GRID MODERNIZATION INITIATIVE PEER REVIEW

GMLC 1.3.4 – Industrial Microgrid Analysis and Design for Energy Security and Resiliency

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Industrial Microgrid Analysis and Design for Energy Security and Resiliency

High Level Summary

GRID MODERNIZATION INITIATIVE
U.S. Department of Energy

Project Description

ORNL and SNL will design and perform cost/benefit analysis of an industrial-scale microgrid with the goal of sharing lessons learned and best practices with other industries and utilities. The analysis will be performed on the UPS Worldport facility in Louisville, Kentucky.

Project Objectives

- ✓ All-hazards risk analysis of facilities
- ✓ Cost/benefit analysis of industrial-scale microgrids
- ✓ Potential for grid services provision
- ✓ Roadmap to industrial microgrid deployments & lessons learned

Value Proposition

- ✓ Industrial utility customers often spend hundreds of thousands to millions of dollars in backup systems and standby generation in case of sudden loss of electricity supply due to outside influences such as severe storms.
- ✓ Utilities stand to benefit from the modernized grid, however they are often hesitant to invest in new technologies.
- ✓ This project aims to demonstrate reliability improvements for industrial customers can also benefit utilities and provide a methodology applicable to other areas of the country.

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Project Team

Project Participants and Roles

ORNL – Lead, Efficiency and Ancillary Services Analysis

SNL – Microgrid Design, Cost/Benefit Analysis

UPS – Industry Partner

Waste Management – Industry Partner

Prime Time Computing – Risk Analysis

Burns & McDonnell – Support, *Biogas analysis*

Harshaw Trane – Support, *Biogas analysis*

Kentucky Government - Support

PROJECT FUNDING			
Lab	FY16 $	FY17$	FY18 $
ORNL	$600k	$0k	N/A
SNL	$400k	$0k	N/A

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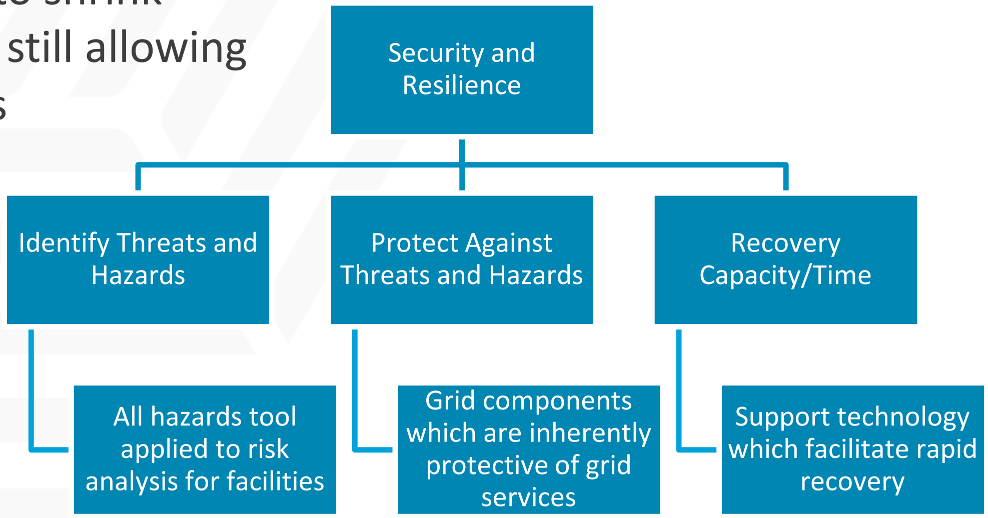
Relationship to Grid Modernization MYPP

Utilizing an all-hazards approach for risk assessment of the Louisville area and UPS facilities

Taking steps to address specific electrical risk through the use of microgrid(s)

Looking at reduced capacity operations to shrink investment in microgrid resources while still allowing facilities to operate during contingencies



