ENERGY EFFICIENCY AND ENVIRONMENT | RELIABILITY, POWER QUALITY AND SAFETY | ENABLING CUSTOMER ACTION | OPERATIONAL EFFECTIVENESS

PEER

Performance
Excellence in
Electricity
Renewal

Defining Sustainable Power

Leveraging a Microgrid Approach

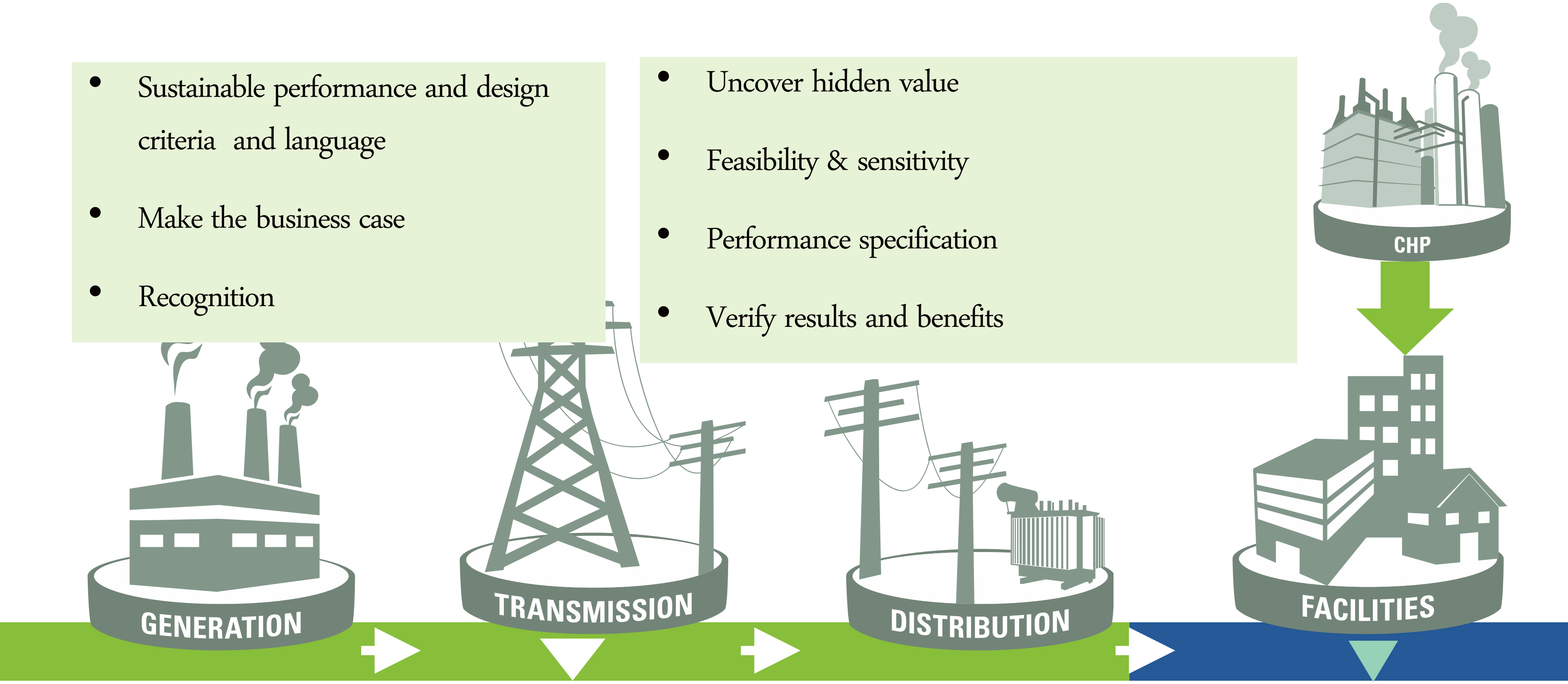
PERFECT POWER INSTITUTE

DEFINING SUSTAINABLE POWER

Sustainable design and assessment systems like LEED and PEER™ transform industries and stimulate innovation:

- Sustainable performance and design criteria and language
- Make the business case
- Recognition

- Uncover hidden value
- Feasibility & sensitivity
- Performance specification
- Verify results and benefits



