

Flow Battery Testing & Demonstration Project

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The Project

- Partnership with two corporations
- 3-year program (started back in 2015)
- Focused on a variety of technologies
- Multi-application and multi-sector
- Aligned with their corporate mission and technology goals
- Provide opportunities for students, faculty and staff
- Develop IP and build capacity
- Raise the visibility of the San Antonio area

The Project – 1st Year

- Establish Partnership
- Identify technologies of interest
- Market survey
- Identify key companies
- Questionnaires and Phone Interviews
- Site visits
- Selection
- Procurement

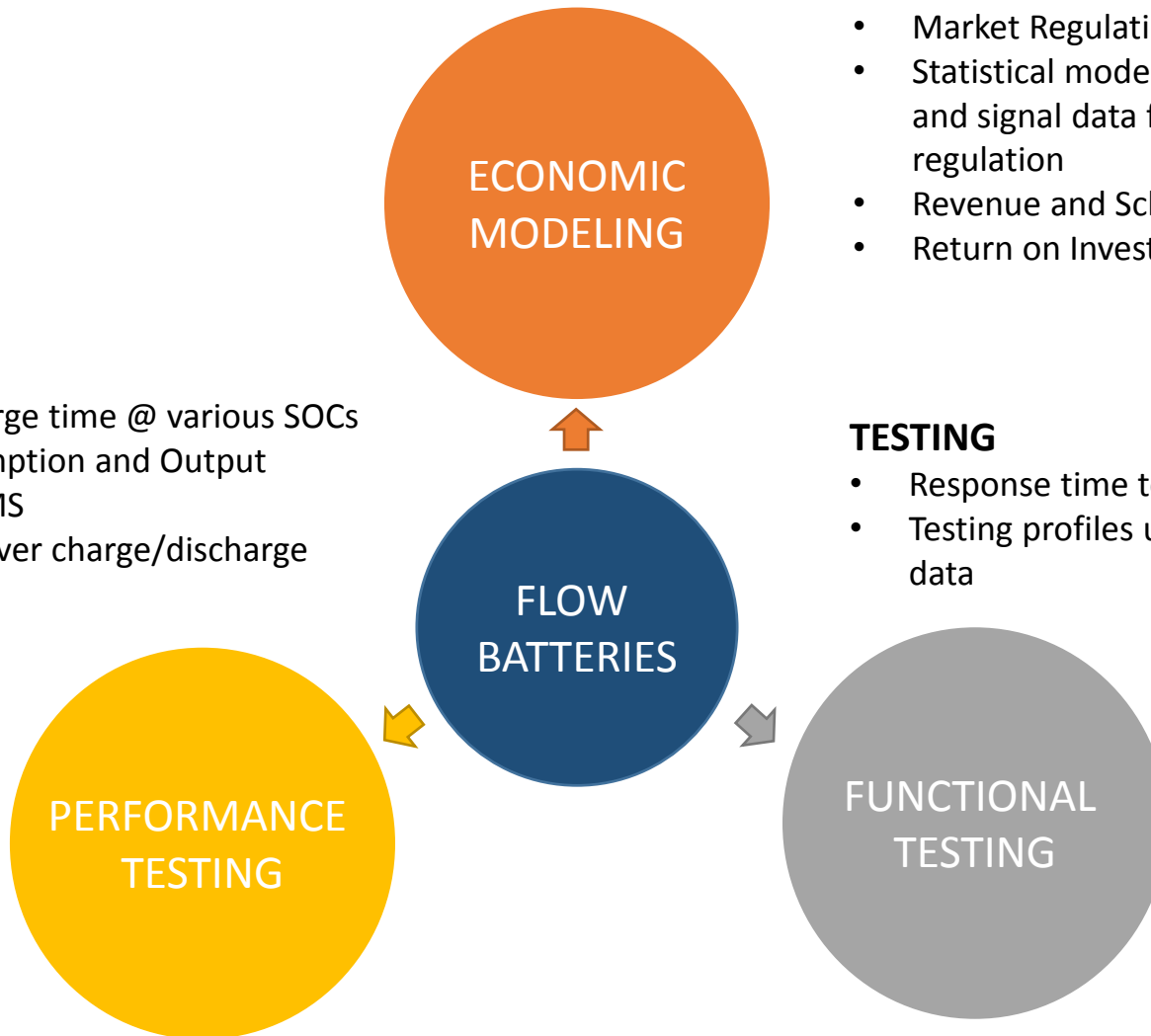
The Project – 2nd Year

