Clean Energy Systems Integration Lab

Washington State University

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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Outline

- 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

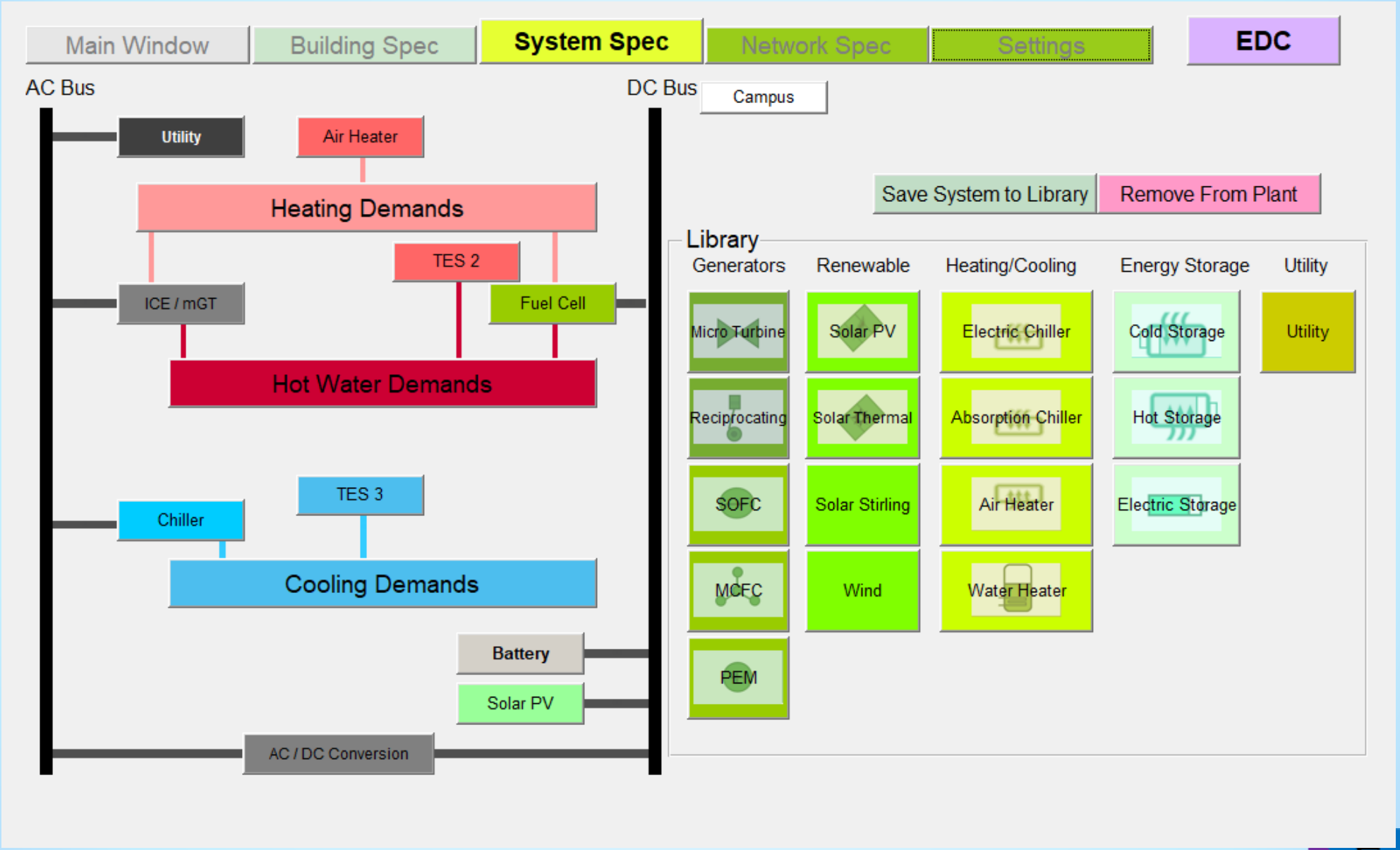
» Control Tool:

> 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



Ancillary Service Markets

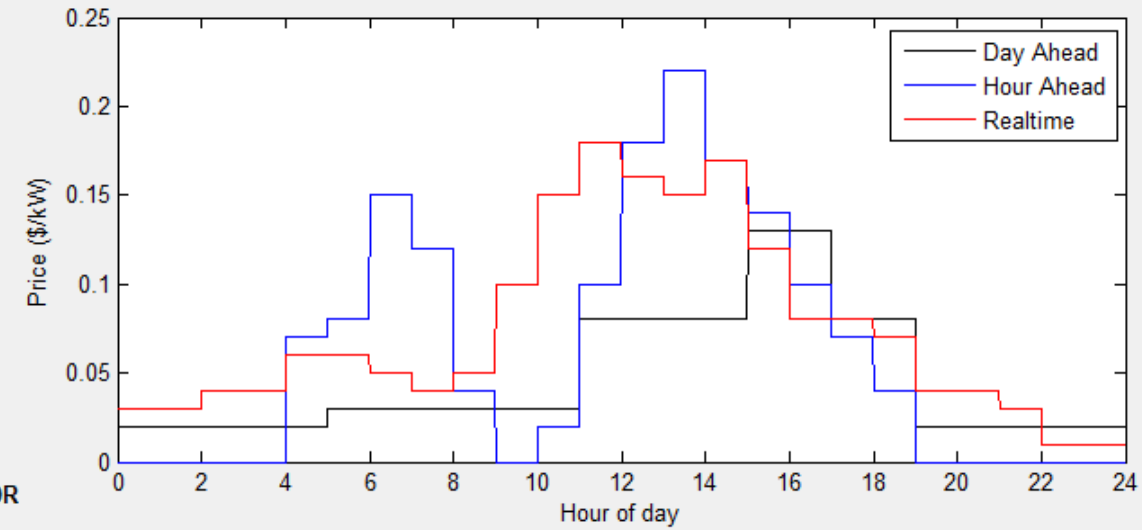
DISPATCH

Main Window | **Market Services** | Historian/Forecast | Network View | Settings | EPT

Market Prices

Capacity Market Prices

Bidding | Commited



Real Time — Hour Ahead

Gen — DR

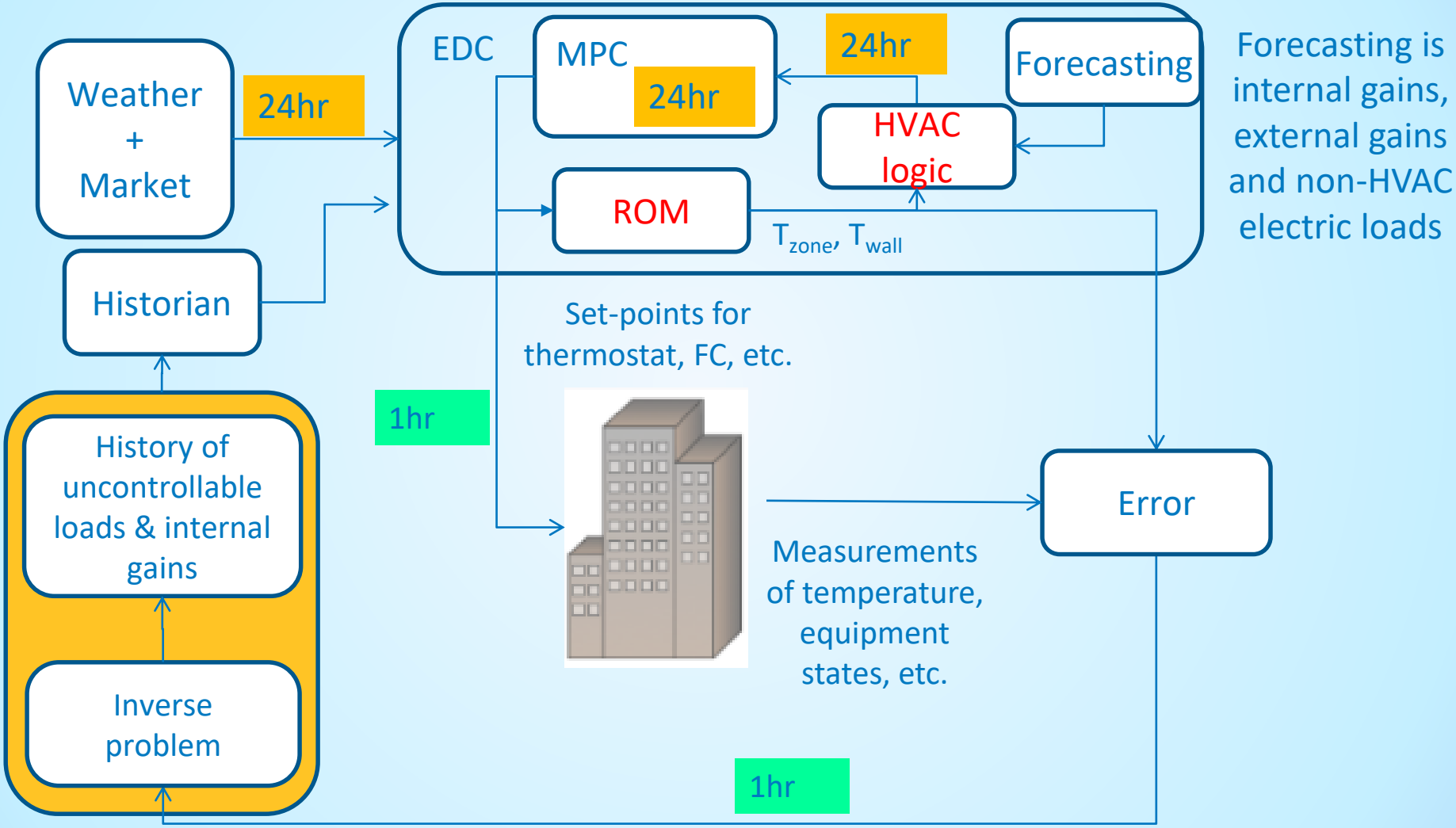
Forecasted Capacity (kW)

