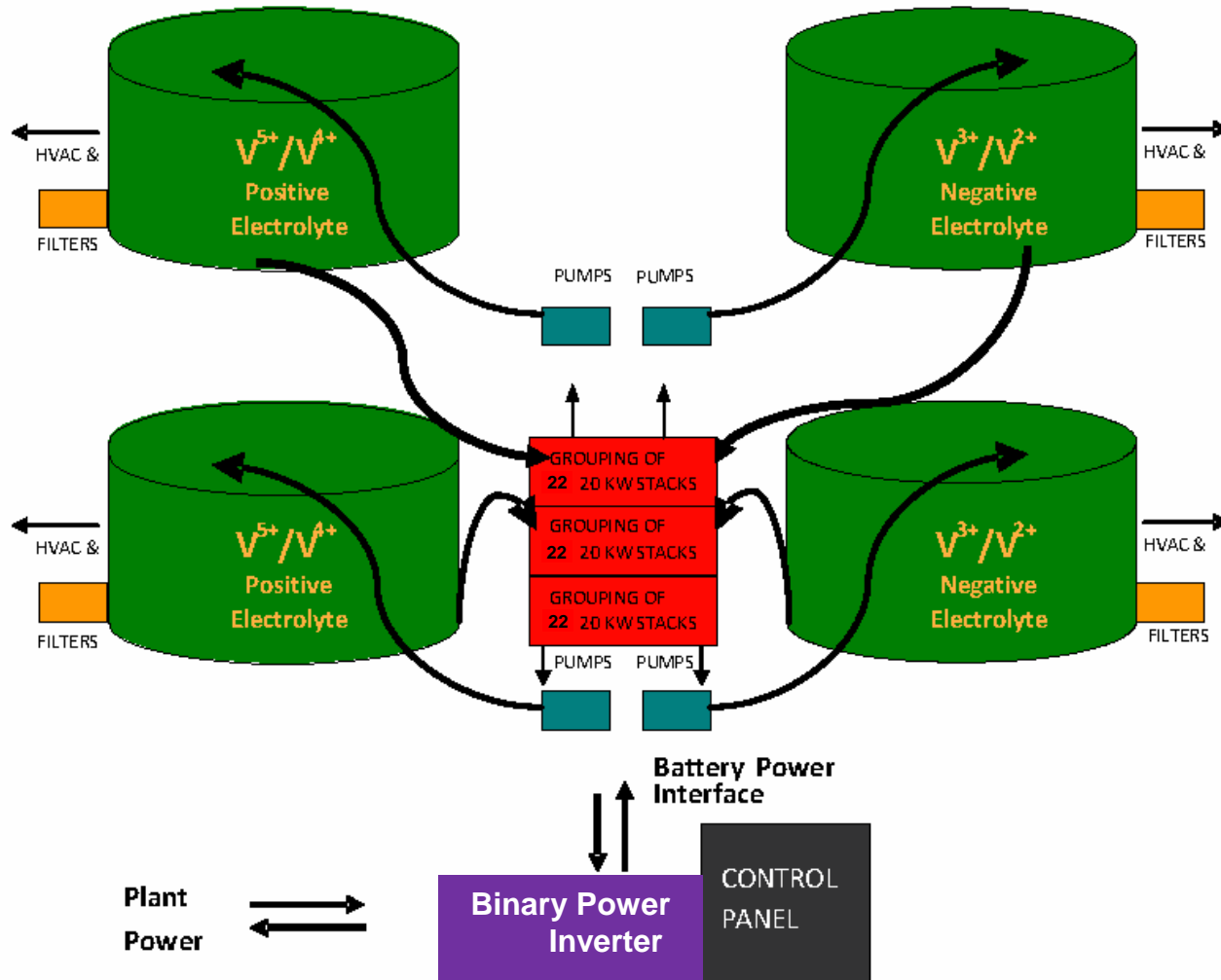
# Current Progress

(Continued)

- Battery Building Motor Control Center at Painesville Municipal Electric Plant



# Current Battery Layout



# Current Progress

(Continued)

- **Round Trip Efficiency**

- Flow Frame design parameters undergoing testing/optimization to provide highest AC/AC round trip efficiency

