# Dynamic Pricing

June 2, 2016

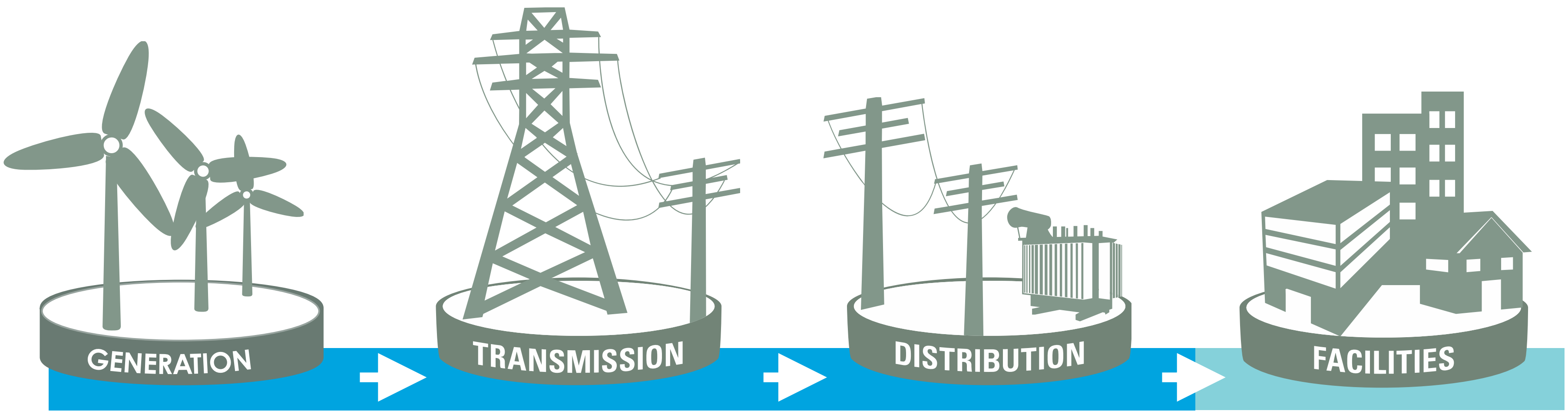
Harvard's Electricity Policy Group

# Discussion Topics

- Microgrid Architecture
- Utility Microgrids: Building a Foundation for Price Response
- The Role of Dynamic Pricing
- Dynamic Pricing Optimization & Customer Investment

# PEER

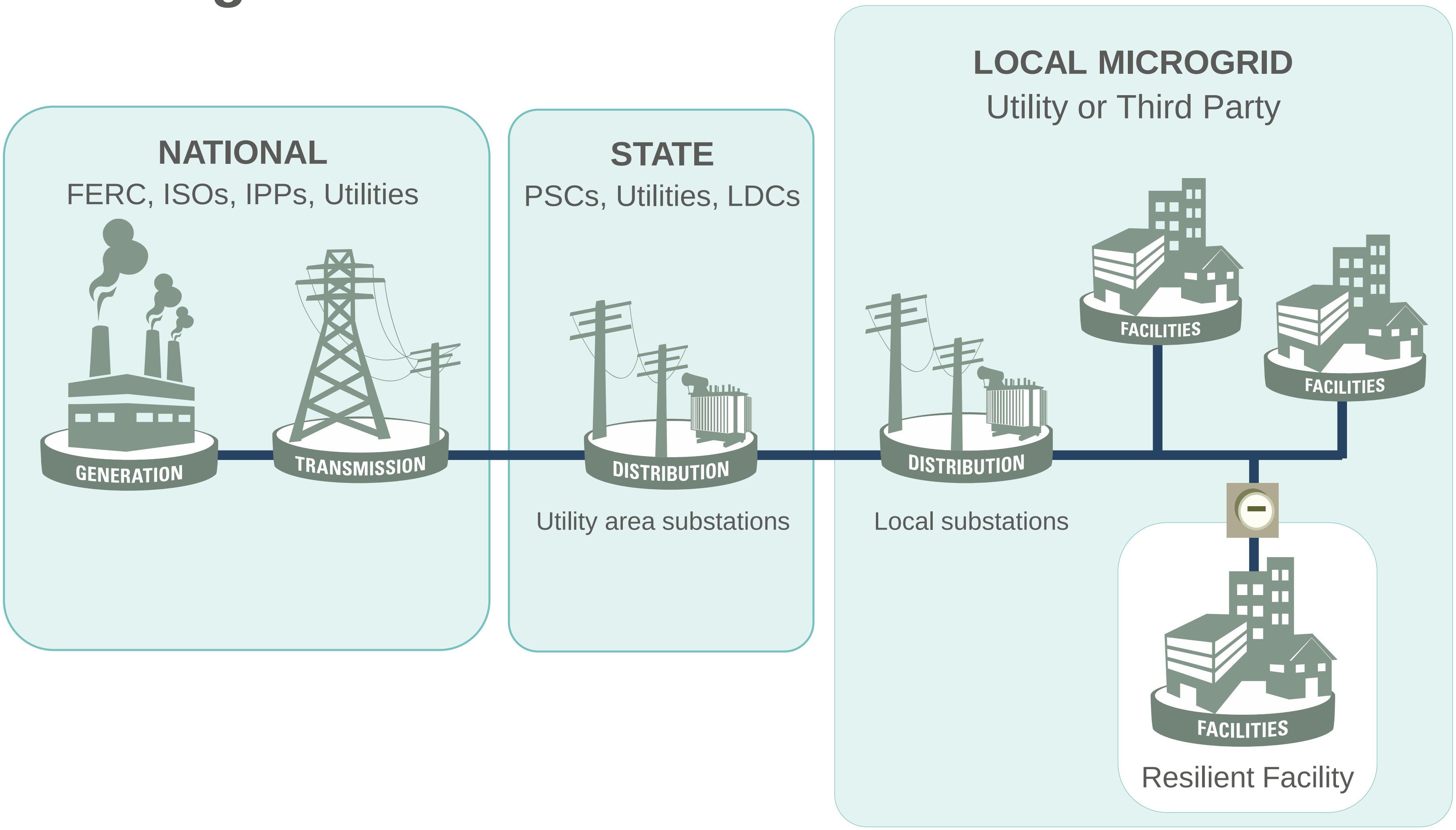
- Through LEED, USGBC created a common language, standard, and framework for advancing knowledge, technology and innovation in sustainable buildings
- Now USGBC aims to repeat LEED's success for the energy delivery system leveraging PEER




Performance Excellence in Electricity Renewal ™

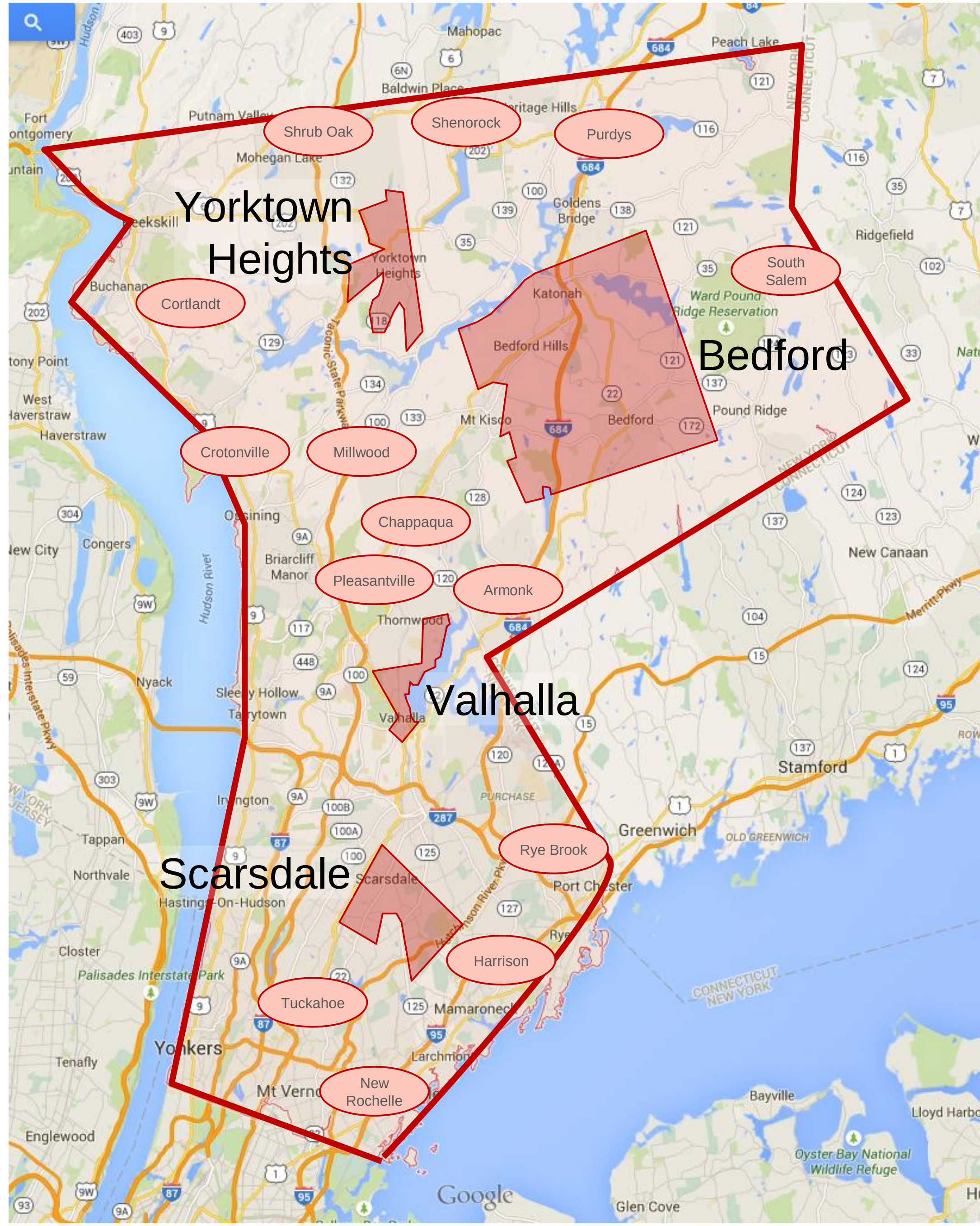
# MICROGRID ARCHITECTURE

# Microgrid Architecture



# Utility Microgrid Mapping

| Substation Outage Metrics | Performance | |
|---|---|---|
| | City | Utility |
| Frequency | 2.6 | 1.2 |
| Duration, min | 1,700 | 160 |
| Utilization | 45% | 55% |
| % of Capacity | 93% | NA |