- Commissioning
- Testing
 - Performance
 - Functional
- Analysis of ISO data (ancillary services and pricing)
- Understanding technology, benefits, limitations, capacity, sizing, scheduling, integration
- Evaluation of costs and potential applications

Project Overview

VALIDATION

- Charge/Discharge time @ various SOCs
- Energy Consumption and Output
- Accuracy of BMS
- Performance over charge/discharge cycles



SIMULATION

- Market Regulation Research
- Statistical modeling to forecast price and signal data for frequency regulation
- Revenue and Scheduling Optimization
- Return on Investment Calculations

TESTING

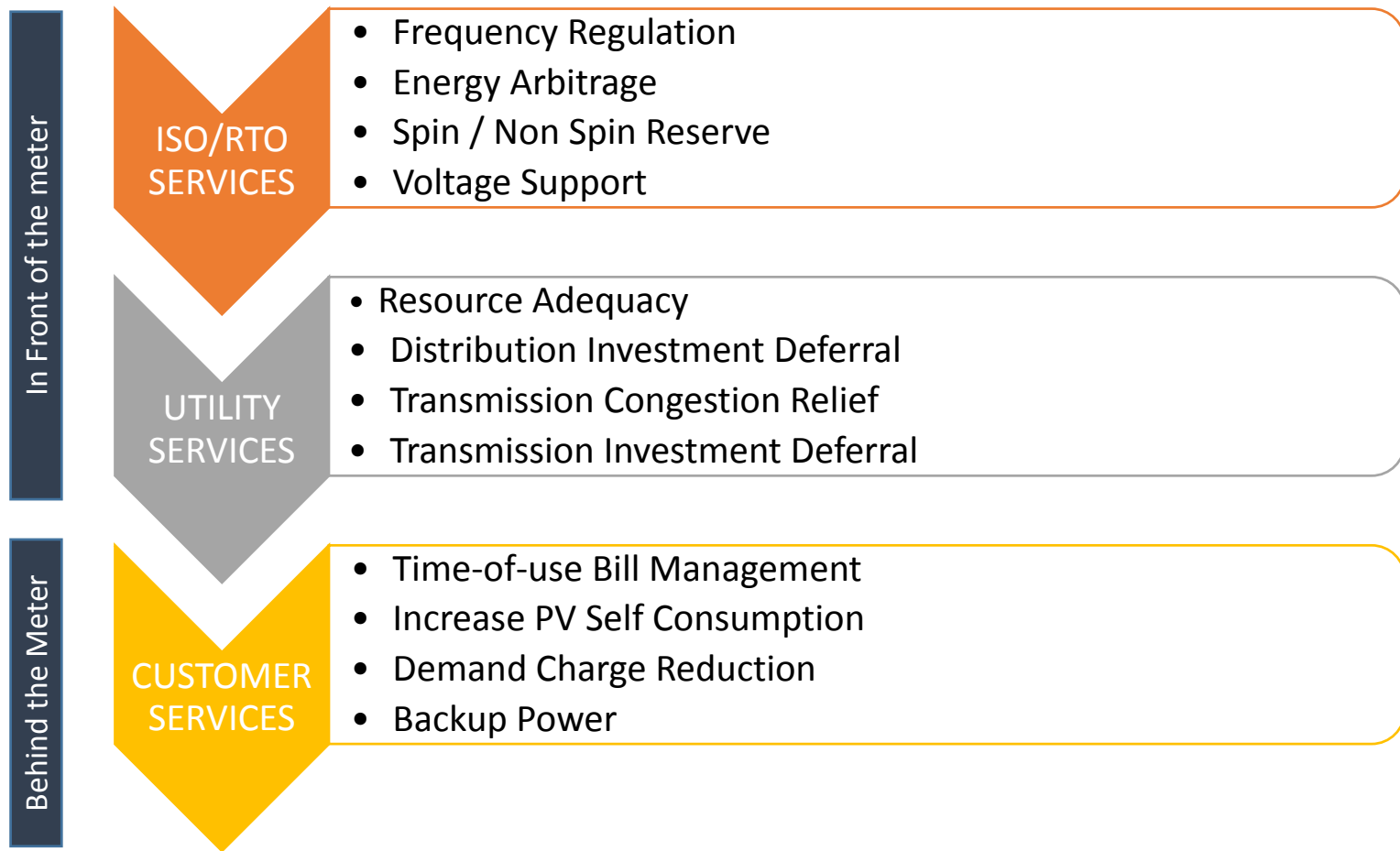
- Response time to FR signals
- Testing profiles using historical signal data