- Shunt Currents
- Parasitic Losses
- Electrical Efficiency

- **Intellectual Property**

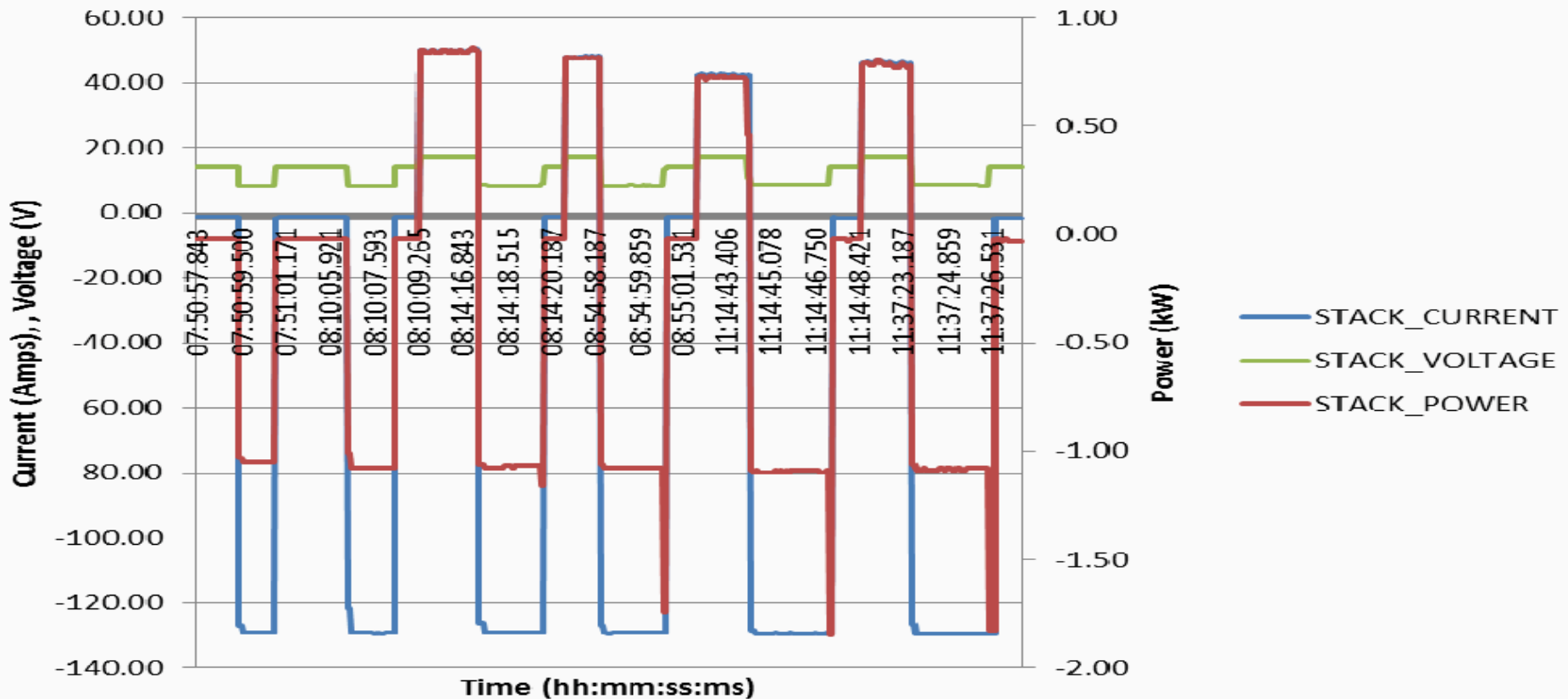
- 10 Potential Patents Identified/2 in Process

# Current Progress

(Continued)