	12-1am	1-2am	2-3am	3-4am	4-5am	5-6am	6-7am	7-8am	8-9am	9-10am	10-11am
Excess Gen Capacity	0.0200	0.0200	0.0200	0.0200	0.0200	0.0300	0.0300	0.0300	0.0300	0.0300	0.03
DR Capacity	0	0	0	0	0.0700	0.0800	0.1500	0.1200	0.0400	0	0.02
Total Bid Capacity	0.0300	0.0300	0.0400	0.0400	0.0600	0.0600	0.0500	0.0400	0.0500	0.1000	0.15

Forecasted Prices ($/kW)

	12-1am	1-2am	2-3am	3-4am	4-5am	5-6am	6-7am	7-8am	8-9am	9-10am	10-11am	11-12pm
Day Ahead	0.0200	0.0200	0.0200	0.0200	0.0200	0.0300	0.0300	0.0300	0.0300	0.0300	0.0300	0.0800
Hour Ahead	0	0	0	0	0.0700	0.0800	0.1500	0.1200	0.0400	0	0.0200	0.1000
Real Time	0.0300	0.0300	0.0400	0.0400	0.0600	0.0600	0.0500	0.0400	0.0500	0.1000	0.1500	0.1800

Control with a real building



Planning Tool

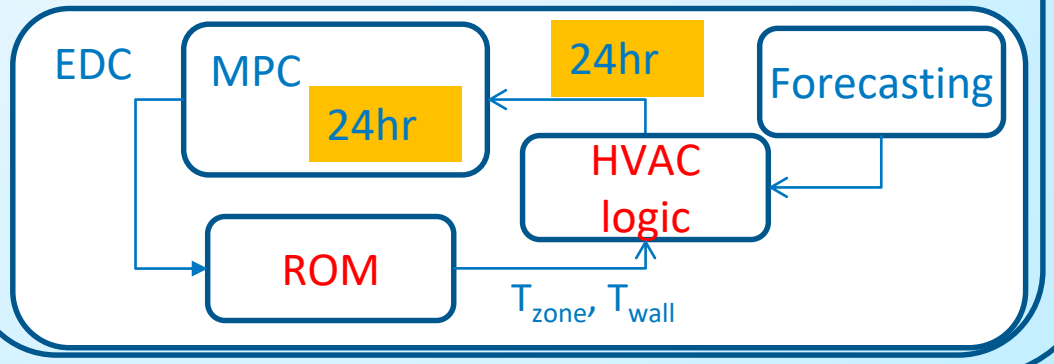
- All modes of the EDC will be available: Planning, Dispatch, and Control, both with & w/o building model
  - Default will be planning, i.e. “perfect” forecast and running 1 day a month

Optimal configuration and sizing

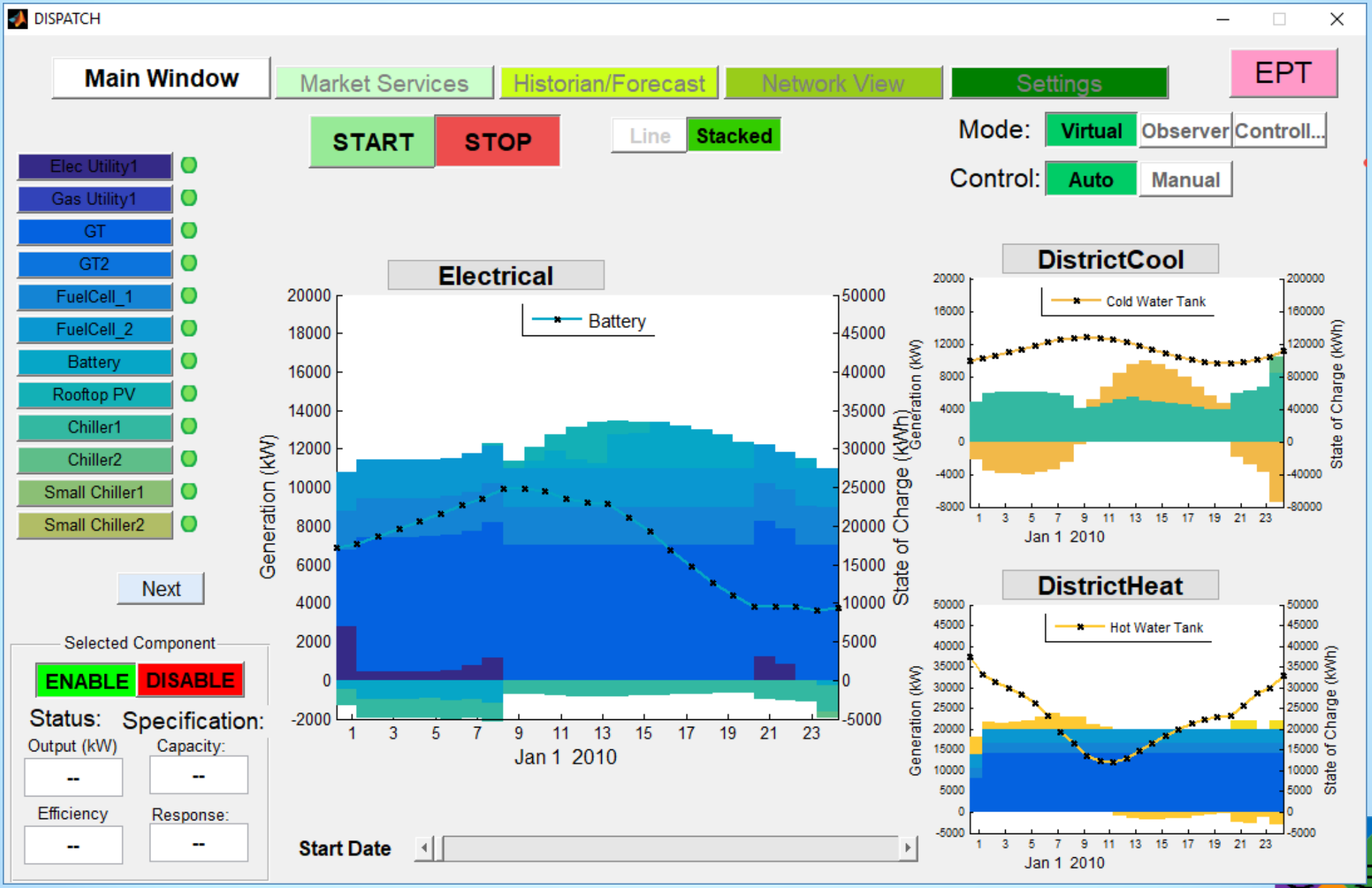
- Adjust system/component sizes
- Test different system arrangements, i.e. w/ or w/o thermal storage
- Compare 20-year system cost or payback

