Microgrids: A Rare Paradigm Shift in Electricity Generation and Delivery

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by

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Outline

1. What are Microgrids?
2. Why do we Need Microgrids?
3. The CERTS Microgrid
4. Distributed Energy Resources Customer Adoption Model (DER-CAM)

History of U.S. Electricity Sector

phases of centralization

1. isolated developments (pre 1900)
2. consolidation and monopolization (1900-1933)
3. fossilization and total centralization (1933-1980)

phases of decentralization

1. independent investment (avoided cost) (1980-1995)
2. wholesale (and some retail) competition (1995-)
3. decentralization and full competition? (2000-)

(What is the role of microgrids?)

Microgrid: A Definition

A ***controlled*** grouping of energy (including electricity) sources and sinks that is connected to the macrogrid but can function independently of it.

Two Main Benefits to Developers of Microgrids:

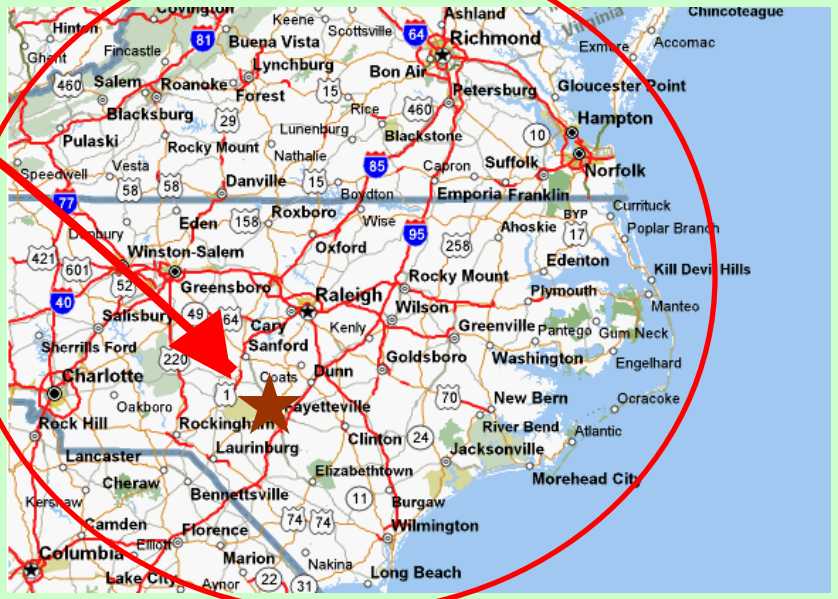
- **improve efficiency by combined heat and power (CHP)**
- **provide heterogeneous power quality and reliability (PQR)**

There are other potential societal benefits, e.g.

- **protect vital public services**
- **offer a place for small-scale renewables**