Analysis of ISO Data



- Integration of renewables
- Deployment and demonstration
- Rules and regulations
- Historical data
- Revenue potential vs grid reliability
- Understand the market and its players
- Integration with traditional resources
- Benefits at Transmission, distribution, customer levels

Energy Storage Applications



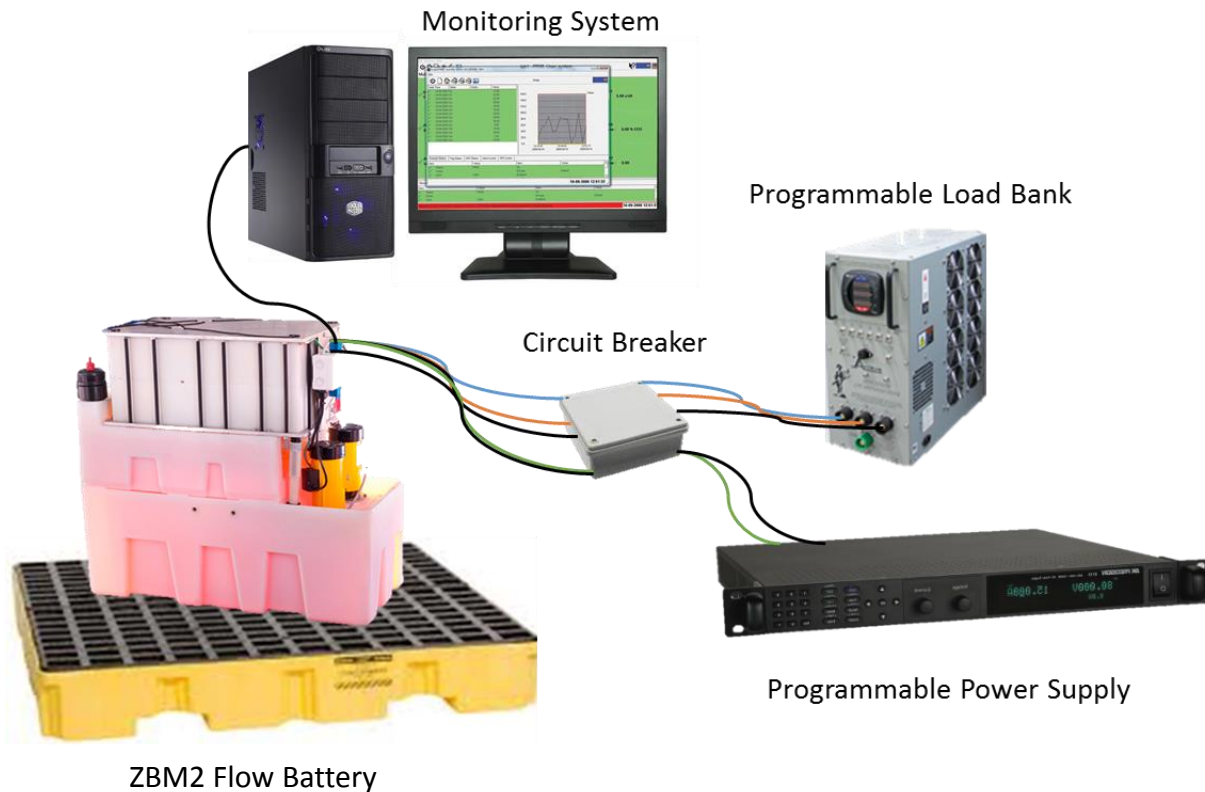
Redflow ZBM2



Zinc Bromide Flow Battery

- DC Voltage Operating Range: 40-58 V (48 V nominal)
- Absolute Range: 30-72 V
- Power Rating: 0-3kW (5kW Peak, discharge)
- Net Energy Range: 0 to 10kWh
- Net Energy Eff.: 80% DC-DC Max
- Operating Temperature: 50-122 °F
- Integrated BMS
- Modular, Flexible, Scalable

Redflow ZBM2



