

# Dynamic Distribution System: A Blueprint for Global Cities

# Sustainable Energy for Global Cities

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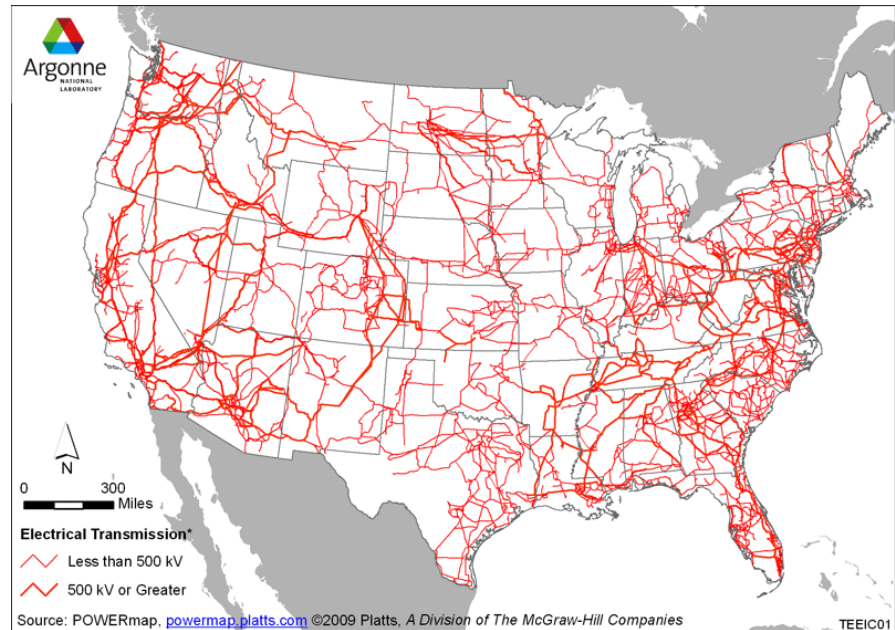
Wisconsin Energy Institute  
UNIVERSITY OF WISCONSIN-MADISON



# Sustainable *Electrical* Energy for Global Cities

## Global Cities

- More renewables
- More Resiliency
- More Efficient
- Smart use of conventional fuels
- Reduced emissions



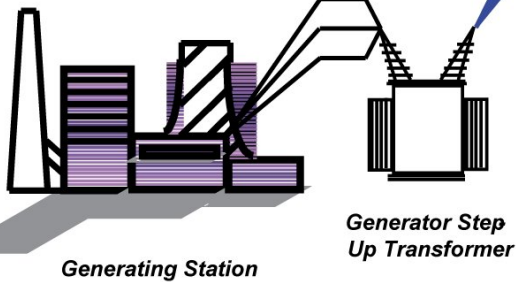
The National Academy of Engineering includes the electrical power system as one of the top engineering achievements of the twentieth century



# The electric delivery system

## Basic Structure of the Electric System

**Color Key:**  
Blue: Transmission  
Green: Distribution  
Black: Generation



Transmission Lines  
500, 345, 230, and 138 kV

Transmission Customer  
138kV or 230kV

Substation Step-Down Transformer

Subtransmission Customer  
26kV and 69kV

Primary Customer  
13kV and 4 kV

Secondary Customer  
120V and 240V

Distribution Losses 2-4%

Generation Losses 40-70%

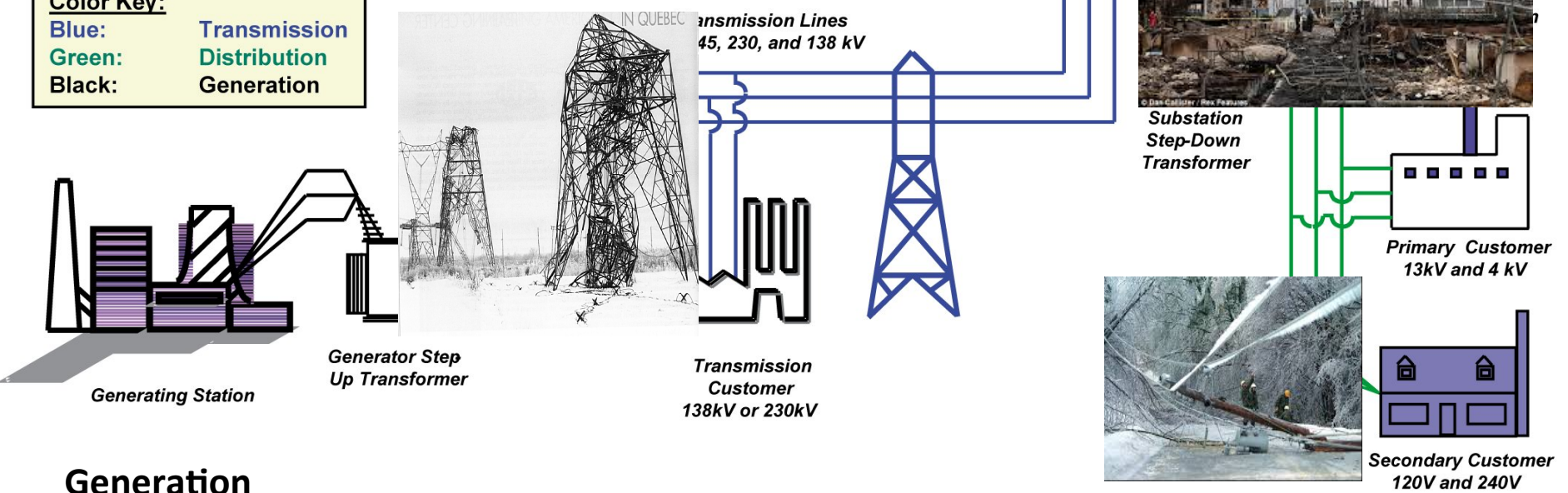
Transmission Losses 1-2%



# Problems with the electric delivery system

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### Distribution



**Generation**  
 Losses 40-70%

The system is not resilient!