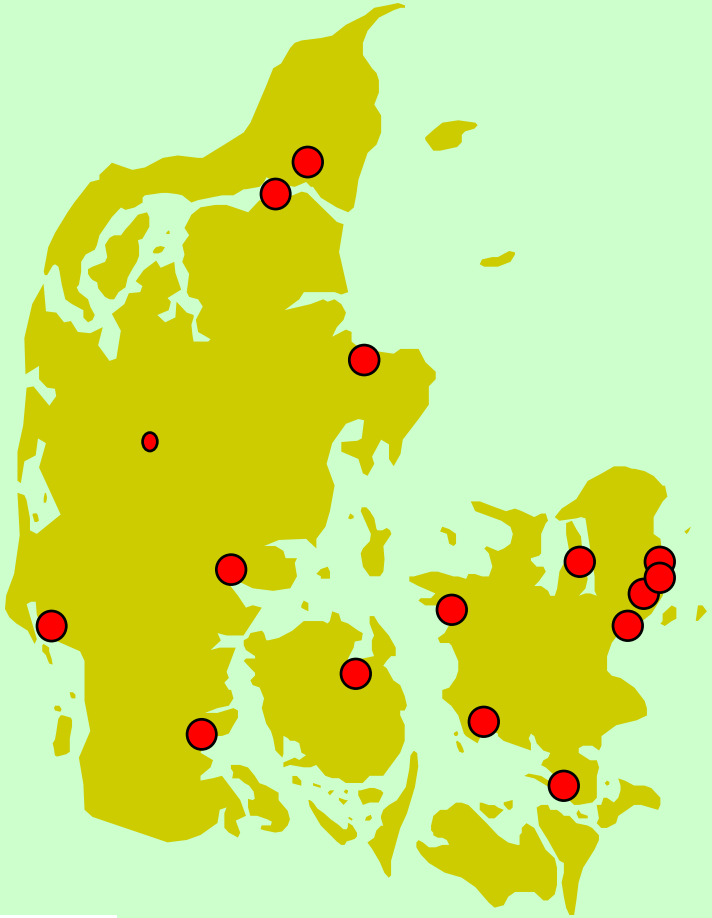
Fort Bragg Army Base, North Carolina

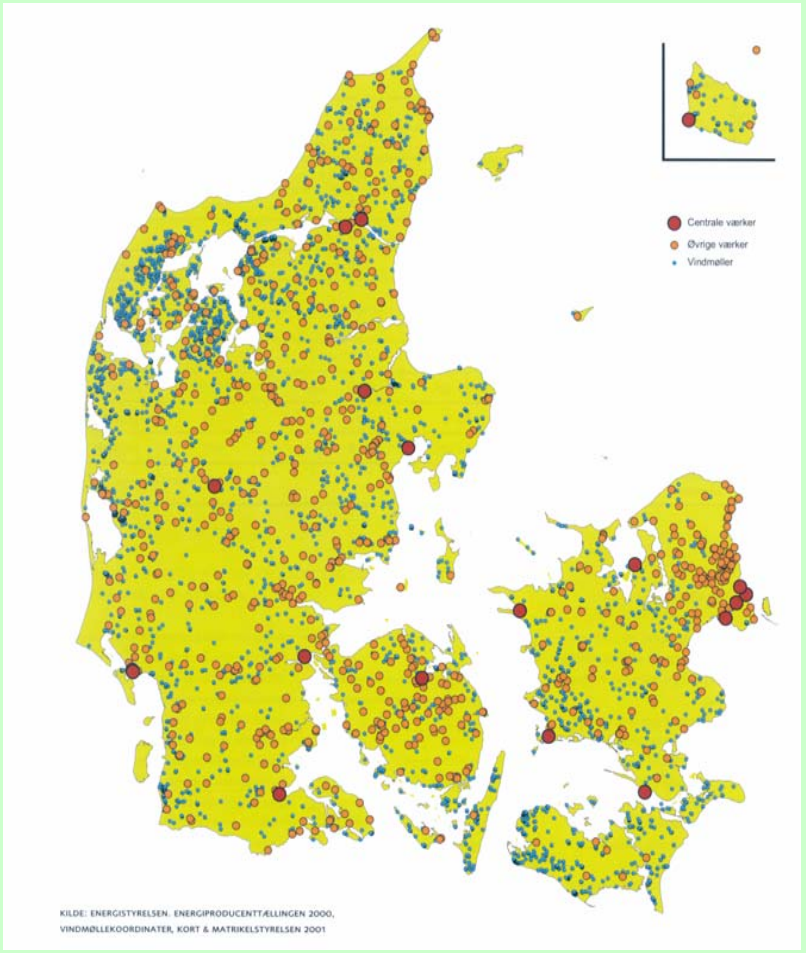
Fort Bragg,
North Carolina



Fort Bragg Army Base, North Carolina

Development of Denmark's Power System (1980-2000)





source: Eltra (grid operator of western Denmark)

2. Why do we need Microgrids?

Why Do We Need Microgrids?