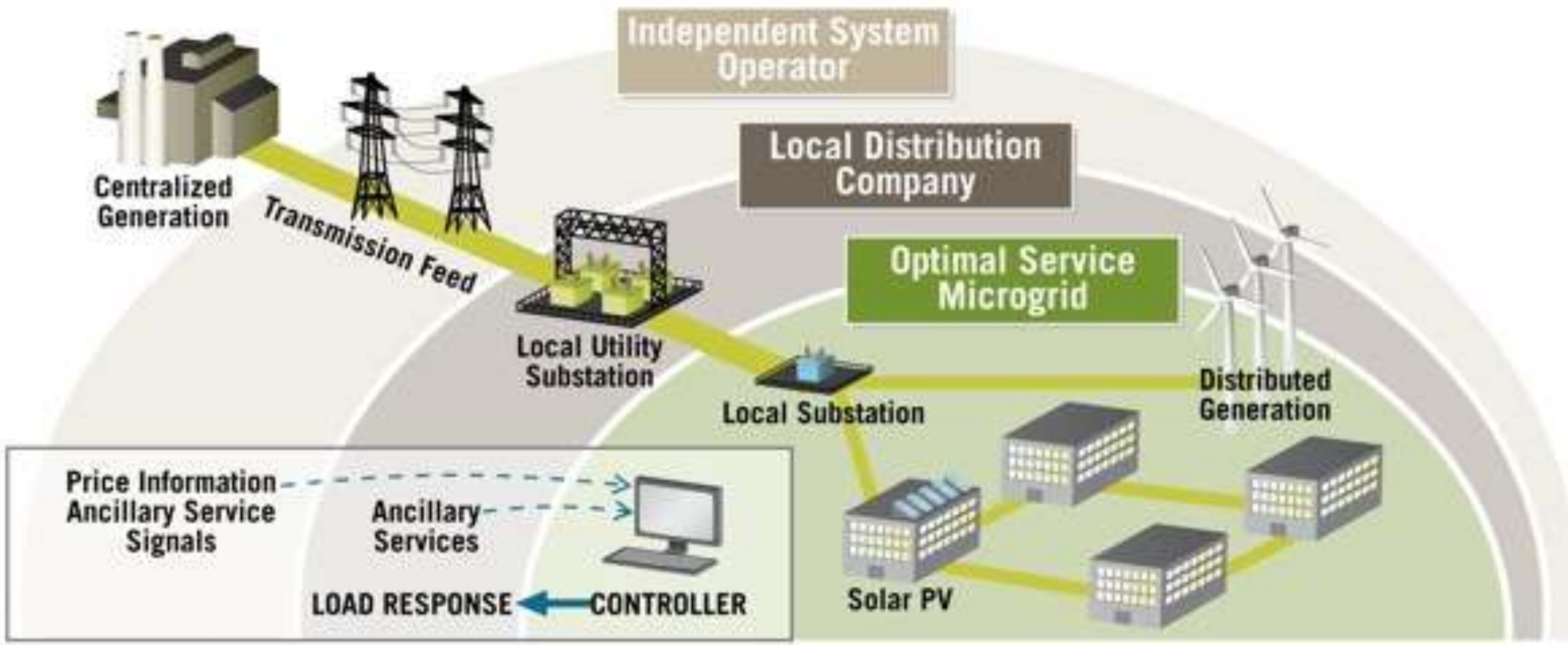
PPI PEER ™

LEED, Energy Star, BPI

WHERE TO START? MICROGRID APPROACH

Buildings ▶ Microgrids ▶ Utility ▶ ISO

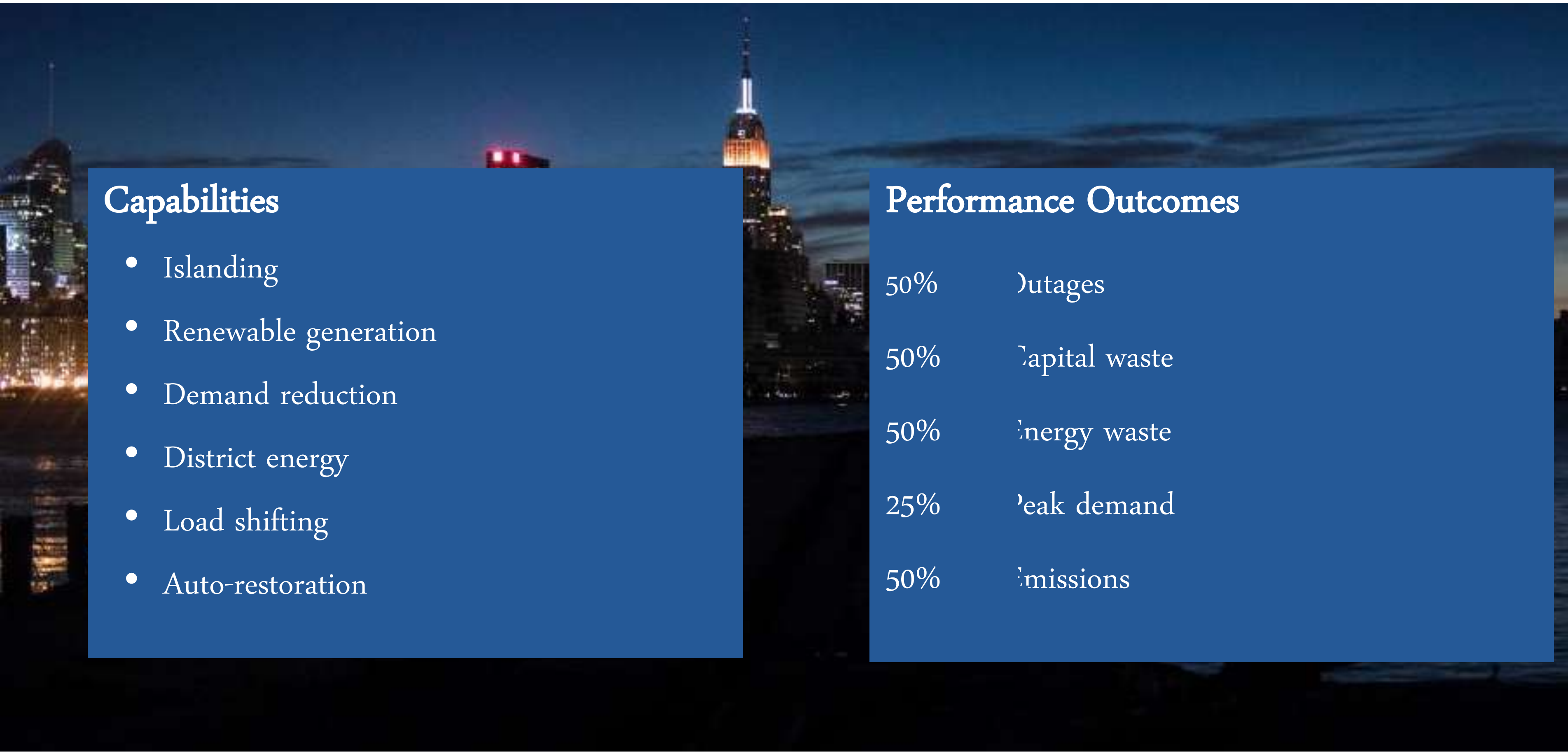
- Cities/Utilities
- Private – campus, developments, network of buildings



Optimal Service Microgrids help utilities achieve higher levels of performance by responding to signals and providing value-added services back to the bulk grid.

PERFECT POWER INSTITUTE

Microgrids connect buildings to provide sustainable power, as well as, key customer and grid services.



Capabilities

- Islanding
- Renewable generation
- Demand reduction
- District energy