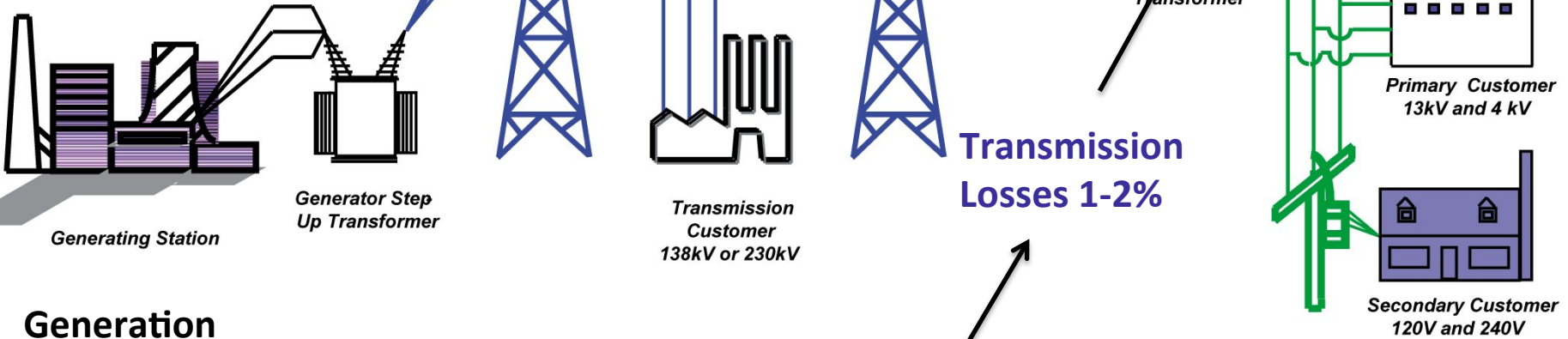


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**Distribution Losses 2-4%**