Case evaluation

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

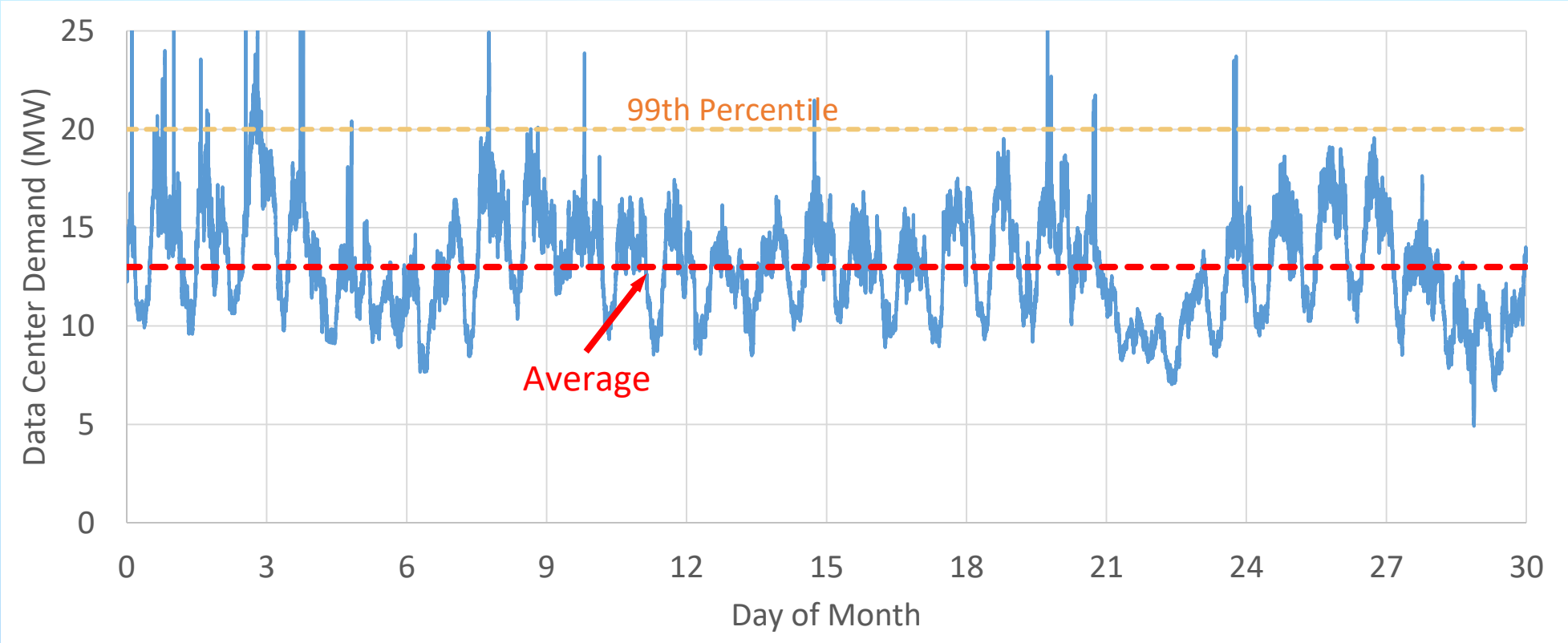


Control Interface

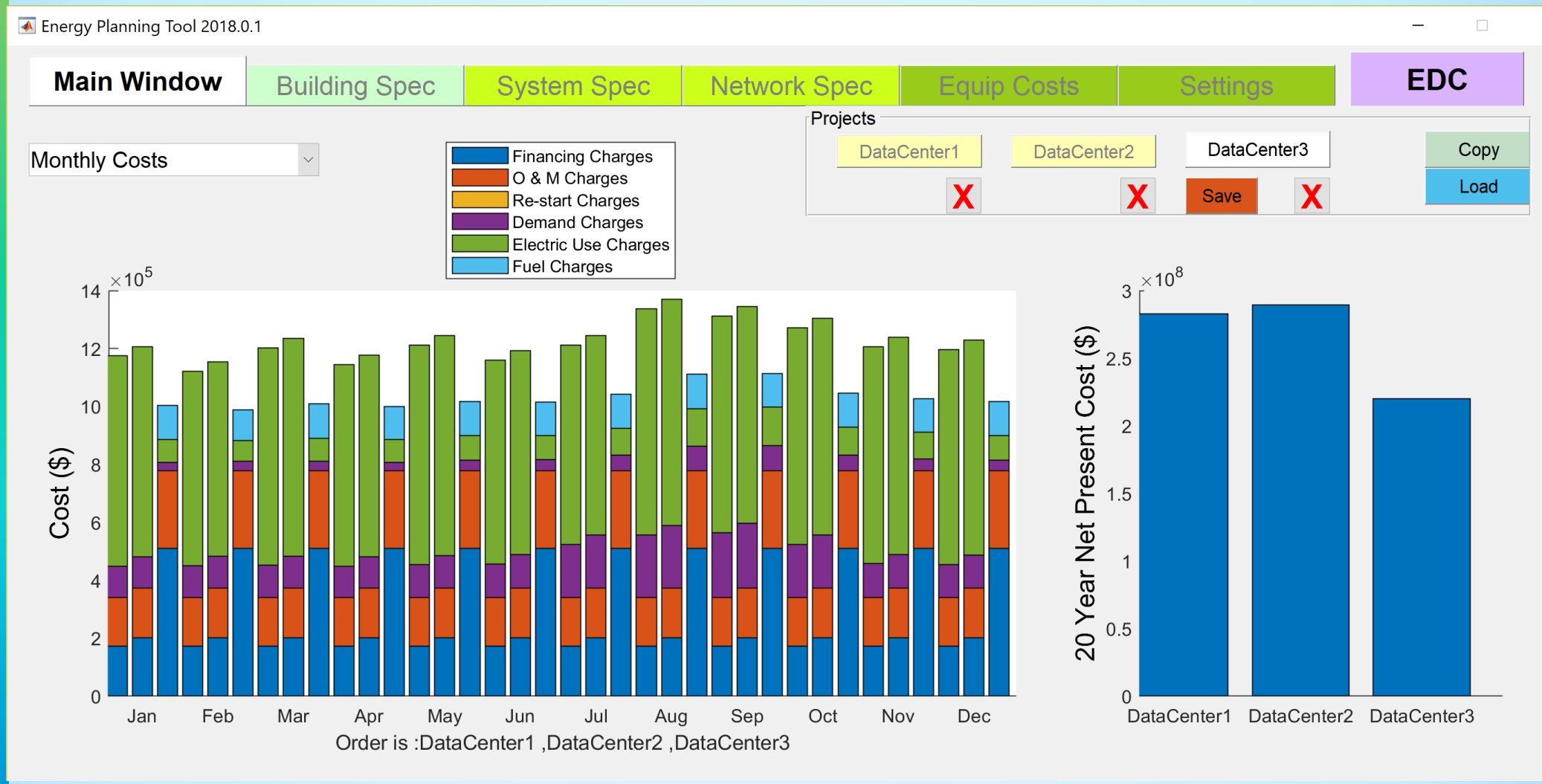