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Approach

- Task 1 – Microgrid Evaluation
  - Analyze three critical industrial facilities with open-source software and provide a narrowed search space of microgrid options
- Task 2 – Risk Analysis
  - Utilize an all-hazards tool to determine current risk and risk reduction as a result of the project
- Task 3 – Energy Efficiency and Ancillary Services
  - Utility rate structures used to identify most valuable services to the grid
- Task 4 – Generation Upgrades
  - Options for combined head and power (CHP) for electrical generation and heat load requirements
- Task 5 – Energy Resiliency and Cost/Benefit Optimization Modeling and Analysis
  - Cost/benefit study for three microgrids serving critical operations

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Key Project Milestones

Milestone (FY16-FY18)	Status	Due Date
Kickoff Meeting with Stakeholders	Complete	4/12/16
Initial Microgrid Design	Complete – 1 site	10/1/16
Risk Analysis Completed	Complete - Preliminary	4/1/17
Contracts in Place for Biogas Analysis	On Hold	4/1/17
Energy Efficiency and Ancillary Service Analysis	In Progress	10/1/17
Generation Upgrades Analysis	In Progress	10/1/17
Cost/Benefit Modelling and Analysis	Complete – 1 site	10/1/17

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Accomplishments to Date

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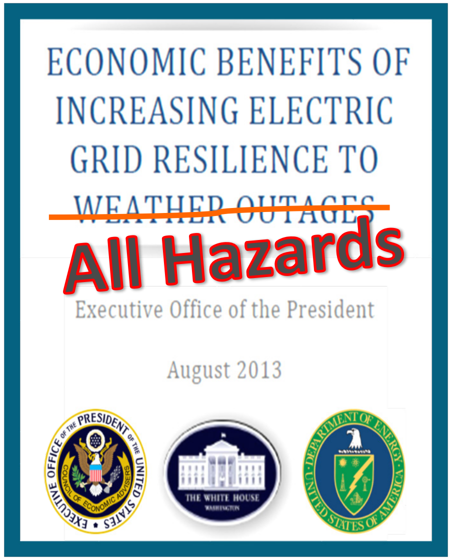
U.S. Department of Energy

- Analysis utilizes open-source software
- Two site visits to UPS Worldport to tour facilities and infrastructure
- Met with utility and industry stakeholders to discuss rate programs and partnerships
- Identified critical industrial and electrical infrastructure
- Performed microgrid analysis on a critical industrial facility
- Data collection underway for two more microgrid sites
- Modelling and simulation have resulted in upgrades to existing DOE tools


ECONOMIC BENEFITS OF INCREASING ELECTRIC GRID RESILIENCE TO ~~WEATHER OUTAGES~~

All Hazards

Executive Office of the President

August 2013

Option	Facility A	Facility B	Tie	Cost ($K)	Overall Availability (Ci)	Post-Startup Availability (Ci)	Post Startup Occurrences with Load Loss (Ci)	Overall Diesel Efficiency
Baseline	550 kW	550 kW	No	$740,000	97.909024%	97.914717%	4.67%	24.03%
Baseline with Tie	550 kW	550 kW	Yes	$1,255,000	99.989214%	99.995262%	4.55%	25.91%
Baseline with Additional Facility A Gen	550 kW (x2)	550 kW	No	$1,509,500	98.879204%	98.88567%	2.91%	24%
Baseline with Additional Facility B Gen	550 kW	550 kW (x2)	No	$1,509,500	98.222782%	98.228565%	3.18%	23.7%
Baseline with Additional A & B Gen	550 kW (x2)	550 kW (x2)	No	$2,279,000	99.939886%	99.945881%	1.02%	23.96%
Facility A Microgrid	550 kW (x2)	550 kW	Yes	$2,024,500	99.993829%	99.999745%	2.59%	25.82%
Facility B Microgrid	550 kW	550 kW (x2)	Yes	$2,024,500	99.994035%	99.999988%	0.15%	25.72%
Facility A-B Microgrid	550 kW (x2)	550 kW (x2)	Yes	$2,794,000	99.993963%	99.999995%	0.2%	25.69%