**Transmission Losses 1-2%**

**Generation Losses 40-70%**

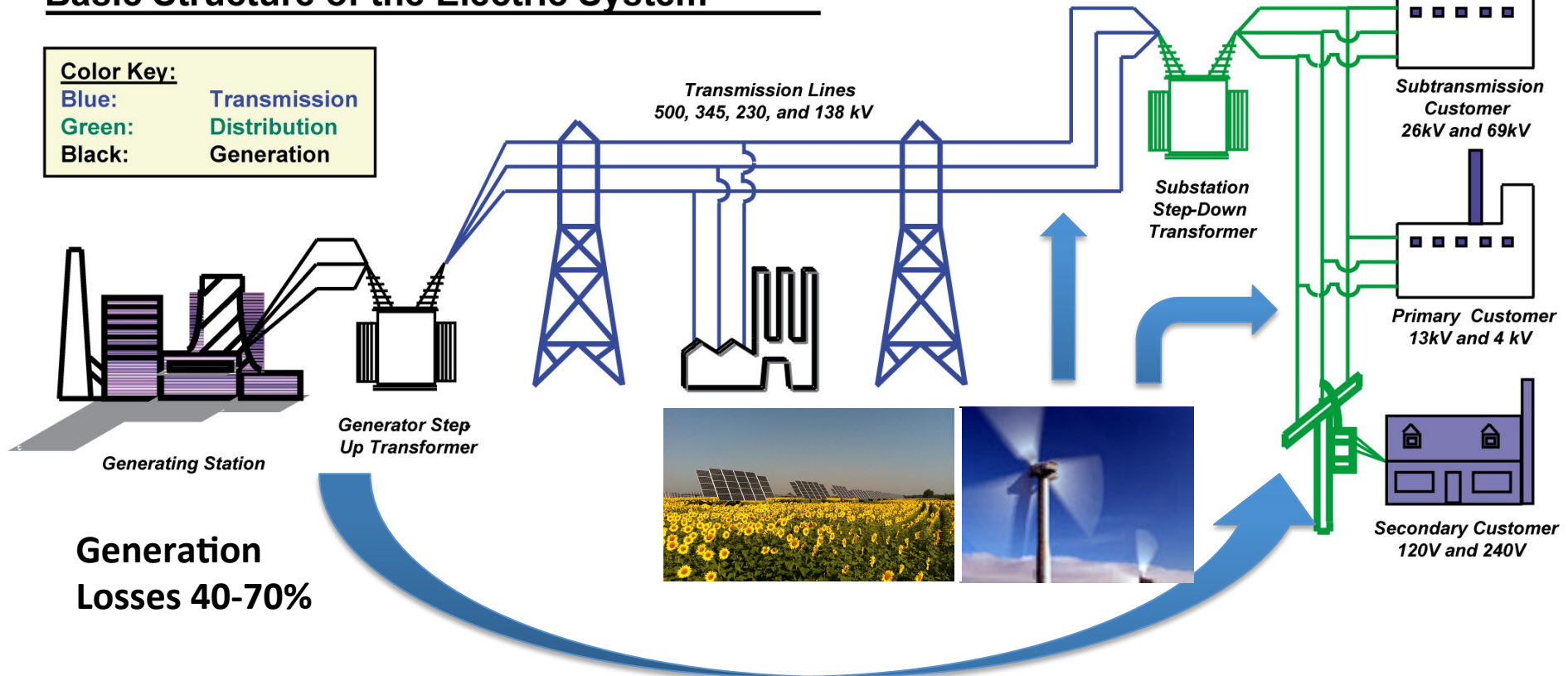
**2/3 of energy is loss to heat\***



# Electric delivery system with distributed energy resources

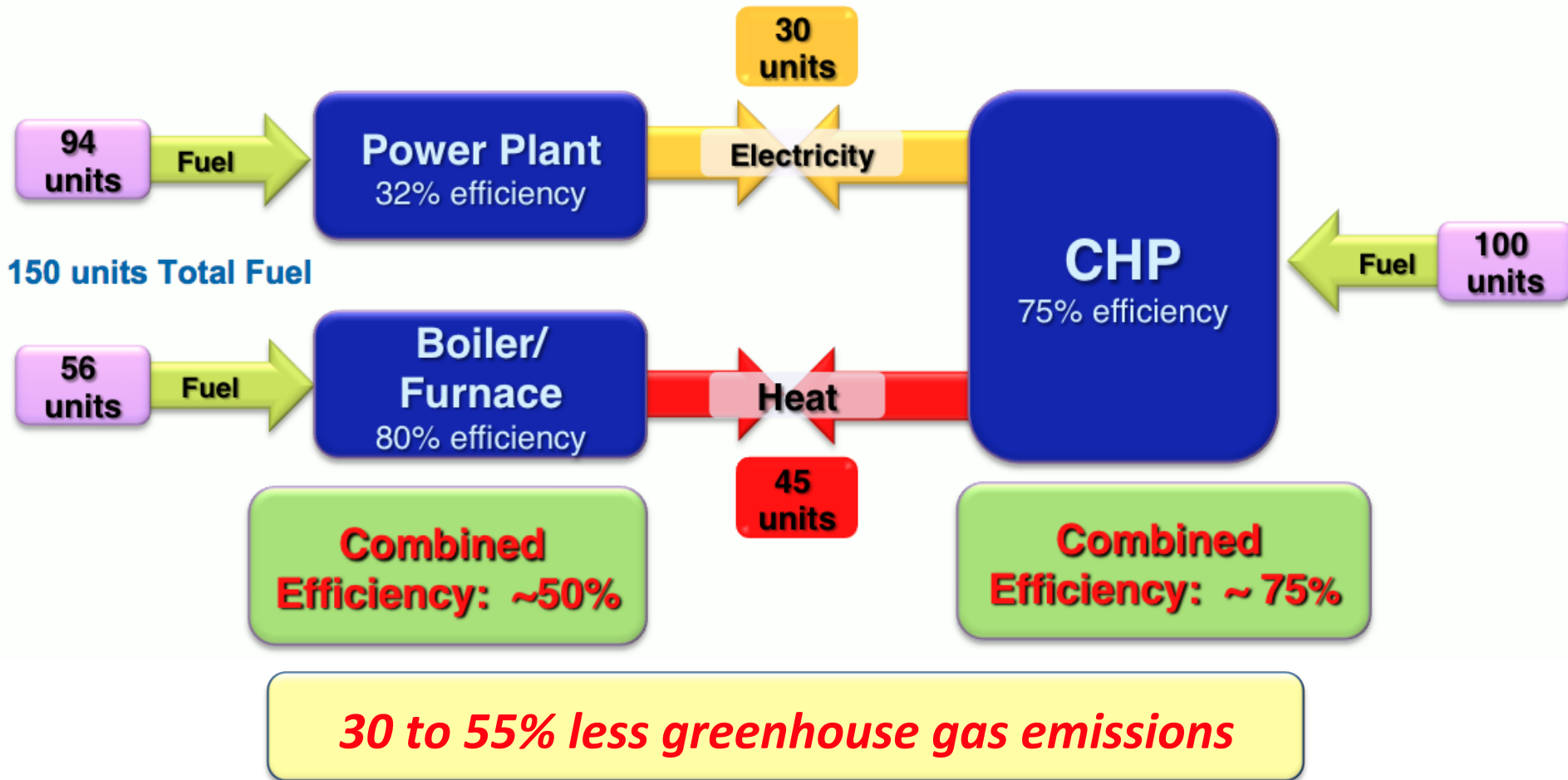
## Basic Structure of the Electric System

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Move more generation closer to the load centers to use the *waste heat* and *provide local resiliency!*

# Advantage of Combined Heating and Power (CHP)



- CHP delivers major boost in energy efficiency while simultaneously significantly reducing CO<sub>2</sub> emissions





