Clean Coalition

Making Clean Local Energy Accessible Now

DEMAND RESPONSE:

A Critical Component of Community Microgrid Power Plants in a Clean Energy Future

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How Demand Response will save the world

February 8, 2018

What are the

roadblocks and problems

to getting to a
fossil-fuel free future?

What is slowing us down?

What are the problems we will need to solve?

Part I: The End of the World as We Know It

Five Key Emerging Issues

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1. Load-Generation mismatch: The Duck and Nessie
2. Intermittency of renewable technologies
3. Increasing Distribution complexity
4. Resilience
5. Replacing obsolete natural gas

Problem 0: Climate Change

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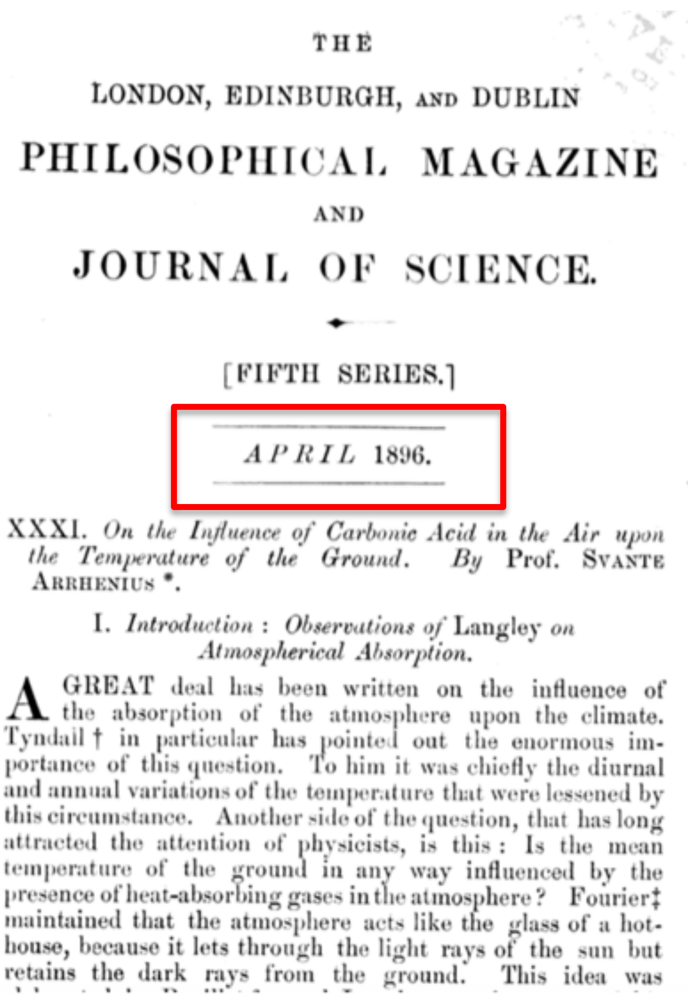

THE

LONDON, EDINBURGH, AND DUBLIN

PHILOSOPHICAL MAGAZINE

AND

JOURNAL OF SCIENCE.

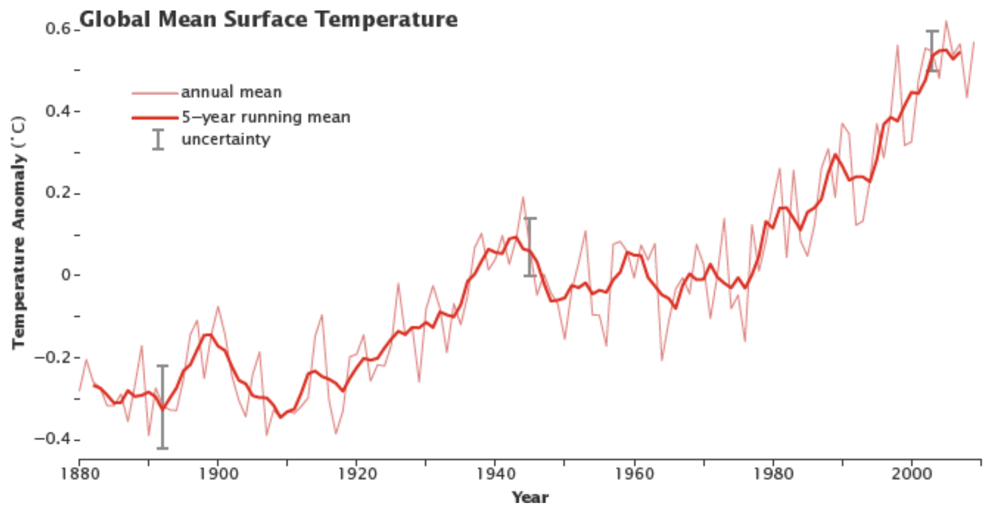
[FIFTH SERIES.]

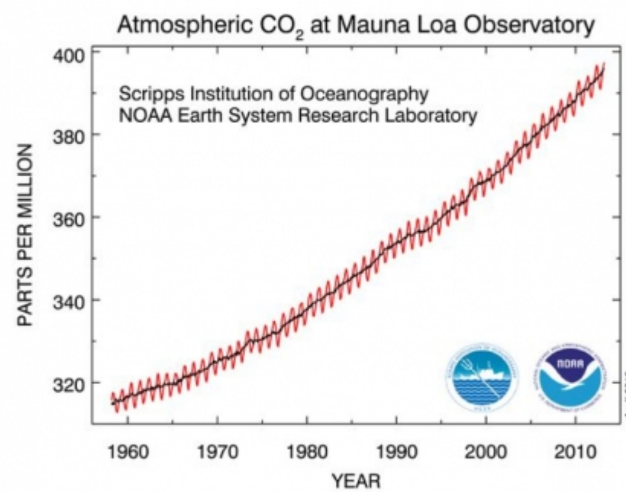
APRIL 1896.

XXXI. *On the Influence of Carbonic Acid in the Air upon the Temperature of the Ground.* By Prof. SVANTE ARRHENIUS *.

I. *Introduction: Observations of* Langley *on Atmospherical Absorption.*

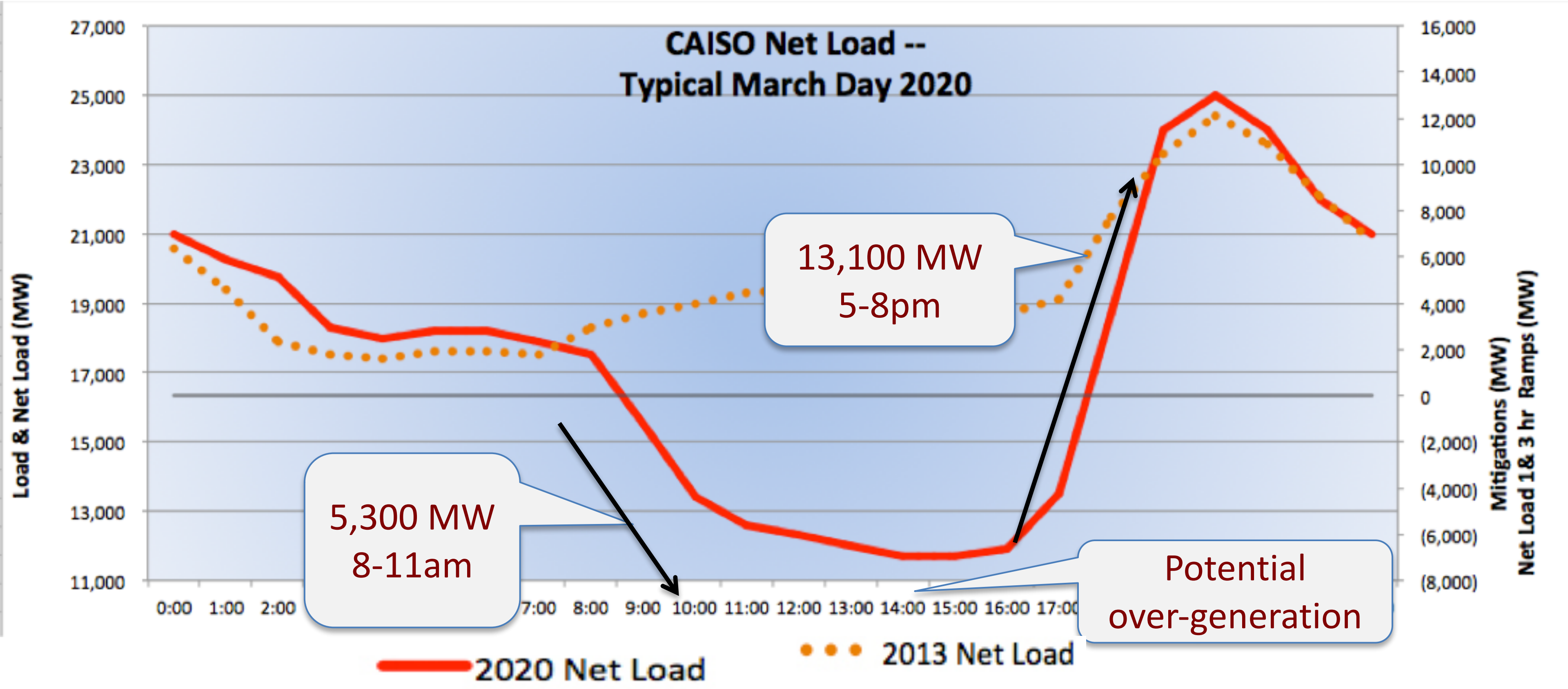
A GREAT deal has been written on the influence of the absorption of the atmosphere upon the climate. Tyndall † in particular has pointed out the enormous importance of this question. To him it was chiefly the diurnal and annual variations of the temperature that were lessened by this circumstance. Another side of the question, that has long attracted the attention of physicists, is this: Is the mean temperature of the ground in any way influenced by the presence of heat-absorbing gases in the atmosphere? Fourier‡ maintained that the atmosphere acts like the glass of a hot-house, because it lets through the light rays of the sun but retains the dark rays from the ground. This idea was





- **122 years *should* have been enough time to deal with climate disruption**

Problem 1: Load-Generation Mismatch
CAISO Duck Chart (2020 Issues)



- At a grid scale, renewable generation requires flexibility to match load to generation

Problem 1: Load-Generation mismatch
The Nessie Curve: The Future of Uncoordinated DER?

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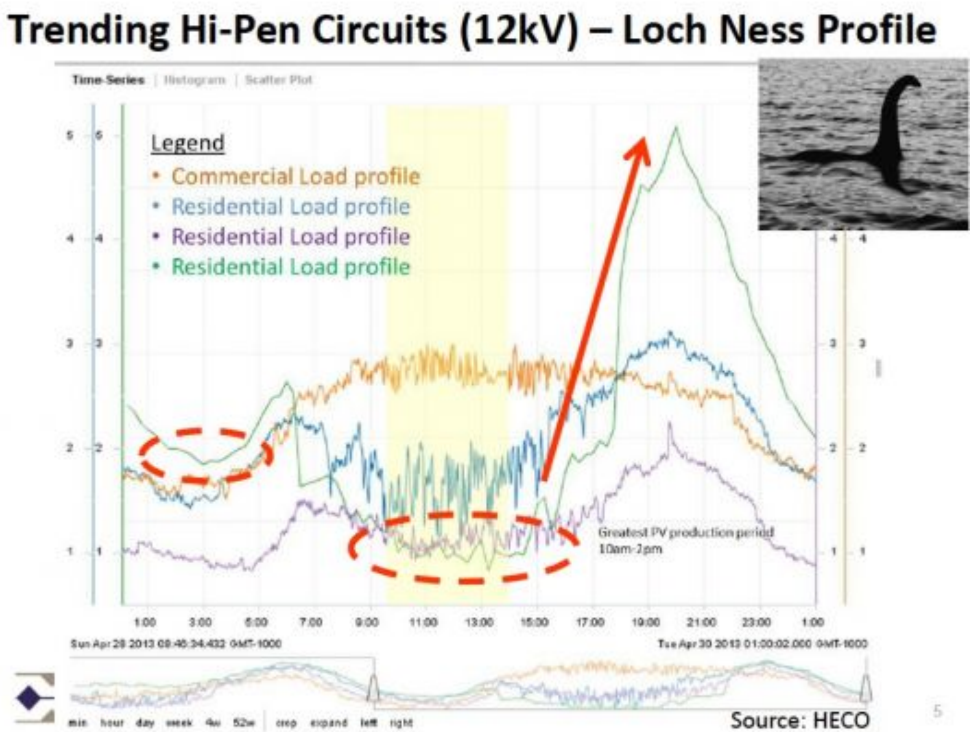

- **In Hawai'i, beyond ducks are lake monsters: the Nessie Curve**
- Very high penetration and small grids mean energy can outstrip load.
- This is a load management problem.

https://www.greentechmedia.com/articles/read/hawaiis-solar-grid-landscape-and-the-nessie-curve

Problem 2: Intermittency

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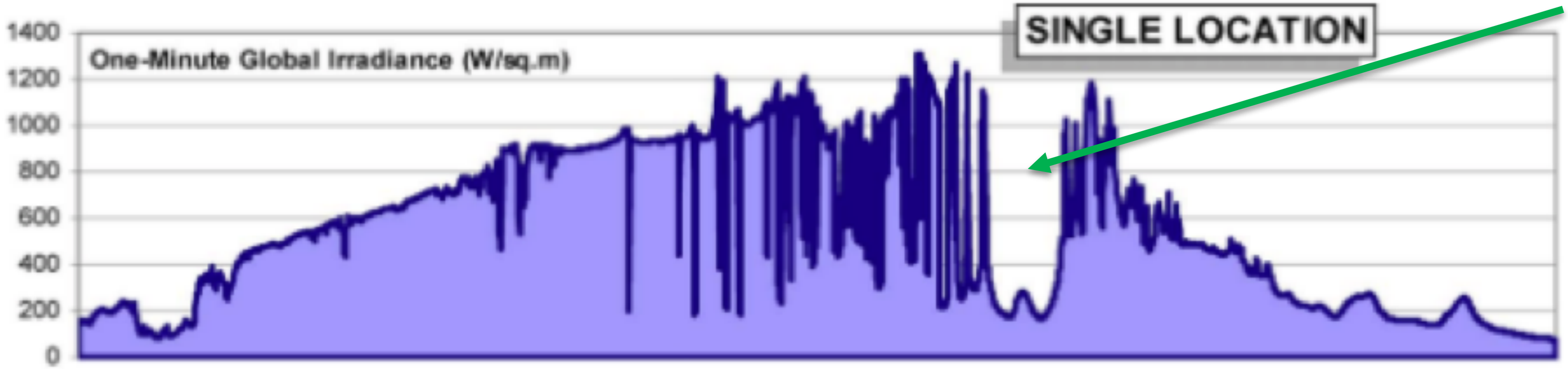
Weather as resource?



- Since renewables largely depend on natural sources, the grid will need vastly greater flexibility to match load to generation

https://blogs.scientificamerican.com/plugged-in/renewable-energy-intermittency-explained-challenges-solutions-and-opportunities/

Problem 3: Distribution Diversity

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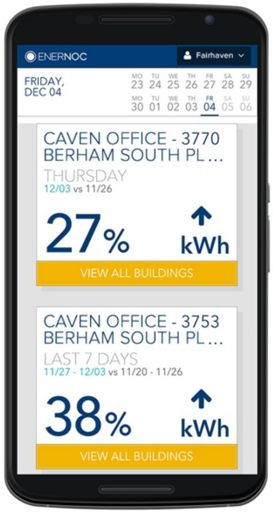


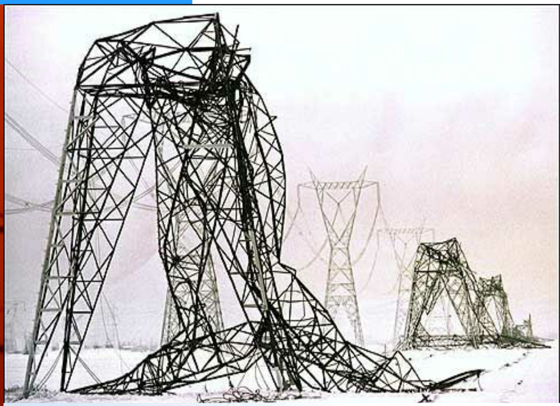
- Increasing diversity of distribution edge devices make grid management more volatile.