Case Study: Data Centers

- 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 …



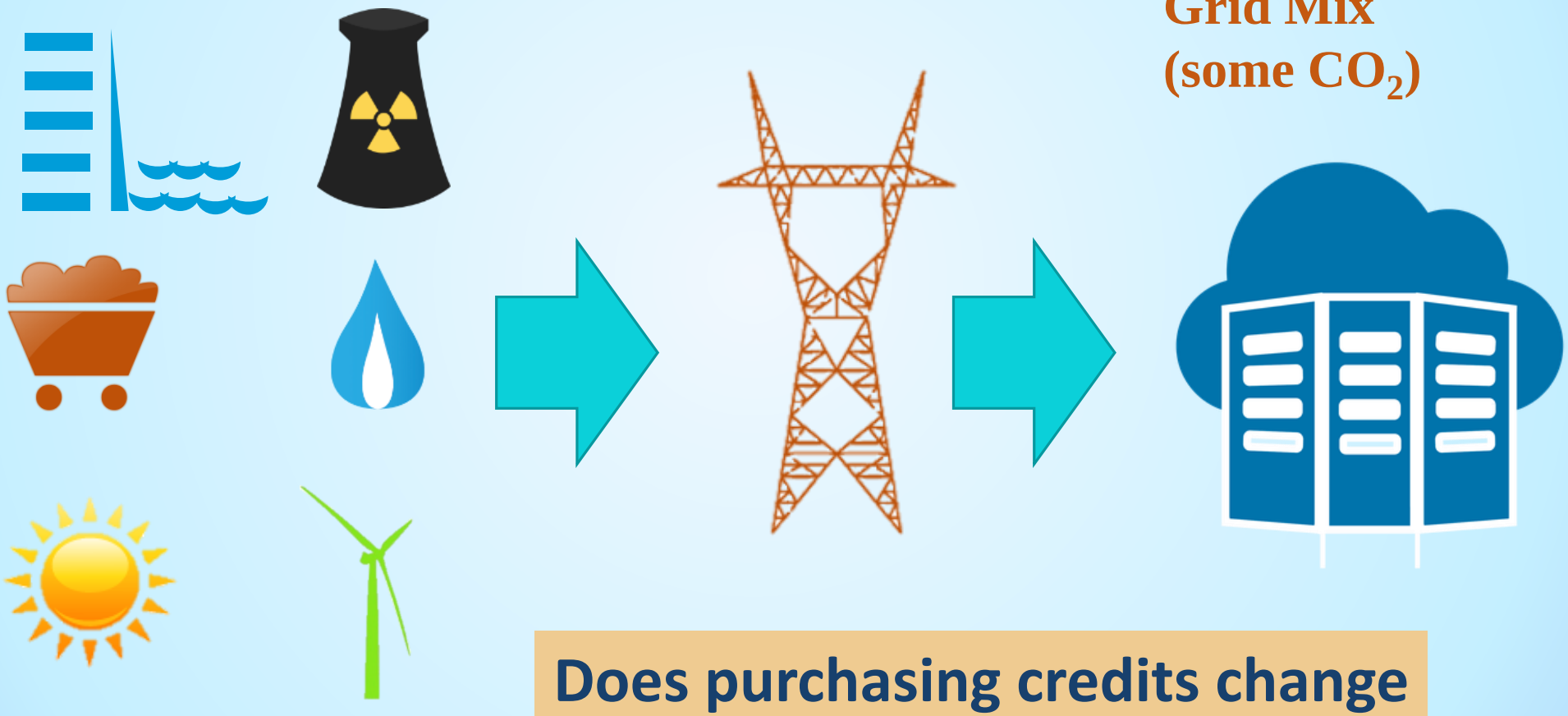
Results



Sustainability of Fuel Cells