Laboratory Setup

Performance Testing Plan

Characterization

- Static Capacity Test
- Full Cycle at variable power discharge
- Partial Cycle Test at Variable SOCs

Cycle Life and Calendar Life

- 5-day continuous cycle within 0-100% SOC
- 5-day continuous cycle with 30% SOC reserve
- Variable SOCs self-discharge test (100% and 50%)

Safety Test

- Overcharge test and high power discharge test
- Minimum charge test or trickle charge test

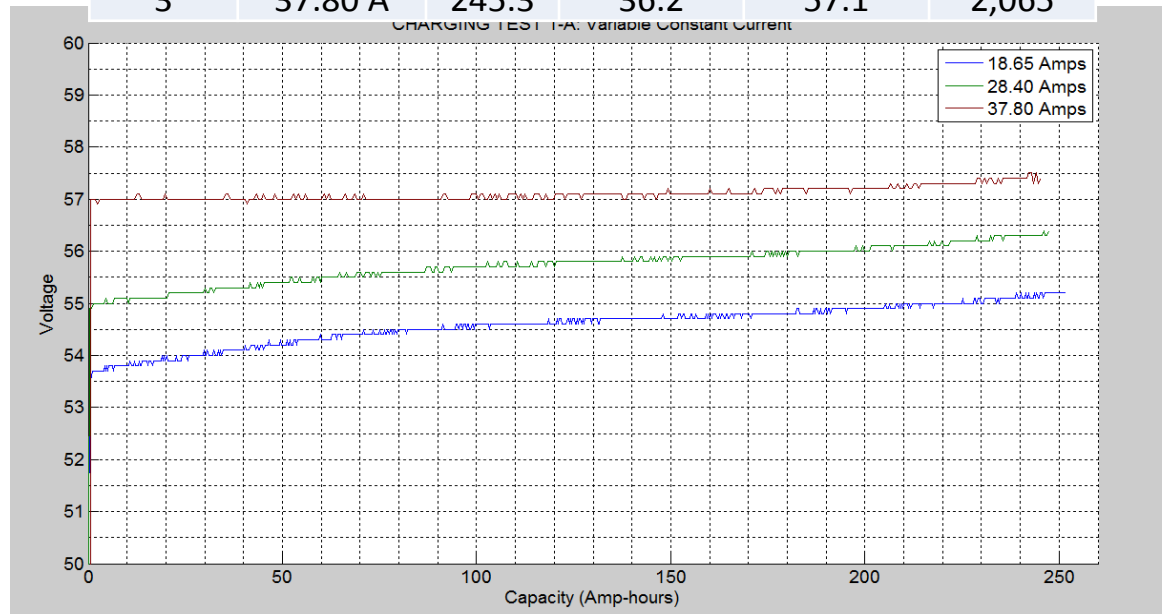
Redflow ZBM2 - Testing



- Constant Current
- Constant Voltage
- Constant Power
- Constant Resistance
- Auxiliary Loads during Charge and Discharge
- Full Cycle
- Partial Cycle
- 5-day Continuous Cycle
- Minimum Charge (trickle)