- Load shifting
- Auto-restoration

Performance Outcomes

50%	Outages
50%	Capital waste
50%	Energy waste
25%	Peak demand
50%	Emissions

DEFINING SUSTAINABLE/SECURE POWER

Performance Excellence in Electricity Renewal™

ENERGY EFFICIENCY AND ENVIRONMENT

Promote energy efficiency and environmental responsibility

ENABLING CUSTOMER ACTION

Engage customers as partners and investors in sustainable power

PEER

SECURITY

Ensure the reliability, power quality and safety of electricity

RELIABILITY, POWER QUALITY, AND SAFETY

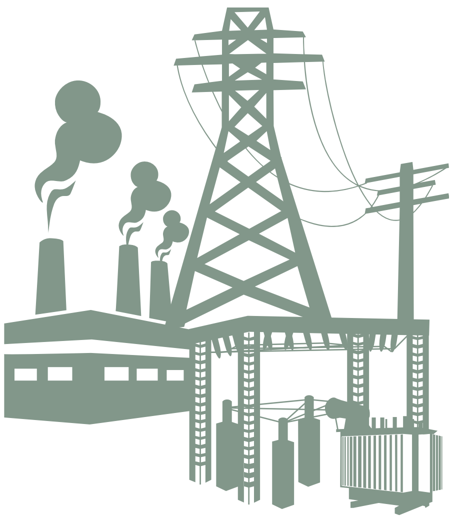
Identify and eliminate waste to get more value out of investments