4. Resilience

Thomas Fire 2017

Ventura and Santa Barbara:

- 85,000 customers lose power from a "transmission emergency" caused by "loss of critical infrastructure"



Problem 5: Replacing obsolete natural gas peakers

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- Fossil fuels are going away
  - Climate change
  - Price
- Renewables must rise to meet ALL grid functions, one way or another.
  - Meet all load with generation
  - Provide reliability
  - Provide ancillary services

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BRIEF

Puente gas plant should not be approved, California energy committee says

pv magazine Subscriptions USA EDITION

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California rejects gas peaker plant, seeks clean energy alternatives

What the grid needs now…

- Grid resilience and robustness means jointly managing load and generation.
- Small pieces of the grid, loosely connected allows the grid to be operated from the bottom up, not the top down

Demand Response will be critical

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- Jointly matching load and generation means flexibility and responsiveness at both ends.
- Demand Response is cheap.
- Demand Response can be implemented locally.
- Demand Response can complement other technologies.

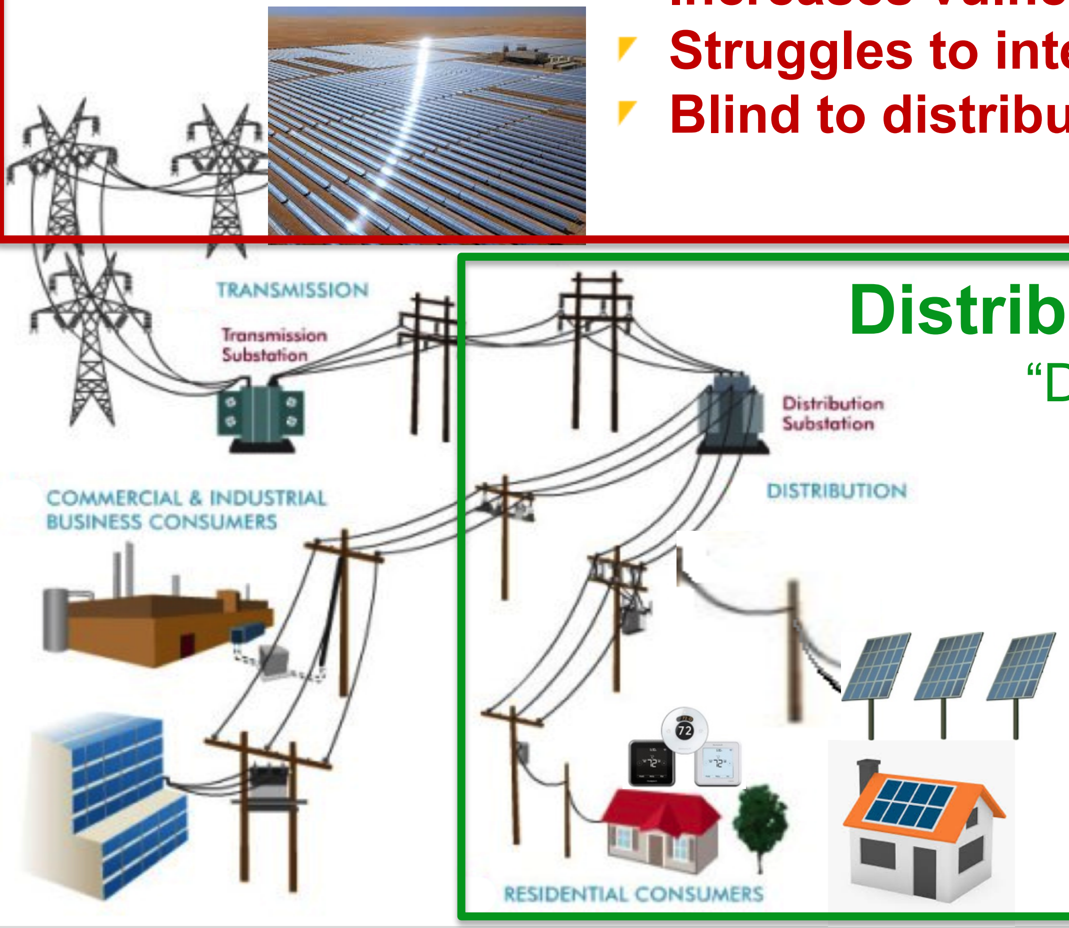
Demand Response plays a key role in tackling very big grid management issues: Local Capacity Requirements

Part II: Demand Response in Community Microgrids as ground-up alternative to the central generation paradigm

Two Approaches to managing challenges

Relying on remote Generation "All Eggs in one basket"

- **Requires expensive large scale transmission**
- **Increases vulnerability to disturbance anywhere**
- **Struggles to integrate renewables**
- **Blind to distribution device diversity**



Distributed Energy Resources

"Diversify, diversify, diversify!"

-not Thoreau

- **Often more cost-effective**
- **Greater reliability and resilience**
- **Provides local management of renewables**
- **Easier management of distribution diversity**

But what if…

What if Demand response doesn't show up?

Blahblahblah

What if PV fails to generate power?

What if the sun doesn't shine?

Doesn't Distributed Generation-served Load need the transmission grid as "backup"?

When was the last time more than a million customers lost power from a DER failure?

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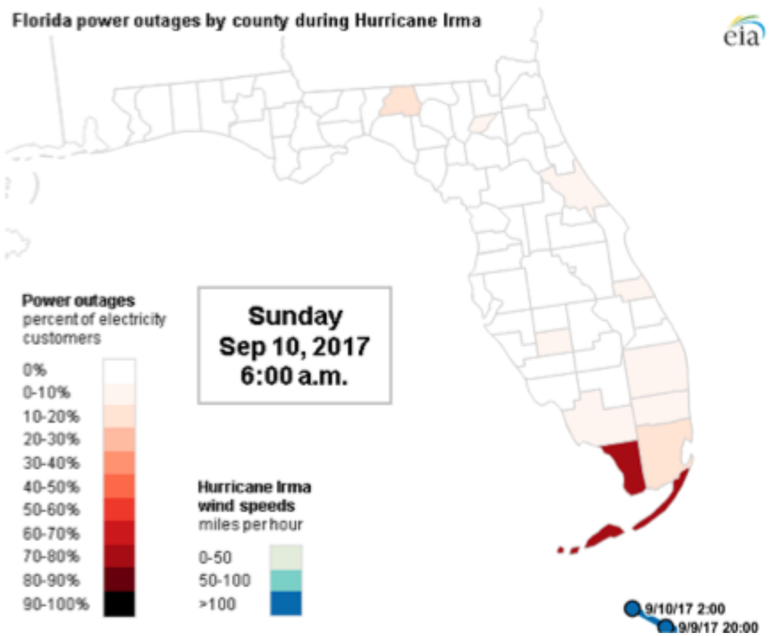
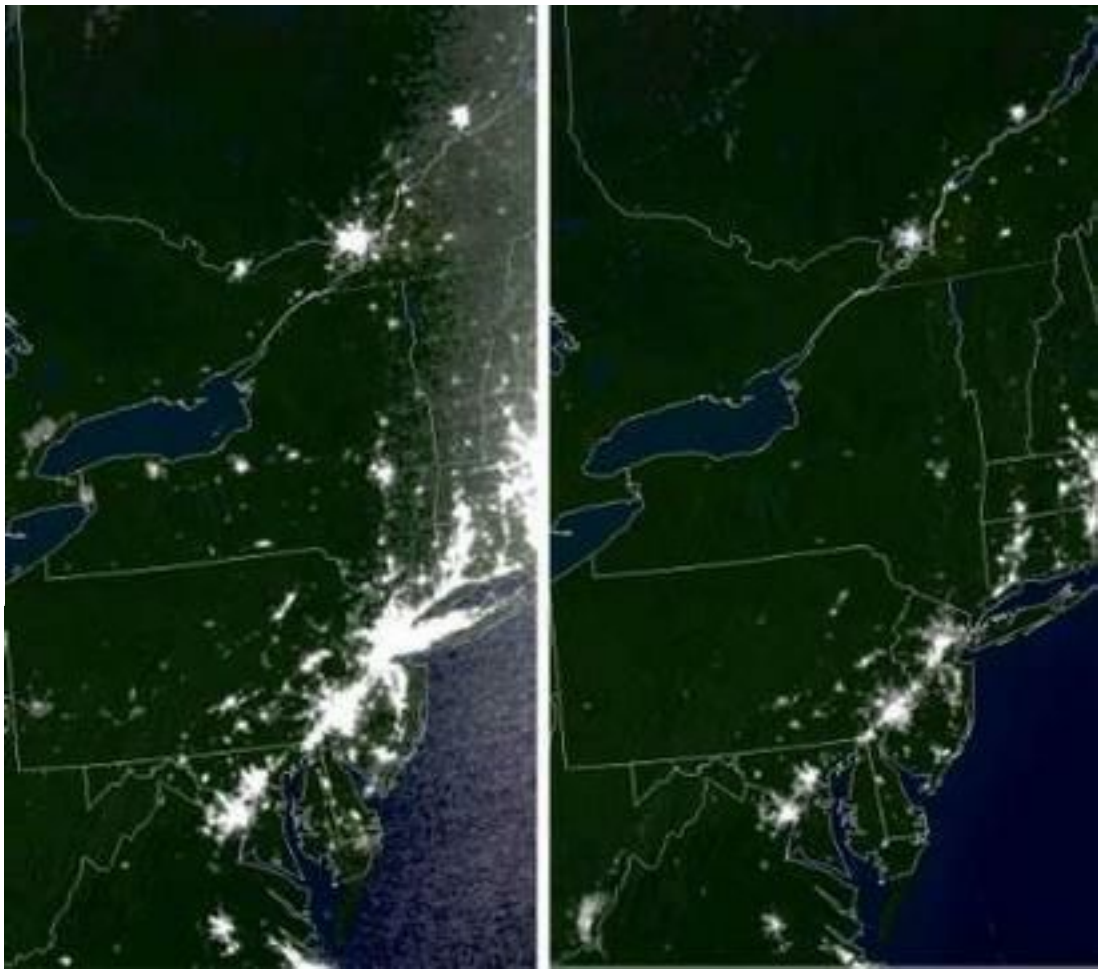


Before 2003 black out | Seven hours after



A review: about that transmission grid backup idea….

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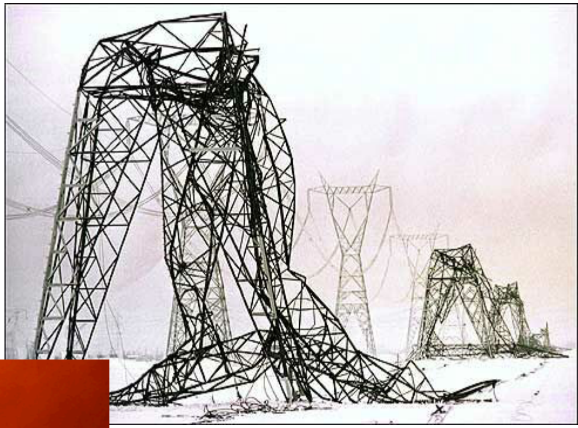

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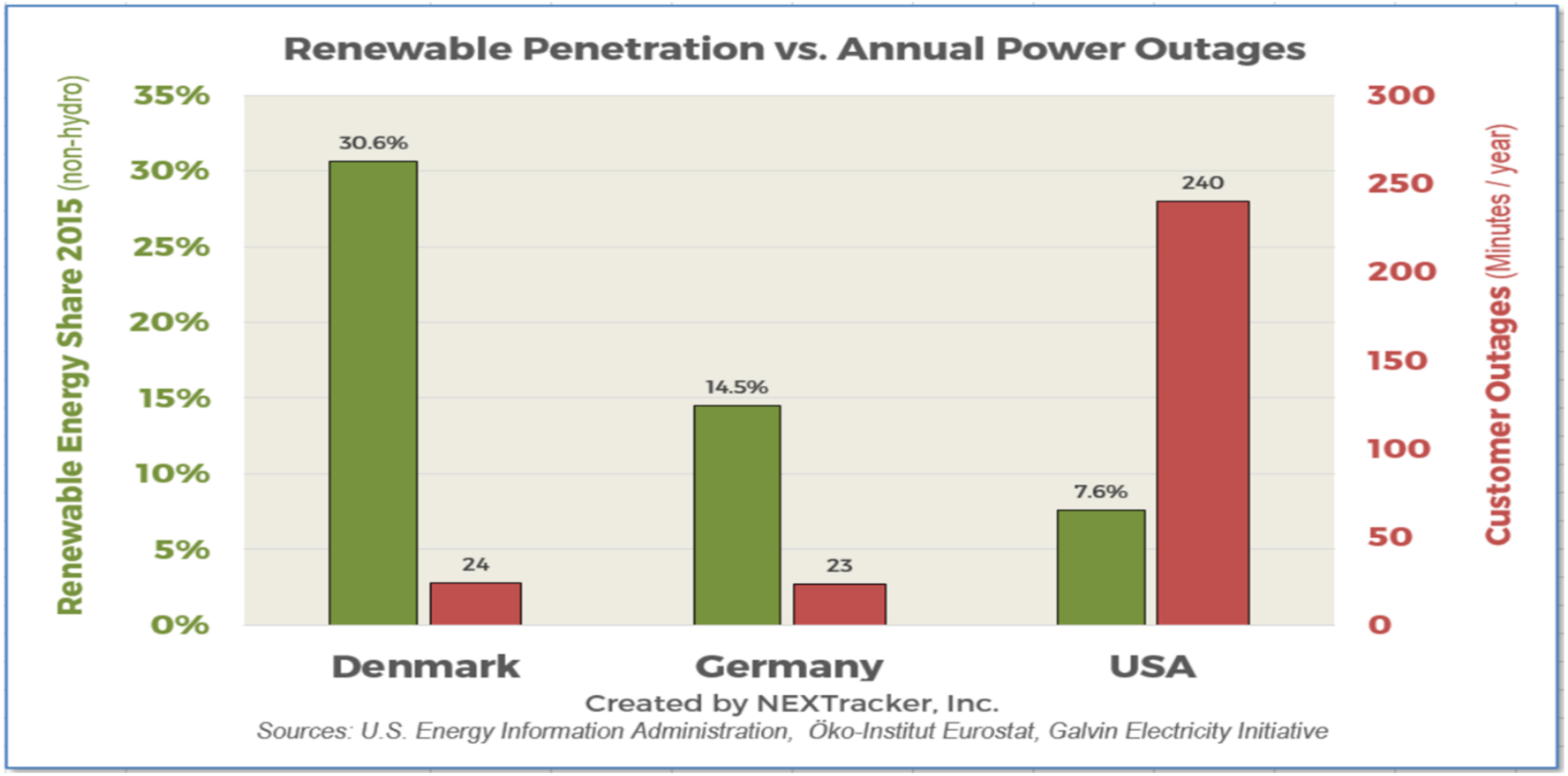
High renewable penetration correlates with **HIGH RELIABILITY**



Daniel Shugar, https://www.linkedin.com/pulse/response-rick-perry-regarding-renewables-grid-stability-daniel-shugar, April 27, 2017
David Hochschild, CEC, David Owen, CAISO, **Renewable energy no threat to electric grid, as Trump aides claim,** S.F. Chronicle, June 16, 2017