# Shifting the Focus to Performance

## Capabilities

- Islanding
- Protected infrastructure
- Renewable generation
- Demand reduction
- District energy
- Load shifting
- Auto-restoration
- Grid services

## Performance Outcomes

50% ↓ Capital waste / costs

100% ↓ Interruptions

50% ↓ Energy waste

25% ↓ Peak demand

50% ↓ Emissions

100% ↑ Resiliency

# PEER Performance Scorecard Examples

| Performance Criteria | Performance |
|---|---|
| **Outage Duration (SAIDI) & Frequency (SAIFI)** | **240 min / 1.3** |
| **Price Response & Grid Service (DR, storage, gen)** | **10%** |
| **Load Duration Curve (Utilization)** | **45%** |
| **% of Capacity** | **93%** |
| **Reliability & Resiliency Capability** | |
| Islanding Capability | 5% |
| Substation Alternate Supply | 0% |
| Distribution Auto Restoration | 40% |
| Distribution Redundancy | 40% |
| Distribution Master Controller | 0% |
| **Energy Efficiency and Environmental Index** | **75%** |
| Energy Efficiency, MMBtu / MWh | 9 |
| $CO_2$ Intensity, lb. / MWh | 1,100 |
| Water Intensity, gal / MWh | 300 |
| Renewable generation | 5% |

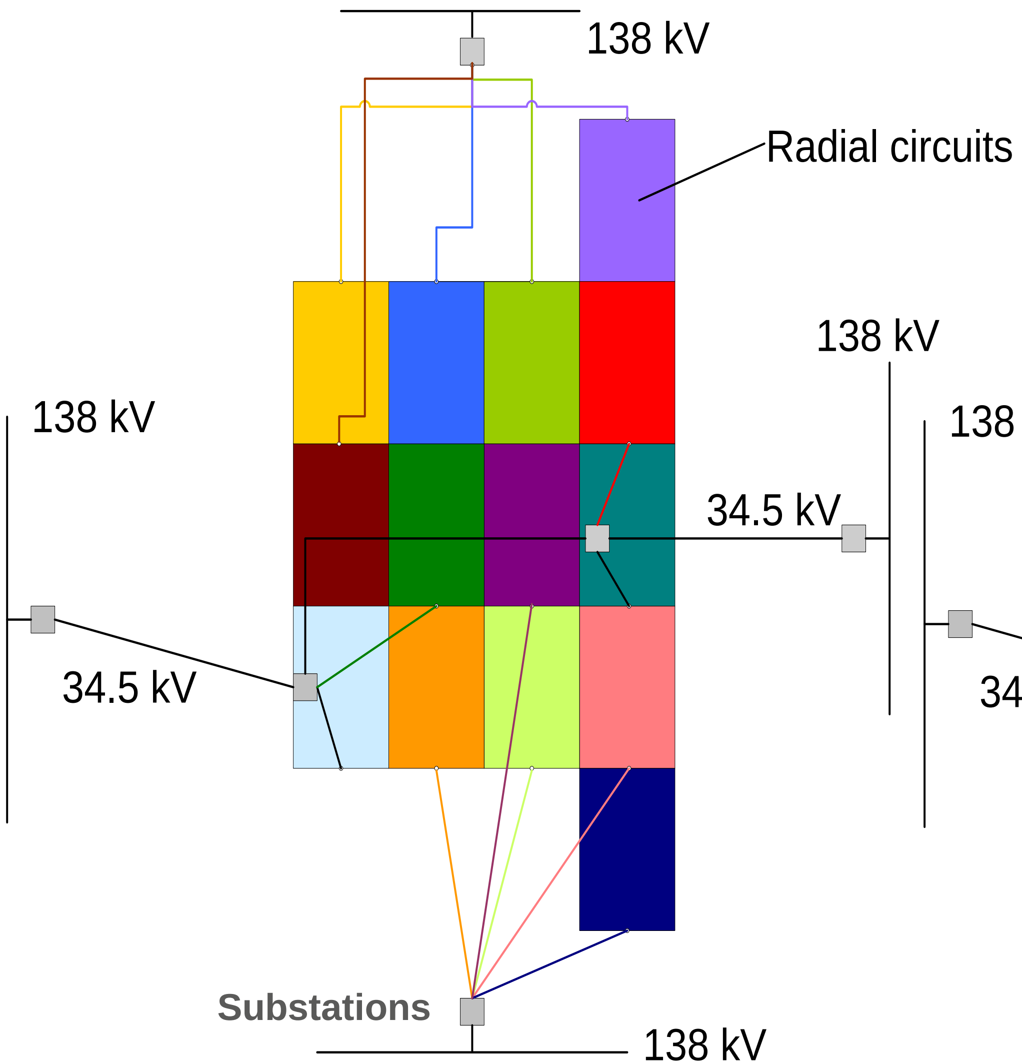
# UTILITY MICROGRIDS:

## Building a Foundation for Price Response

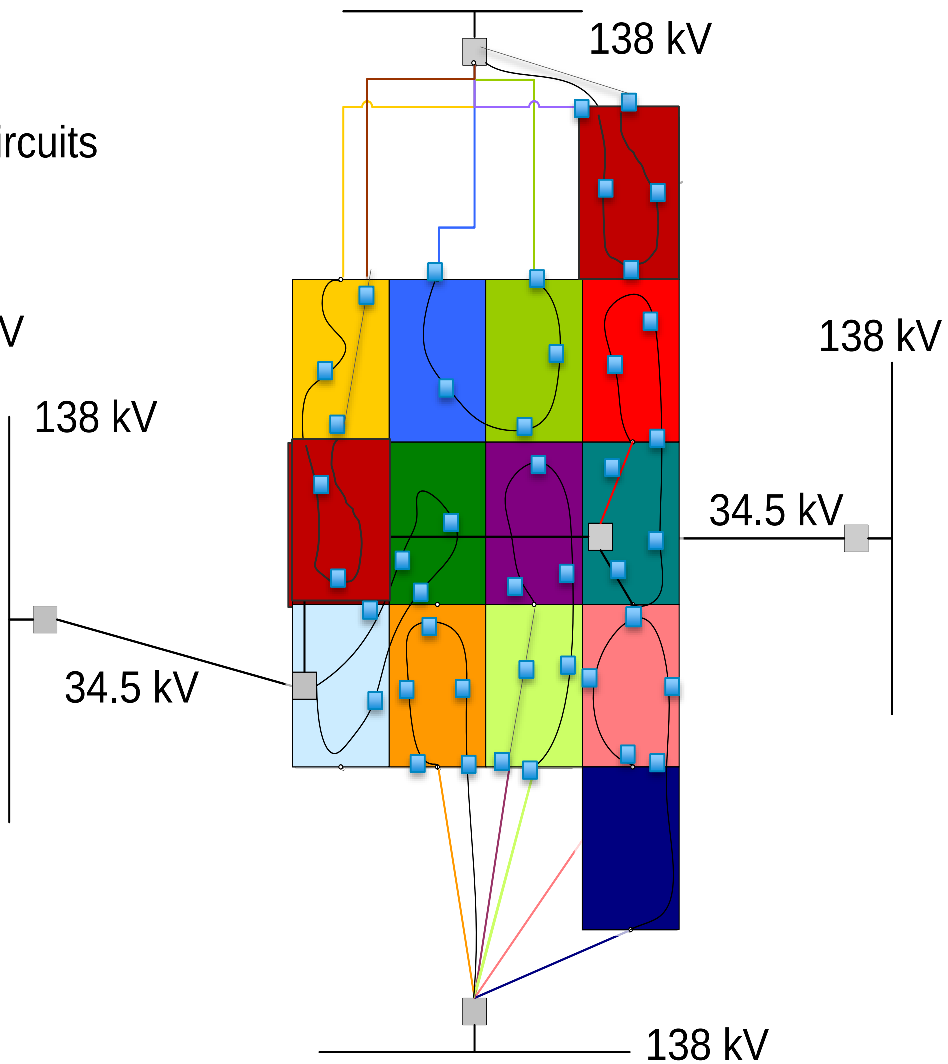
# Utility Microgrids

## Building a Reliable and Resilient Distribution System

### Radial

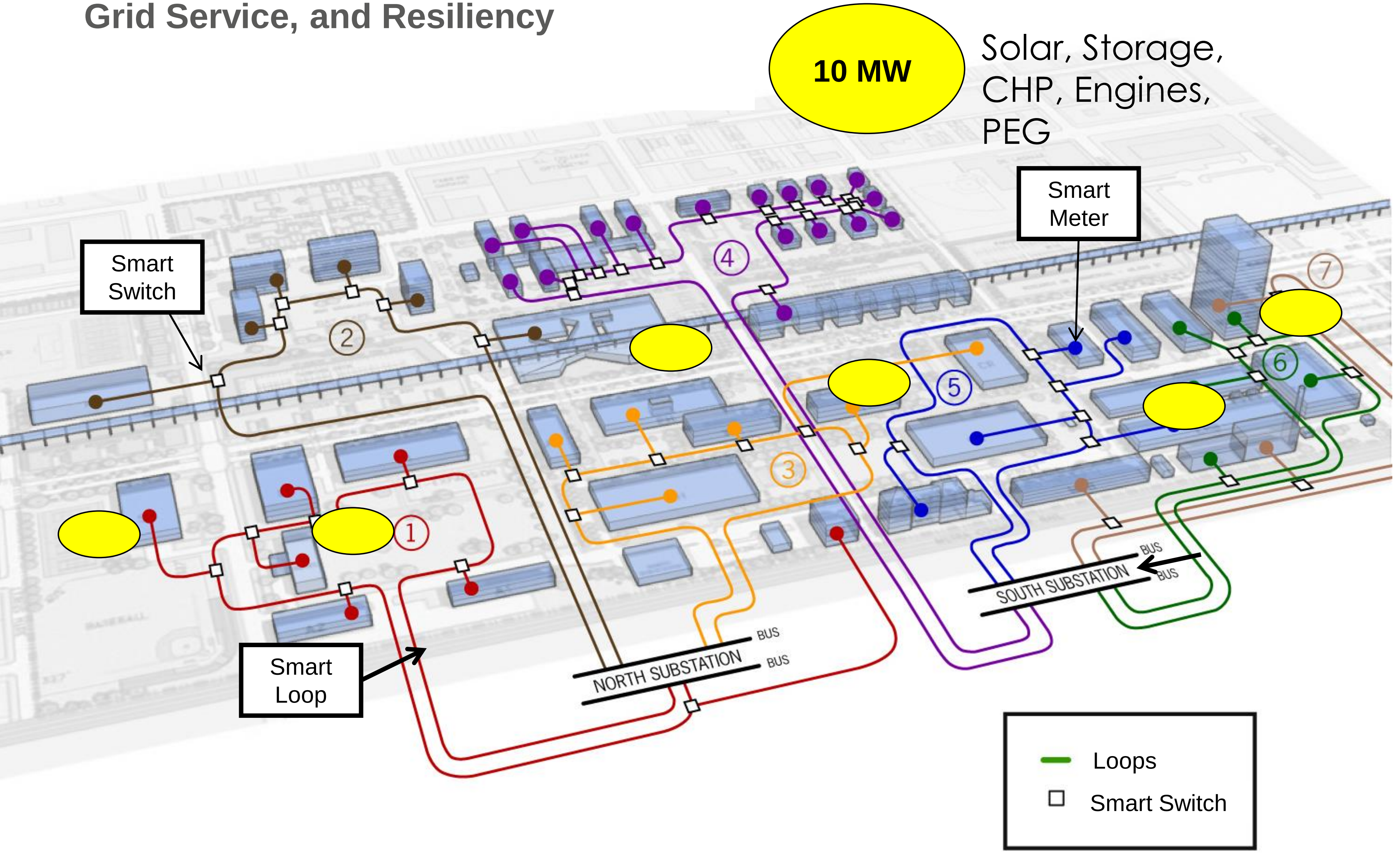



### Self Healing, Load Shifting, & Two-Way Power Flow



# Microgrids

## Distributed Energy for Price Response, Grid Service, and Resiliency

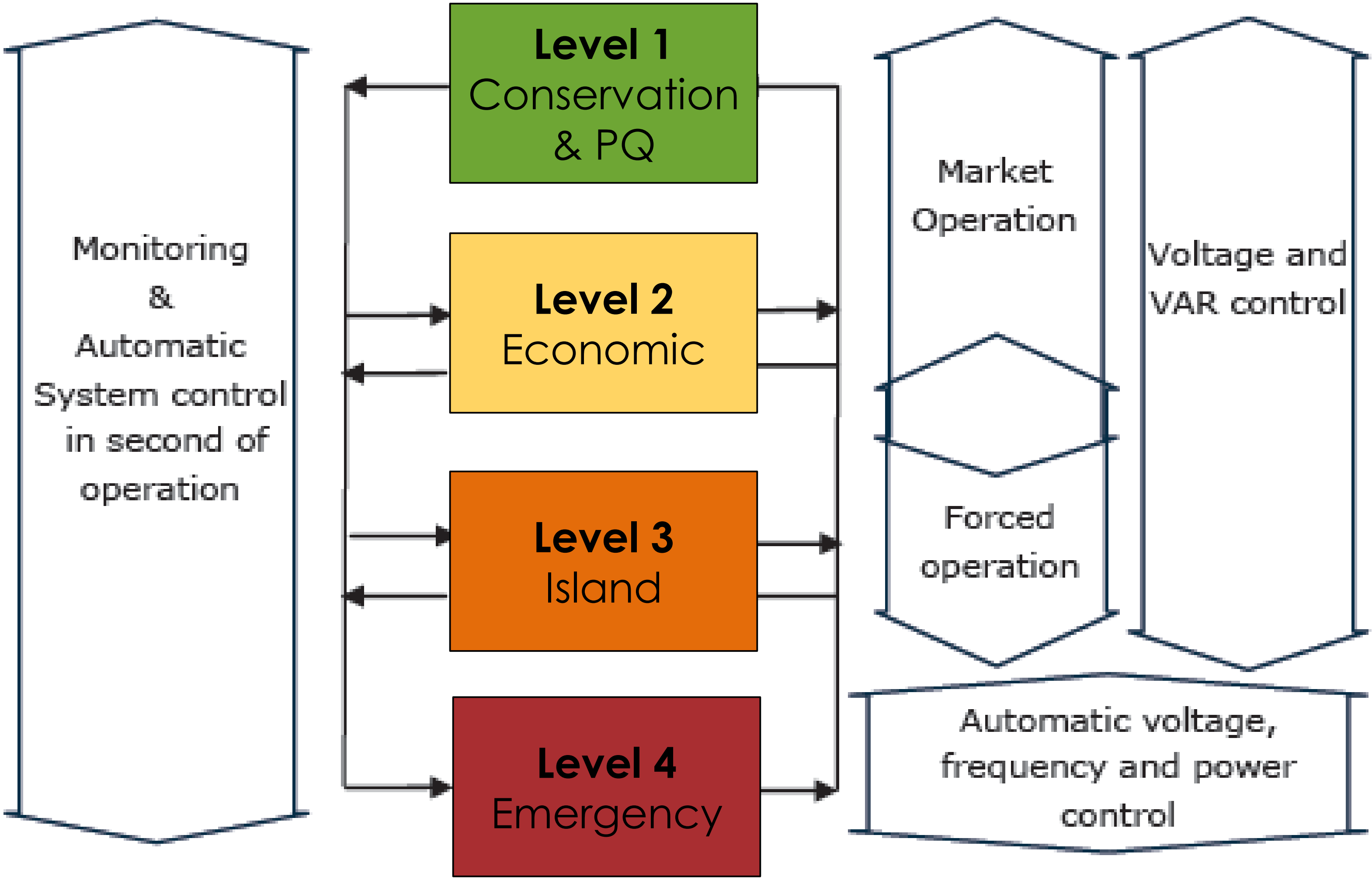


# Utility Microgrids

## Resiliency: Critical and Essential Service

| Critical and Essential Service | Circuits | Address | Resiliency Capability |
|---|---|---|---|
| Local Hospital | | | |
| Police Station/Coms | | | |
| Storm Water Pumping Station A | | | |
| Storm Water Pumping Station B | | | |
| Convalescent Center | | | |
| Senior Home | | | |
| High School (Shelter) | | | |

