Modeling Workflow
Completing a DER-CAM analysis in 7 steps

Mar. 7th, 2018
Before we begin...

Simulation vs Optimization

Simulation:
• Pre-defined set of rules
  if PV output < Load:
    if Battery SOC > Min: Decrease Battery SOC
• One possible output per input (not optimal)
• Very fast

Optimization (DER-CAM):
• Define boundaries for each variable
  Min <= Battery SOC <= Max
• Entire feasible region of possible output
• Define an objective function
• Find the solution in the feasible region that optimizes the objective
• Problems may become very large and take time to solve
DER-CAM

DER-CAM is a decision support tool for decentralized energy systems

Finds optimal portfolio, sizing, placement, and dispatch of DER in buildings and microgrids

- Energy loads
- Electricity & fuel prices
- DER technologies
- Local weather
- Topology

Many variables!

DER-CAM

- Optimal DER Portfolio
- Optimal DER Sizing
- Optimal DER Placement
- Optimal DER dispatch
DER-CAM Project Workflow:

1. Define topology or select single-node model
2. Define end-use loads & other site data
3. Define utility tariff & export options
4. Define DER options & parameters

5. Run base-case without new DERs
6. Define investment options for new DERs
7. Run investment cases to find optimal DER capacities.
Define topology or select single-node model
1 – Define Topology

Start by deciding between single or multi-node

- Single node models can be a good first approach
- Faster to solve, less data required
- Ideal if loads can be aggregated:
  - Strong network, no loss or voltage concerns
  - Optimal DER placement not required

- Multi-node models provide additional depth
- (Optimal) power flow and heat flow is integrated in the analysis
- Optimal DER placement is provided

- Choosing between single or multi-node happens when creating a new project
- This decision cannot be changed later on
1+2+3 – Using the databases

Single node example...

- Large Office Building in San Francisco
Define end-use loads & other site data
2 – End-use loads and site data

End-use loads...

- Up to 3(+3) “design days” per month
2 – End-use loads and site data

End-use loads...

- Up to 3(+3) “design days” per month
2 – End-use loads and site data

Other site data...
Define utility tariff & export options
3 – Utility tariffs and export options

Electricity and fuel prices...

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<td>Part Peak</td>
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<td>$0.24</td>
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$3.94267 per meter per day

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3 – Utility tariffs and export options

Electricity and fuel prices...

Hint: to create a microgrid model from the perspective of the utility or DSO tariffs can be replaced by costs they would incur to serve clients.
3 – Utility tariffs and export options

Export Options...

This input contains the hourly price profiles for energy exported from the local system to the grid, each day type (peak, week, weekend) and each month. The unit of PX are $ per kWh and should represent average hourly prices.
Define DER options & parameters
4 – DER Options and Parameters

Continuous vs Discrete!?
4 – DER Options and Parameters

Technologies included...

**Discrete:**
- Conventional generators and CHP units
  - Continuous duty, load following
- Wind generators

**Continuous:**
- PV, Solar Thermal
- Storage
  - Conventional, Flow Batteries, EVs, Heat storage
- Heat pumps
- Absorption chillers
- Central cooling / heating
4 – DER Options and Parameters

Existing DER...
- Do you want to fix the exact DER size?
- If so, what size are you forcing?
- Is this an existing DER?
- If so, how old is it?
Run base-case without new DERs
5 – Running the Base Case

Base Case...

Understanding DER-CAM

Objective function:
Minimize total energy costs (or CO2) such that:
• energy balance is preserved
  – energy supply (t) = energy demand (t)
• technologies operate within physical boundaries
  – power output (t) <= max output
• financial constrains are verified
  – max payback: savings obtained by the use of new DER must generate savings that repay investments within the max payback period

To use DER-CAM, at least two runs are needed: 1) Base Case; 2) Investment
5 – Running the Base Case

Base Case...
By default, investment is disabled on “New” models
Define investment options for new DERs
6 – Defining Investment Options

Investment Case...

This is where the optimization starts!

• Enable / disable technology groups
• Enable / disable specific technologies
• Define reference values (from Base Case)
• Define financial values (Payback time, discount rate)
• Run the model!

E.g. PV + Storage mode, 5% discount rate, 12 year payback
6 – Defining Investment Options

Investment Case...

Max Payback
- DER-CAM uses technologies with different lifetimes
- “Max Payback” is a global payback
- Acts as a constrain
Min (total energy costs) such that annual savings / investment <= Max Payback

Annualized Capital Costs
- Different technology lifetimes require a method to compare them fairly
- Annualized Capital Cost is the cost per year of owning the equipment
- Total Energy Costs will include Annualized Capital Costs

Optimization algorithm
- “Greedy” approach
  - More of what is most efficient
- Solver precision & problem size
  - Flat solution space
- Indifferent preference
  - Cost vs Benefit
6 – Defining Investment Options

Investment Case...

E.g. PV + Storage mode, 5% discount rate, 12 year payback

Enable technology group

Define reference values
Run investment cases to find optimal DER capacities.
7 – Run investment case

Investment Case...
E.g. PV + Storage mode, 5% discount rate, 12 year payback
7 – Run investment case

Investment Case...
E.g. PV + Storage mode, 5% discount rate, 12 year payback
THE END

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Define topology or select single-node model
1 – Define Topology

Start by deciding between single or multi-node

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![New Project Dialog](image)
1 – Define Topology

If you selected multi-node...

• Single node models do not require further topology definition
• For multi-node models, the next steps consist of:
  – Creating nodes (up to 20)
  – Establishing connectivity
  – Defining the characteristics of the topology elements

To create a new node..
- Pick “Topology” from the menu
- Right-click grey area to “Add Node”
- You can have up to 20 nodes
1 – Define Topology

To establish connectivity...
- Right-click any node and select “Properties”
- Define key properties of that node:
  - Does it have a load?
  - Is this where the microgrid connects to the utility (Point of common coupling)?
  - Should this be the “slack” / reference node for load flow calculations?
  - Where is this node located? (lat. / long.)
- Establish connectivity to other nodes:
  - Add line, transformer, high temperature, or low temperature pipe between this and any other node
1 – Define Topology

To define the characteristics of topology elements...
- Define the properties of relevant elements under “Power Flow Parameters” or “Heat Transfer Parameters” or use predefined
- In “Topology” view, right-click an element and select “Properties”
- Choose one of the options from the “Type” dropdown box
One extra step...
- “Map” view is also available
- Requires at least one node to have lat./long. values
- Moving nodes in the Map view updates estimated lengths
- Length used for calculation is always user-defined
1 – Define Topology

Not quite over yet...
- Two power flow models are available (radial / meshed)
- Some overall options are available, including:
  - Is this a DC network?
  - Are loads purely resistive, or include active / reactive power consumption?
- Each model can be further specified, including:
  - Min / Max acceptable voltage levels
  - Enabling / disabling the current or voltage magnitude constraints

Each option and parameter is documented in the right side, including references and additional recommendations.