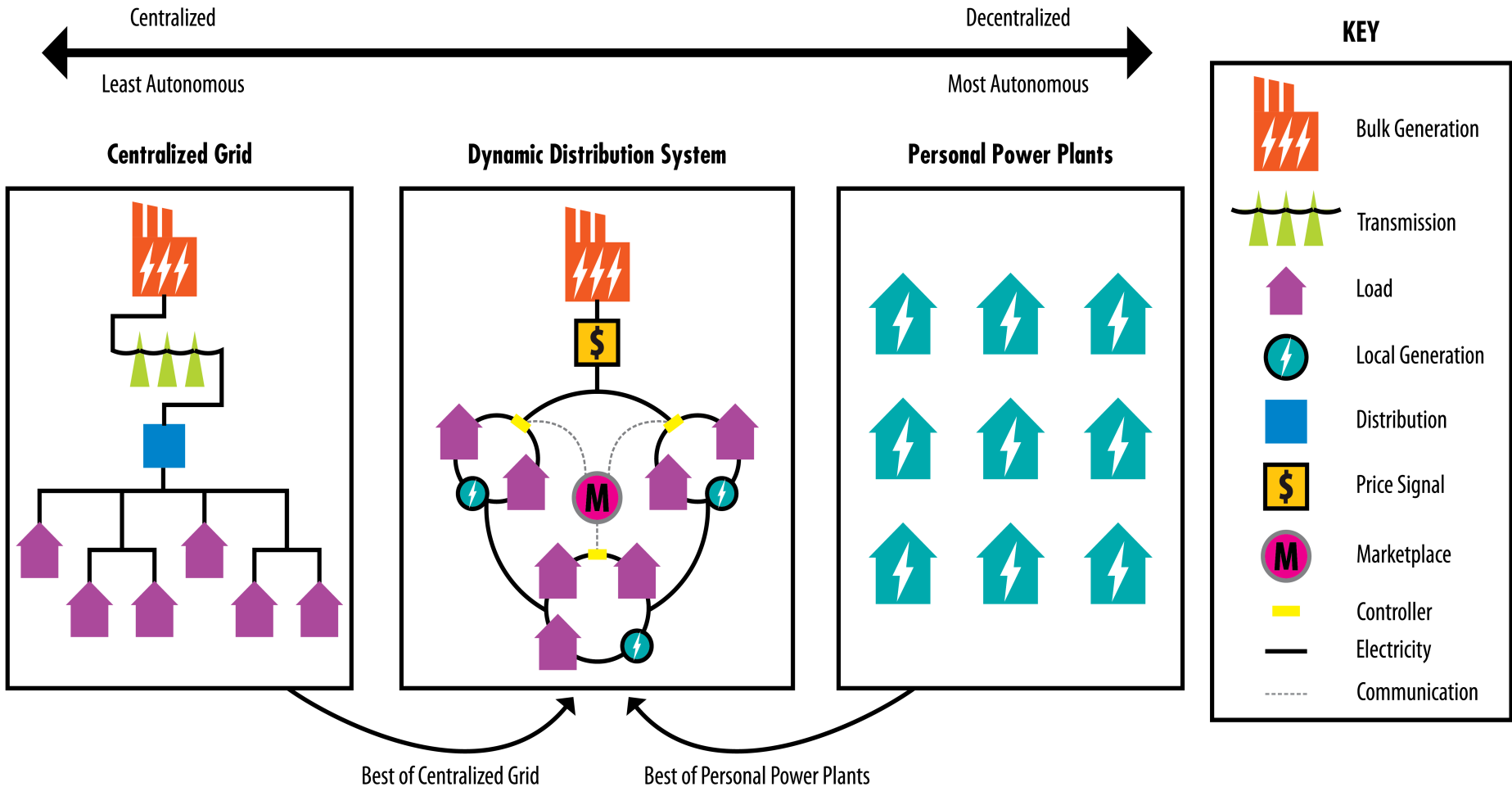
Generation in buildings provides local resiliency

*CERTS Microgrid provides valuable advantages during outages during Superstorm Sandy*





# Central generation vs. distributed energy resources





# Global Cities

## need to use the best of both worlds



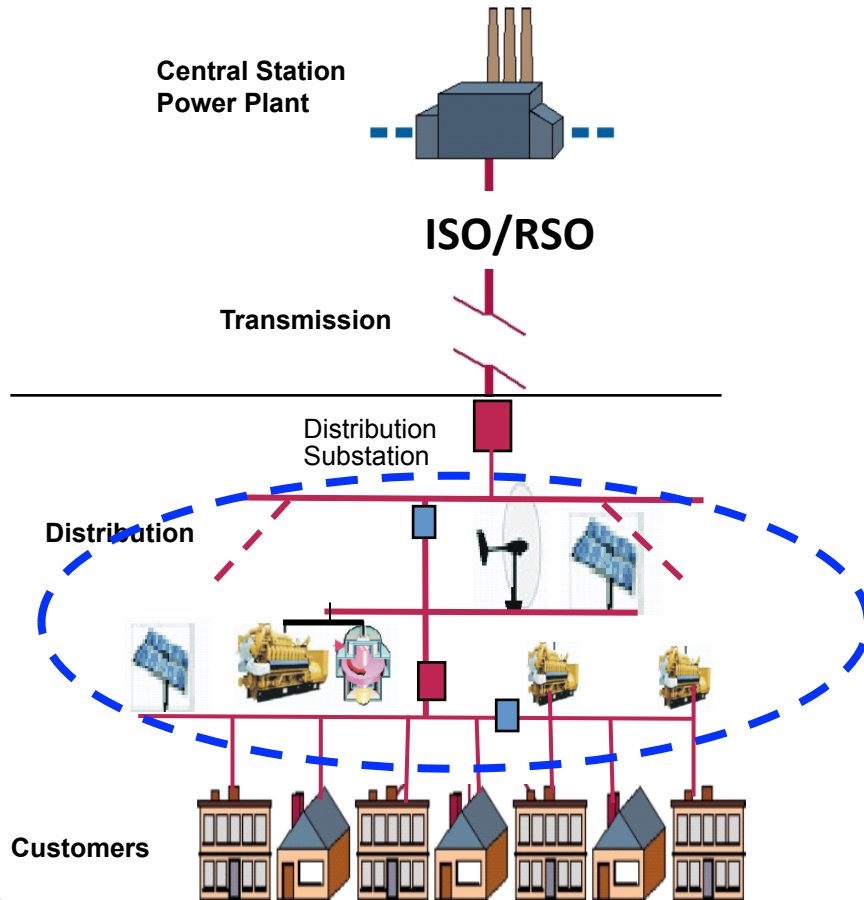
**Central with low CO<sup>2</sup>**  
(Economy of scale, 100s MW)