» Renewables & NG account for all new generation

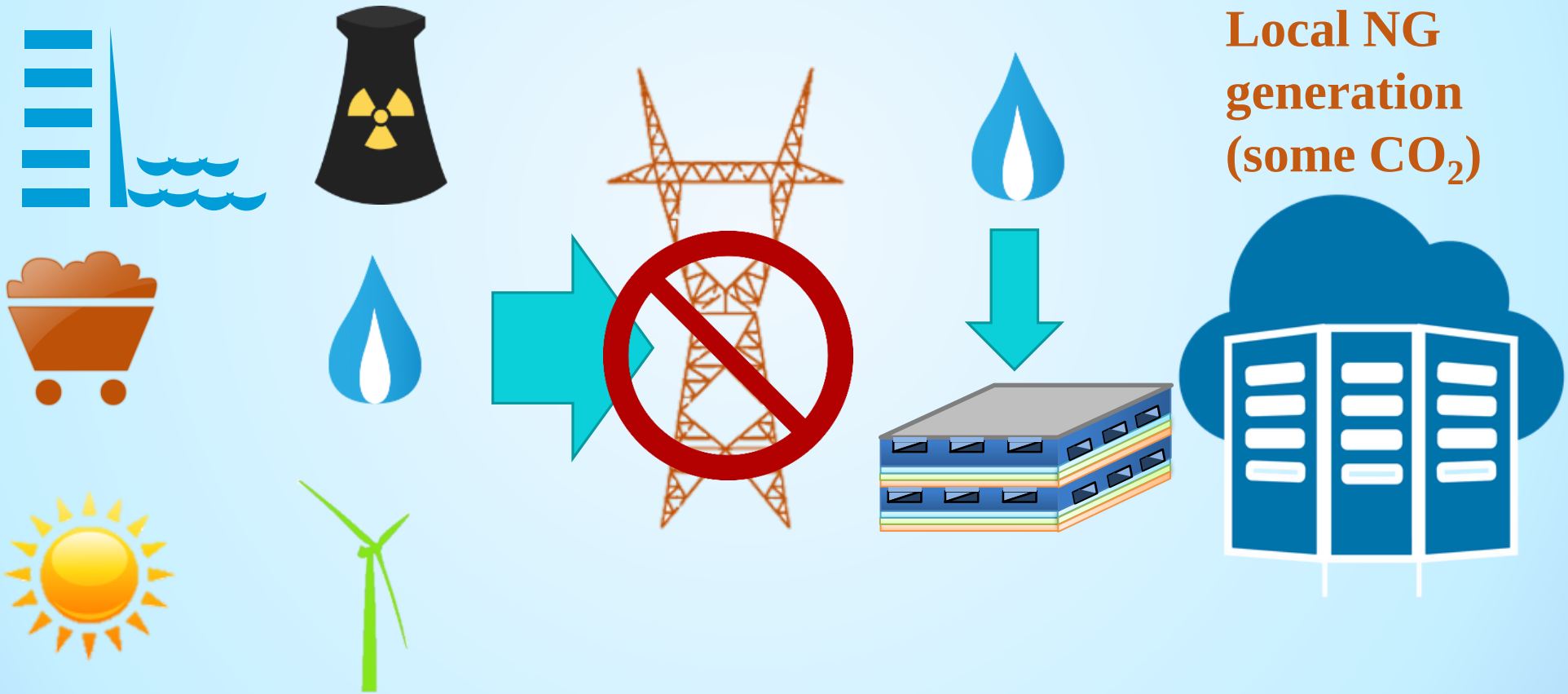
» Retirements of coal & nuclear



Does purchasing credits change the net grid CO2 emissions?