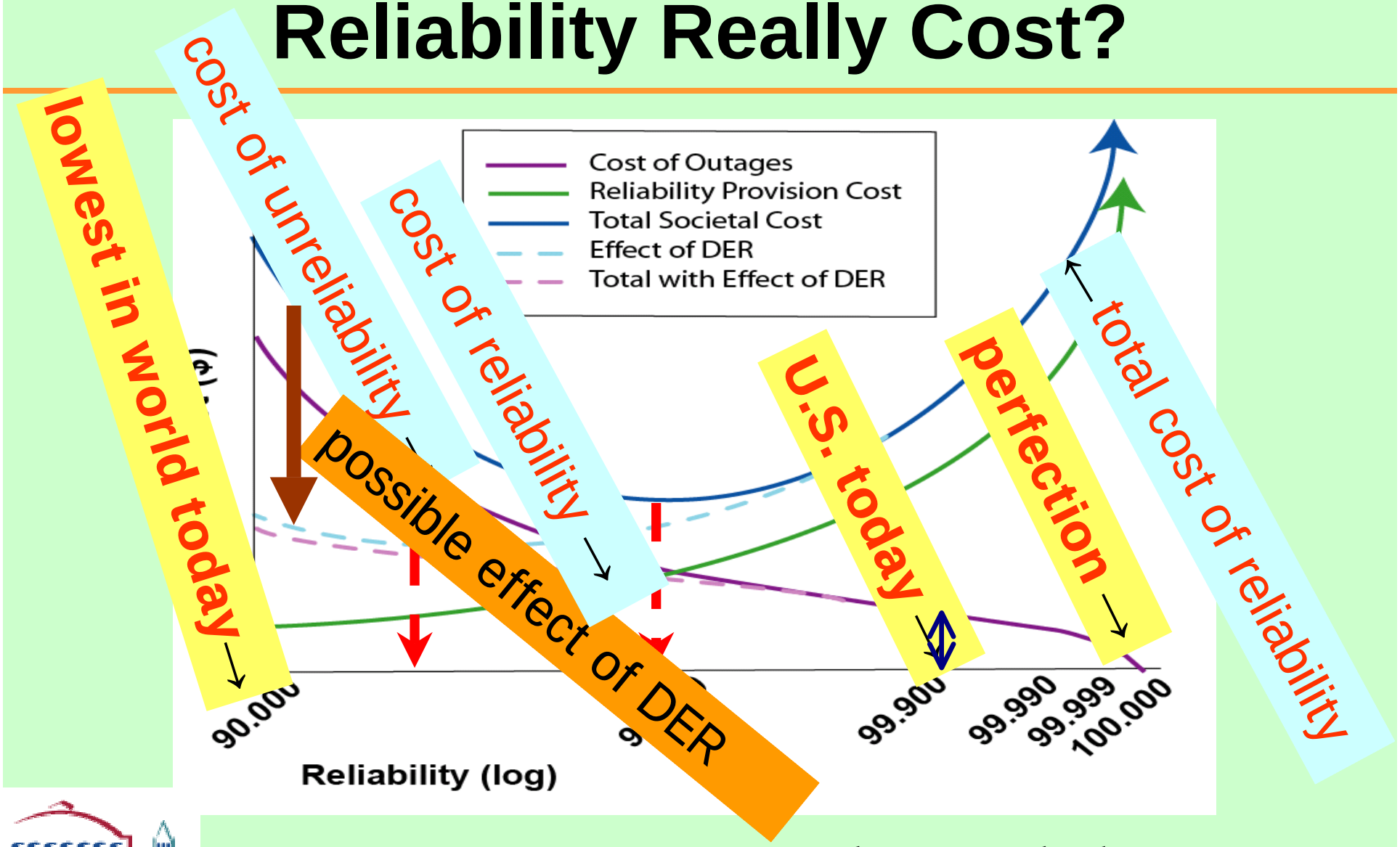
negatives of the Macrogrid

- restrictions on power system expansion
- centralized power system planning
- volatile bulk power markets
- insecure system
- multiple infrastructure interdependencies
- limited qualities of power

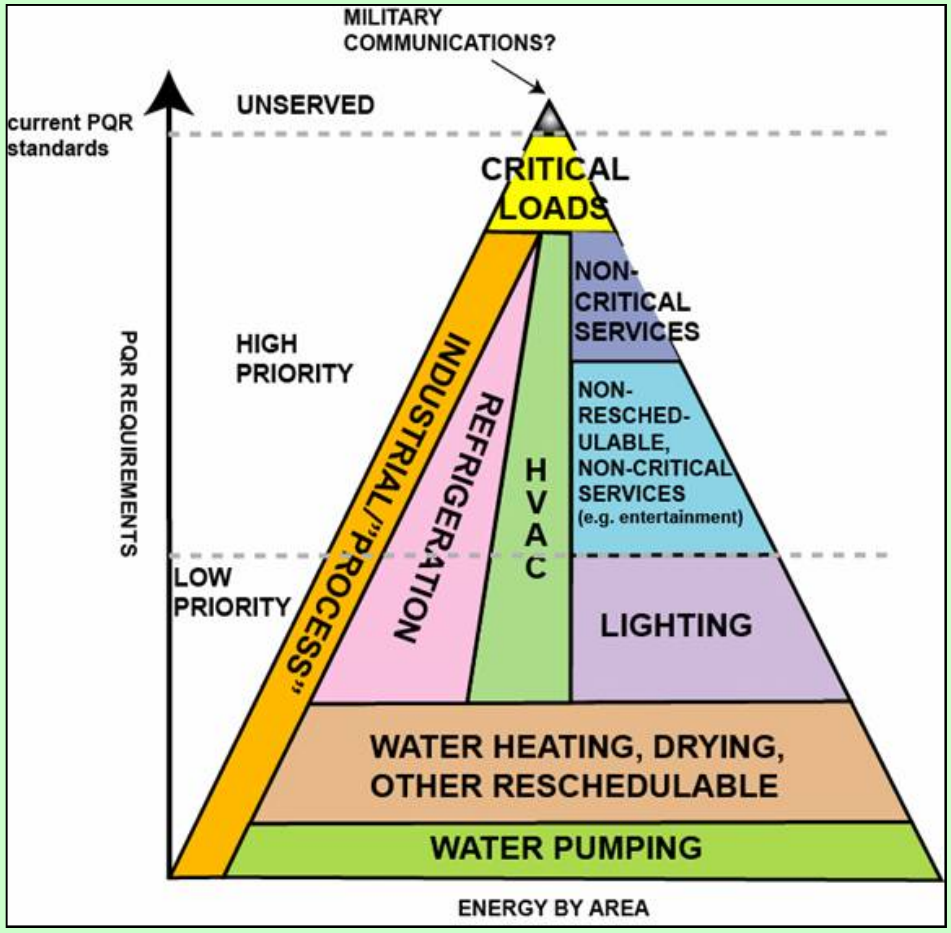
positives of Microgrids

- push efficiency limits (use CHP to lower carbon)
- heterogeneous power quality and reliability (PQR) (deliver gourmet power to demanding end uses)
- robust decentralized system
- other external benefits (protect vital services)

What Does Power Quality and Reliability Really Cost?