# Utility Microgrids
## Master Controller

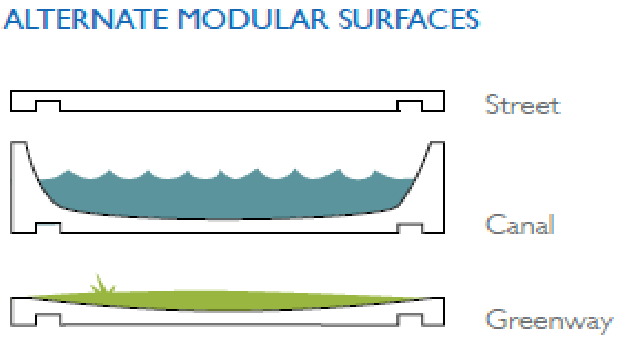


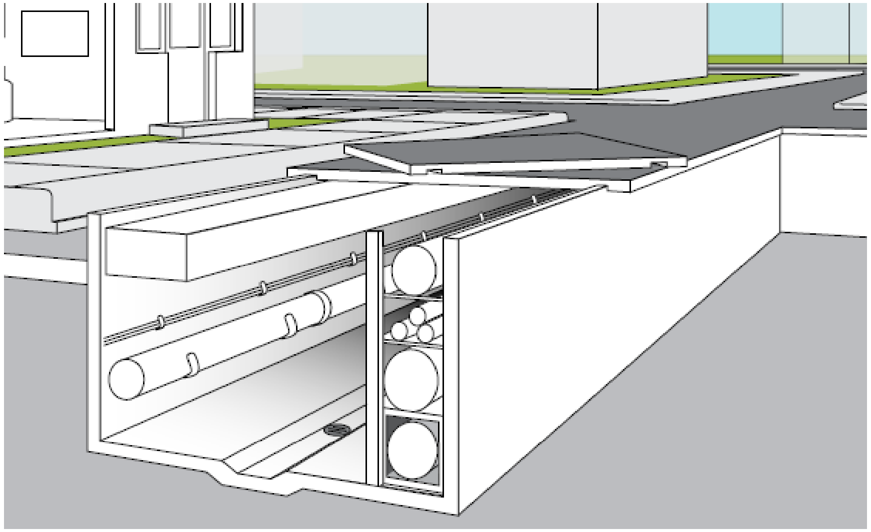

http://www.energynautics.com/downloads/publikationen/Paper_Energynautics_Overview_Danish_Cell_Project.pdf

# Leverage Utility Microgrids

## Establish new service / revenue riders

- Master Controller
- City Grid Investment
  - City direct investment
  - Rider LGC
- New Development
- Smart Grid Investment
- District Energy
- ?



# THE ROLE OF DYNAMIC PRICING

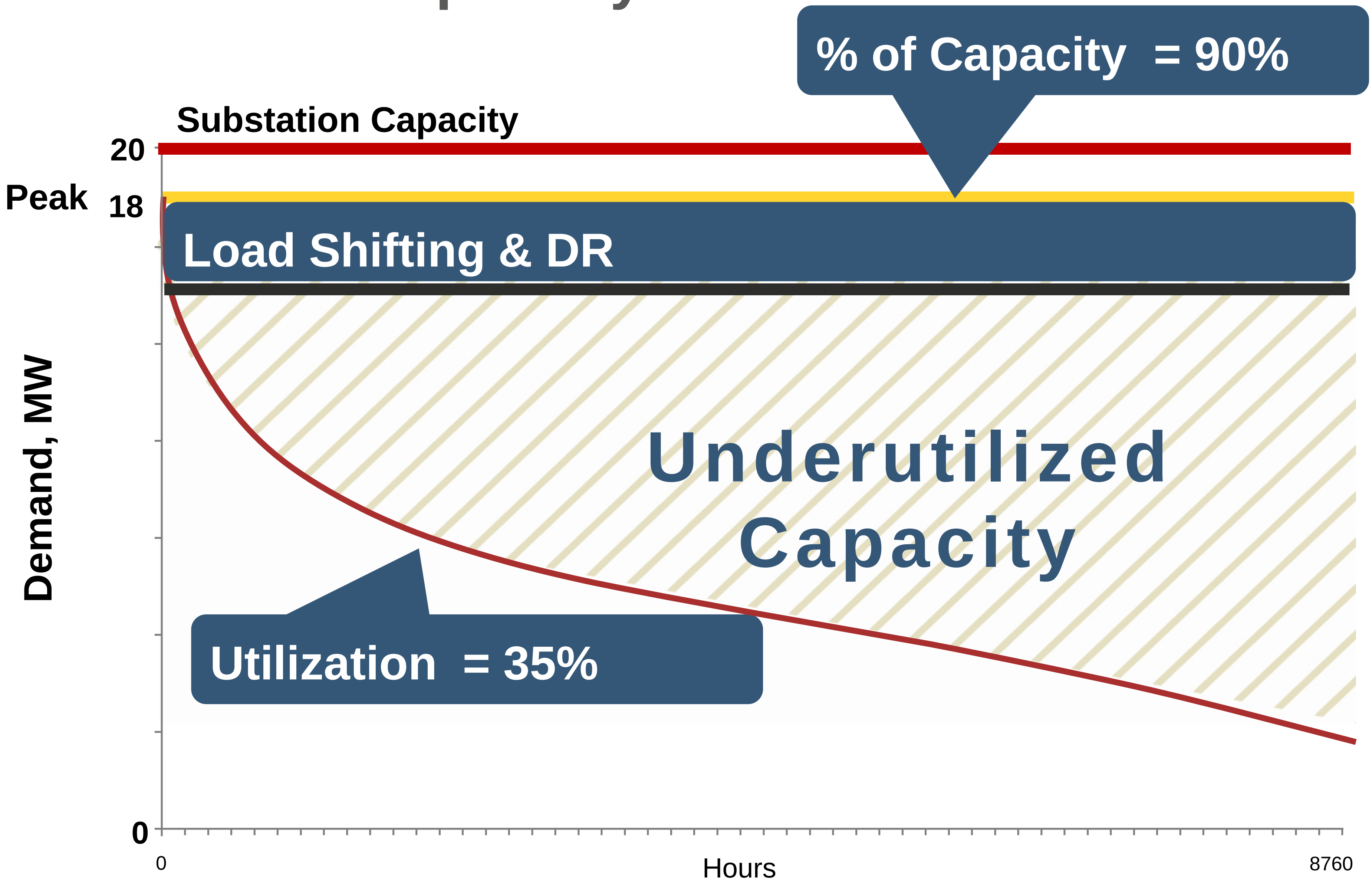
# Dynamic Pricing Goals and Impacts

**TABLE 1: Efficacy of Various Rate Structures in Achieving Select Outcomes**

| | EVENT-BASED RATES | | | | | MARKET-BASED RATES | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| DESIRED OUTCOME | Flat Price | DR Payment | CPP | Direct Load Control | Rebate for Reduction | TOU Pricing | Tiered Pricing | Real-Time | Day-Ahead | Increasing Block |
| Conservation | low | low | low | low | low | high | high | med | med | med |
| Consumer cost reduction | low | low | low | low | low | low | med | high | med | low |
| $CO_2$ reduction | low | low | low | low | low | med | high | med | med | low |
| Permanent demand reduction | low | low | low | low | low | med | high | med | med | low |
| Temporary demand reduction | low | high | high | high | med | low | low | low | low | low |
| Load shifting (e.g. PHEV) | low | low | low | low | low | high | high | high | high | low |
| Price responsiveness | low | med | low | low | med | med | high | high | high | low |