## Battery Response Time

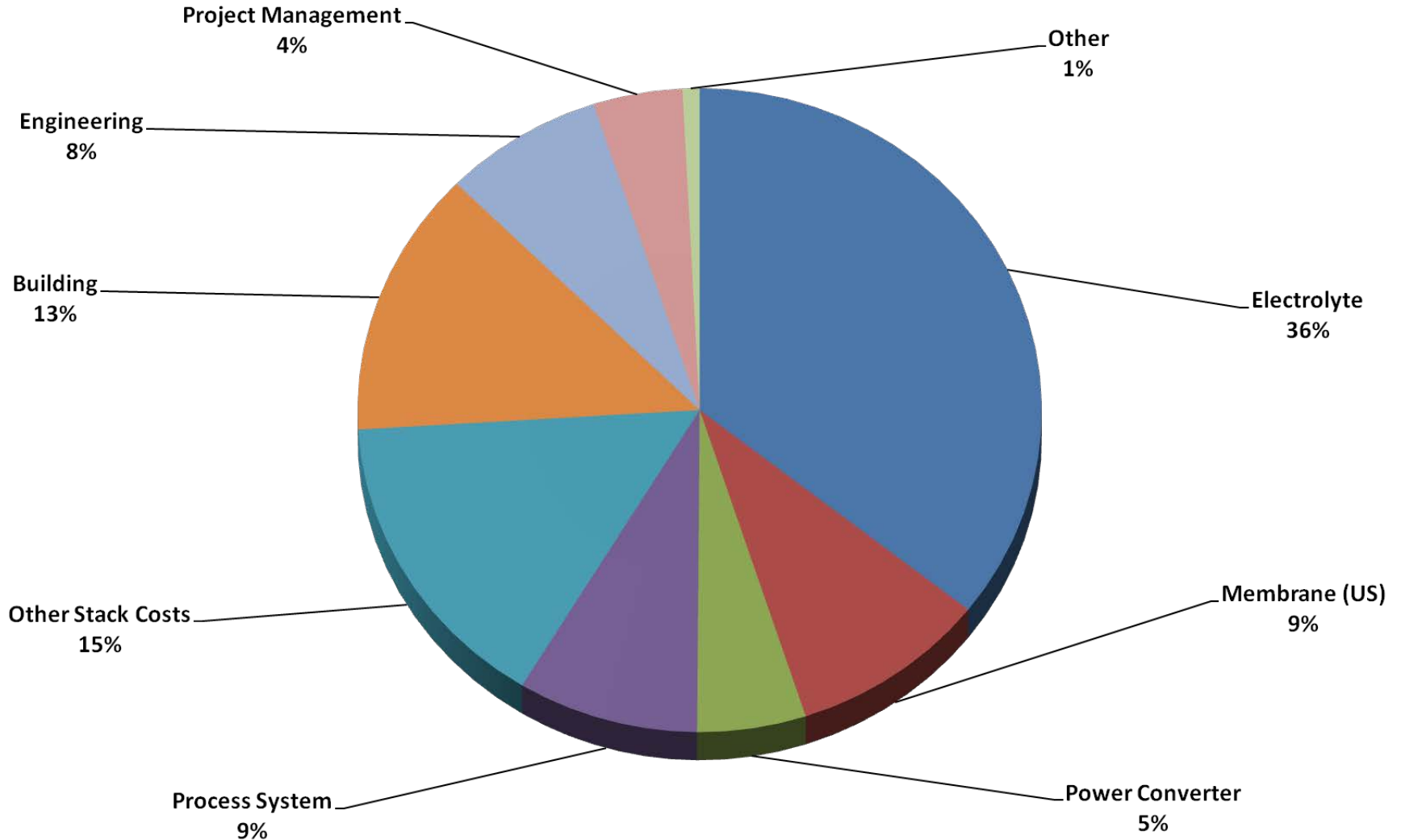
- Rapid (<50 millisecond) response time from charge to discharge with no operator interaction