Resilience

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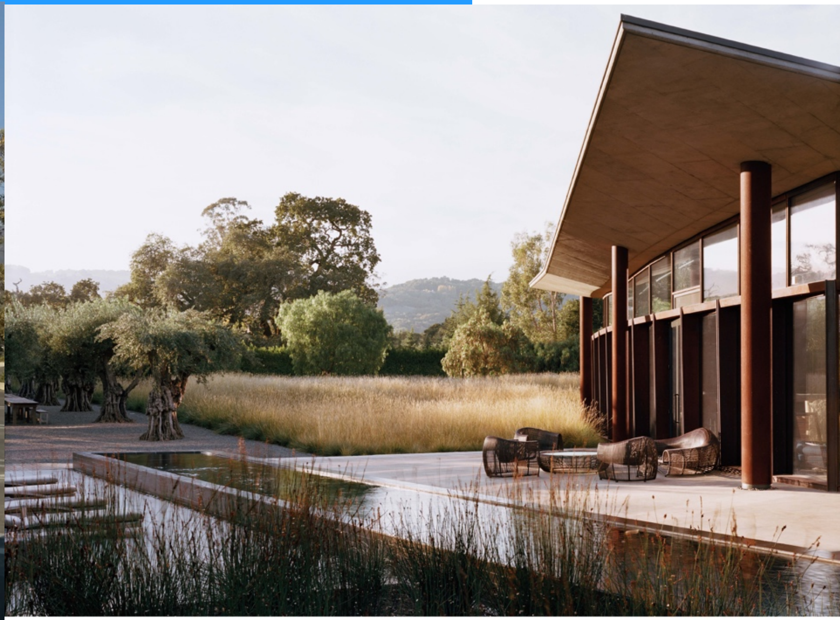

Photo: Vicky Sambunaris, https://www.asla.org/2009awards/144.htm

- During the Tubbs fire in Sonoma, Stone Edge Farm maintained power for 10 days with a microgrid.
- SimpliPhi Energy in Ojai was threatened by Thomas Fire

Part III: A Case Study in replacing obsolete natural gas peakers

Replacing obsolete natural gas peakers with Community Microgrids

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Two natural gas peakers in Moorpark subarea **rejected** by CEC and CPUC

- CAISO showed **energy storage** can replace 312 MW of natural gas at a cost of $1.1 Billion!
- Clean Coalition showed DER can do the same thing for half the cost
  - 220 MW of Solar
  - 130MW/540 MWh of Energy Storage
  - 128MW of Demand Response
- **Costs ratepayers less.**

DER are cheaper than natural gas peakers

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	Puente Power Project	Solar+storage (Puente Only)	Solar+storage (Puente and Ellwood)
Operations & Maintenance ($/MWH (gas) or $ per kW capacity (solar))	$4.72	$35.00	$50.00
Fuel Costs ($/MWH)	$28.22	$0.00	$0.00
Nameplate (MW)	262	130	220
Operating Hours per year	2,190	2,190	2,190
MWH/ year	573,780	284,700	481,800
Annual O&M and Fuel	$18,900,313	$4,550,000	$11,000,000
Battery Capacity (MW)		75	130
O&M Cost per kw		$20	$20
Annual battery O&M		$675,000	$1,170,000
Installed cost	$299,000,000	$394,795,574	$591,743,318
Total 30 year O&M and Fuel costs	**$567,009,396**	**$156,750,000**	**$365,100,000**
Mortality and Illness costs	$85,921,590	$0	$0
Total 30 year cost (nominal)	**$951,930,986**	**$551,545,574**	**$956,843,318**

Replace SONGS voltage support – DG/Storage + Advanced Inverters

Clean Coalition

VS

$80 million
2 Synchronous Condensers
San Luis Rey Substation
450 MVAr
(minus line losses = **400 MVAr**)

800 MW of DG solar + storage with advanced inverters, oversized by 10% set at 0.9 Power Factor = **400 MVAr**

CAISO proposed 320 MW DG solar + 580 MW storage = **900 MW** **(plus 1,400 MW of nat gas)**

Part IV: Community Microgrids as local solution

Building the Grid from the ground up

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Community Microgrid-based distribution grids can provide

- Local balancing
- Shaping of DER profiles
- Complementary DER diversity
- Resilience
- Providing local renewable energy

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Large-scale grid regionalization involves

- Large-scale, complex operations
- Long, expensive transmission lines
- Little visibility into distribution grid events
- Hope

http://www.hcn.org/issues/45.21/the-latest-interior-

Building the Grid from the ground up

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Community-level Demand Response

- Scaled to community area/substation area
- Direct Load Control or Automated Load Control
- Premium on fast responsive
- Many calls a day
- Not scheduled as day-ahead
- Not responsive to Transmission System Operator calls.

Community-level Resilience

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Residential or institutional-scale resources

- HVAC
- Water Heaters
- EVs
- Laundry facilities
- Prioritized load shedding

What is a microgrid?

U.S. DOE Microgrid Exchange Group:

A microgrid is

- a group of interconnected loads and distributed energy resources
- *Within clearly defined electrical boundaries that acts as a*
- Single controllable entity with respect to the grid.
- A microgrid can connect and disconnect from the grid to enable it to operate in both grid-connected or island-mode.

Typical Microgrid

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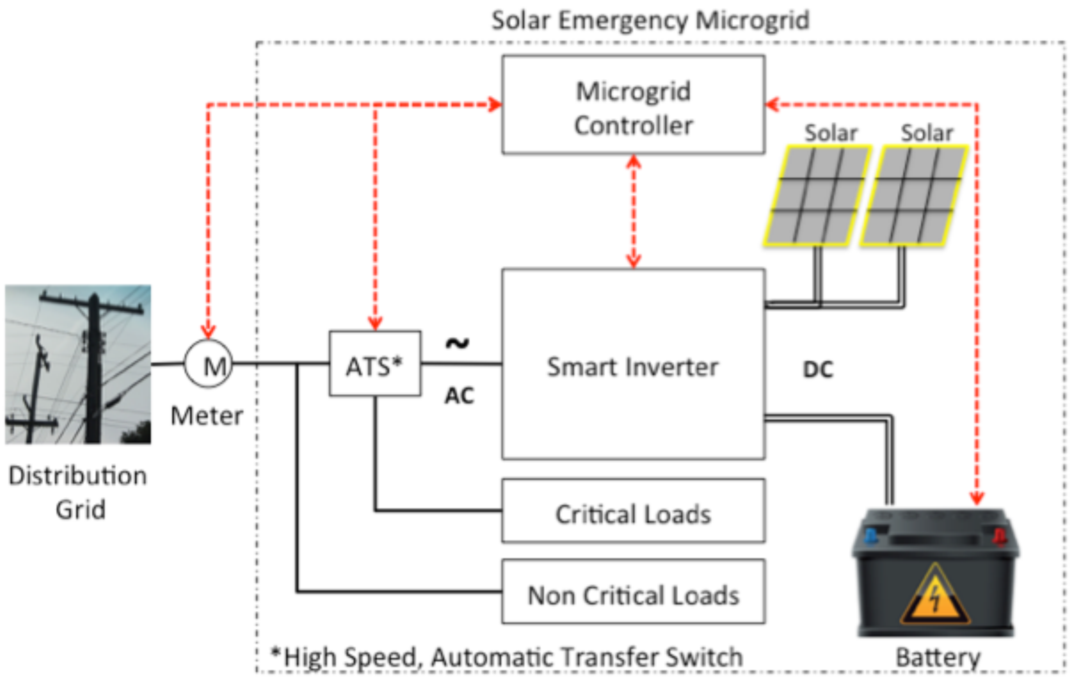
- A collection of DER behind a single meter.
- Islandable during outages to maintain critical loads
- Might include rudimentary demand response (shutting off non-critical loads)

- Example: A Solar Emergency Microgrid (SEM) has 3 basic components:
  - Solar; energy storage; and monitoring, communications & control
- A SEM provides <u>indefinite</u> back-up power for critical loads
  - Ideal for police and fire stations, emergency operations centers and shelters, critical communications and water infrastructure, etc



What is a *Community* Microgrid?

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A Community Microgrid is a design for operating a high renewable penetration electric grid.

- A group of interconnected loads
- High penetration of distributed energy resources
- **In a distribution area served by one or more distribution substations**
- **Aggregated across multiple sites**
- **Staged capability for ongoing renewable power backup for critical and prioritized loads across the grid area**
- Single coordinated controllable entity within the grid.

The multi-site substation area foundation means CMGs can be

- readily extended throughout a service territory
- and replicated around the world

Community Microgrid Vision

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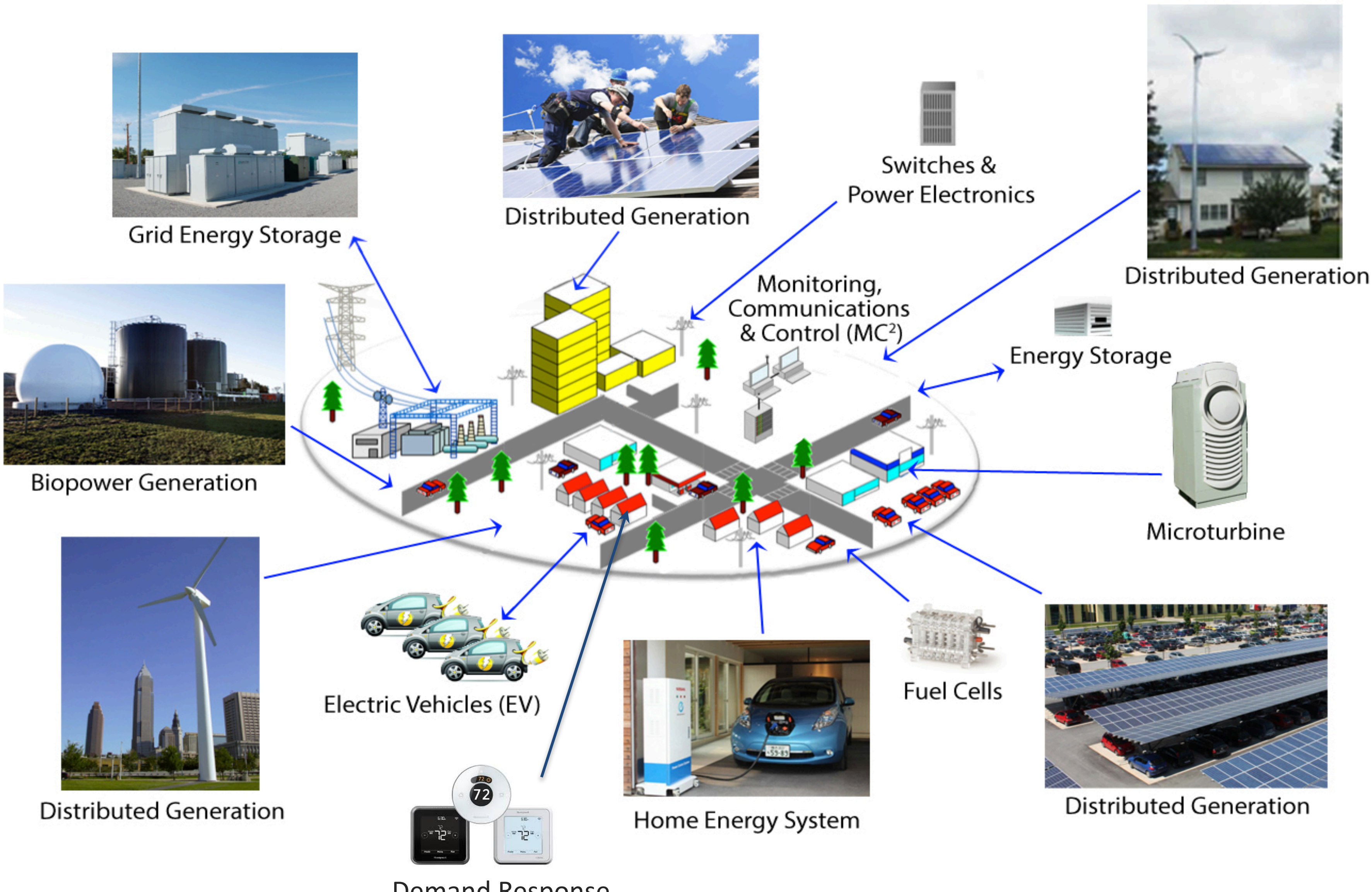

A simple microgrid

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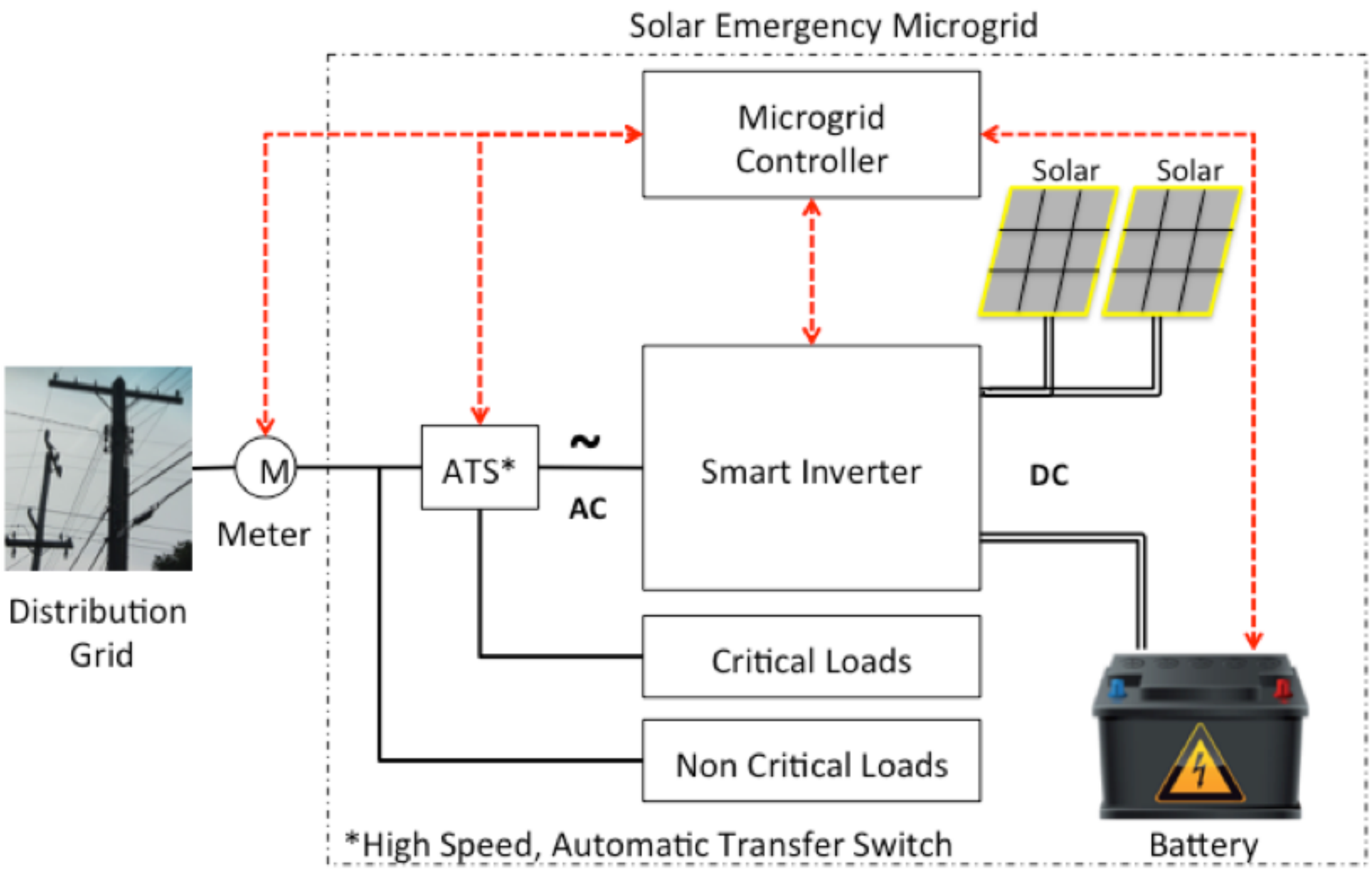