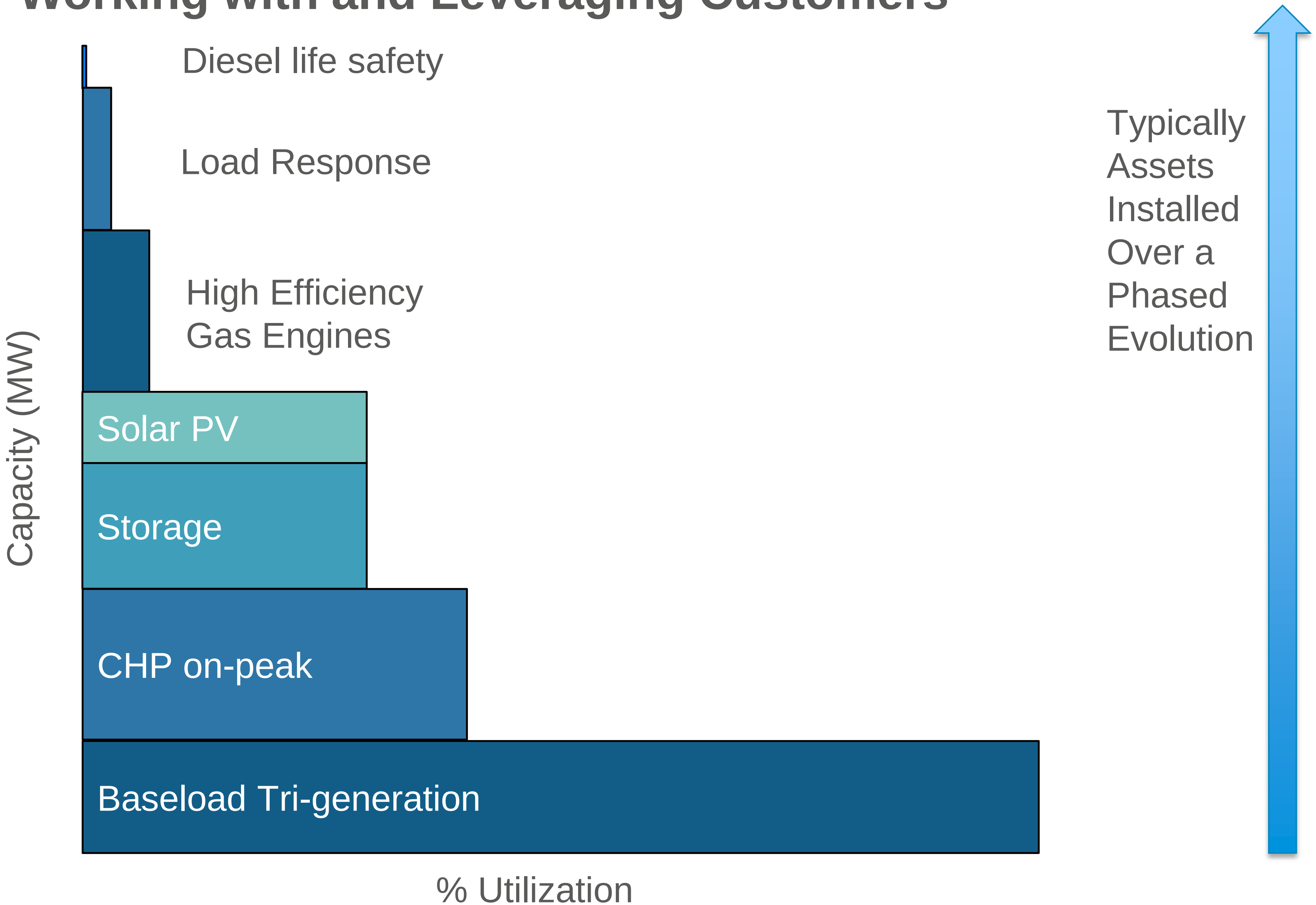
Source: Galvin Electricity Initiative

# Utility Operational Effectiveness: Customer Capability



# Utility Microgrids

## Working with and Leveraging Customers



# Utility Microgrids

## Working with and Leveraging Customers

Rate structures can influence load curves for customers

**Net Impact:**

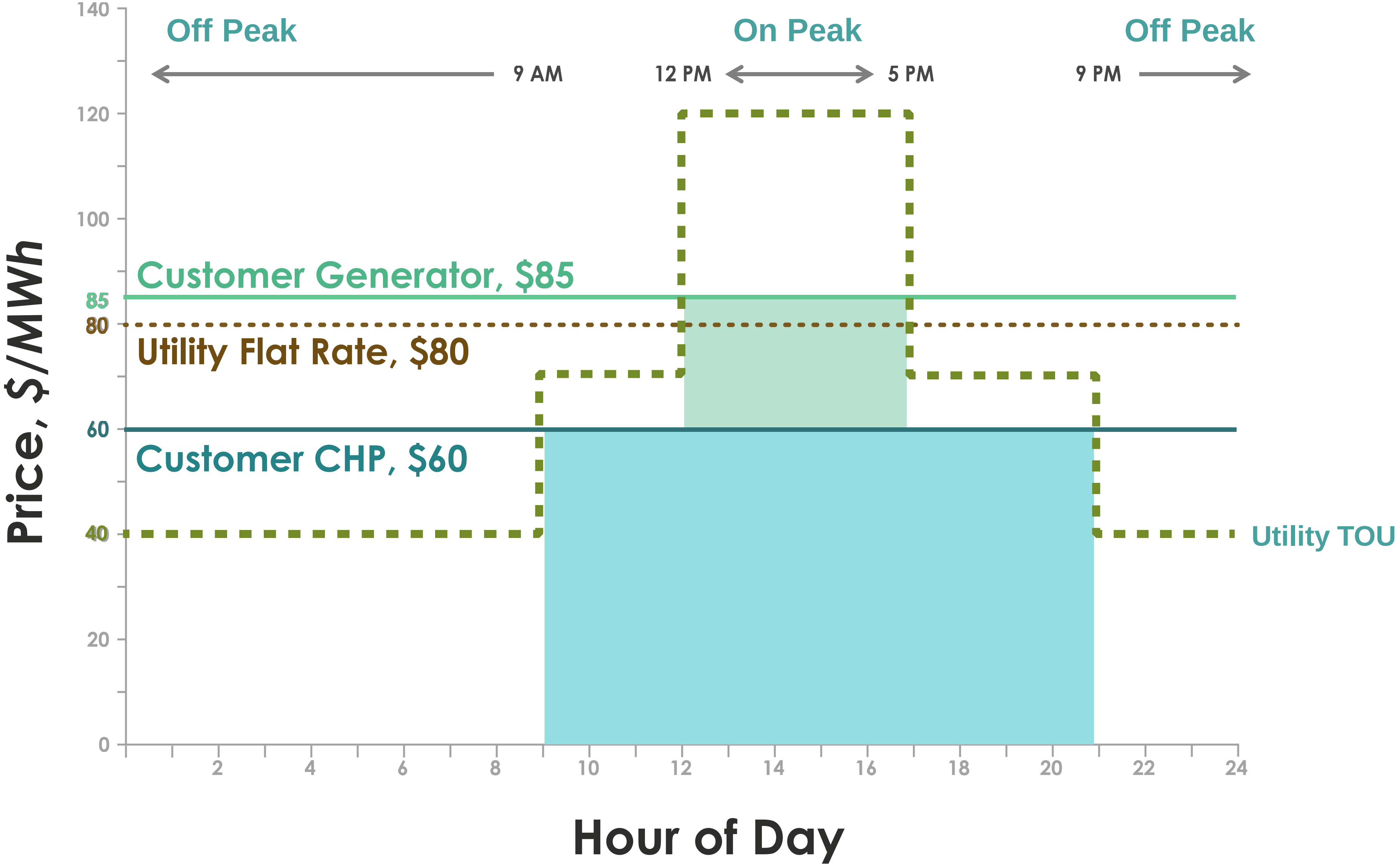
**Overall Utility Load Curve is Flattened**

**Investment in Expansion is Avoided**

**Less Reliance on Expensive Peaking Units and Elastic Markets**

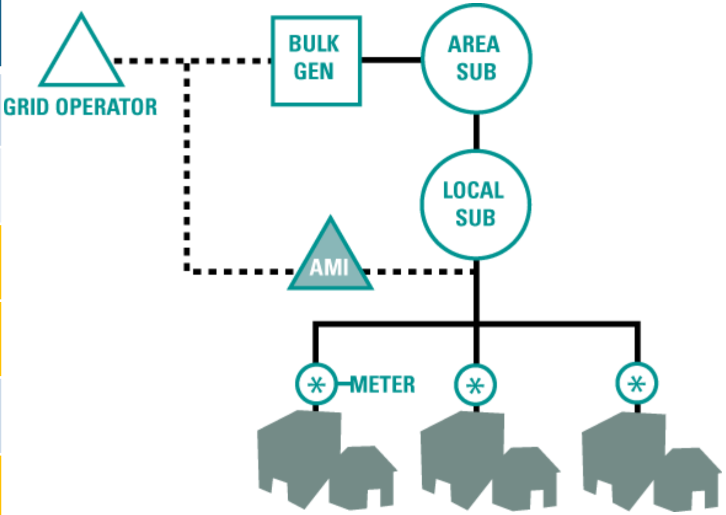
# DYNAMIC PRICING OPTIMIZATION & CUSTOMER INVESTMENT

# Using TOU to Manage Customer Action



# Flat Rate

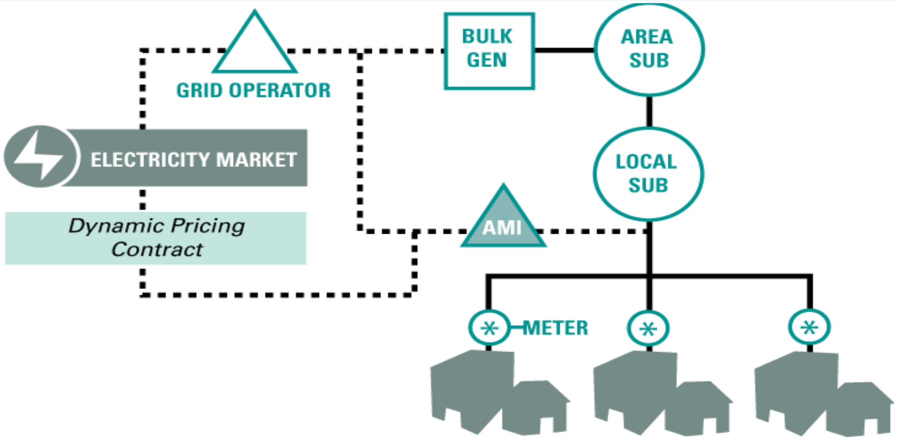
| | Baseline |
|---|---|
| Peak demand / CHP size, kW | 2,000 / 600 |
| Total Consumption, kWh/year | 10,000,000 |
| On-Peak (9am to 6pm, M-F) | $80 |
| Off-peak | $80 |
| Generator Annual Output, % | **52%** |
| Generator Operations Cost, $/MWh | $60 |
| Capital Cost for 1,000 kW CHP, $ | $1,200,000 |
| **Annual Electric Savings, $/year** | **$105,000** |




Simple Payback: **11 years**

# TOU Rate

| | Baseline | Dynamic Pricing |
|---|---|---|
| Peak demand / CHP size, kW | 2,000 / 600 | 2,000 / 600 |
| Total Consumption, kWh/year | 10,000,000 | 10,000,000 |
| On-Peak (9am to 6pm, M-F) | $80 | $210 |
| Off-peak | $80 | $55 |
| Generator Annual Output, % | 52% | 16% |
| Generator Operations Cost, $/MWh | $60 | $60 |
| Capital Cost for 1,000 kW CHP, $ | $1,200,000 | $1,200,000 |
| **Annual Electric Savings, $/year** | **$105,000** | **$230,000** |