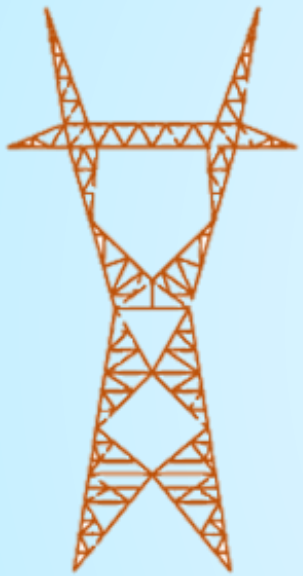
Sustainability of Fuel Cells

- » 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



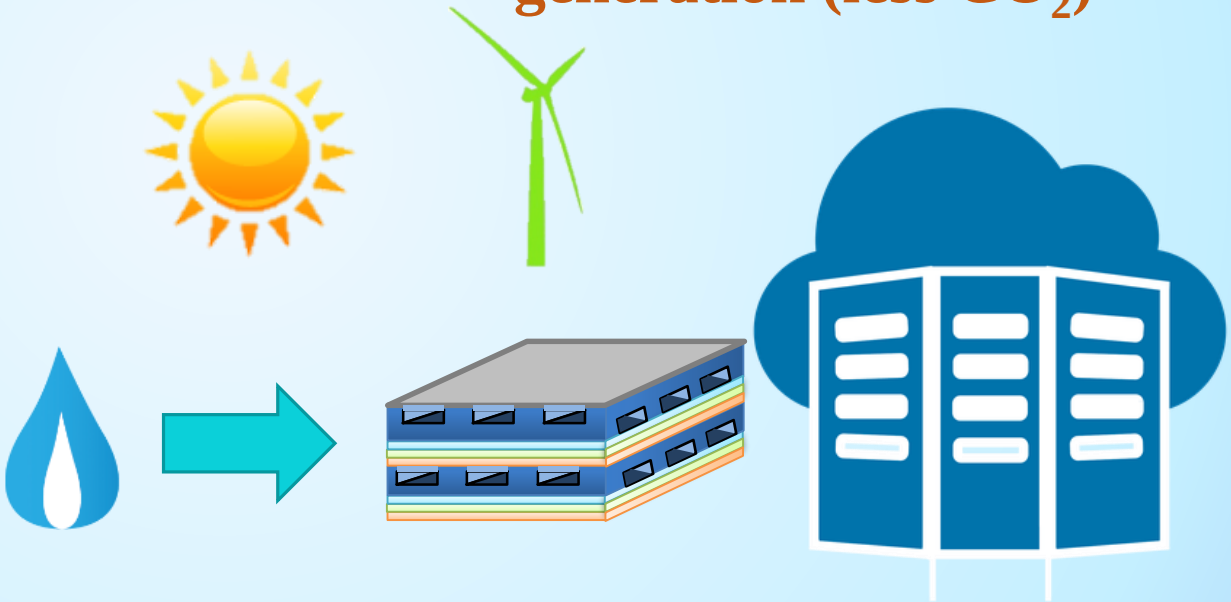
Sustainability of Fuel Cells

» Fuel cells + solar/wind on-site can result in significantly lower CO_2 emission factors