A Community Microgrid

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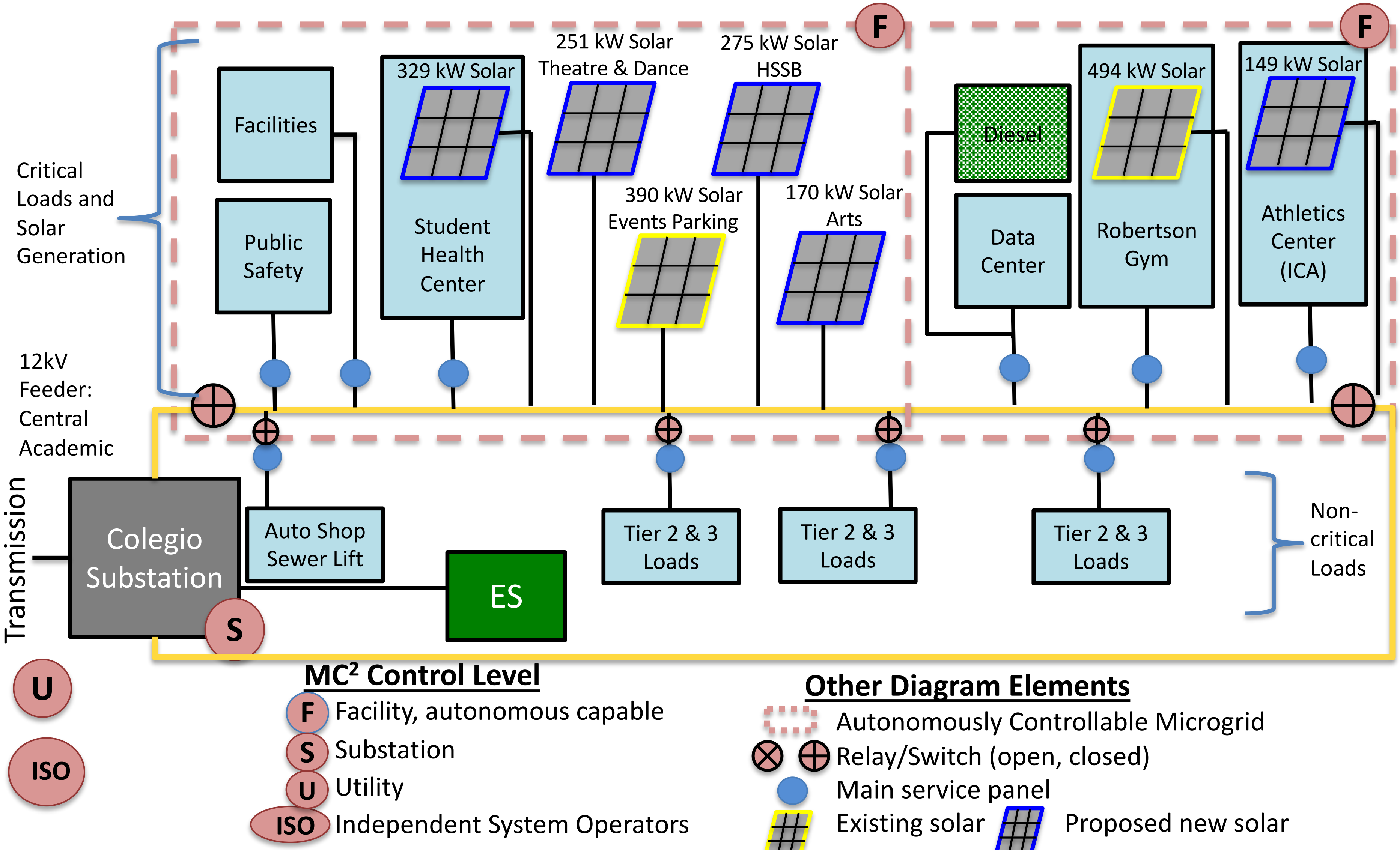

http://www.metronews.ca/news/toronto/2017/06/29/giant-rubber-duck-canada-150.html

Part V: Demand Response saves the world from Ducks

UCSB and Isla Vista

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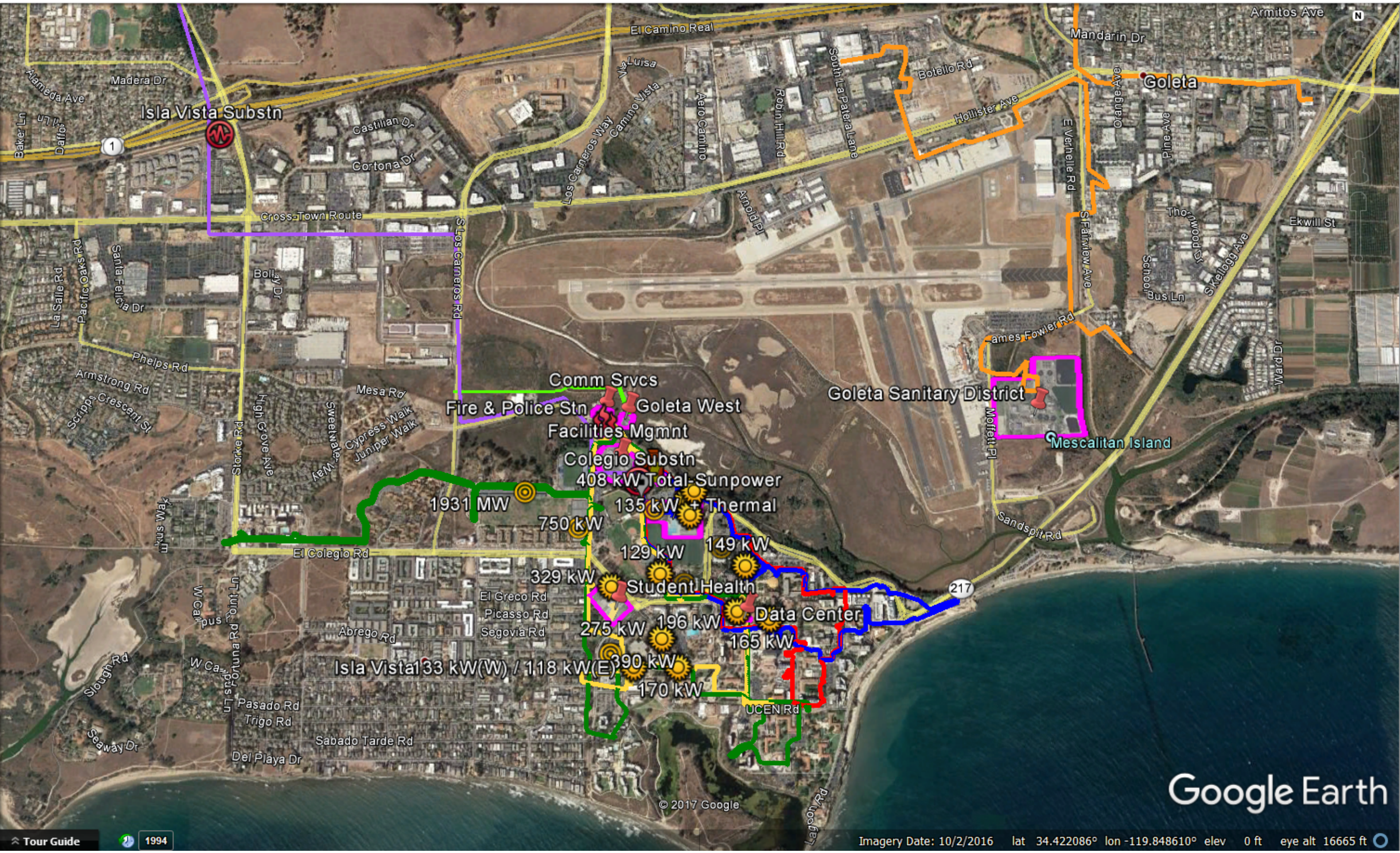

UCSB Target Loads and Solar Generation

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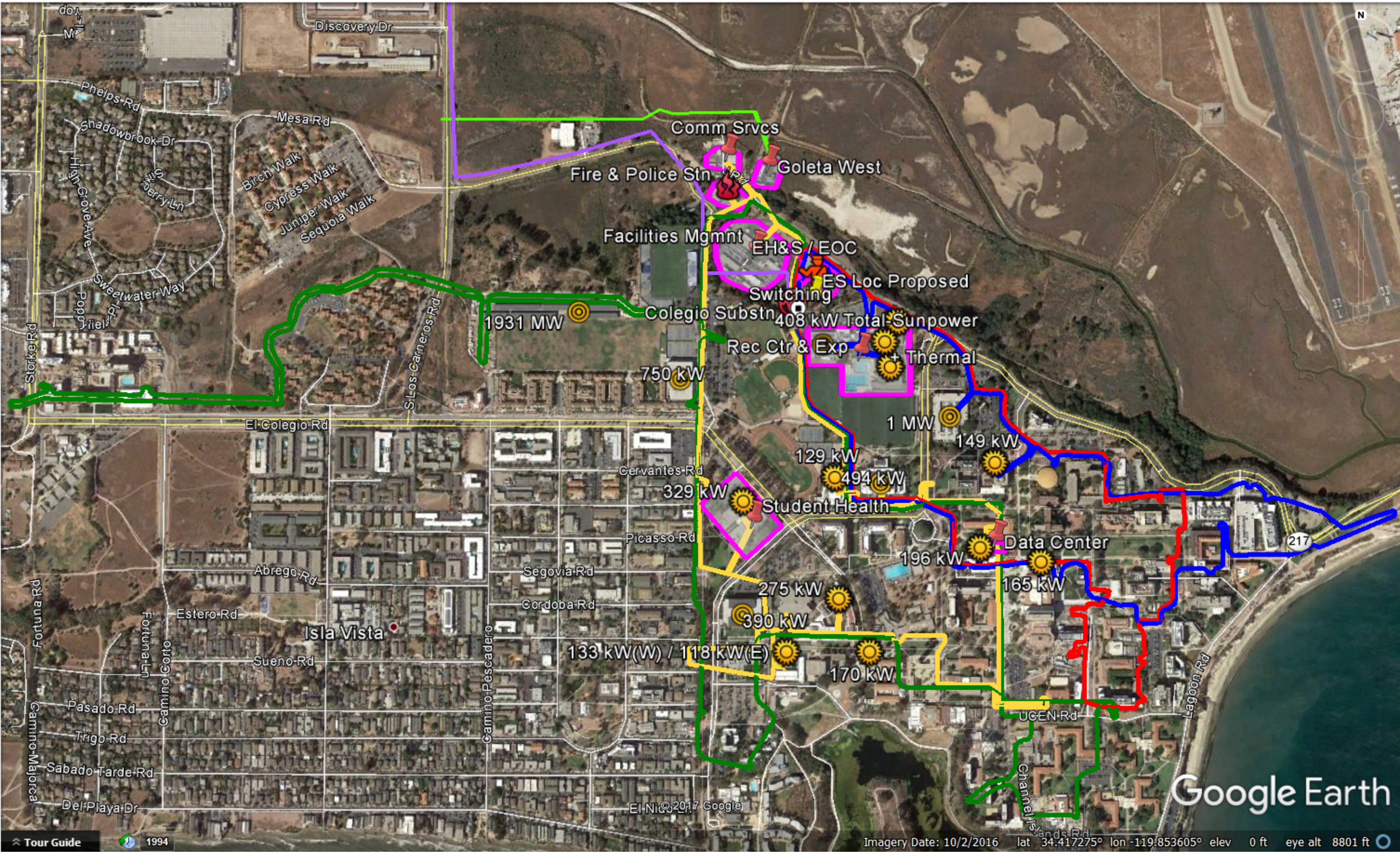

UCSB Community Microgrid CA Feeder

Central Academic feeder (yellow) block diagram

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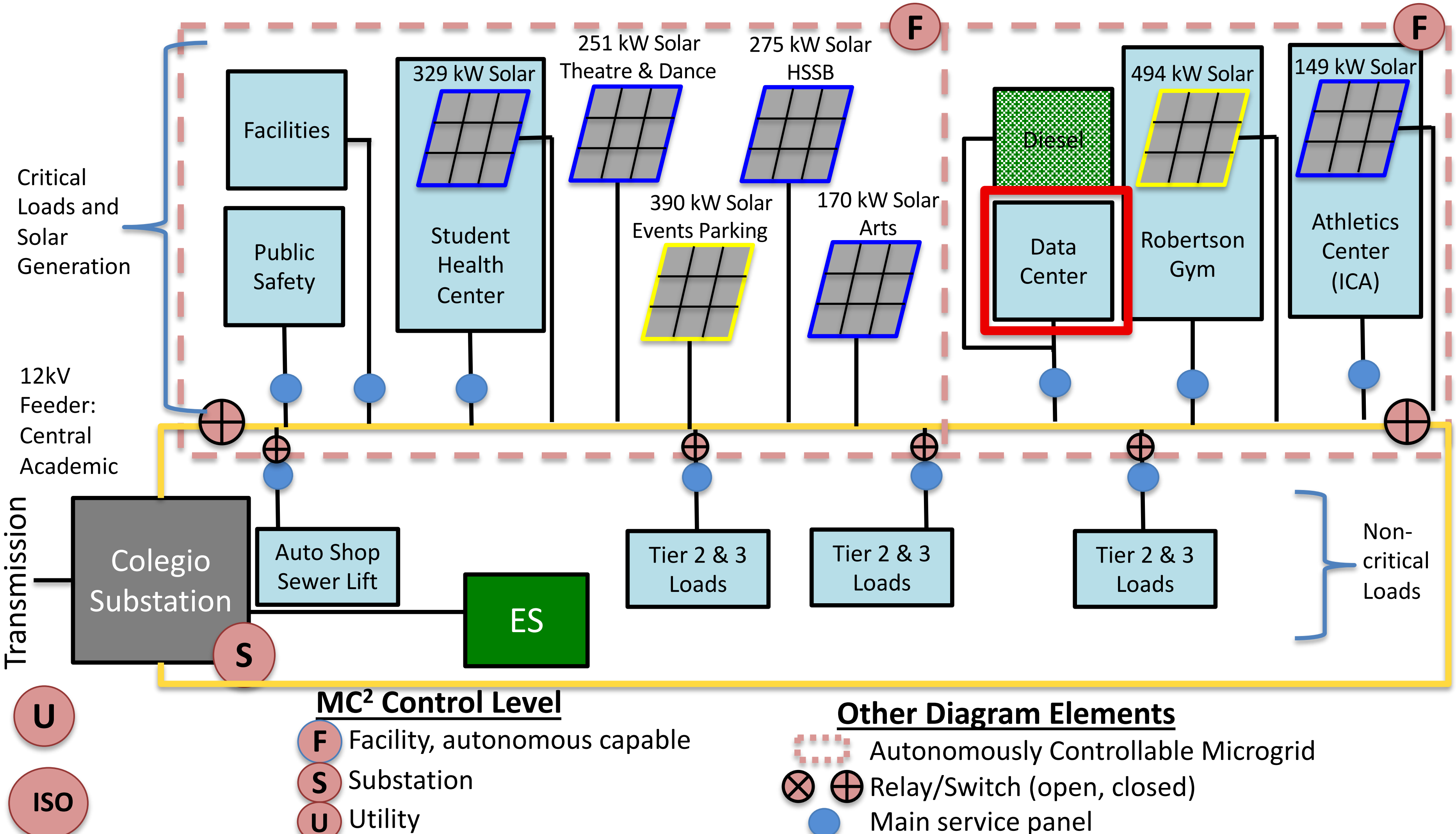