Simple Payback: **5 years**

# Customer Price Response Case Study Boston MA

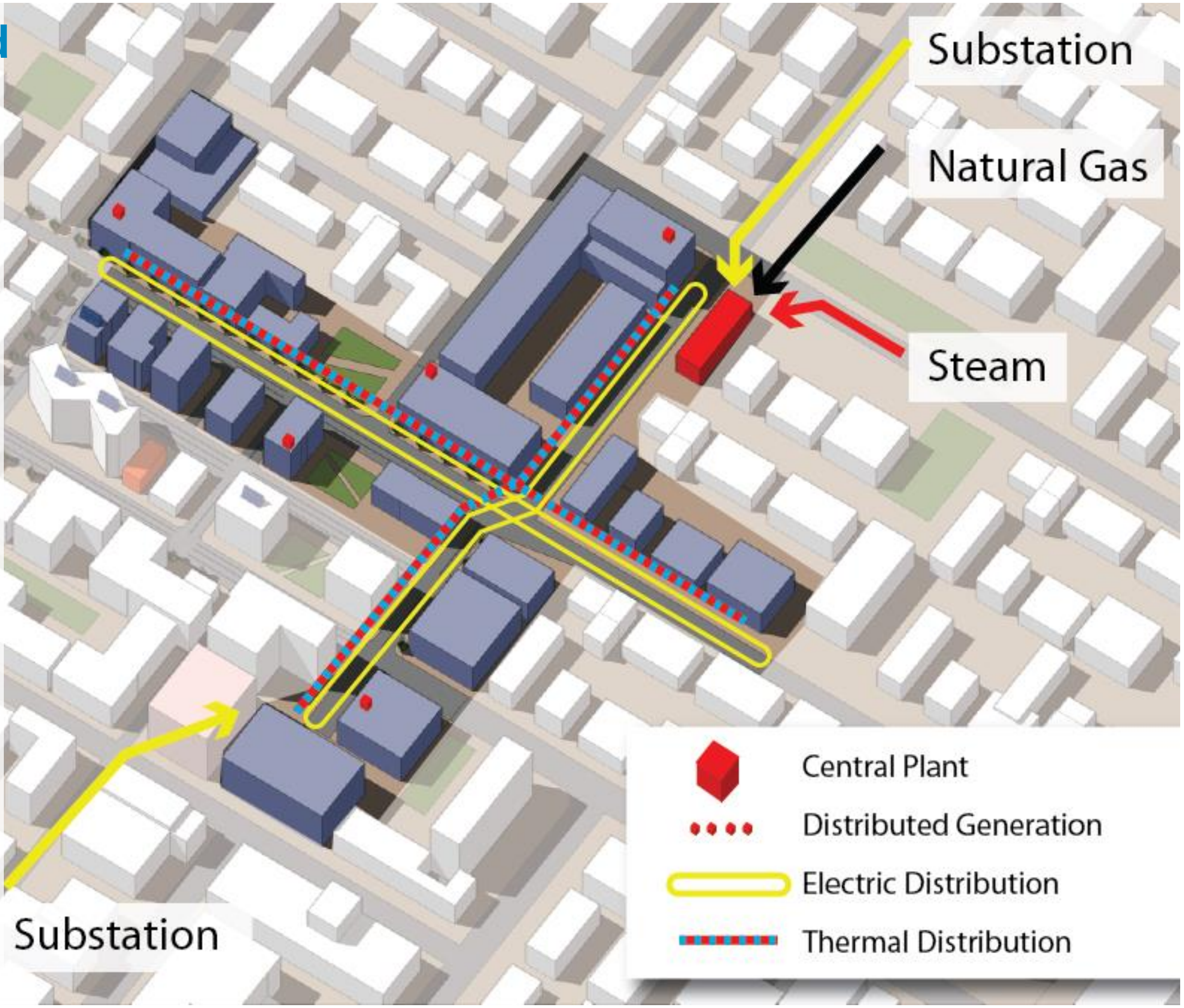
**Medical Campus Microgrid**
**6 Million Square Feet**
**70 Buildings**

| User | M sq-ft |
|---|---|
| Outpatient | 2.6 |
| Inpatient | 2.4 |
| Office | 1.0 |

**Peak Demand: 15.5 MW**

**Annual: 75,000 MWh**

**Thermal: 190,000 MMBtu/yr**



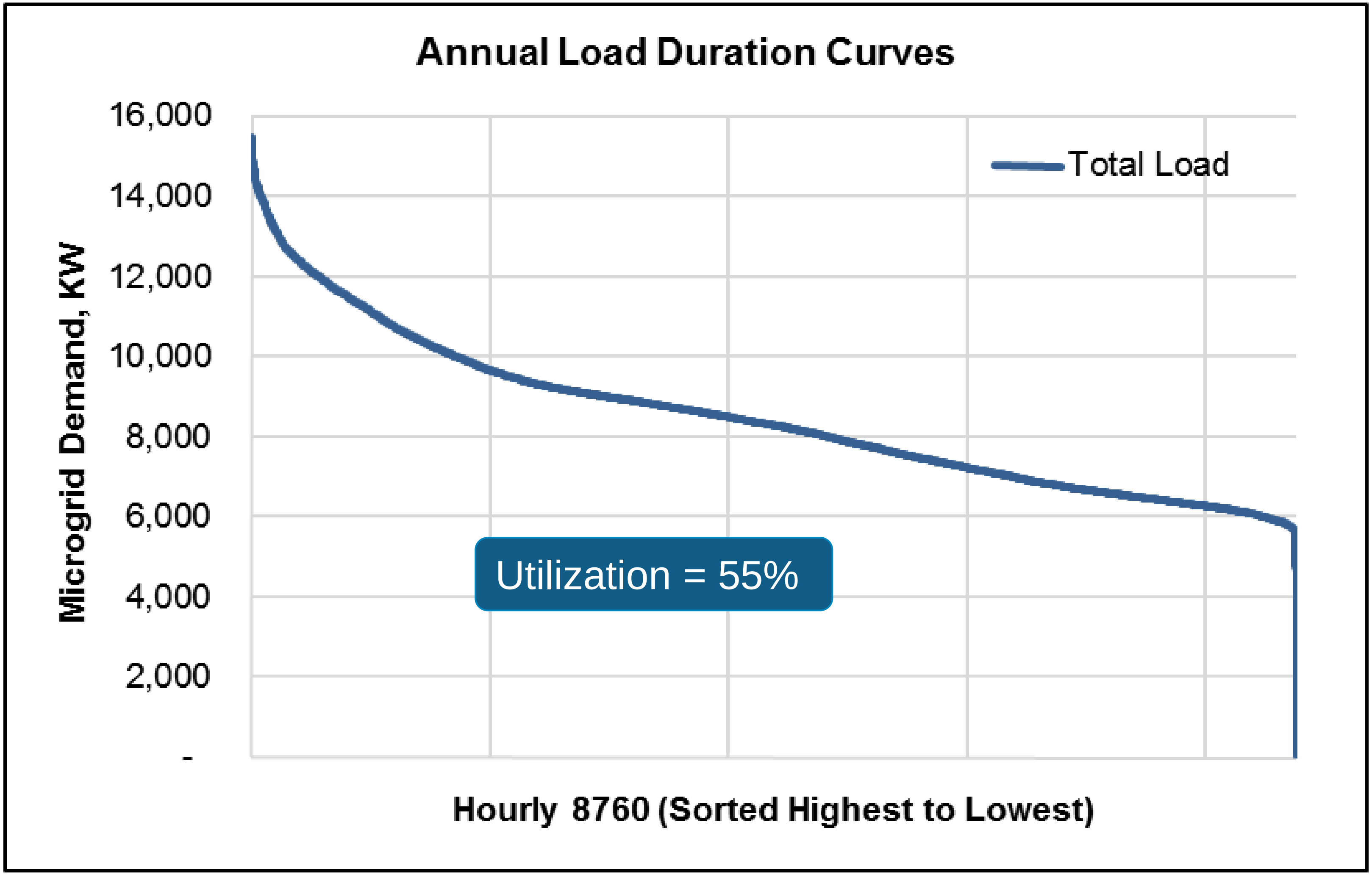
# Case Study Rates

## Scenarios & Assumptions (2015 prices)

| Description | CASE 1 NSTAR | CASE 2 NGRID |
|---|---|---|
| Demand Charge - Summer, $/kW-mo | 23 | 4 |
| Demand Charge – Winter, $/kW-mo | 18 | 4 |
| Standby Charge, $/kW-mo | 8.6 | 0 |
| T&D Charge On-Peak, $/MWh | 10 | 46 |
| T&D Charge Off-Peak, $/MWh | 6 | 38 |

| Description | CASE 1 | CASE 2 |
|---|---|---|
| Power Supply Cost, $/MWh | 75 / RTP | 69 / RTP |
| Natural Gas Fuel Cost, $/MMBtu | 7.5 | 7.5 |
| ISO Capacity Charge, $/kW-yr | 40.8 | 40.8 |