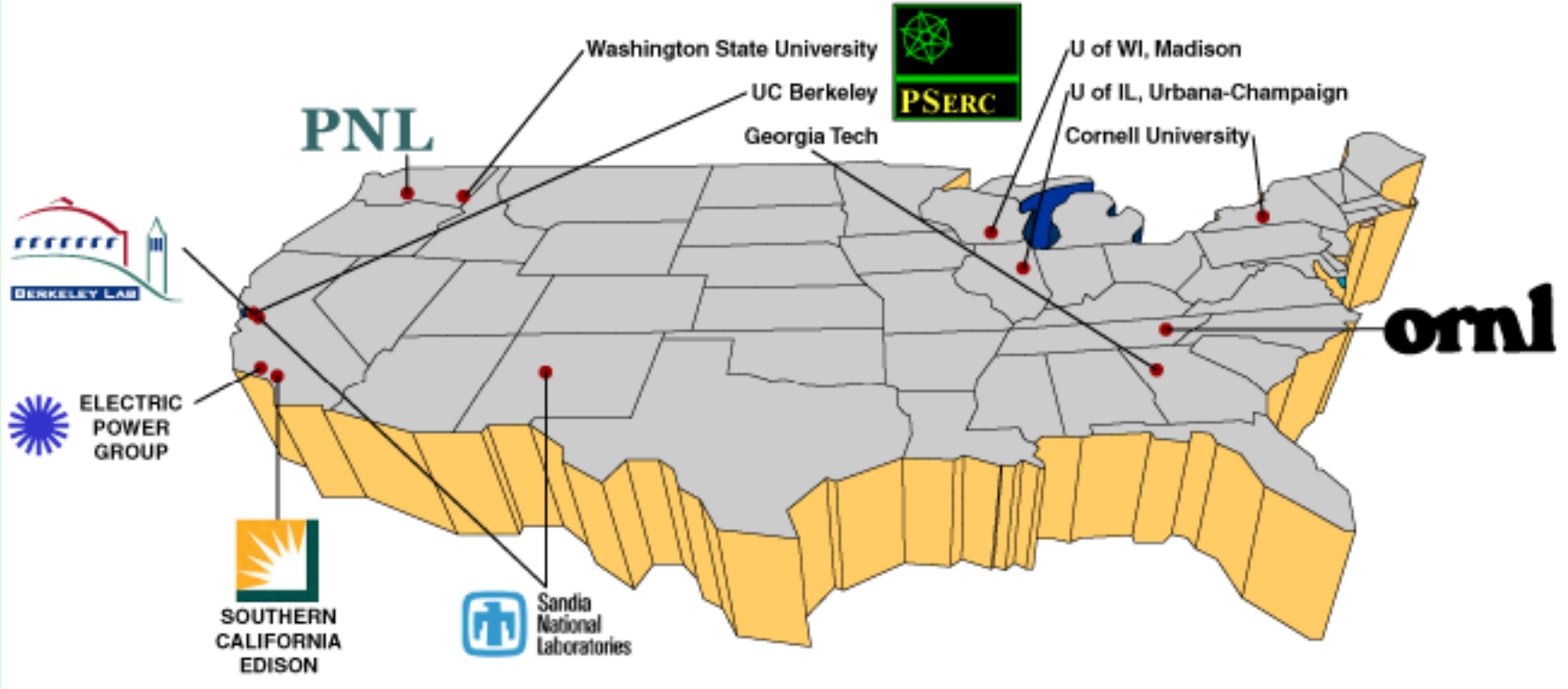
An PQR Pyramid



- Loads are often broken down by time and enduse but not by PQR requirements.
- The most demanding PQR requirements are not met.
- Highly sensitive loads are small and they could be smaller.
- Local supply could tailor PQR to the needs of the enduse.

3. The CERTS Microgrid

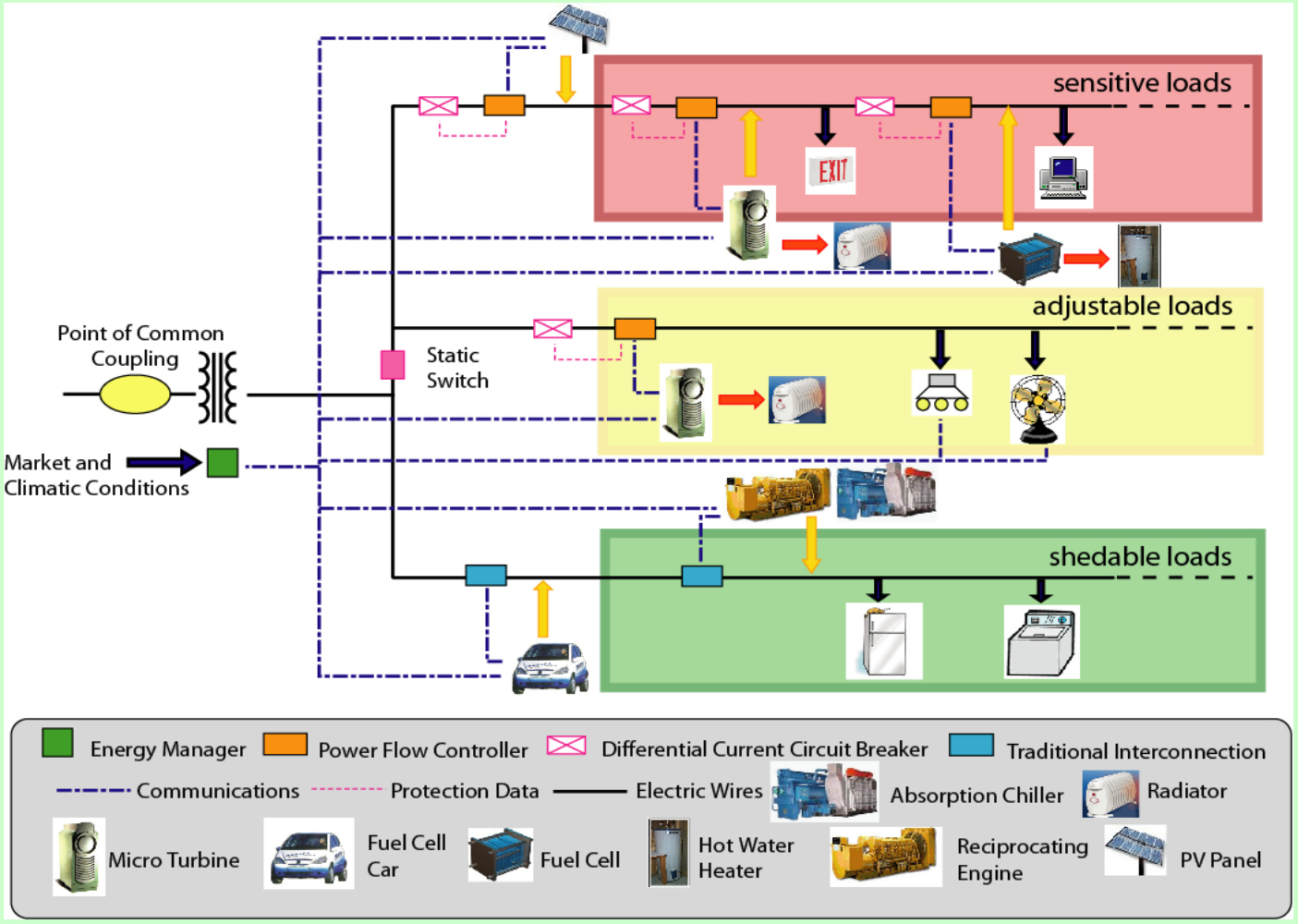
Consortium for Electric Reliability Technology Solutions (CERTS)