MC² Control Level

- F Facility, autonomous capable
- S Substation
- U Utility
- ISO Independent System Operators

Other Diagram Elements

- Autonomously Controllable Microgrid
- Relay/Switch (open, closed)
- Main service panel
- Existing solar
- Proposed new solar

UCSB Community Microgrid RN Feeder

Research North feeder (blue) block diagram

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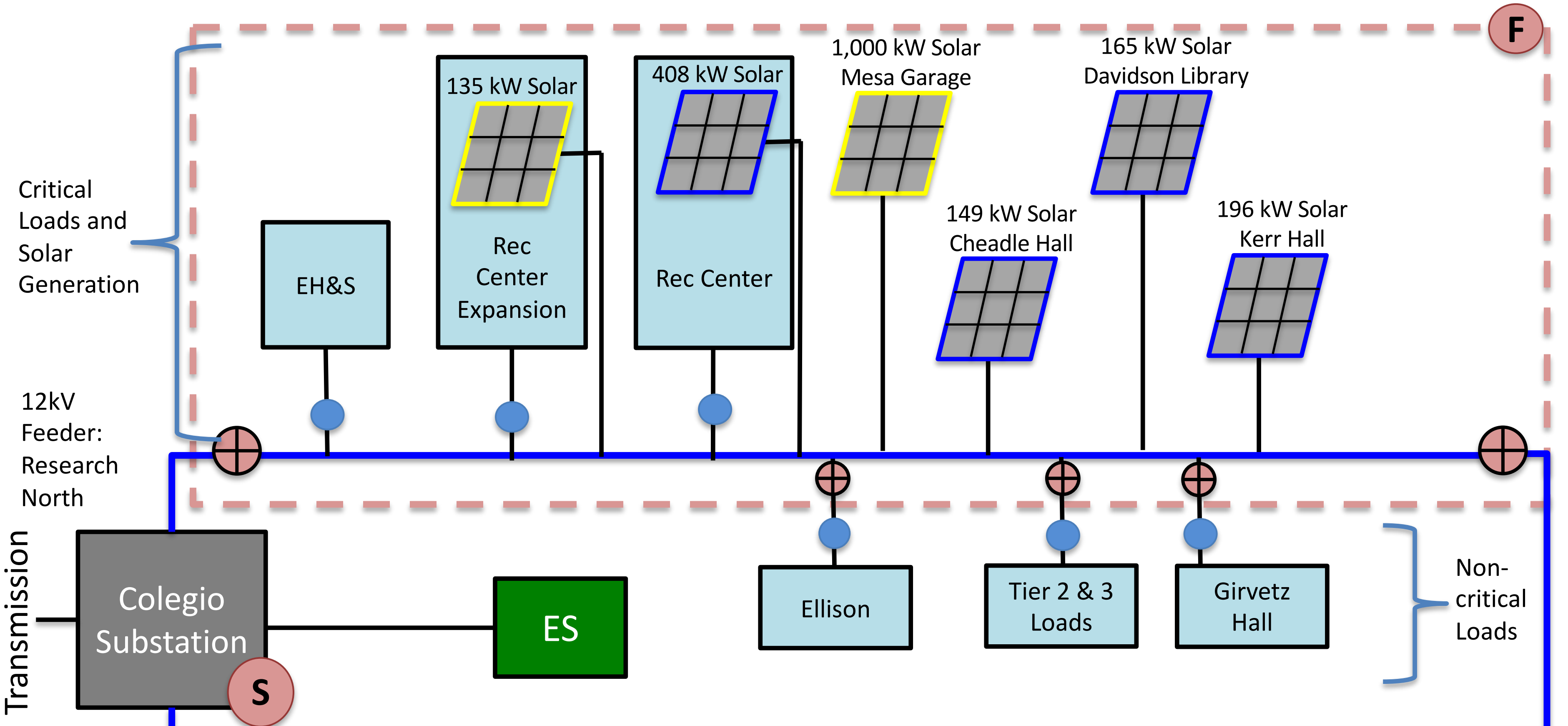

MC² Control Level

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Other Diagram Elements

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- Main service panel
- Existing solar
- Proposed new solar

The Role of Community Demand Response in managing a community microgrid

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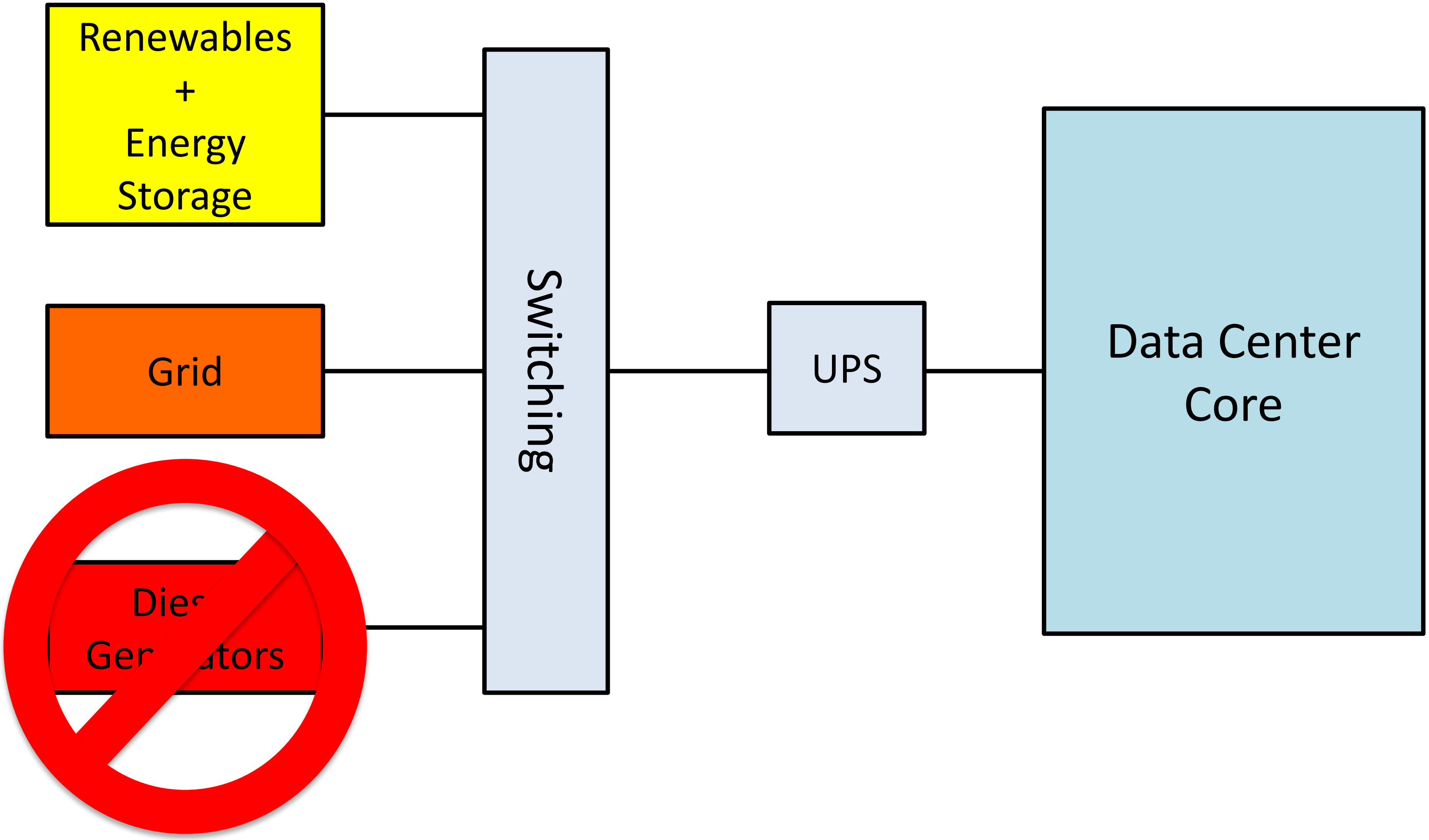
- Demand Response is a part of a network of DER that work together to form a **single resource.**
- Automated and Direct load control of non-critical loads allows **balancing of PV output.**
- The **most cost-effective resource** for load modification.
- Preserves battery cycles to promote longevity of batteries

Renewables for Data Center Energy & Resilience



UCSB Community Microgrid Numerical example
Key Statistics

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Component	Load/Capacity
Colegio Substation Load	Up to 15MW
PV Solar	7.0 MW
Demand Response	3.0 MW
Battery	4.0 MW/ 16MWh
Target MW	5MW

Flattening the Duckling: Load and Solar

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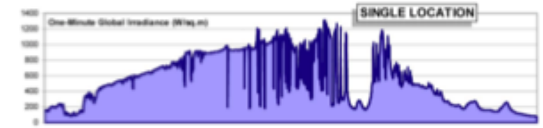
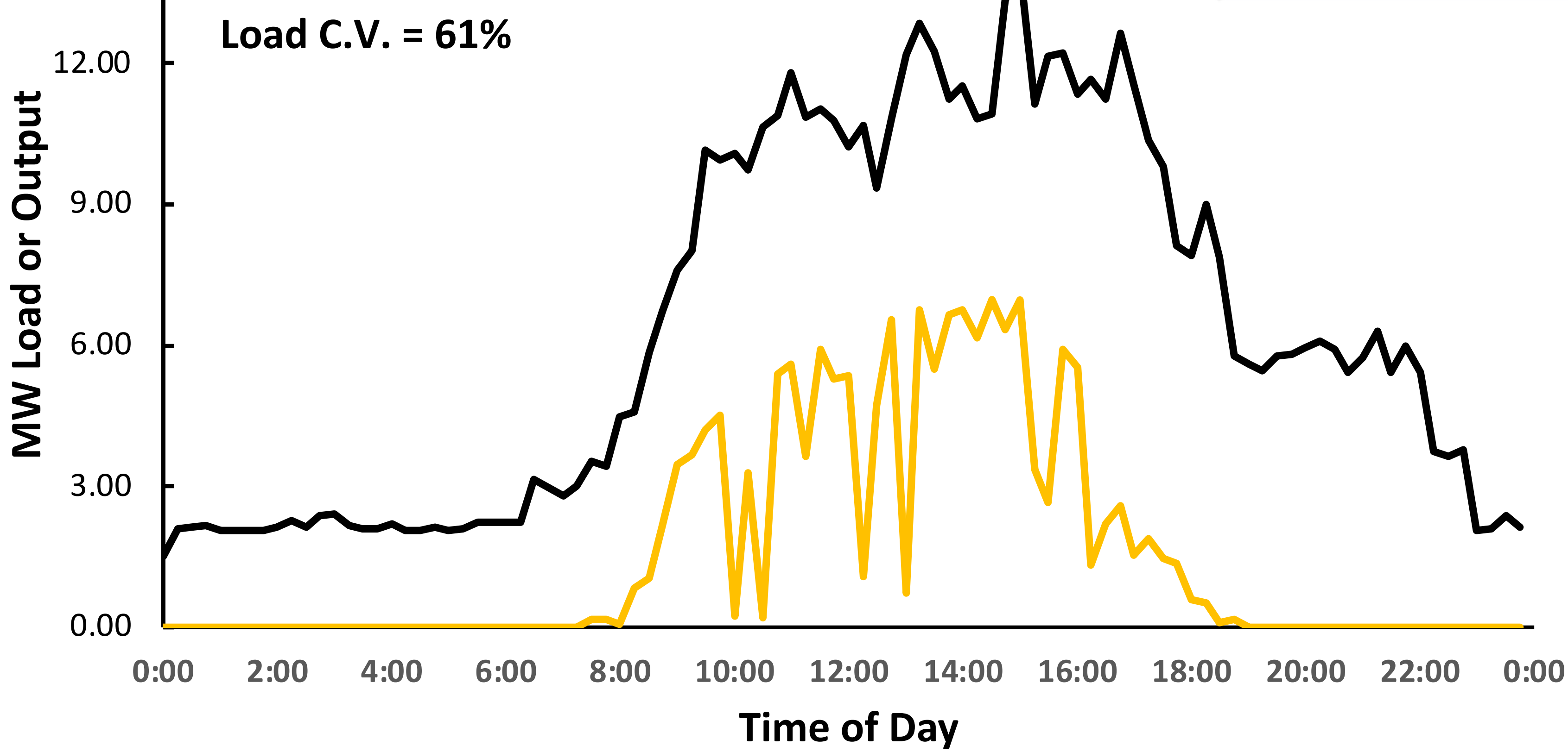
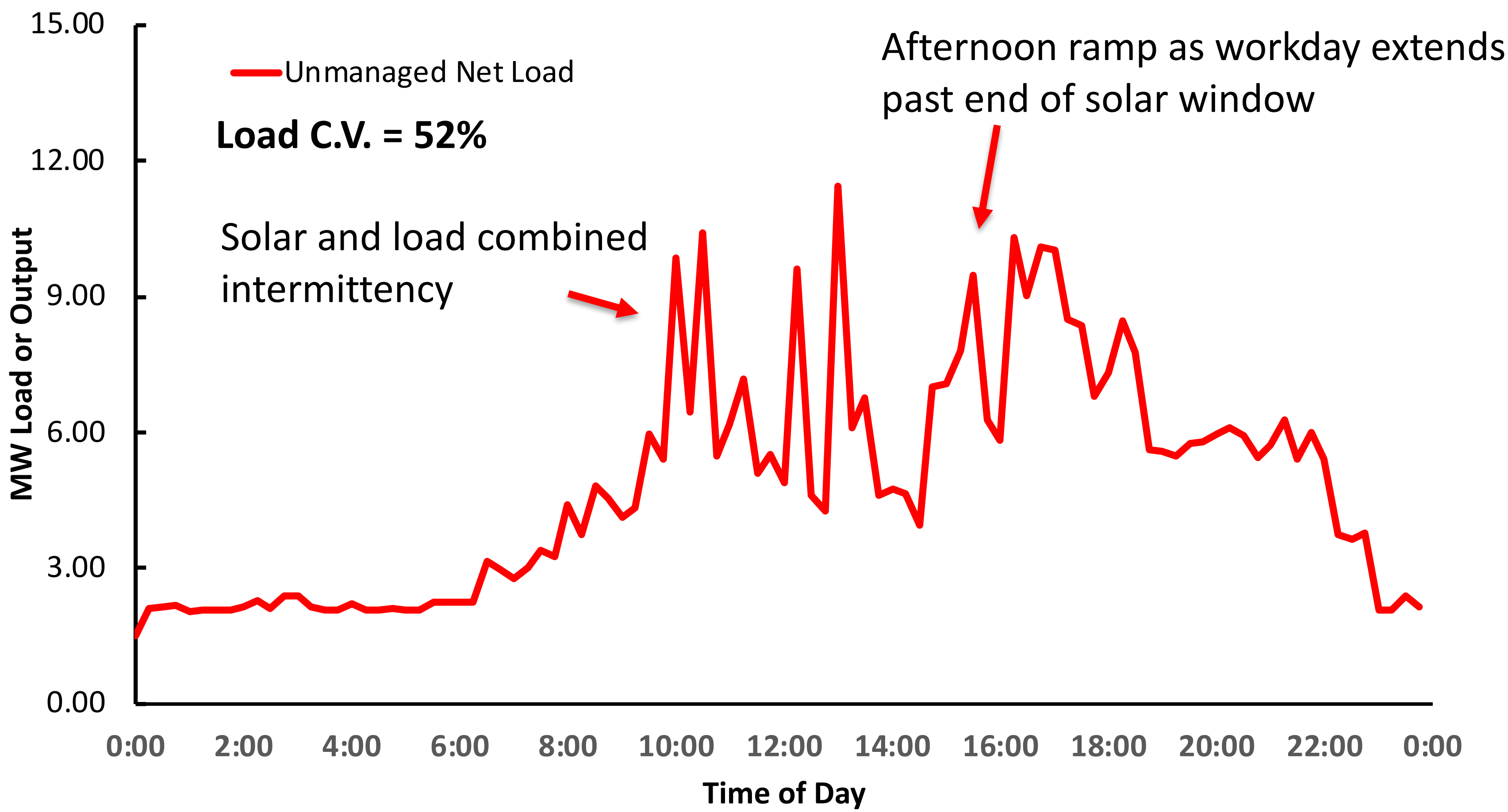




- The Collegio Substation is modeled here as having average peak loads in the 12-15 MW rang
- The UCSB Community Microgrid is modeled based as including residential profile.
- PV output based on CAISO profiles, with random “clouds” modifier.