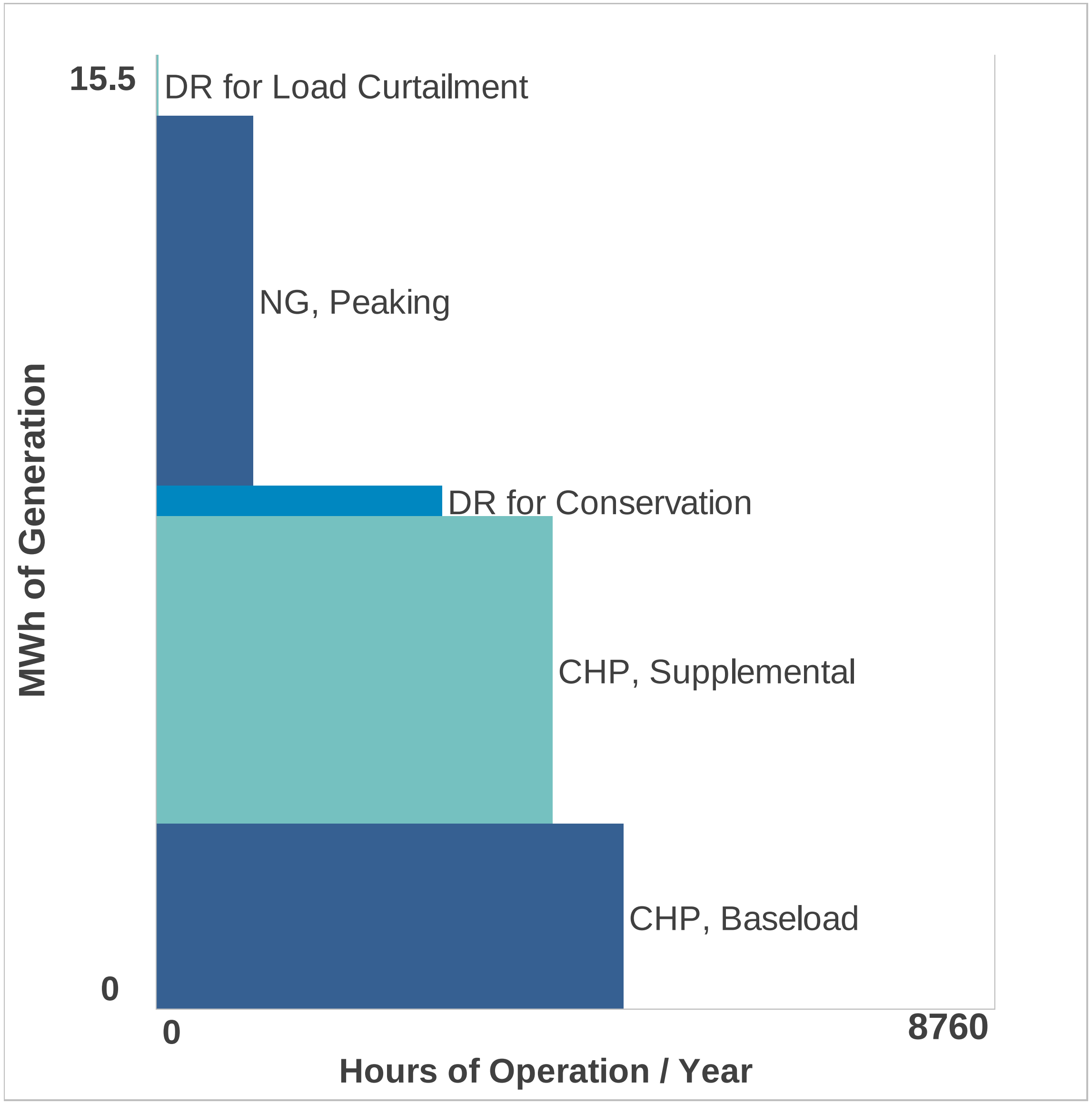
# Customer Annual Load Duration Curve



# Customer Baseline Annual Energy Costs

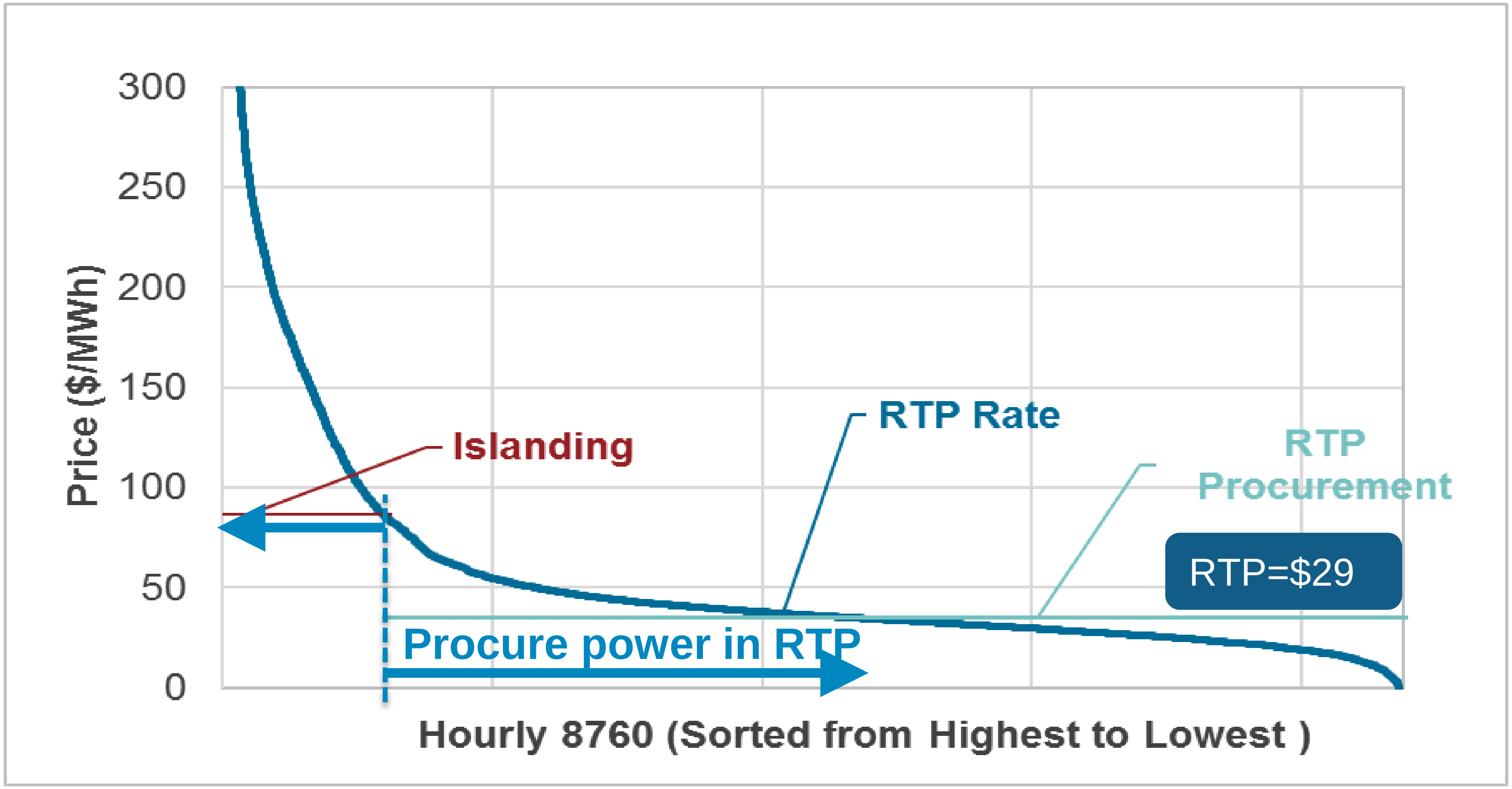
| Description | Sample Project 1 ($/MWh) | Sample Project 2 ($/MWh) |
|---|---|---|
| Thermal Energy | 21 | 21 |
| Electric Energy | 131 | 126 |
| Power Supply | 75 | 69 |
| Demand/Standby Charge | 40 | 8 |
| Capacity Charge | 8 | 8 |
| T&D | 8 | 41 |
| Power Factor | | |
| Power Quality Damage | | |
| Power Outage Costs | | |
| **Baseline Cost** | **152** | **147** |

