Exceptional service in the national interest

Sandia National Laboratories

SAND2016-8151 C

Microgrid Design Toolkit (MDT)

24 October 2016

John Eddy, Ph.D.

Microgrid Design Toolkit (MDT) Principal Investigator

System Sustainment & Readiness Technologies Department

Sandia National Laboratories, Albuquerque, NM

jpeddy@sandia.gov

U.S. DEPARTMENT OF ENERGY | NNSA National Nuclear Security Administration

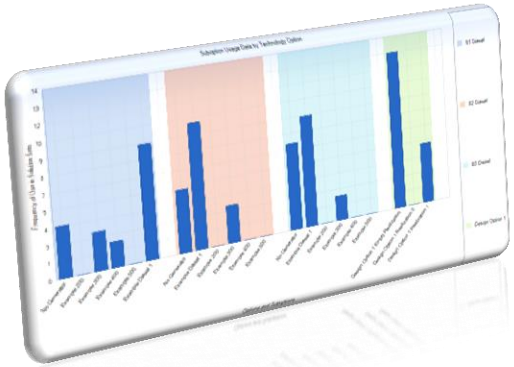
Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000. SAND No. TBD.

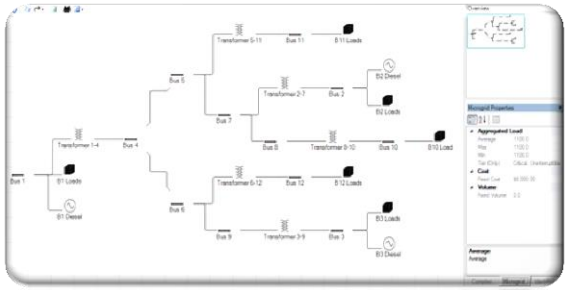
MDT Purpose

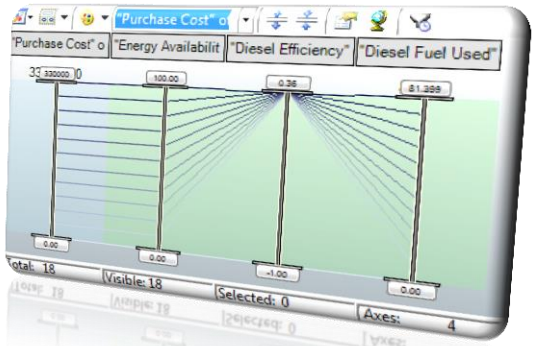
The Microgrid Design Toolkit (MDT) is a decision support software tool for microgrid designers in the early stages of the design process.

The software employs powerful search algorithms to identify and characterize the trade space of alternative design decisions in terms of user defined objectives. Common examples of such objectives are ***cost***, ***performance***, and ***reliability***.

Once the trade space has been characterized, the software provides many views and features to help explore that trade space to extract information







Progress

- MDT 1.1 Beta is now available for download from http://www.energy.gov/oe/services/technology-development/smart-grid/role-microgrids-helping-advance-nation-s-energy-syst-0
  - Has been downloaded more than 400 (unique) times since posting on 4/6/16.
- Several organizations have agreed to review the software
  - Port of Los Angeles
  - MelRok
  - IPERC
  - Burns & McDonnell
  - MIT Lincoln Labs
- Further development is underway with the US Marine Corps. Improvements to both the analytics and the user interface are in progress.

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 **70 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.

Current uses of the MDT include:

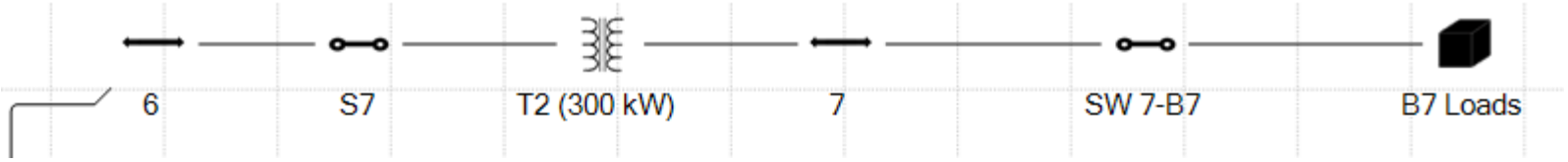
- Continued use for the Marine Corps
- A backup power system assessment and Microgrid Design of the UPS Worldport facility in Louisville, KY.
- A backup power system assessment and Microgrid Design of the city of New Orleans, LA.

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*.