Flattening the Duckling: Unmanaged net load



- Without local balancing, net load is still volatile.

Flattening the Duckling: Fast Demand response complements Solar

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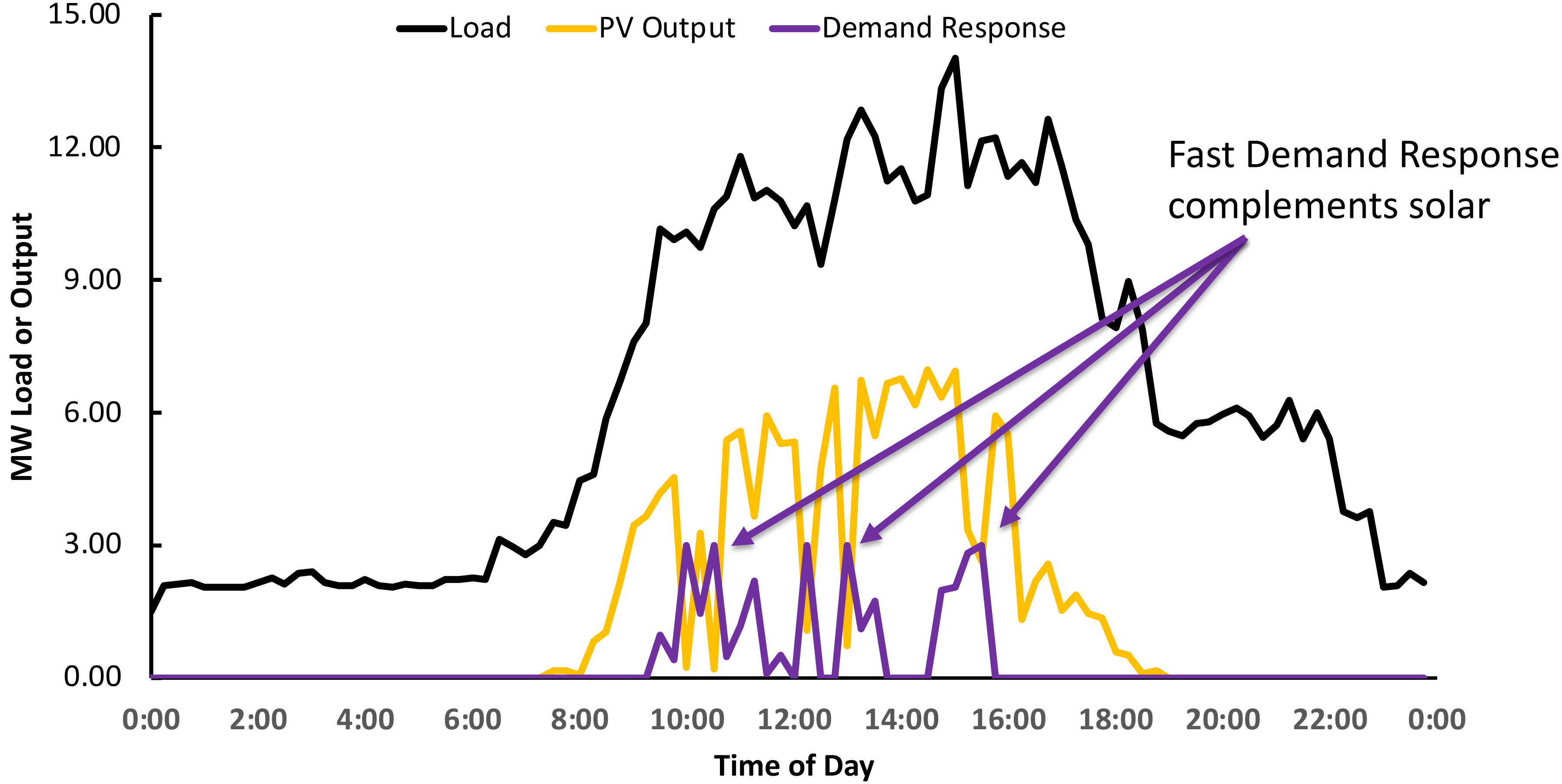

Instead, Fast Automated Demand Response tracks solar to provide smoother load profile

Flattening the Duckling: Local Balancing
Add in batteries for the evening and DR support

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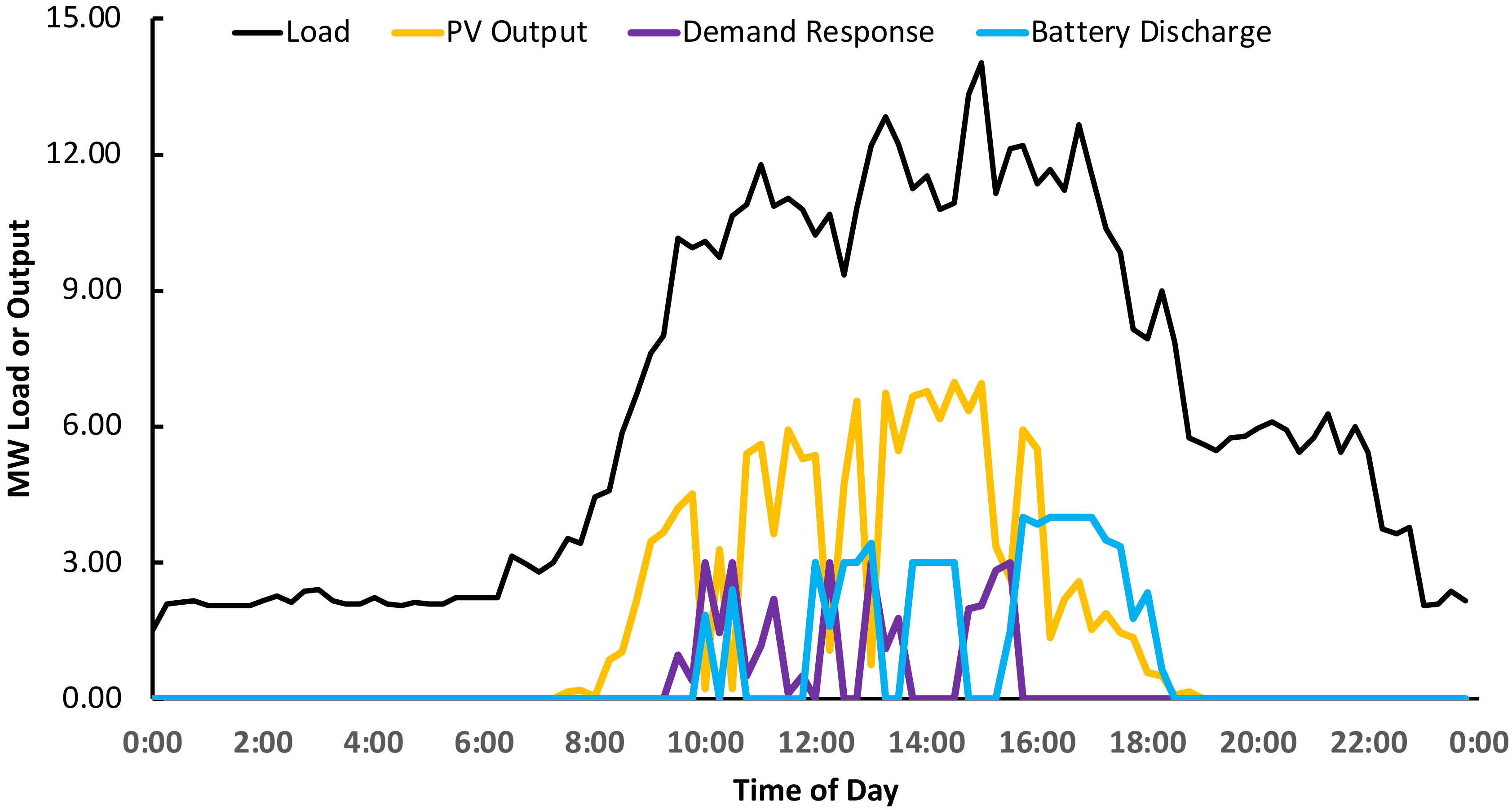

Batteries support shifted DR through the day and reduce evening ramp

Flattening the Duckling: Community Microgrid DER Local Balancing

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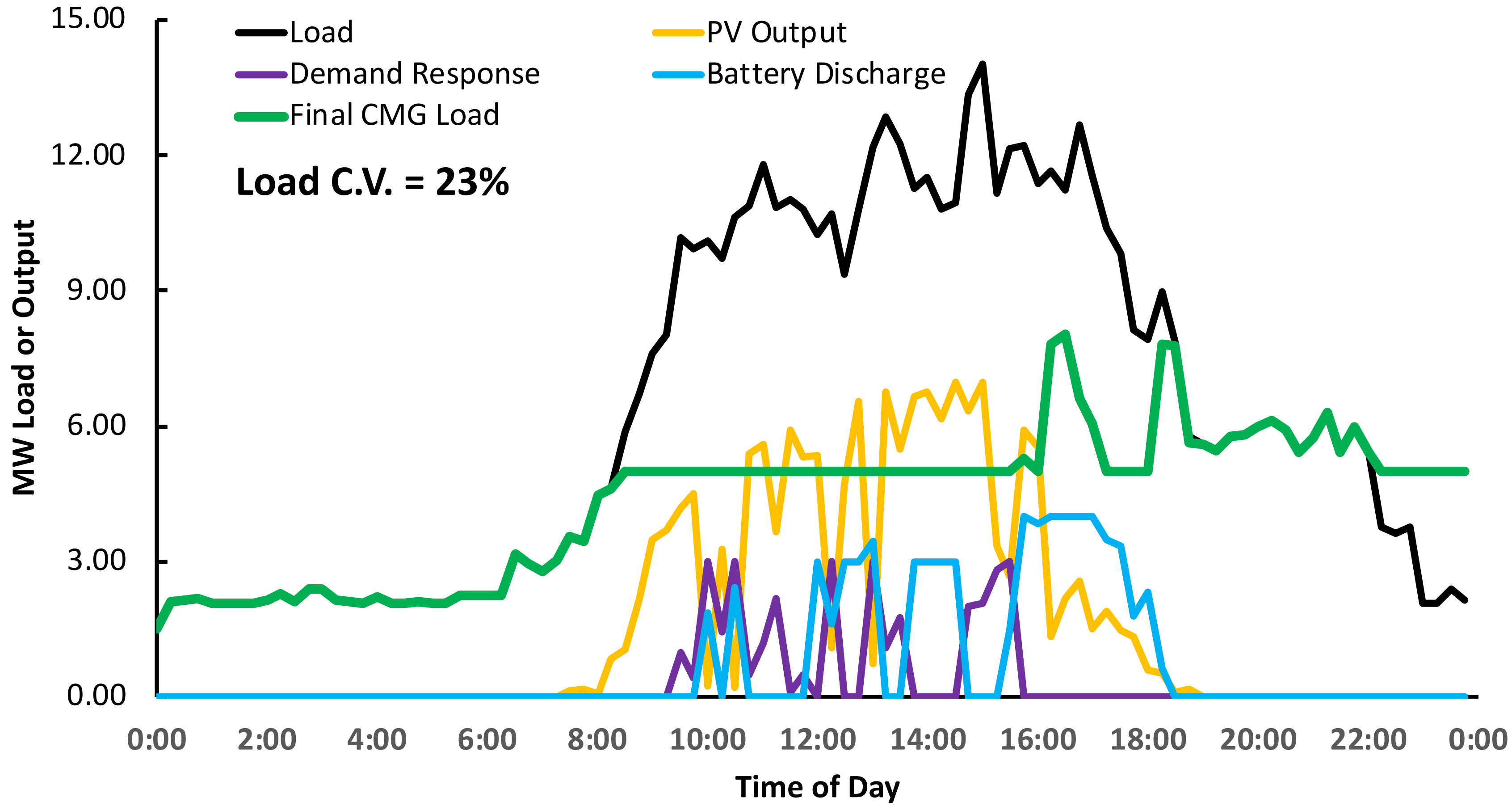

Locally balancing complementary technologies can eliminate load and supply volatility.

Flattening the Duckling:
Community Microgrid DER Local Balancing

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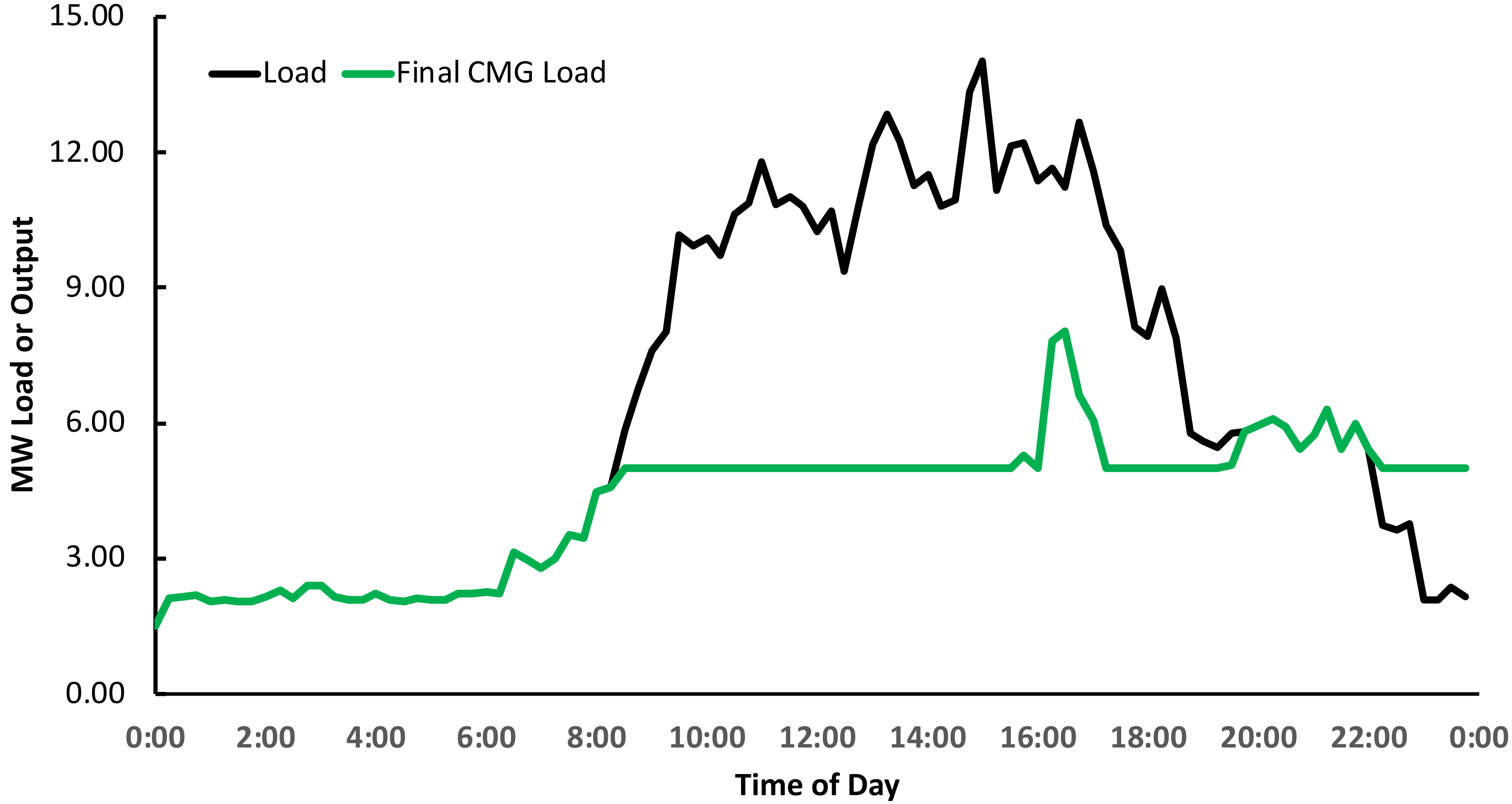

