SAND2020-1807C

# ISGT 2020

20 February 2020

## The Microgrid Design Toolkit

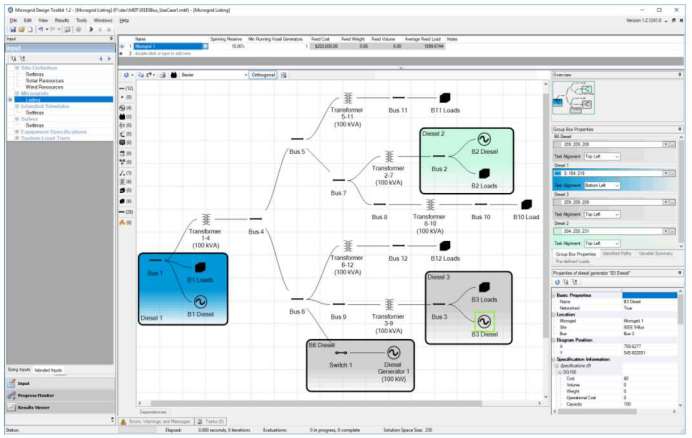
2017 R&D 100 WINNER

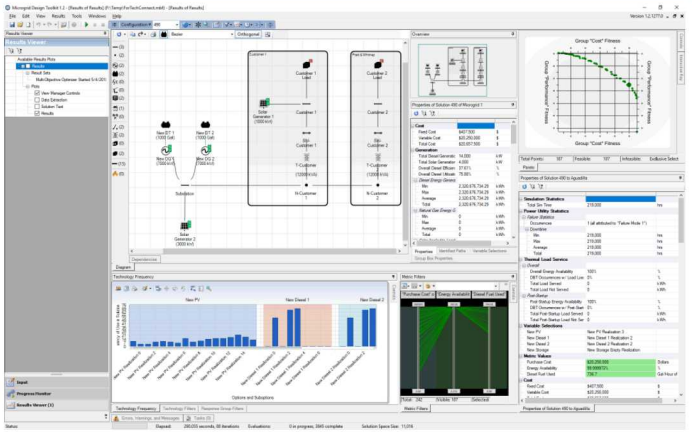
PRESENTED BY

John Eddy, Ph.D. *Principal Investigator*

# What is MDT

- MDT is a visual design and trade-space optimization capability for microgrids.
- A multi-objective optimization algorithm executes a discrete event Monte-Carlo simulation to characterize performance and reliability of candidate microgrid designs.
- Produces a Pareto frontier of efficient alternative Microgrid designs and visualizations to help a designer understand the trade-offs.





## History

**SPIDERS** (2011)

**v1.0 Publicly Released** (2016)

**Use for GMLC and Others** (2017-*)

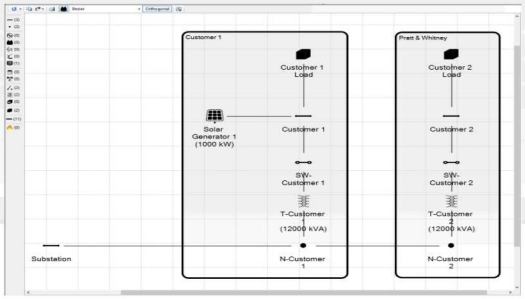
**DOE OE Funding** (2014)

**USMC SYSCOM Funding** (2016)

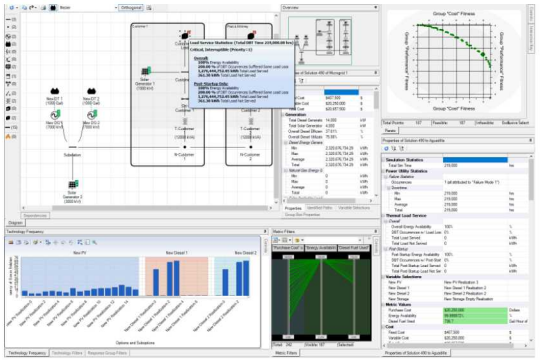
**R&D 100 Award** (2017)

# MDT Process

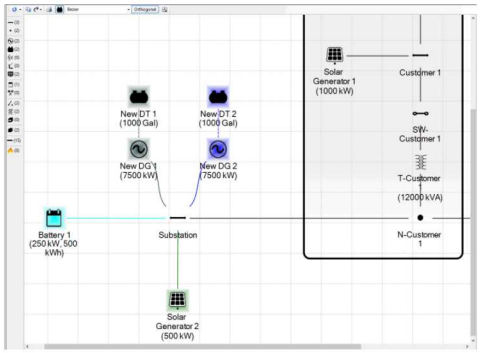
## Define Baseline System




## Investigate Results



## Specify Design Options




MICROGRID DESIGN TOOLKIT

Optimize

## Define Design Objectives

| Metric | Limit | Objective |
|---|---|---|
| Energy Availability | 98% | 99.999% |
| Fuel Burn Rate | 100 Gal/hr | 65 Gal/hr |
| Renewable Penetration | 25% | 60% |

# Uses

***The US Marine Corps*** Expeditionary Energy Office (E2O) used the MDT to assess microgrid power systems and *Mobile Electric Hybrid Power Sources (MEHPS)* for expeditionary units and brigades.