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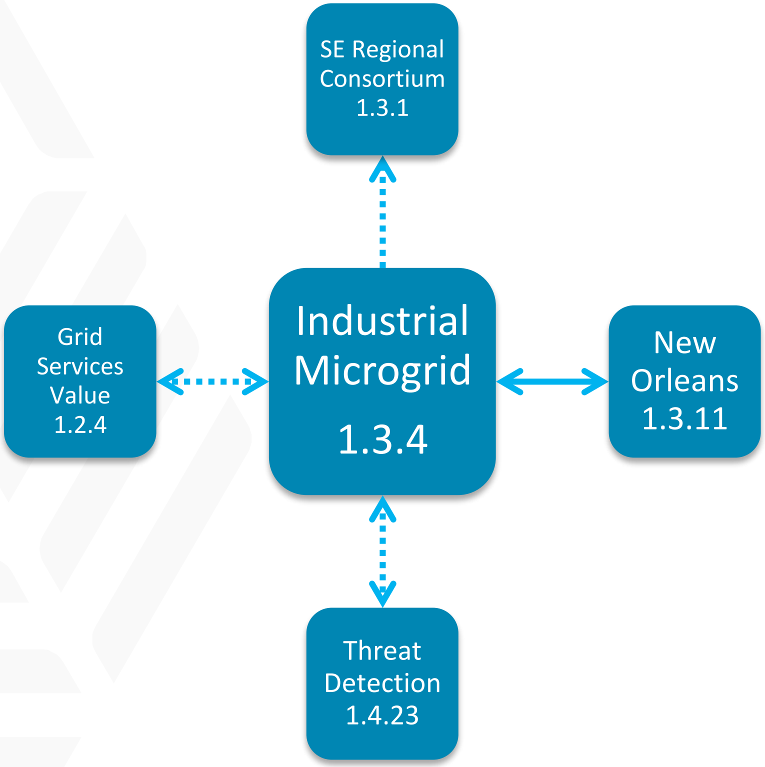
Response to December 2016 Program Review

Recommendation	Response
Please look into using the "Solar Glare Hazard Analysis Tool" to address any issues for integrating solar technologies near the airfield.	The tool has been investigated and discussed with UPS, and currently there is no issue with airfield solar as it pertains to pilot safety.
Please make the deliverable applicable and accessible to others looking to implement microgrids.	Opportunities to make the results more generic are considered while performing testing. The final report will attempt to convey how the results could be applicable to others in industry.

Communications:

Currently no forums or publications have been public, due to the business sensitive nature of the data and electrical diagrams. A document approved for public release will be made available at the conclusion of the project.

Due to the short nature of this project, we hope to share lessons learned and results with other GMLC projects.



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Next Steps and Future Plans

- The lab team will continue to refine results based on new data
- Real-time modelling and CHP analysis is underway and should be ready to test in the coming months
- Final report completed by end of FY17
  - Targeted at other industries and utilities interested in microgrids for critical industrial facilities.
- Aim to deliver the results to the hands of industrial consumers and utilities interested in microgrids to stimulate conversation on grid modernization.
- Expect results can be used as lessons learned for other grid modernization projects