The Power of locally balancing complementary technologies …

Flattening the Duckling: Firm Load limit

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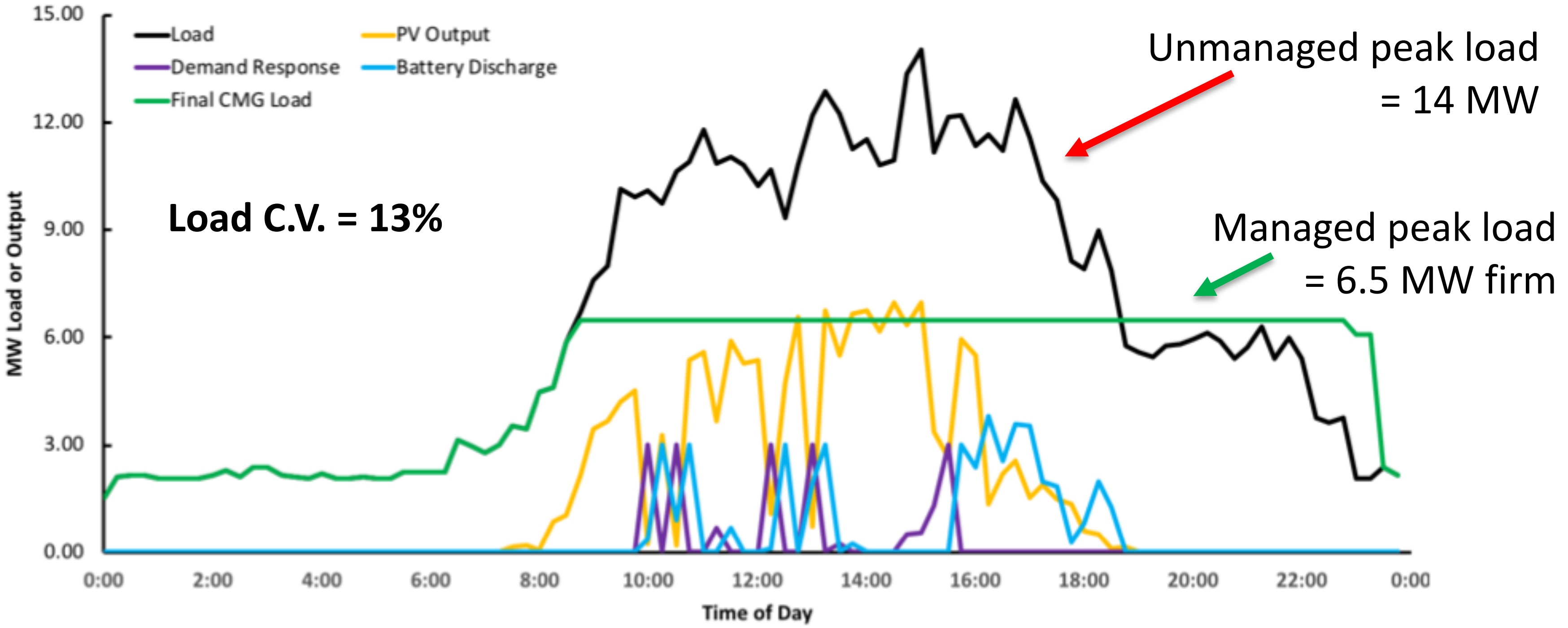


If Community Microgrids can guarantee a maximum load, they should get compensated:

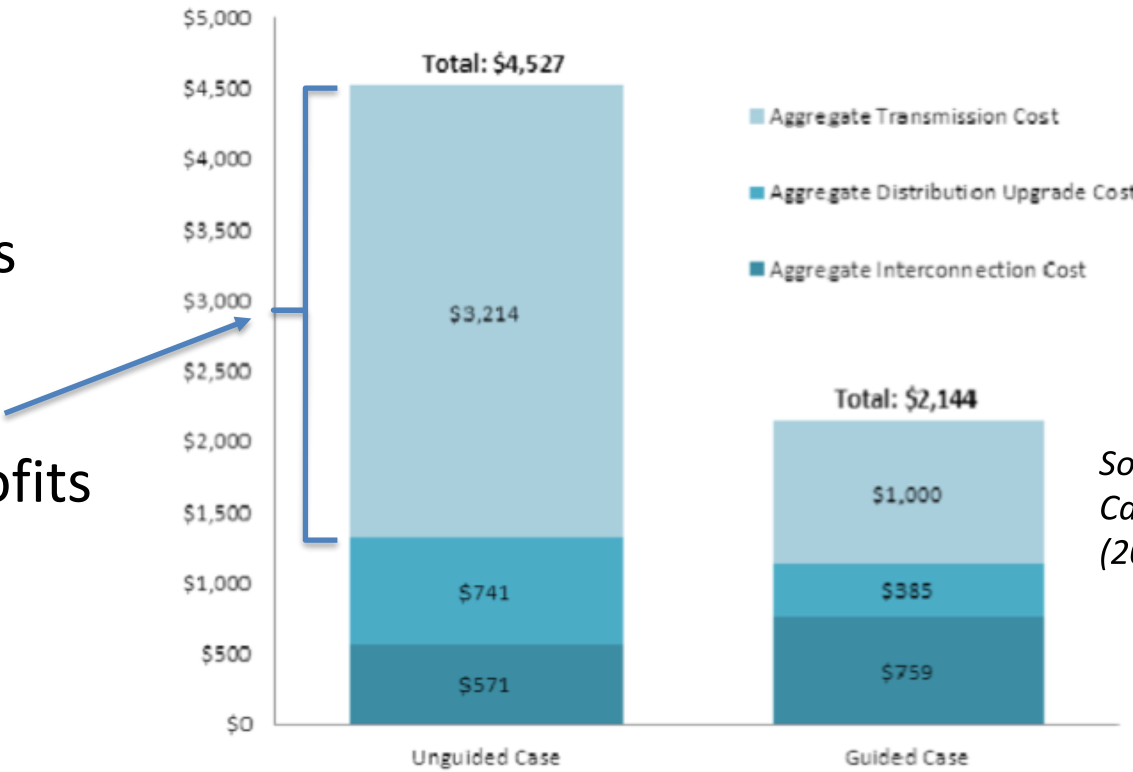
- Reliability
- Avoided Transmission Costs
- Avoided Distribution Costs

Unplanned DER siting adds hundreds of millions to ratepayer costs.

- Southern California Edison found that planned siting of ~4 GW of local renewables would reduce SCE's upgrade costs by over $2.2 billion

Large new transmission needs increase:

- Rate base
- Guaranteed profits



Source: Southern California Edison (2012)

Transmission is borne by ratepayers. DER interconnection borne by developer.

Community Microgrid DR Value Proposition

- To the Community Microgrid:
  - Allows for cost effective managed performance.
  - Preserves battery cycles to promote longevity of batteries
- To the Customer:
  - The customer signs up for a Community Microgrid, not Demand Response.
- To the Grid:
  - Small, well-behaved pieces.
  - More cost effective grid investment and design
- To the grid operator:
  - Turns unruly distribution in to a small set of resources

Toothpicks…

Part VI: The Big Picture:

The Distribution System Operator

The Big Picture

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...organized in the right way can do surprising things

The Building Block: A Community Microgrid

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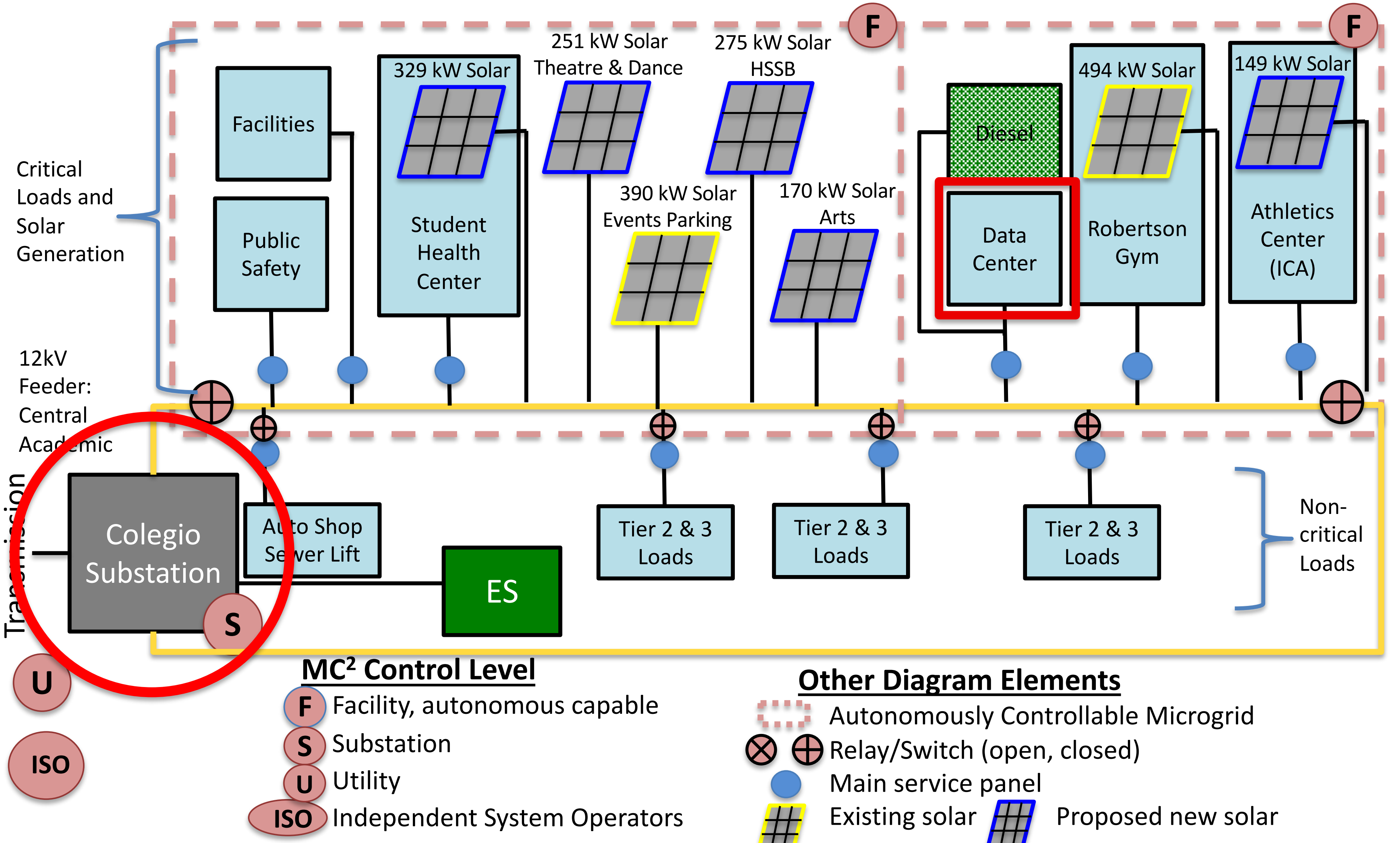

A Community Microgrid can manage load and dispatch from DER.

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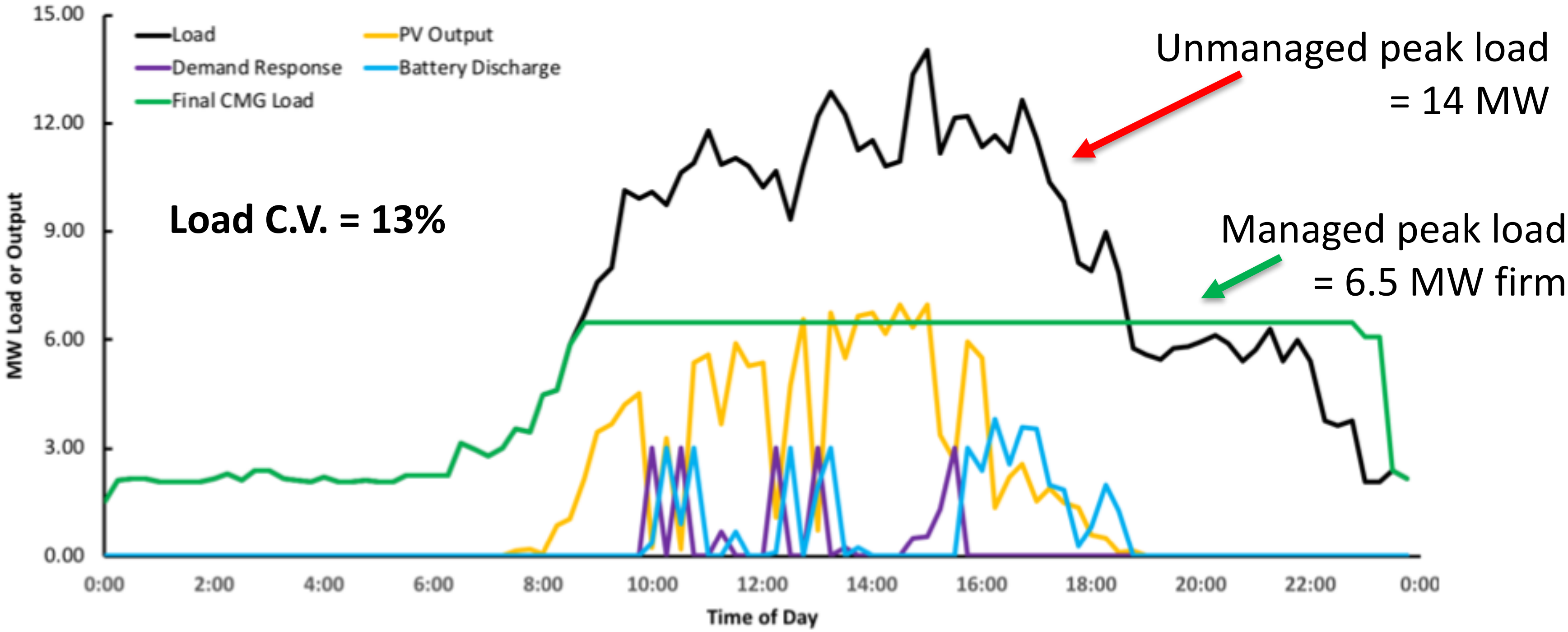
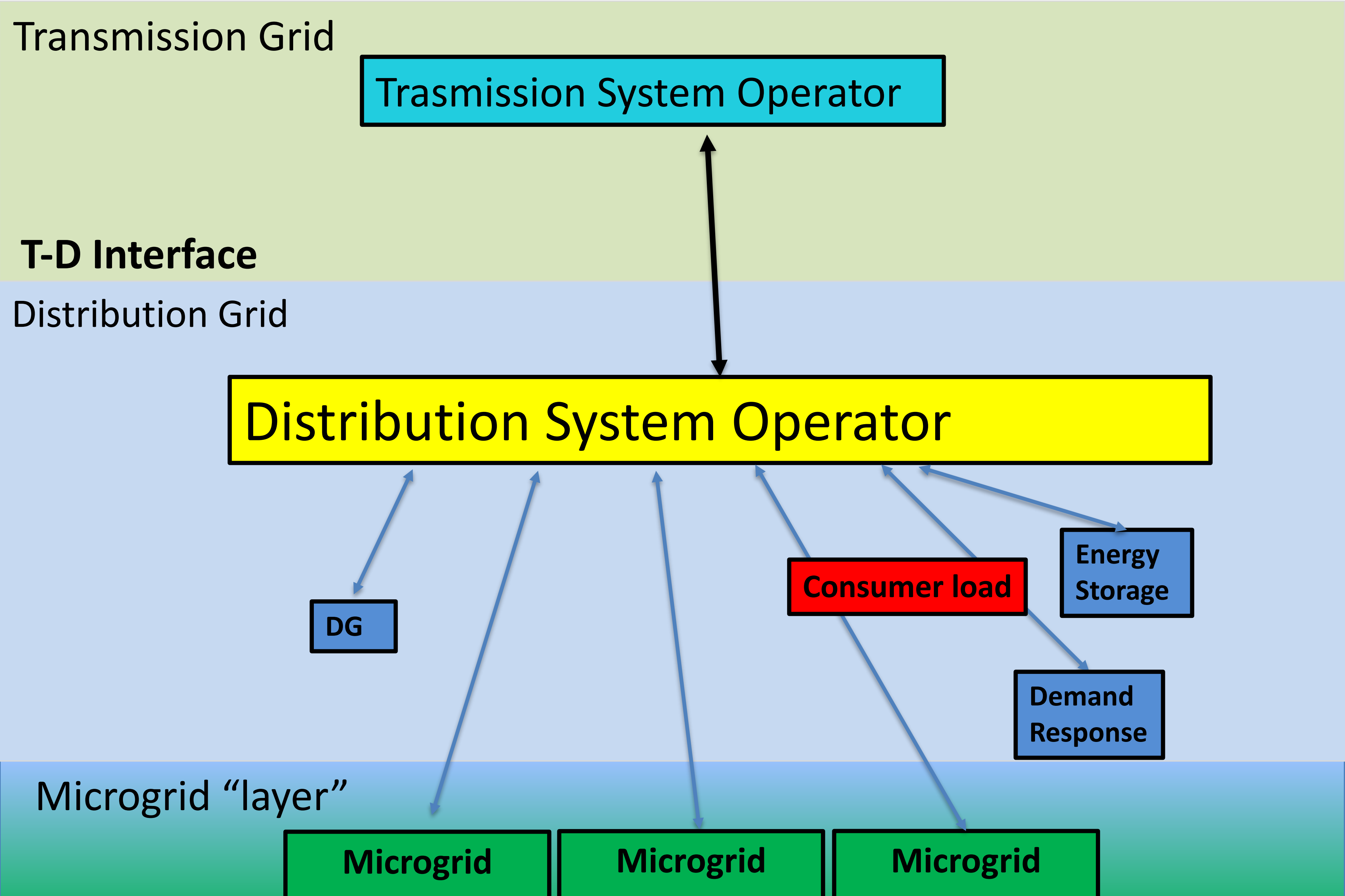