Over **50 microgrid models** were developed in the MDT and used to provide design support for these islanded power systems.

***The SPIDERS Program*** used a predecessor to the MDT to develop the preliminary microgrid designs for 3 military bases.

- Joint Base Pearl Harbor-Hickam
- Fort Carson
- Camp Smith

These microgrids are currently in operation on these installations

***The City of Hoboken, NJ*** used a predecessor to the MDT to develop the preliminary microgrid design for backup power in response to Hurricane Sandy.

The primary goals of this design effort were to mitigate the impacts of extreme flooding on the distribution systems and electricity service throughout the city.

***Other Past and Current uses of the MDT include:***

- Remote community power system assessments for villages in Alaska (Shungnak, Cordova).
- A backup power system assessment and Microgrid Design of the UPS Worldport facility in Louisville, KY.
- A backup power system assessment and Microgrid Design of the city of New Orleans, LA.

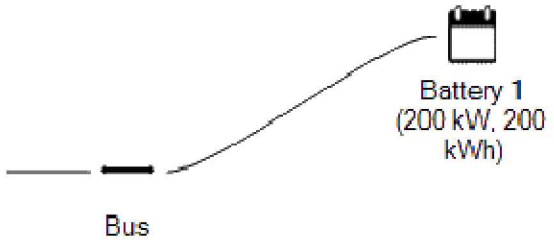
# Treatment of Storage in MDT

- MDT supports 2 battery use paradigms:

1. The battery is treated as an energy source of last resort and charging is done when there is excess generation online and available
   - More renewables than can be consumed or
   - Enough fossil generation to charge without *exceeding reserve limits*.

2. The battery is used as a top tier energy resource similar to renewable power. This power supply impacts unit commitment and dispatch such that it may prevent or delay the starting of offline fossil generators. Charging is done when there is any available generation
   - More renewables than can be consumed or
   - Enough fossil generation to charge without exceeding capacity.

Storage assets can be design variables and trade-space results can help size and locate storage assets in preliminary microgrid designs.



# Acknowledgements and Contacts

Development of the MDT has been funded primarily by the Department of Energy Office of Electricity Delivery & Energy Reliability. Other sources include the USMC, GMLC, DoD, and Sandia.

John Eddy
*Sandia Principal Investigator for the MDT*

jpeddy@sandia.gov

## Download Link

http://www.energy.gov/oe/services/technology-development/smart-grid/role-microgrids-helping-advance-nation-s-energy-syst-0

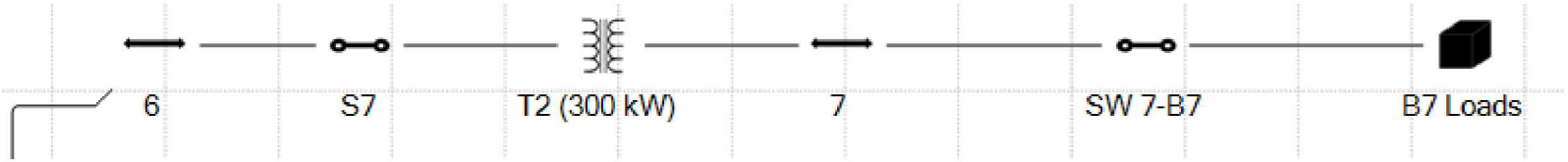
# Backup Slides

# Usage

***What would a designer do with the MDT? What are the input requirements?***

A designer would input the details of their design problem in terms of:

- **Microgrid topology** (busses, lines, transformers, generation sources, storage assets, loads, …). In addition to ***fixed topology***, one can define ***topological decision points***. Examples could include *how big a generator should be*, *whether or not a battery or PV system should be included*, *whether or not redundant connections are needed*.




- **Asset Parameters.** Each item in the grid must be configured. Data includes capacities, reliability parameters, cost, etc.