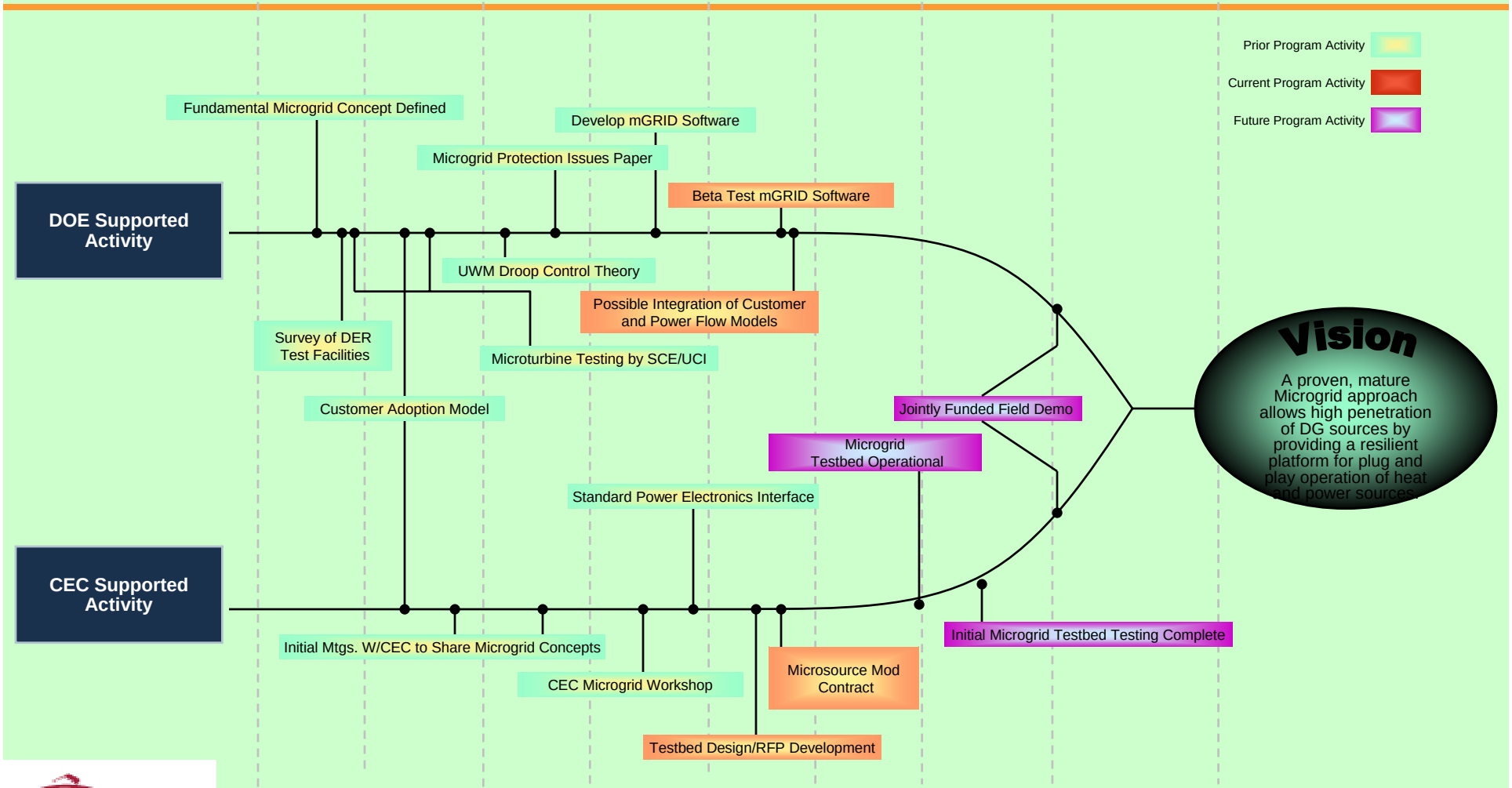
The CERTS Microgrid is ...