- **Design Goals.** The MDT has many built-in metrics that can be computed to determine the quality or "goodness" of a microgrid design. The user can choose which ones to use. Some examples are *Purchase Cost*, *Energy Availability*, *Quantity of Fuel Used.*

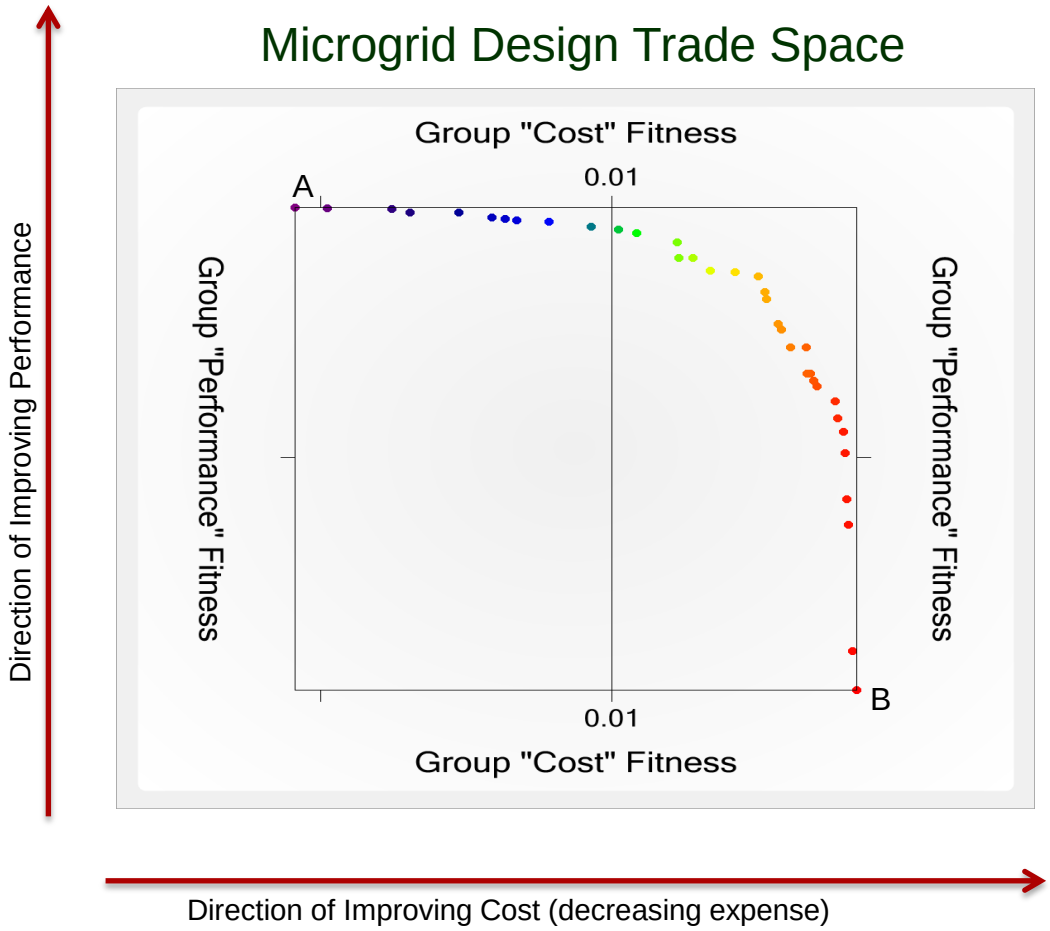
Usage (cont.)

What kinds of questions can the MDT answer?

- **Example MDT analysis questions:**
  - "Should the existing generator on building A be replaced? If so, what type should the new one be and how big should it be?"
  - "Should we build a new building to house additional generation assets and if so, what generation assets should be used and how and where should the building be connected to the grid?"
  - "Should we install a new redundant backup feeder on our microgrid?"
  - "Should we add a PV installation and if so how big? Also, if we add one, should we also add a battery to support it and if so, how big should it be?"
  - "Should we include building X on the other side of the compound in our microgrid or should it remain isolated with its own backup generation?"
  - "We have a new load to include on our installation and may put it in building A, building B, or building C. Which should we put it in or does it not matter?"

Usage (cont.)

The MDT produces a set of solutions that represent efficient trade offs amongst the design objectives. Consider the diagram below.



Each point represents a complete, unique microgrid design.

Point “A” is the highest cost, highest performing solution. Point “B” is the lowest cost, lowest performing solution. There are many options in between representing different trade offs.

Given any point on the chart, no improvement in cost can be made without corresponding decrease in performance and visa versa.

This chart shows 2 objective dimensions, cost and performance. The MDT supports up to 5 dimensions if desired. They are user defined.

Specific metrics as described in a previous slide are combined by the user to create objective dimensions.

In addition to views like this, the MDT has many other views that help investigate the solution set.

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.

Acknowledgements and Contacts

Development of the MDT has been funded primarily by the Department of Energy Office of Electricity Delivery & Energy Reliability. We would like to thank Dan Ton, manager of the Smart Grid R&D program who has provided our funding.

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

Abraham Ellis
Sandia Program Manager for the DOE Smart Grid R&D Program
aellis@sandia.gov

John Eddy
Sandia Principal Investigator for the MDT
aellis@sandia.gov