OPERATIONAL EFFECTIVENESS

SUSTAINALBE POWER BUILDING BLOCKS

Programs & Processes	Financing; Identify & Eliminate Waste; Risks Analysis; Procurement; Aggregation; FMEA; Financing
Capabilities	Net Metering; Underground; CHP; Supply Choice; Smart Switch; Looping; Dist. Energy; Load Shift; **Black Start**; **Islanding**; **Solar**; Ancillary Services; Auto Transfer; Storage
Metrics	DR Capability; Value/Gap; MAIFI; PQ; CO_2/NOx/SOx; % Ren. & CHP; Load Curve; SAIDI/SAIFI; SEI
Prerequisites	Dyn. Price; Data Privacy; Cyber Security; RPS; AMI/SCADA; Improvement Plan; Safety; Local Air Permit
Customer Requirements	C — O — R — E

Value and Gap



Baseline
PERFORMANCE

VALUE

Quantify value of service that project microgrid provides for the bulk grid

Improved
PERFORMANCE

GAP

Quantify the gap in performance, provide justification for investment and path for improvement

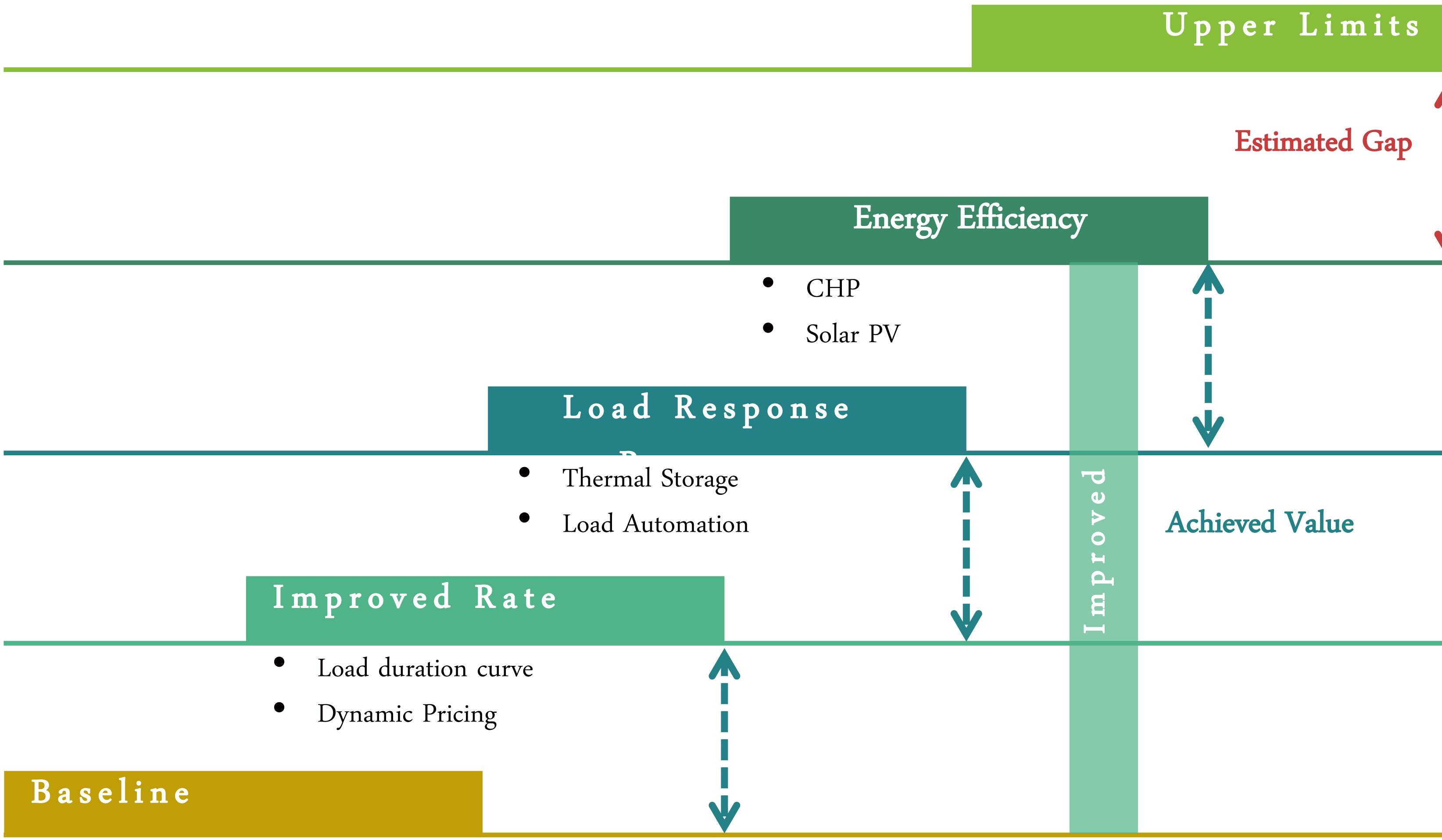
Upper Limits
OF PERFORMANCE

Definition for upper limits of grid performance

The ultimate measure of perfection is that our electric system does no harm – economic, social or environmental.