# Microgrid Islanding & Price Response Capability




Typically Assets Installed Over a Phased Evolution

# RTP Price Duration Curve NE ISO Boston 2014



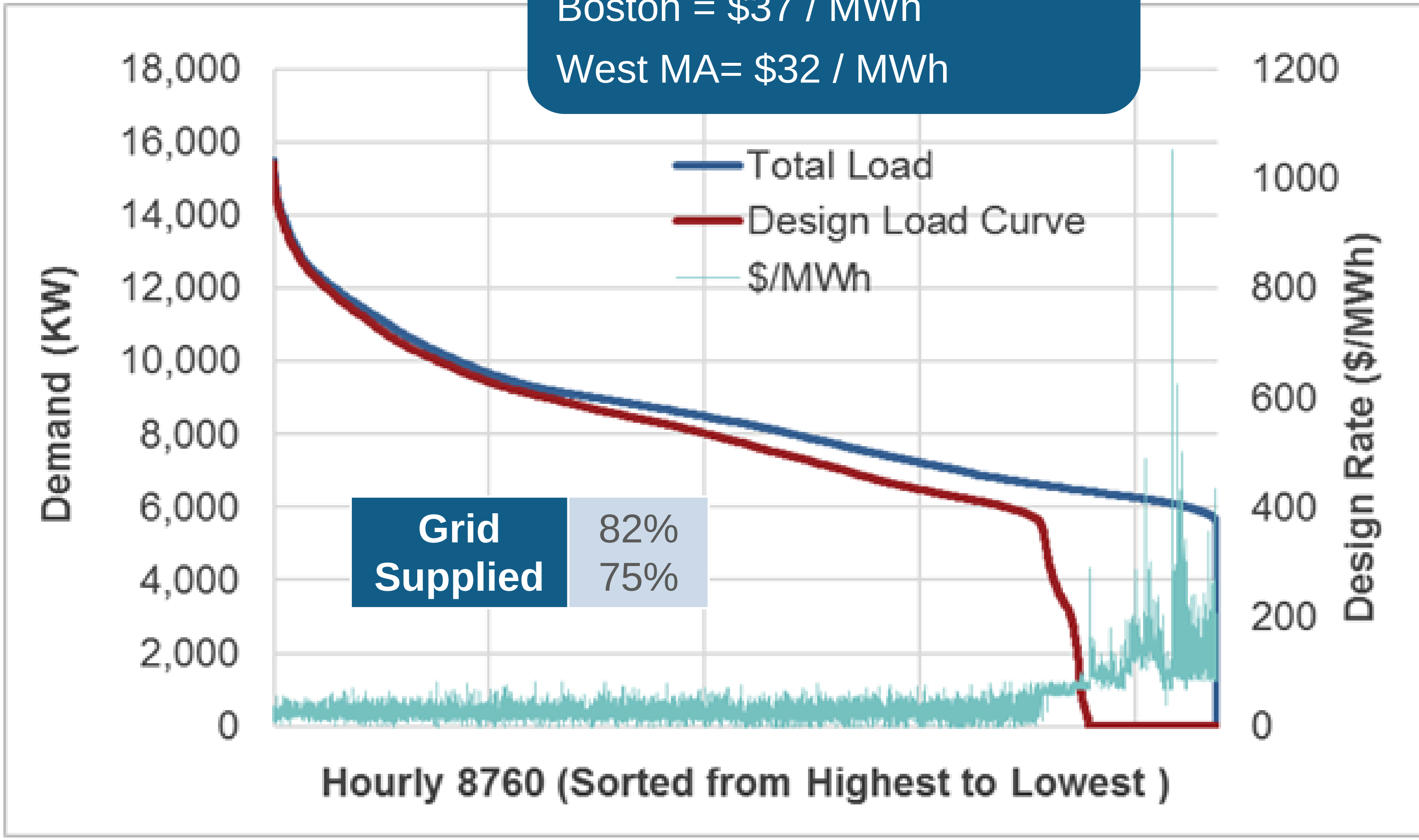
# Microgrid Operating Strategies Case 1

## Real-Time Procurement 2014

RTP Savings

Boston = $37 / MWh

West MA= $32 / MWh



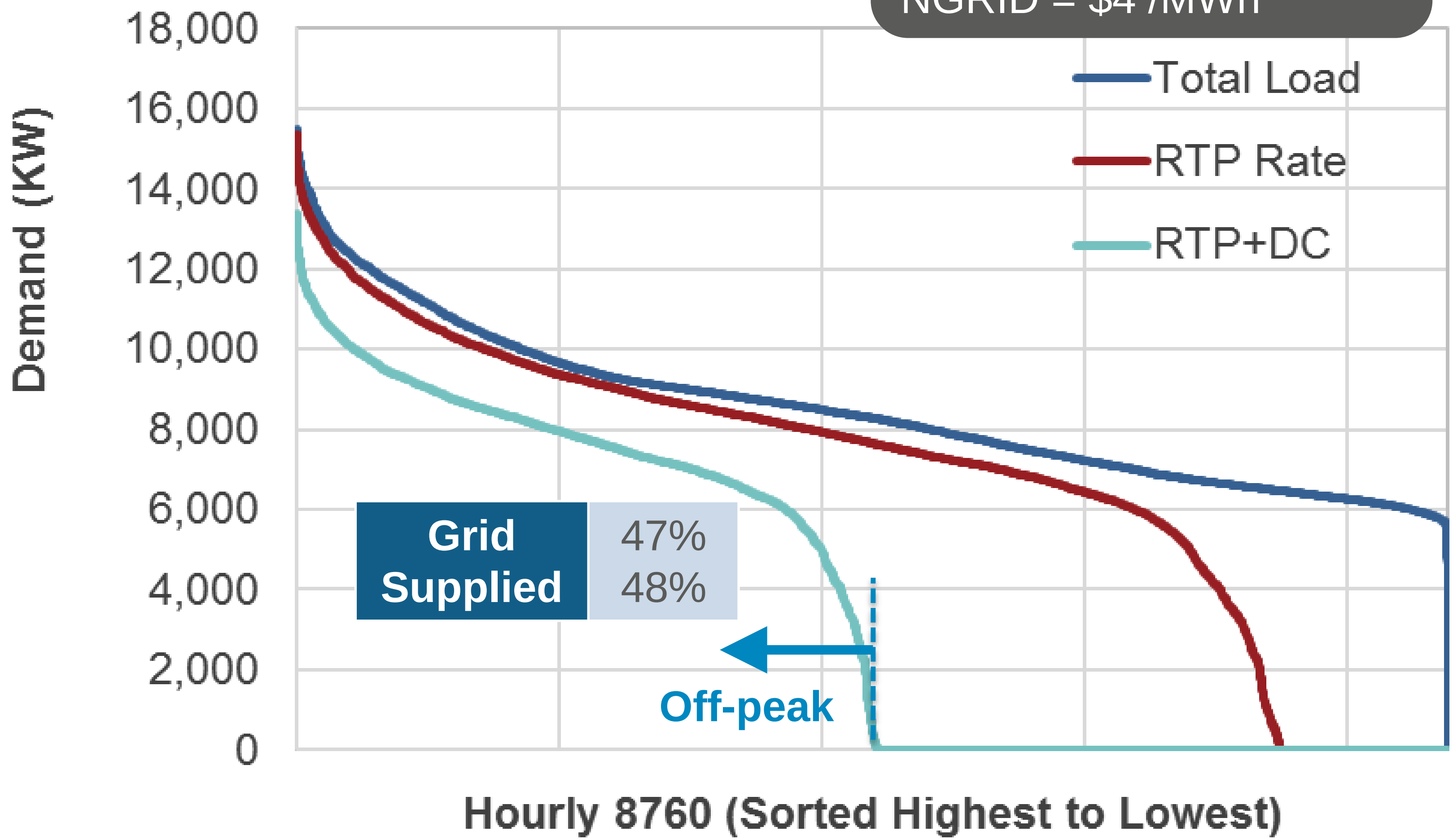
# Microgrid Operating Strategies Case 1

## Demand Charge Reduction

Demand Charge Savings

NSTAR = $12 / MWh

NGRID = $4 /MWh



# Microgrid Capital and Operating Costs

| Description | Capital Cost ($000±30%) | Generation O&M Cost | | SEI (MMBtu/MWh) | |
|---|---|---|---|---|---|
| | | Fixed ($/kW-yr) | Variable ($/MWh) | Min | Max |
| 3 MW Turbine & HRSG | 6,300 | 0 | 8 | 6 | 12 |
| 5 MW Cogeneration | 10,500 | 0 | 12 | 7 | 9 |
| 6 MW Reciprocating Engine | 9,500 | 0 | 12 | | 10 |
| 500 kW DR for Conservation | 500 | | | | |
| 1 MW DR for Load Curtailment | 1,000 | | | | |
| Master Controller | 800 | $150,000 in additional operating costs | | | |
| **Gross Project Cost*** | **29,680** | | | | |

# Microgrid Annual Savings and Payback

| Description | NSTAR | NGRID |
|---|---|---|
| **Baseline Cost** | **152** | **147** |
| Thermal Energy* | 6 | 6 |
| Power Supply* | 37 | 32 |
| Demand/Standby Charge* | 12 | 4 |
| Capacity Charge* | 5 | 5 |
| Electric Distribution* | 3 | 15 |
| Ancillary Service | 1 | 1 |
| Energy Storage | 1 | 1 |
| Demand Response | 3 | 2 |
| Microgrid Operations | (2) | (2) |
| **Savings** | **66** | **64** |
| **% Savings** | **43%** | **44%** |
| **Simple Payback** | **6.0** | **6.2** |

* Includes generation fuel and O&M costs

# Utility Revenue Losses

| Description | NSTAR | NGRID |
|---|---|---|
| **Baseline Utility Revenue/Losses** | **48 / 26** | **49 / 25** |
| Demand/Standby Charge* | 40 / 22 | 8 / 8 |
| Electric Distribution* | 8 / 4 | 41 / 17 |
| **% Lost Revenue** | **54%** | **51%** |
| **Utility Cost in $/kW-yr** | **$125** | **$115** |

- After five years, apply standby charge to recoup losses while offering ancillary service payments for demand response / peak load management.

# Utility Dynamic Rate Optimization

- Continue to utilize standby charge to limit overall DER investment
- Utilize targeted dynamic rates and standby waiver (e.g. five years) to attract investment
  - Essential / critical service
  - Substations nearing capacity limits or for solar PV / PEV
  - Targeted ancillary service payments for demand response / peak load management
  - Transition to dynamic distribution rates, demand based rates, and dynamic demand charges

# Utility Microgrid Outcomes and Benefits

- Utilize self-healing distribution to enable two-way power flow and load shifting
- Leverage utility master controller and customer DER to increase utilization, defer capital costs, and provide for real-time load management and movement
- Targeted dynamic pricing to encourage investment in DER to create a price responsive or elastic distribution system that:
  - Lowers wholesale prices
  - Protects essential / critical service

# QUESTION AND ANSWER