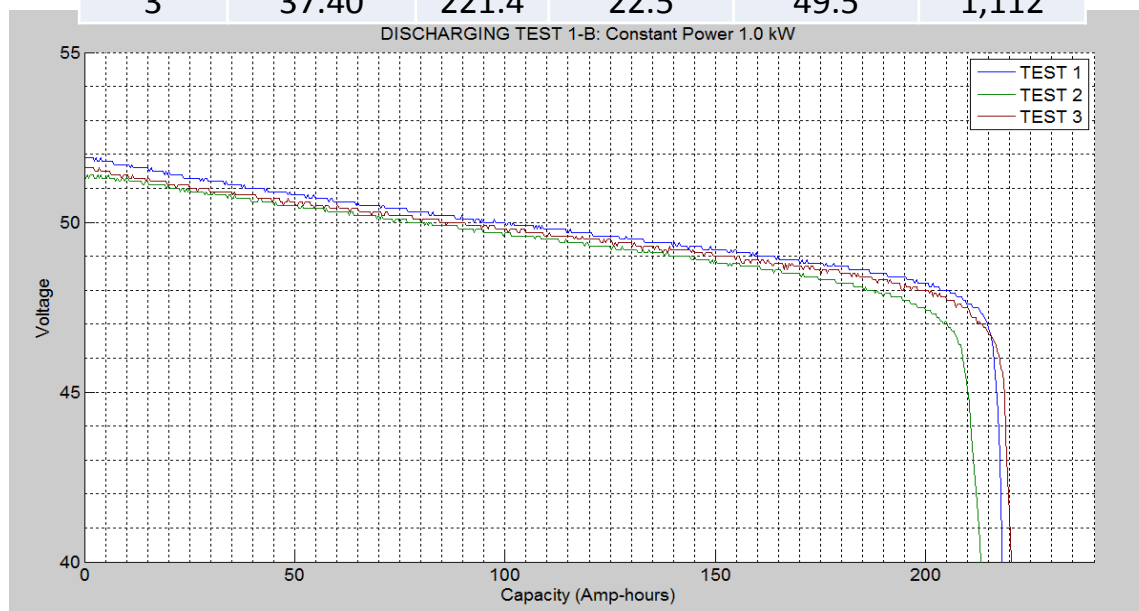
TEST 1: Rate Capability of Variable Charge Currents

CONSTANT CURRENT CHARGE TESTS					
TEST	Charge Rate (A)	Capacity (Ah)	Avg Current (A)	Avg Voltage (V)	Avg Power (W)
1	18.65 A	251.7	17.1	54.6	936
2	28.40 A	247.4	27.0	55.7	1,507
3	37.80 A	245.3	36.2	57.1	2,065



TEST 1: Rate Capability of Variable Charge Currents

CONSTANT POWER (1.0 kW) DISCHARGE TESTS					
TEST	Charge Rate (A)	Capacity (Ah)	Avg Current (A)	Avg Voltage (V)	Avg Power (W)
1	18.65	218.6	22.1	49.8	1,100
2	28.40	214.3	22.3	49.4	1,101
3	37.40	221.4	22.5	49.5	1,112



Cellstrom CellCube FB20



- Vanadium Redox Flow Battery
- Power Rating: 20kW
 - Capacity: 100 kWh
 - DC Voltage Output: 48 V
 - Net Energy Efficiency: Up to 80%
 - Operating Temperature: -40 to 122 °F
 - No degradation
 - Integrated FBC, EMS and Climate Control
 - Modular, Flexible, Scalable

Future Work

- Functional testing for the ZBM2
- Commissioning and testing of CellCube FB20 battery
- Economic evaluation of energy storage services
- Scheduling and sizing of the storage system
- Demonstration project

THANK YOU

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