- Paul O'Neill

CLOSING THE GAP = COST SAVINGS



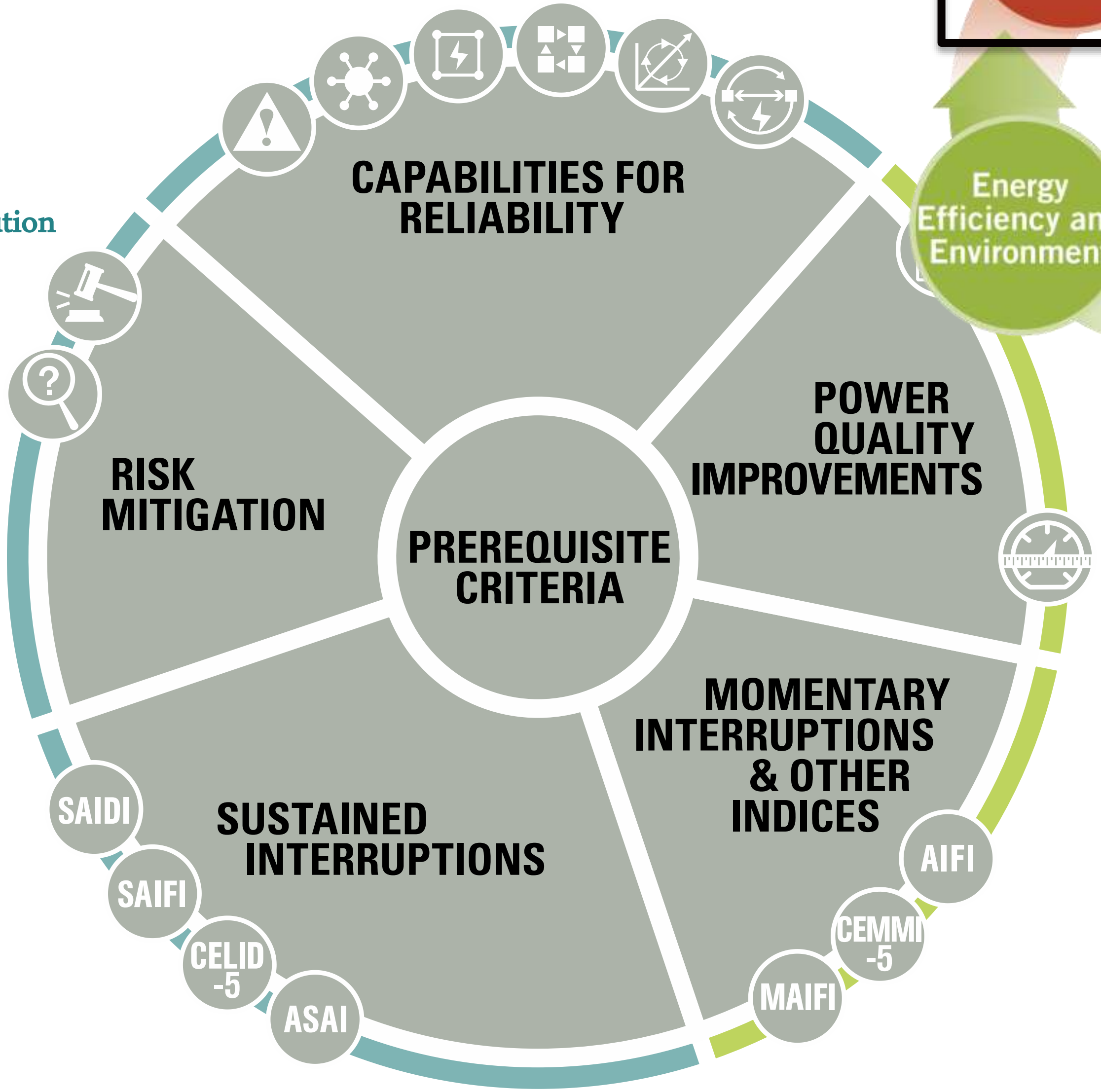
Value (50,000 MWh/10MW)