- controlled by “customers” based on internal requirements subject to the technical, economic, and regulatory opportunities and constraints faced.
- designed and operated to jointly provide heat and power and heterogeneous power quality and reliability.
- a cluster of small (e.g. < 500 kW) sources, storage systems, and loads which presents itself to the grid as a legitimate entity, i.e. as a *good citizen.*
- interconnected with the familiar wider power system, or *macrogrid,* but can island from it.
- controlled by local intelligent inverter like power electronic devices.

Example CERTS Microgrid

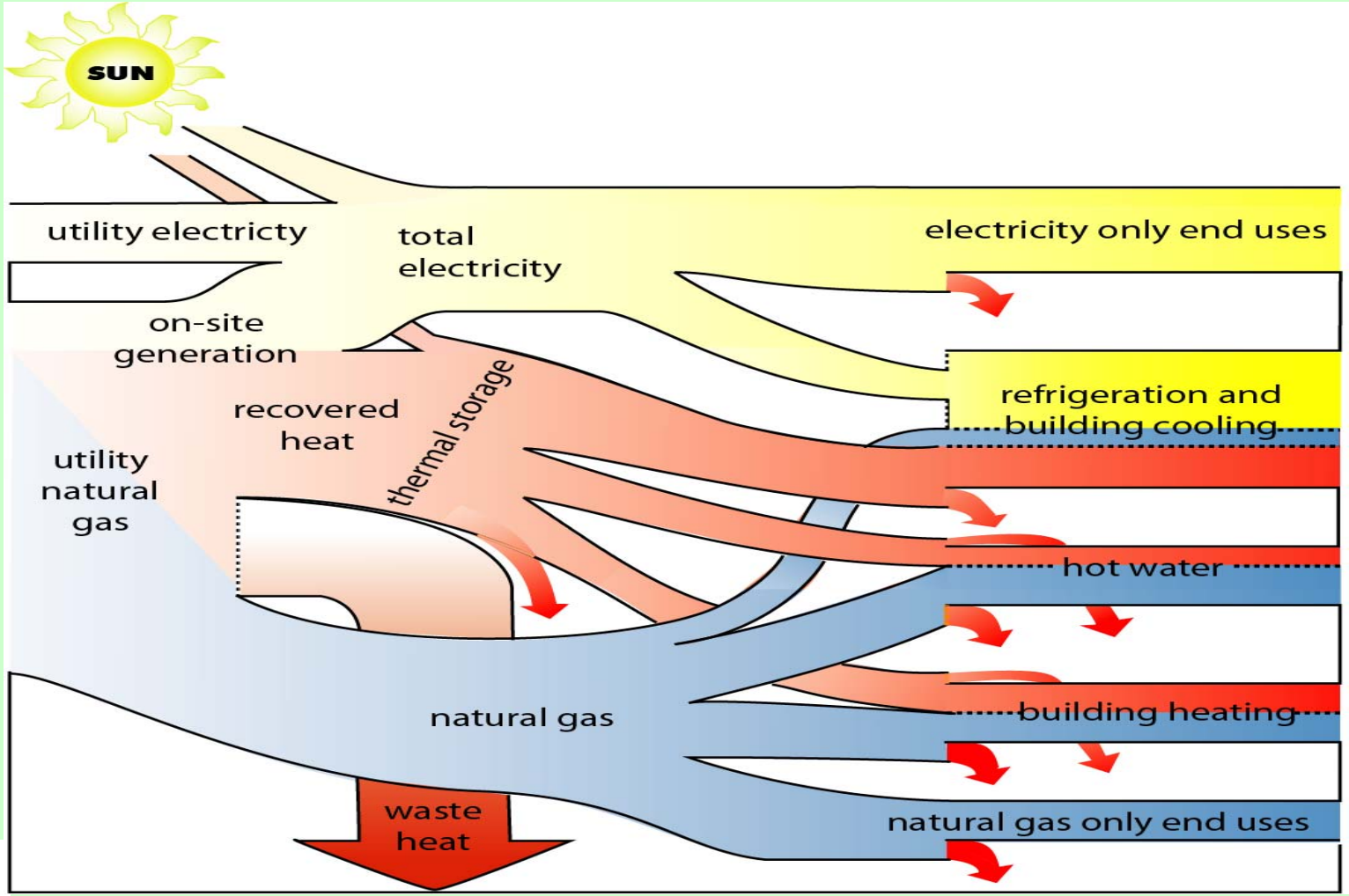


CERTS Microgrid Research