**Small, efficiency and robust**  
(Economy of numbers, 1000s units)

# Problem

## with 1000s of DERs

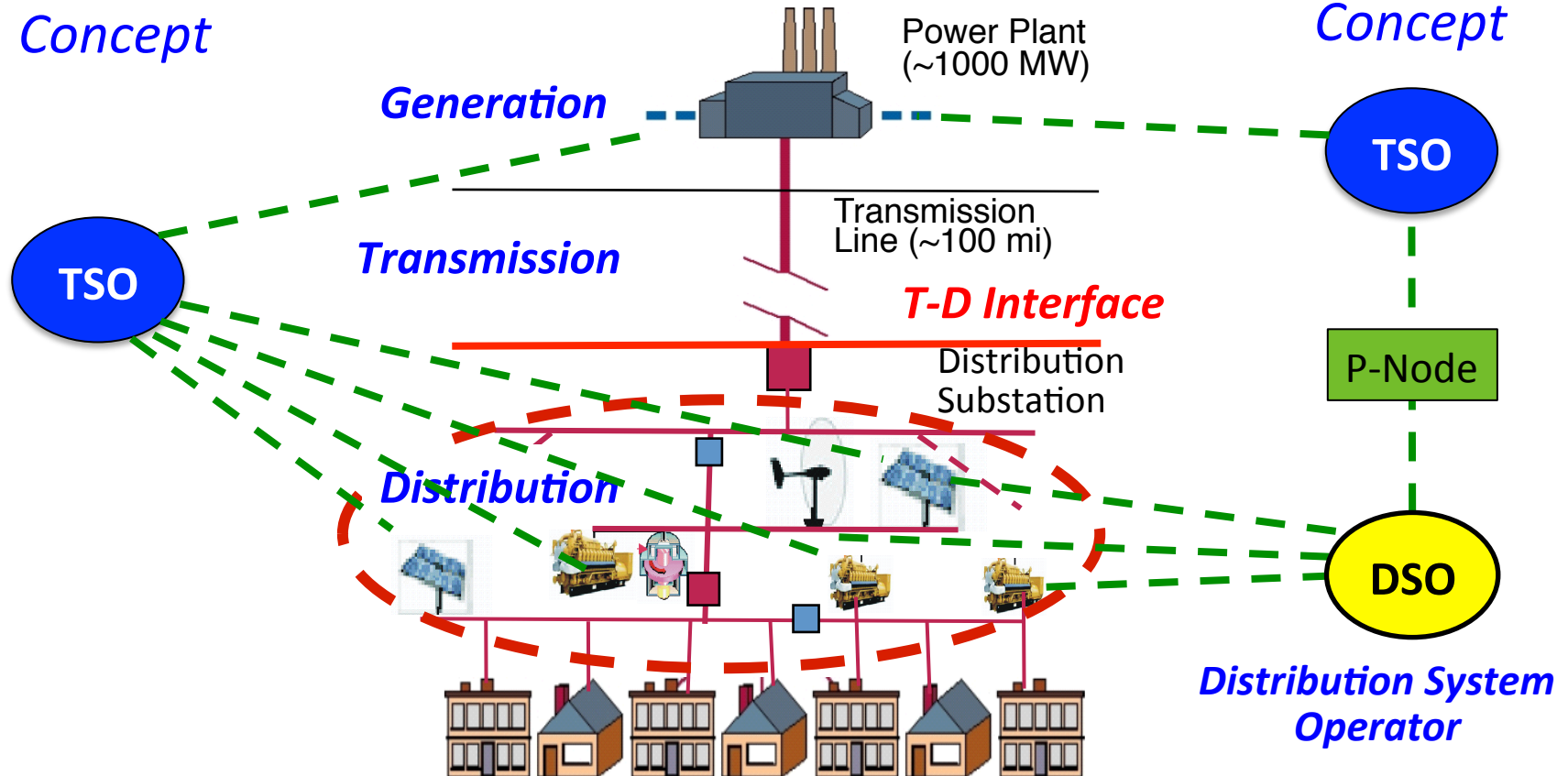
The issue is figuring out how to manage this wide, dynamic set of distributed energy resources and their control points.