# MDT Process

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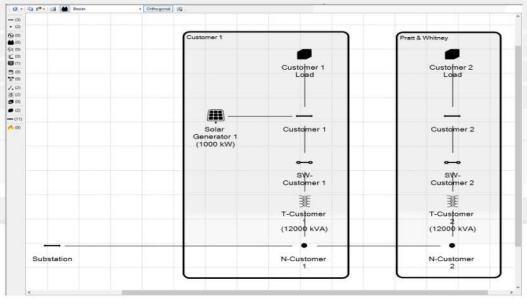


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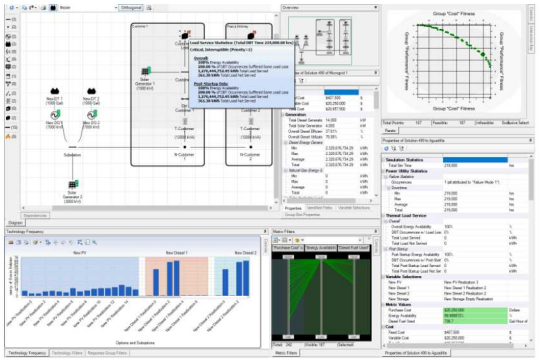

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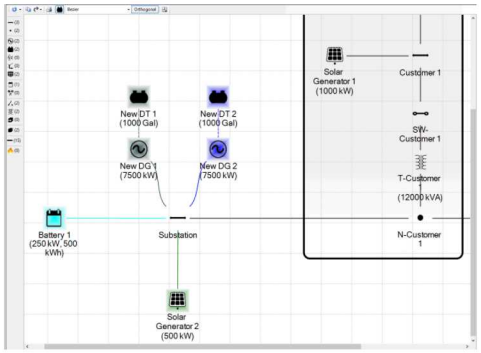


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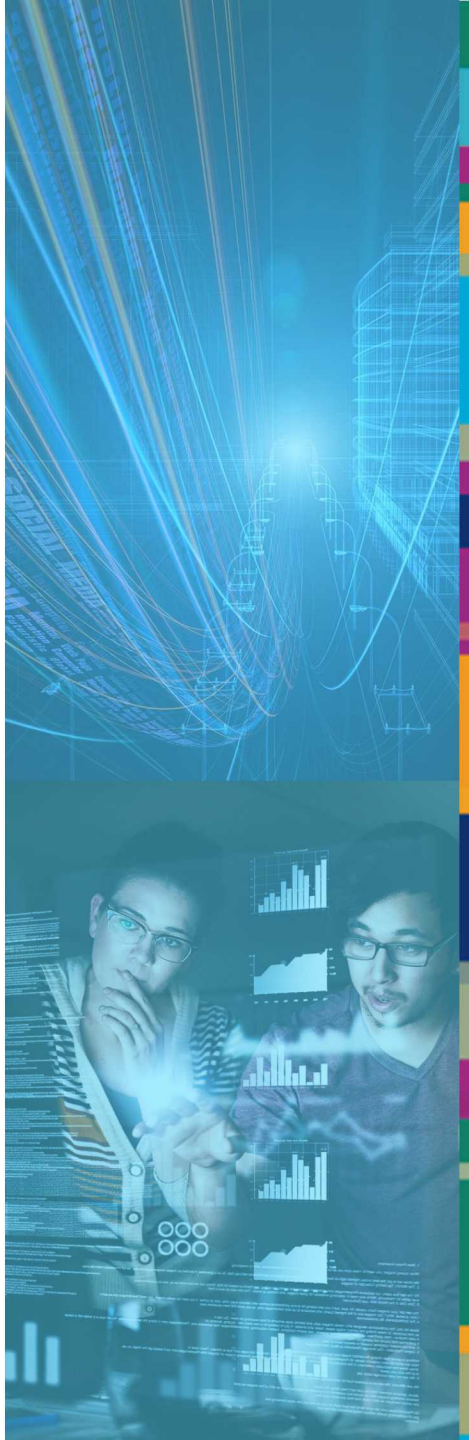
# Value Proposition

## Using the MDT, a designer can:

- Effectively search through very large design spaces for efficient alternatives
- Investigate the simultaneous impacts of several design decisions
- Have defensible, quantitative evidence to support decisions
- Gain a quantitative understanding of the trade off relationships between design objectives (cost and performance for example).
- Gain a quantitative understanding of the trade-offs associated with alternate design decisions
- Identify “no brainer” choices to reduce the number of design considerations
- Perform what-if analysis by altering the input without loss of information to include or not include certain features in a run of the solver
- Perform hypothesis testing by manually generating solutions and comparing to the solutions found by the MDT



# Differentiating Capability

The MDT represents an innovative capability not available elsewhere. It's ability to:

- Perform mid-level topology optimization
- Account for both grid connected and islanded performance
- Account for power and component reliability in islanded mode
- Account for dozens of metrics when performing the trade space search
- Present a user with an entire trade space of information from which to draw conclusions

***Make it a significant advancement over anything available to designers today.***