Performance Criteria	Baseline	Current	Factors	Value
Price, $/MWh	45	30	Real-Time	$750,000
Demand Charge	10	7	$14/kW/mo	$504,000
Source Energy, MMBtu/MWh	9.2	5.3	$4/ MMBtu	$780,000
				$2,034,000

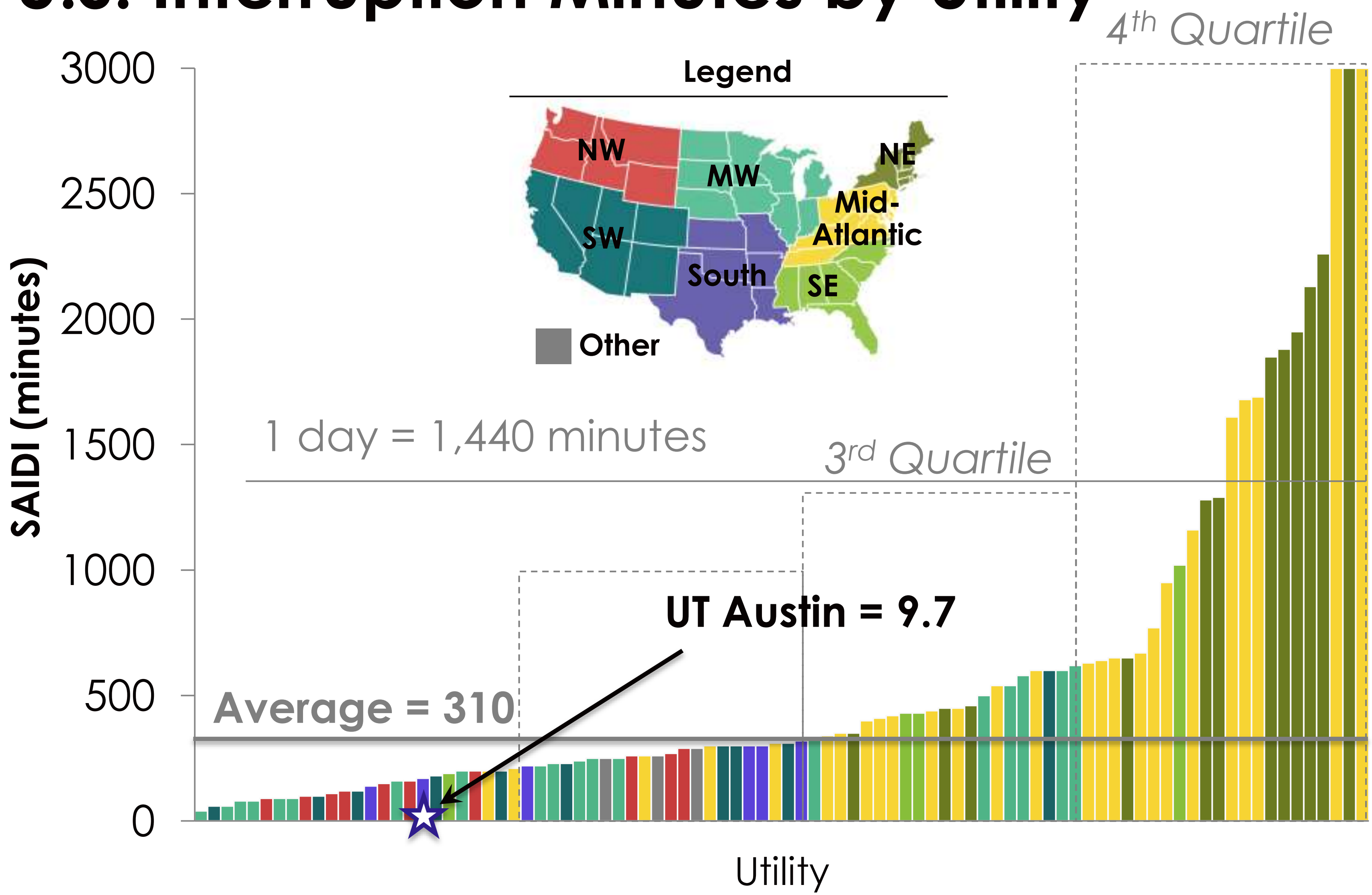
RELIABILITY PERFORMANCE CRITERIA

Capabilities

- Islanding
- Redundant Supply
- Redundant Distribution

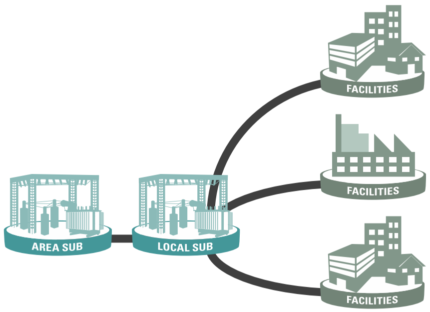


U.S. Interruption Minutes by Utility

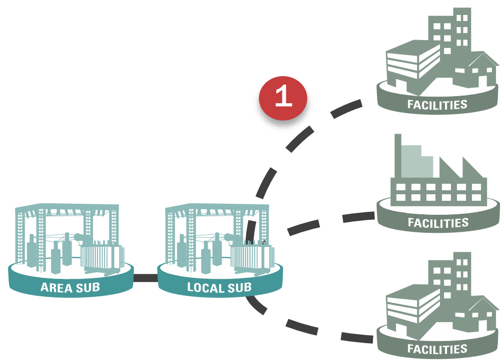


Data source: IEEE 2011, http://grouper.ieee.org/groups/td/dist/sd/doc/

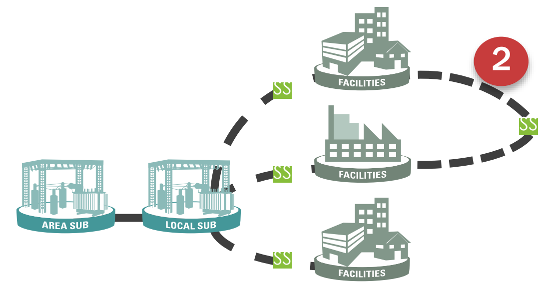
Microgrid Capabilities - Reliability



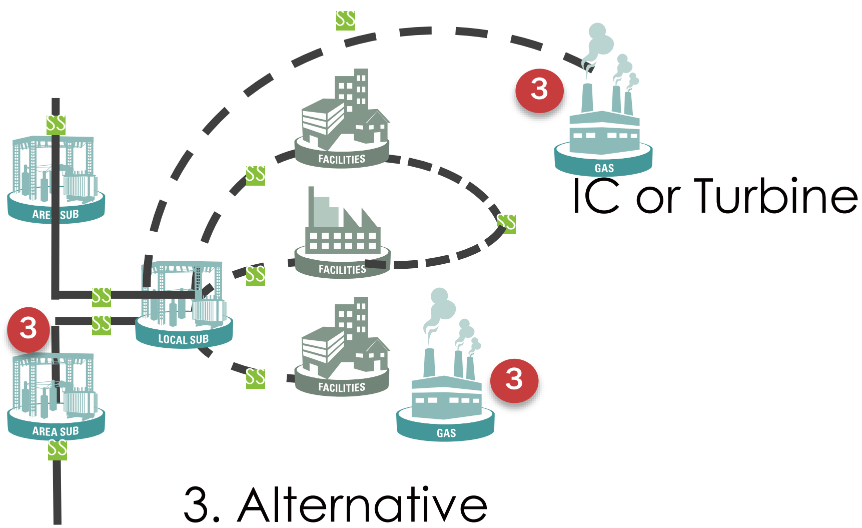
0. Baseline



1. Undergrounding



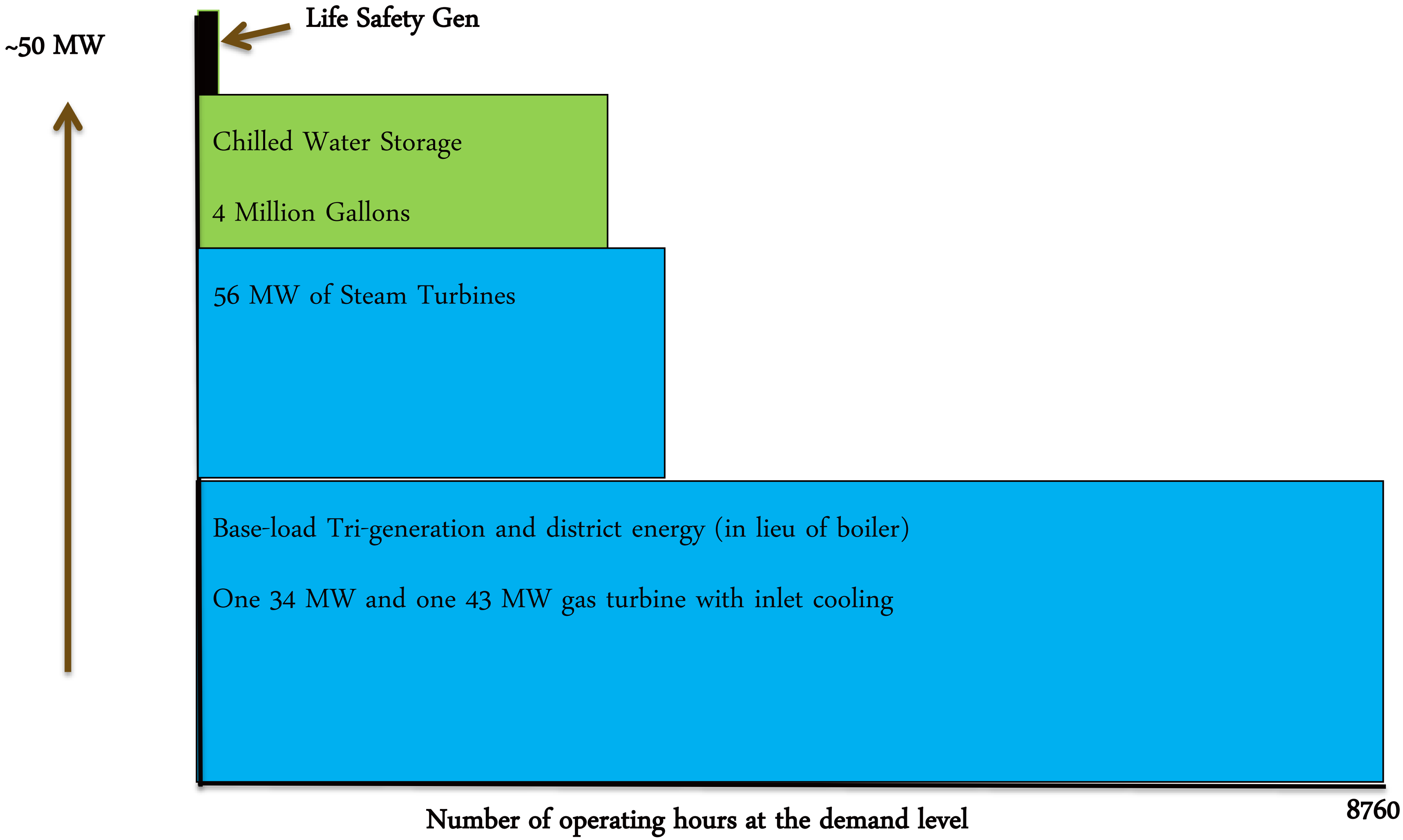
2. Distribution Redundancy



3. Alternative Sources of Supply

4. Islanding

Islanding Capability