# Control Approaches

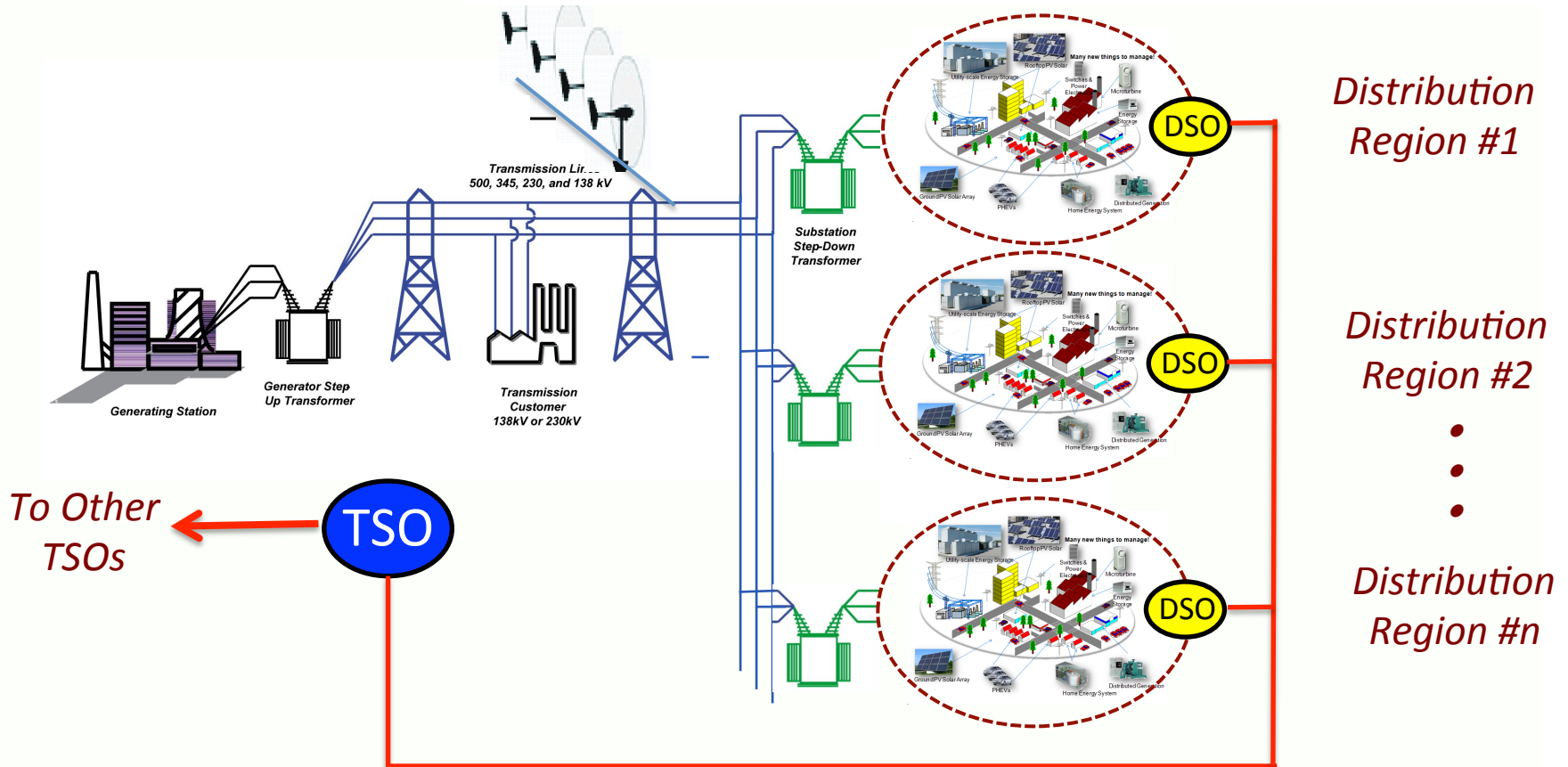
*Expanded TSO  
Concept*

*TSO/DSO  
Concept*



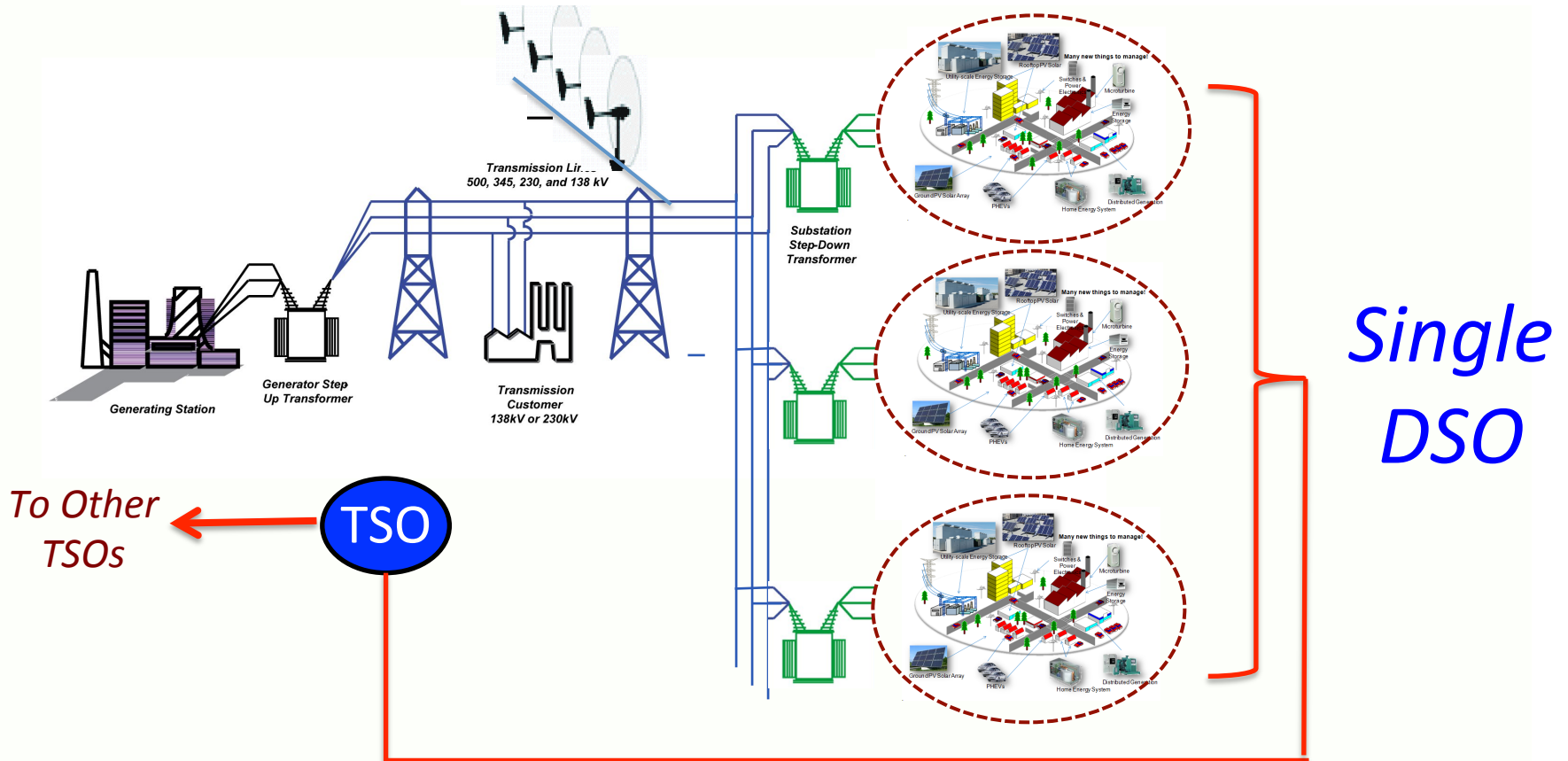
- *Expanded TSO Concept:* TSO role expands to incorporate DER at dis. level
- *TSO/DSO Concept:* Each distribution region has its own DSO which serves as balancing authority and market provider for sources/loads inside region.

# Dynamic Distribution System Architecture



- Proposed DDS architecture is conveniently scalable over a wide range of grid sizes and configurations

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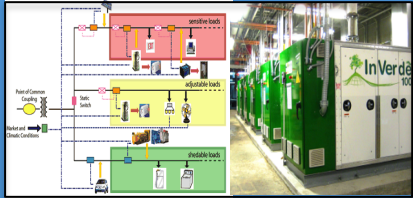