If Community Microgrids can guarantee a maximum load, they should get compensated:

- Reliability
- Avoided Transmission Costs
- Avoided Distribution Costs

The DSO Grid Model: Laminar Decomposition



DSOs solve four emerging problems:
1. GRID RELIABILTY

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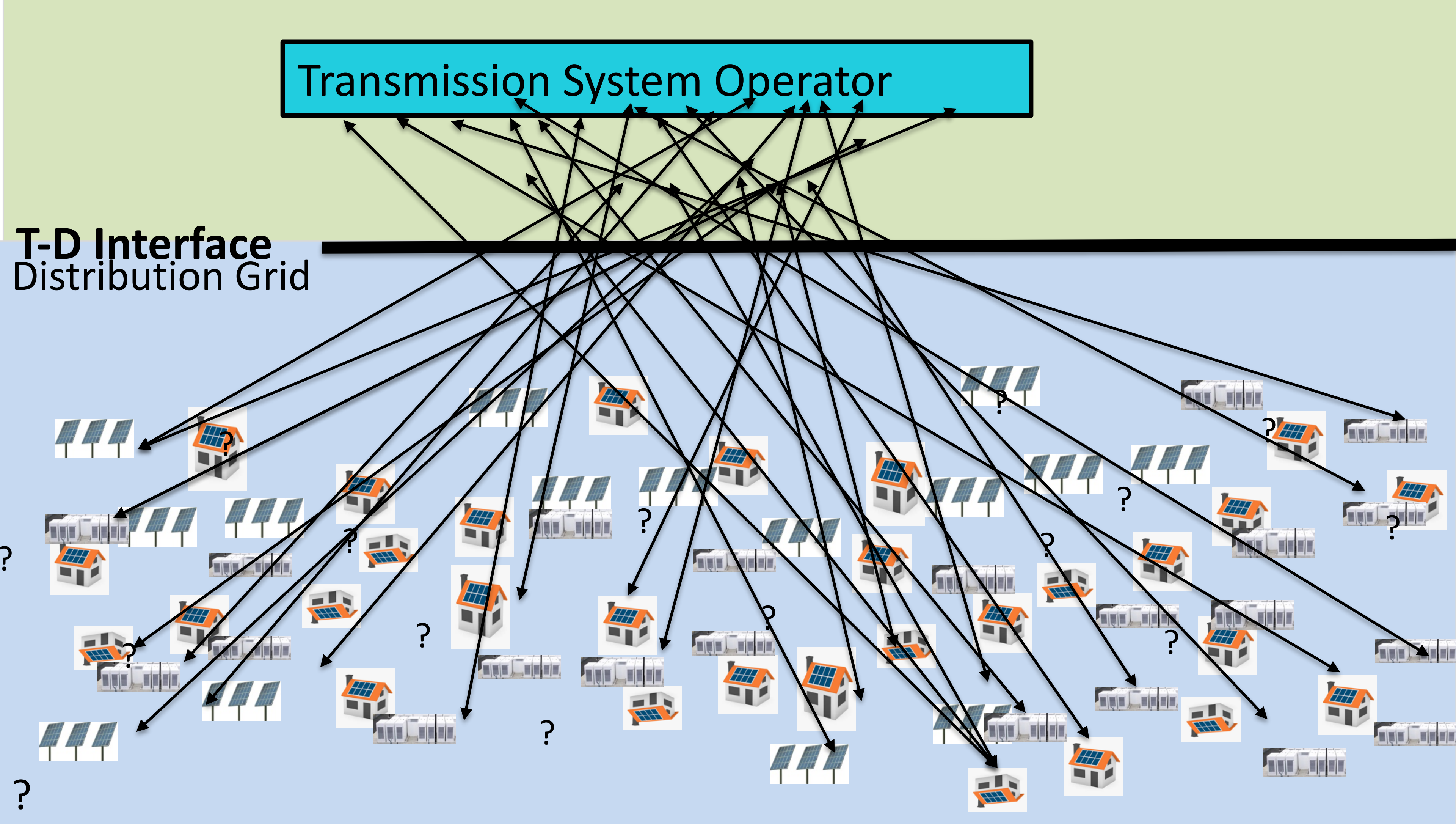
Transmission Grid

The TSO's Nightmare



DSOs work with microgrid operators to provide a reliable grid of small pieces, loosely connected

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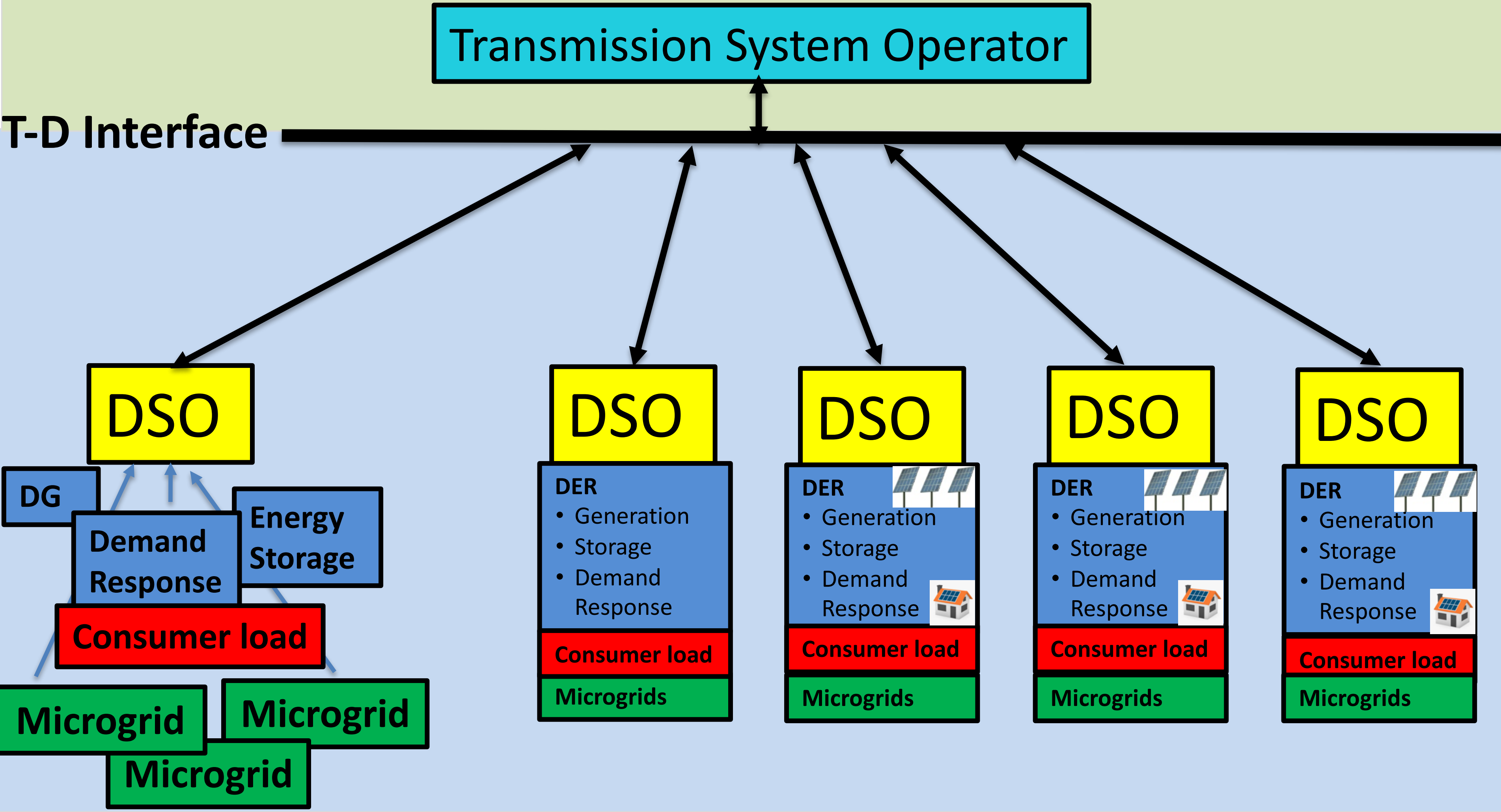
Community Microgrids provide DSOs with stable, predictable distribution grid performance



What does the DSO actually do?

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Key DSO functions

- **Reliability**
  - Maintain distribution grid reliability
  - Implement advanced distribution management functions
    - DERMS
    - T-D- Interface transactions
- **DER Coordinator**
  - Coordinator for distribution grid
  - Coordinator to the T-D interface for transmission grid.

Advanced distribution functionality can make both distribution and transmission more reliable and efficient.

The reality is a bit more complex….

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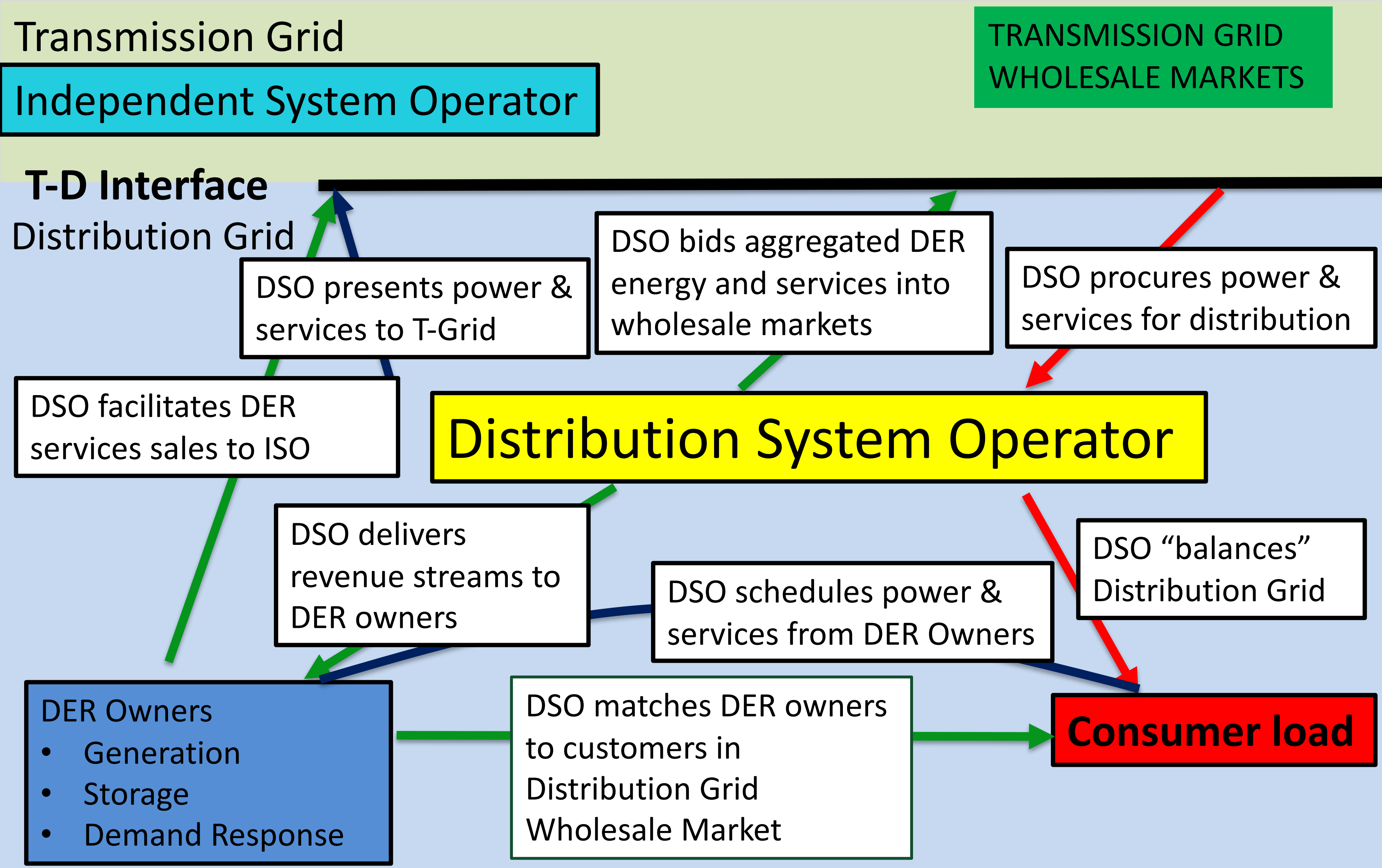

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How Demand Response will save the world