The Role of SOFC in A 100% Renewable Campus Micro-Grid Energy Optimization

Microsoft Fuel Cell Workshop
Wednesday February 28th, 2018

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» Discussion of features/limitations in EAGERS
» Modeling generic 2018 data center
» Addition of on-site solar
» Paradigm shift to primary on-site generation (fuel cells)
» Addition of solar within fuel cell turndown capacity
» Net zero, solar + FC + grid sellback
» True zero, solar + reversible FC + storage
What is EAGERS

Efficient Allocation of Grid-connected Energy Resources including Storage

» A system dynamics model solving the unit commitment and economic dispatch problems for connected energy networks (AC/DC electricity, heating, cooling ....)

» Planning Tool:
  > Represent a building/campus infrastructure
  > Represent local weather/environment conditions
  > Add/remove/re-size energy equipment
  > Adjust grid tariffs and ancillary market participation
  > Simulate optimal building and energy resource management
  > Conduct comparative studies

» Control Tool:
  > Simulate receding horizon control of building & energy assets
  > Represent local weather/environment conditions
  > Unique solver, specific to cases with significant energy storage (shift loads 2-24 hours)
Add/Remove/Edit Energy Hardware
Control with a real building

- Weather + Market
- History of uncontrollable loads & internal gains
- Inverse problem

EDC

MPC

24hr

24hr

Forecasting

HVAC logic

T_{zone}, T_{wall}

Set-points for thermostat, FC, etc.

1hr

Measurements of temperature, equipment states, etc.

1hr

Error

Historian

Forecasting is internal gains, external gains and non-HVAC electric loads
All modes of the EDC will be available: Planning, Dispatch, and Control, both with & w/o building model
  - Default will be planning, i.e. “perfect” forecast and running 1 day a month

Optimal configuration and sizing

- Adjust system/component sizes
- Test different system arrangements, i.e. w/ or w/o thermal storage
- Compare 20-year system cost or payback

Case evaluation

- Run set of design days or entire year
- Infer 20-year system cost or payback period

EDC -> MPC -> 24hr -> Forecasting
EDC -> ROM -> HVAC logic -> Forecasting
Case Study: Data Centers

Generic 2018 data center (PUF ~ 1.25)

- Small office + refrigerated warehouse (2.5MW) + server farm (10MW)
- HVAC system includes swamp coolers and electric chillers
  + Assumed ASHRAE 5A weather (Central Washington)
- Server loads, internal/external lighting, office plug loads, backup generators, air handlers, cooling towers ...

![Data Center Demand Graph]

- 99th Percentile
- Average
Sustainability of Fuel Cells

- Renewables & NG account for all new generation
- Retirements of coal & nuclear

Grid Mix
(some CO₂)

Does purchasing credits change the net grid CO₂ emissions?
Removing load from grid reduces net grid CO2 emissions by factor of marginal CO2 emissions, likely NG CC
Replacing grid electricity with NG self-generation @ ~50% is a wash
Fuel cells + solar/wind on-site can result in significantly lower CO$_2$ emission factors.

- Grid backup
- Local renewable + NG generation (less CO$_2$)
» H2 generation with electrolyzers, storage (compressed gas), and use in fuel cells
» Low round trip efficiency with PEM (<30%)
» Slightly better with SOFC (<60%)
Pressurized SOFC/SOEC with co-production of Hydrogen and Methanation could achieve a net solar energy utilization >70% and use existing NG storage.

Addresses stationary & mobile energy inclusively.
Thank You!

Q & A