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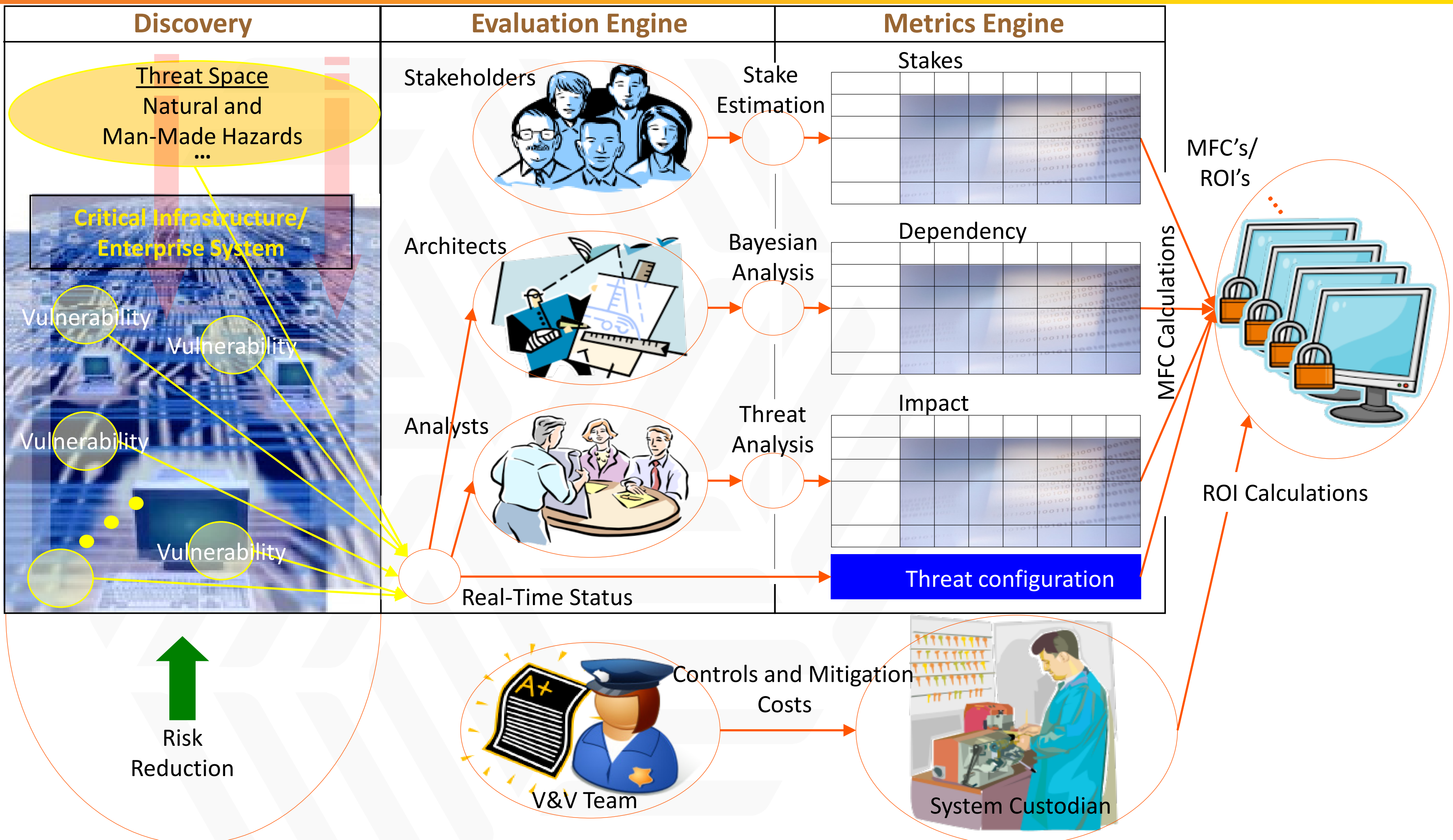
Technical Details