# DDS Resources

**CENTRAL SOURCES**



**MICROGRIDS**



**CUSTOMER LOADS WITH/WITHOUT DER BEHIND THE METER**

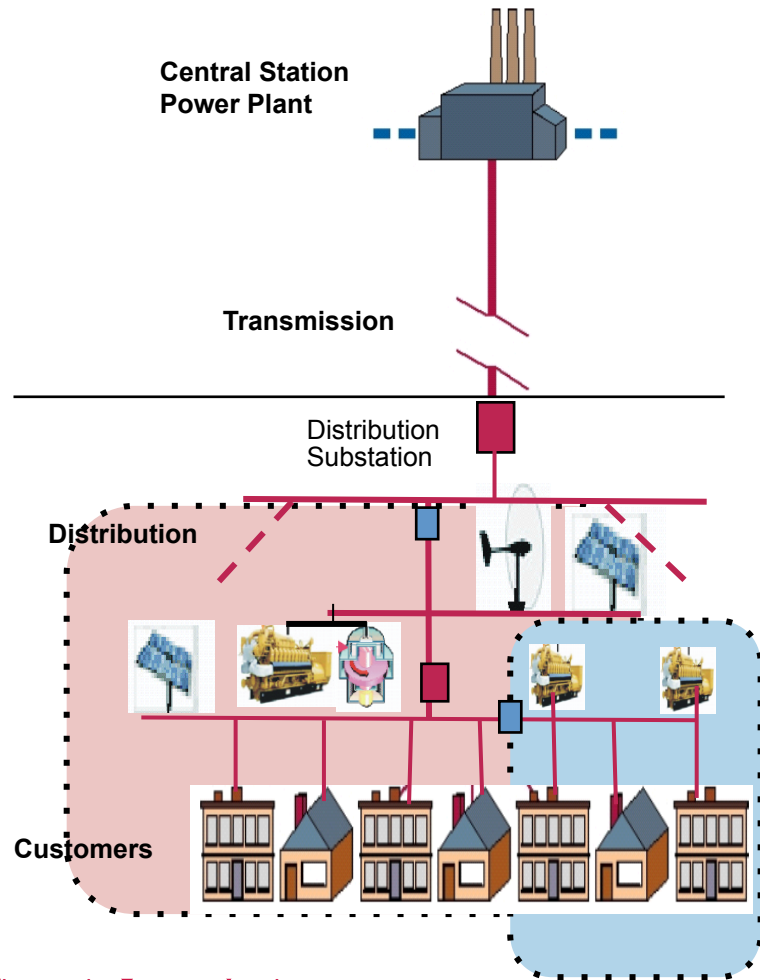


**MERCHANT DER**





# Microgrids: Example of local control



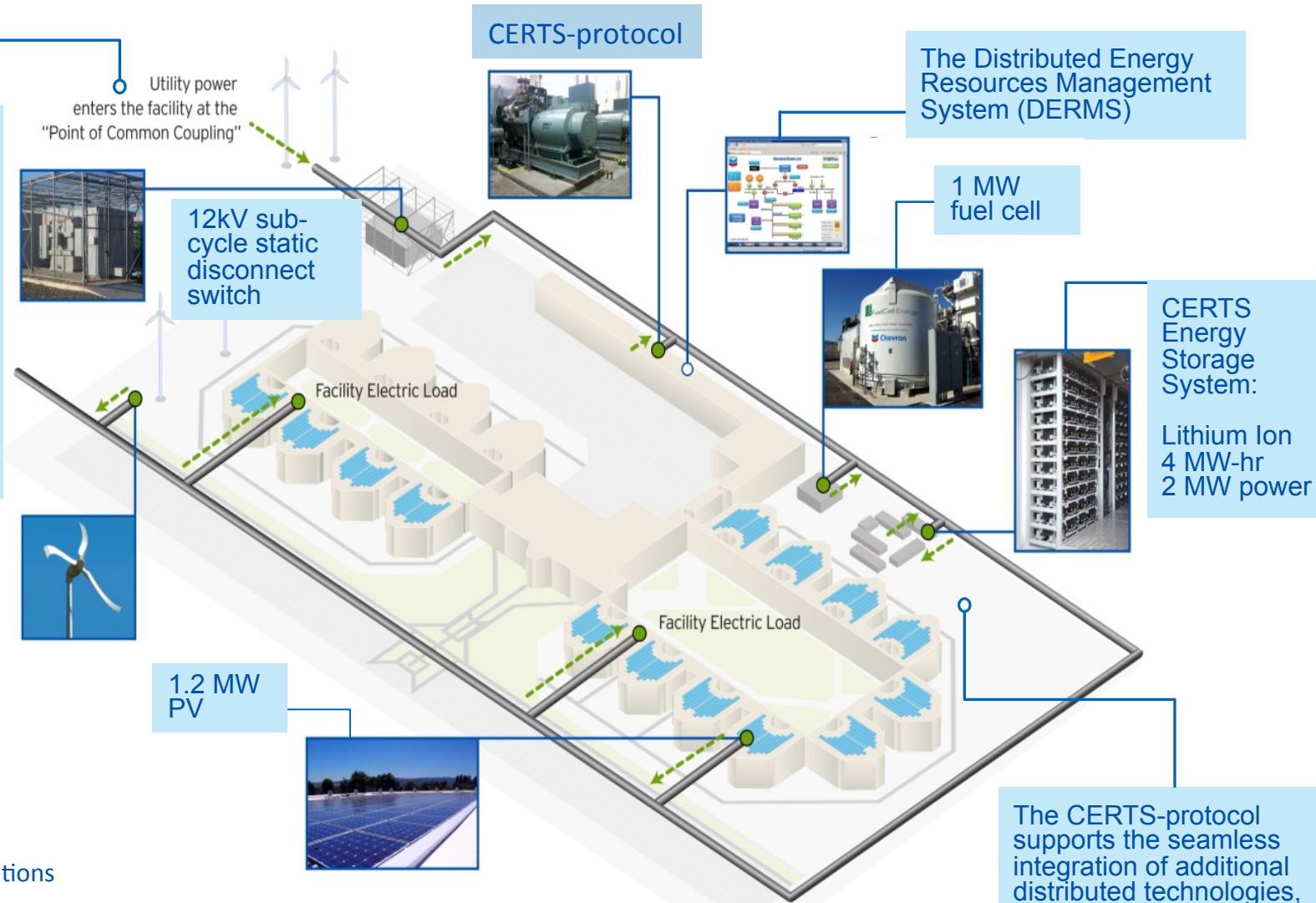
- Cluster DER and loads
- Utilize waste heat
- Operate during loss of power
- Provide local control

Microgrids are a cluster of loads and DER units which can smoothly disconnect from and reconnect to the grid.

They enhance local reliability/flexibility with significant system efficiency improvements through use of waste heat

# CERTS Microgrid: Santa Rita Jail, Ca.

When a disturbance to the utility grid occurs, the automatic disconnect switch enables the facility to "island" itself from the main utility grid and independently generate and store its own energy.



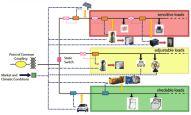
The CERTS-protocol supports the seamless integration of additional distributed technologies, including generation, storage, controls and communications.



# Summary

## DDS: A Blueprint for Global Cities

- TSOs continue to play their current role as balancing authorities (BA) and electricity market providers (MP) at transmission level
- Each distribution region has its own DSO that serves as BA and MP for its region
- Central power plants have responsibility for delivering bulk power to distribution regions
- DSO's act to minimize volatility of power flow from central power plants to their distribution regions
  - DSO use balancing authority and markets to adjust DER power sources, energy storage, and loads to achieve local objectives



# Questions ?