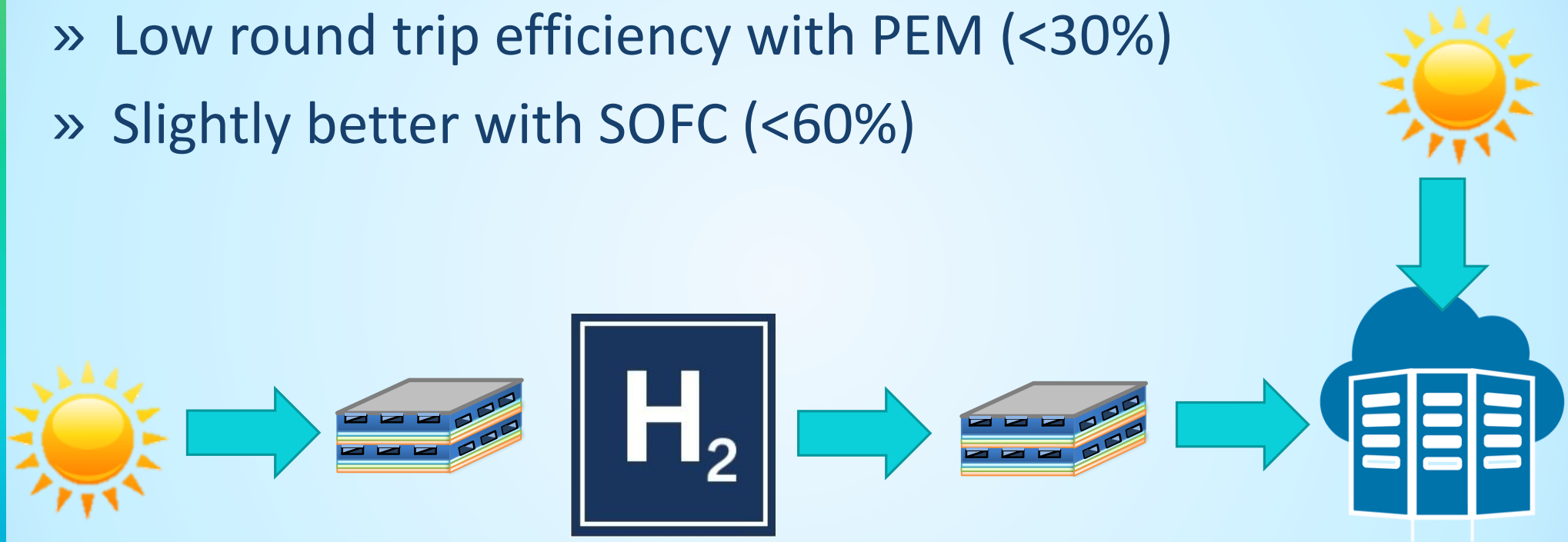
Grid backup

Local renewable + NG generation (less CO_2)



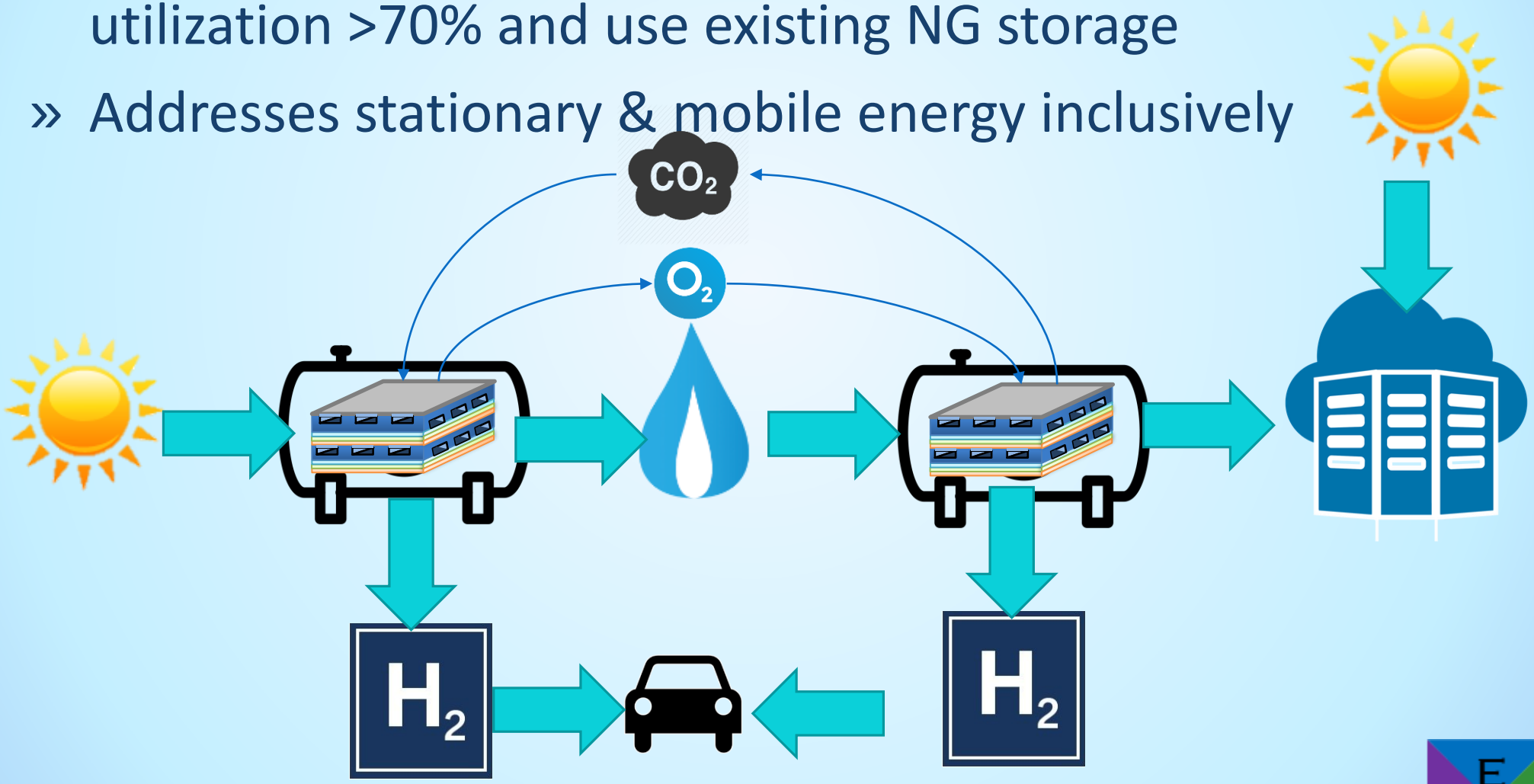
Sustainability of Fuel Cells

- » H2 generation with electrolyzers, storage (compressed gas), and use in fuel cells
- » Low round trip efficiency with PEM (<30%)
- » Slightly better with SOFC (<60%)



Sustainability of Fuel Cells

- » 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!