$$Y_i = \sum_{i \leq j \leq m} X^j \times A_i^j, 1 \leq i \leq n$$

Y: vector of size n
X: vector of size m
A: n×m matrix

$$Y = A \circ X$$

$$MFC(S_i) = \sum_{R_j} FC_{i,j} \times P(R_j)$$

ST: Stakes Matrix
PR: vector of requirement failure probabilities

$$MFC = ST \circ PR$$

$$P(R_i) = \sum_{j=1}^{k+1} \pi(R_i|E_j) \times \pi(E_j)$$

DP: Dependency Matrix
PE: vector of component failure probabilities

$$PR = DP \circ PE$$

$$\pi(E_i) = \sum_{j=1}^{h+1} \pi(E_i|V_j) \times \pi(V_j)$$

IM: Impact Matrix
PT: vector of threat emergence probabilities

$$PE = IM \circ PT$$

$$\boxed{MFC = ST \circ DP \circ IM \circ PT}$$

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Technical Details

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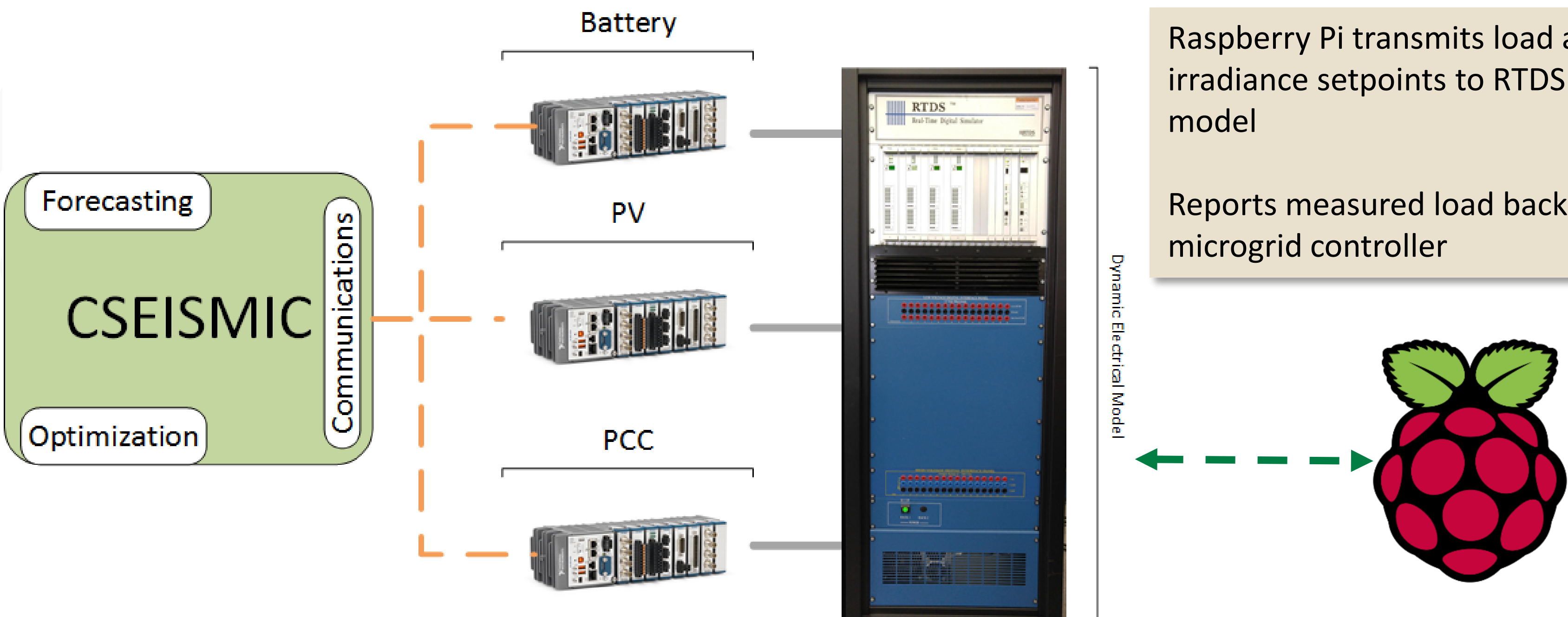
- Simulation of electrical diagram in real time
- Devices modelled in hardware components and interfaced to RTDS
- Communication with microgrid controller through Ethernet



Raspberry Pi transmits load and irradiance setpoints to RTDS model

Reports measured load back to microgrid controller

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Technical Details

- Test results of islanding and resynchronization are provided to show the interactions among device level controllers and the master controller.