4. Distributed Energy Resources Customer Adoption Model (DER-CAM)

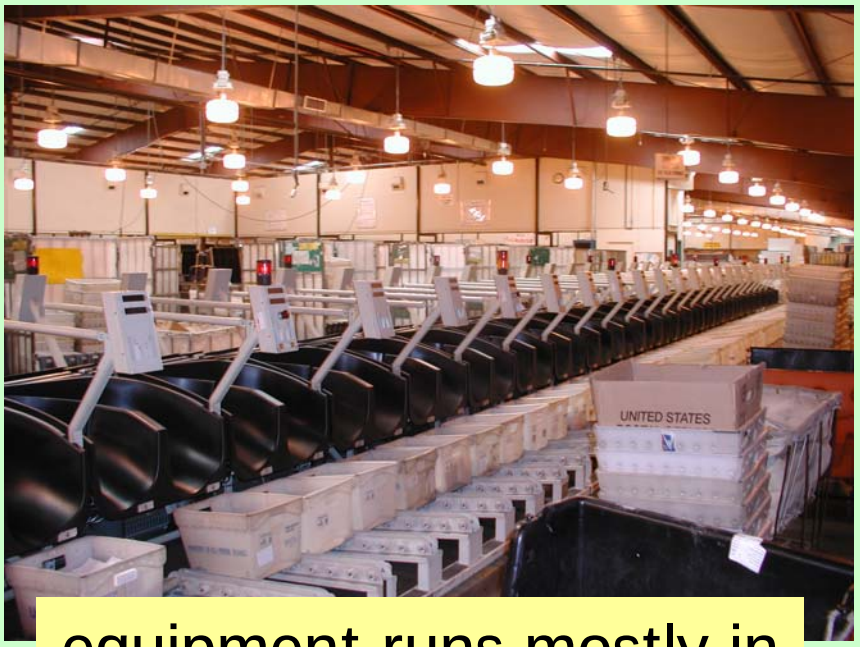
DER-CAM Solves Systemically



San Bernardino USPS, Redlands CA

Redlands, California

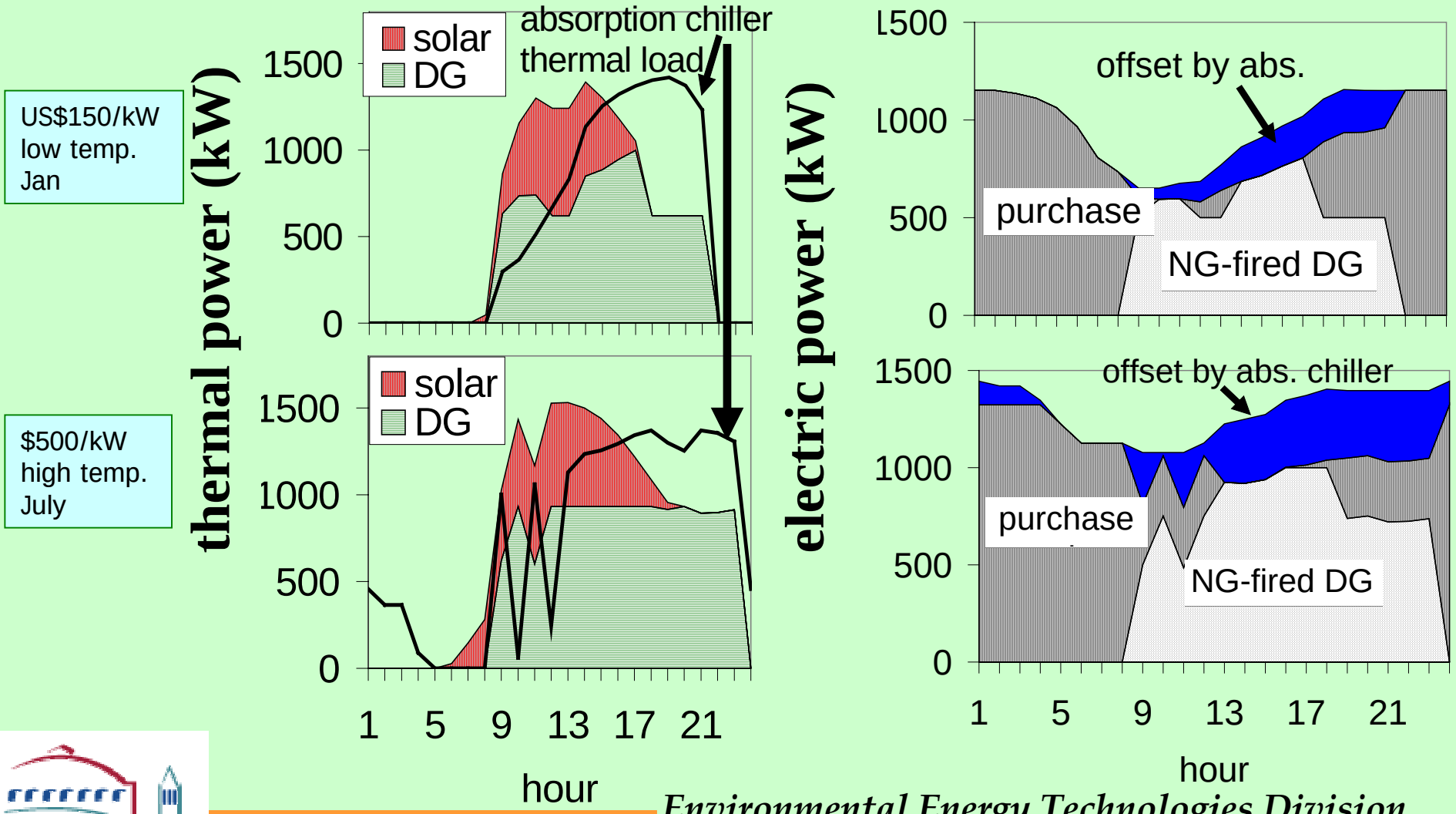
San Bernardino USPS, Redlands, CA



equipment runs mostly in evening and night

32,000 m^2 single-story facility

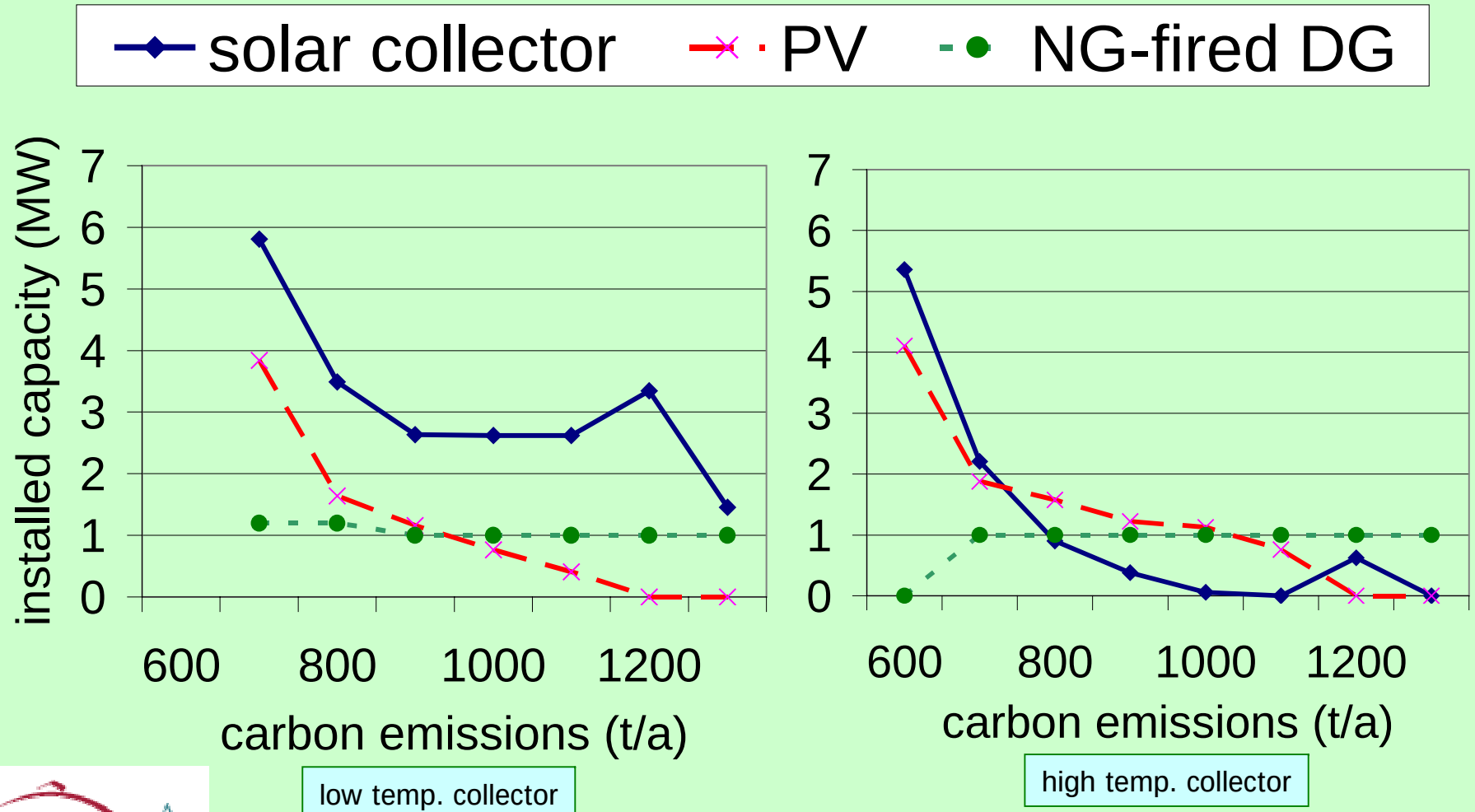
Meeting Absorption Chiller and Electric Loads



Carbon Constraint Results

- high temp. collectors provide carbon savings at lower control cost than low temp. collectors
- for low carbon reductions PV is...
  - more economic than high temp. collectors
  - competitive with low temp. collectors
- solar thermal is still valuable because of storage which offsets evening cooling loads

DER Equipment Installation Under Carbon Constraint (130 g/kWh)



Conclusion

- expansion of electricity supply is constrained in may ways
- microgrids are a way to increase efficiency and lower carbon
- by providing heterogeneous power quality
  needs of a digital society can be met at reasonable cost
- the CERTS microgrid is a specific concept
- DER-CAM solves energy systems endogenously
- DER-CAM results provide
  - valuable starting point for building analysis
  - or can be generalized to produce higher level estimates of DER adoption