## Cyber Security and Interoperability

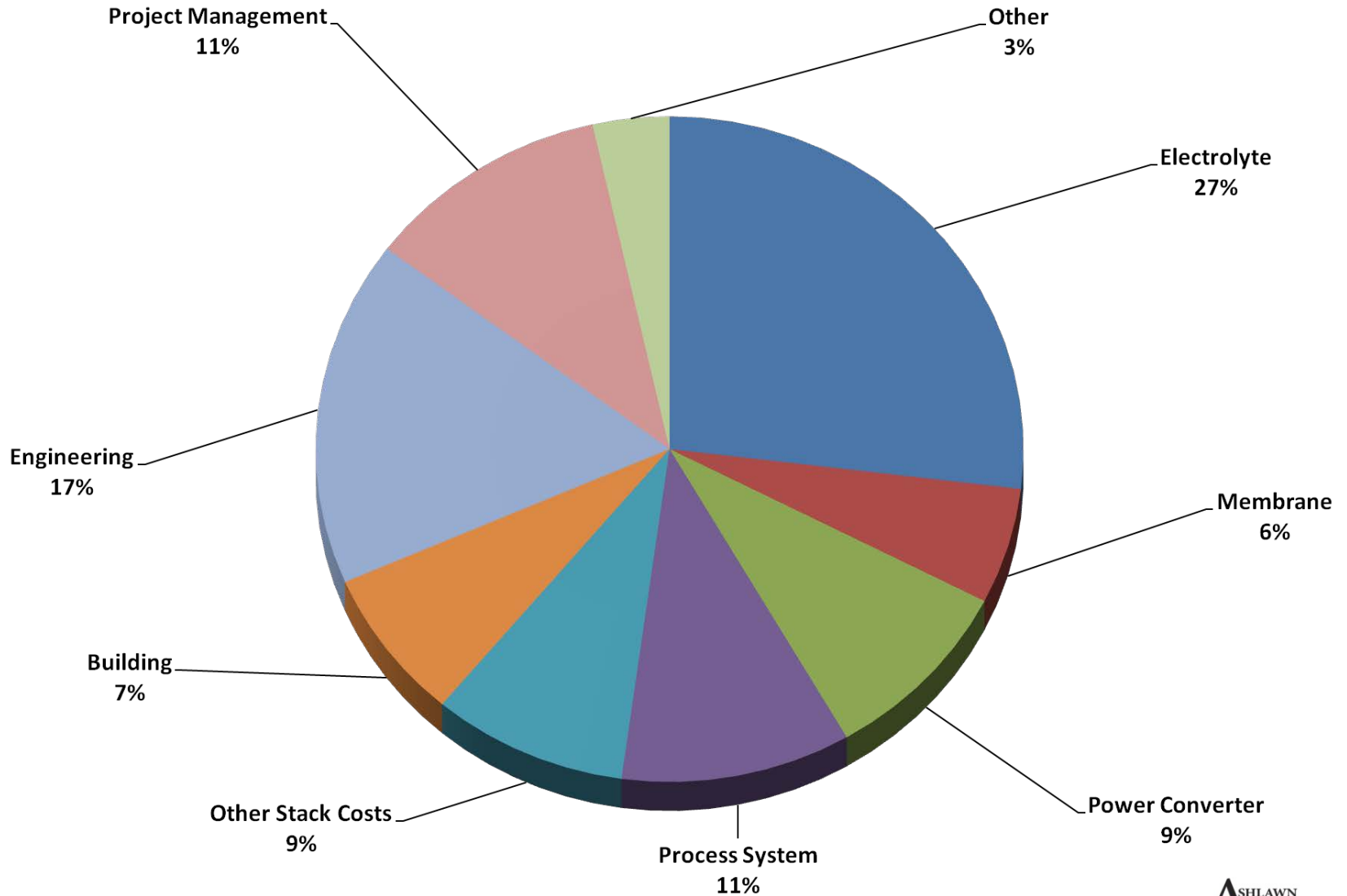
- Threat Reduction / Risk Analysis
  - Project will be air-gapped from plant SCADA (No Remote Data Communications)
  - Not enough current to cause ripple electrical disturbance at PMEP
  - Battery Control System will be locked and secured per applicable NERC standards
  - DOE-approved security policies will be in effect for all information systems

# Major Cost Drivers at Start





# Major Cost Drivers at Present



# Summary/Conclusions

- Project will complete 3 months behind original schedule and is currently over budget
- Component/Process design improvements, inventions and competition have reduced costs
- Test bed confirmation of process design changes have demonstrated/are demonstrating round trip efficiency improvements

# Future Tasks

- Complete trade off analysis between AC/AC round trip efficiency, component cost, shunt current loss and pumping efficiency
- Update Competitive Bids on Components
- Release Long Lead Orders on Manufacturing Equipment/Components
- Optimize Balance of Plant Final Design
- Complete Operational Testing of Improvements
  - 20 kW stack prototype
  - 50% increase in active area
  - Mixed acid scale up
- Install Battery/Initiate Grid Scale Demonstration Phase



# **Painesville Municipal Electric Power Vanadium Redox Battery Demonstration Project**

Questions?