Power Oases Certification

- Life-safety diesels is not sufficient (i.e. immediate response – hours, egress emergency lights)
- Power Oases will be recognized for providing critical community and grid service
- Receive credit for powering entire building or campus for weeks to assist with recovery services
- Receive credit for providing grid service during normal grid operation (e.g. price/demand response, power quality)
- Demonstrate protection from threats

- **Police/Fire**
- **Medical Center**
- **Assisted Living**
- **Schools**
- **Communications**
- **Shelters**
- **Hotels**
- **Fuel Stations**
- **Water, Waste Water, Flood Protection**
- **Residential Towers**

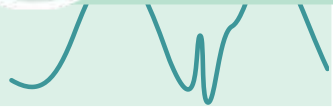
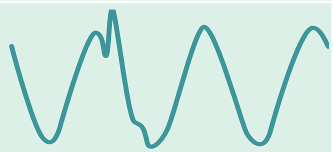
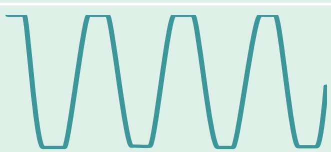
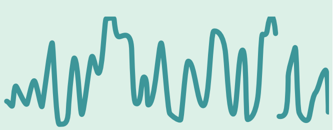
Power Quality Measurements

SCORING BONUS POINTS

UP TO 5 POINTS

CRITERIA DEFINITION

Metrics that describe the electric power that drives an electric load and the load's ability to function properly

	Transients	discharge, load or capacitor switching	filters, isolation transformers
	Oscillatory Transients	Line/ cable switching, capacitor or load switching	Surge Arrestors, filters, isolation transformers
	Sags / Swells	Remote systems, faults	Ferroresonant transformers, energy storage
	Undervoltage/ Overvoltage	Motor starting, load variations, load dropping	Voltage regulators, Ferroresonnant transformers
	Harmonic Distortions	Nonlinear loads, system resonance	Active or passive filters, transformers with cancellation
	Voltage Flicker	Intermittent loads, motor starting, arc furnaces	Static VAR compensator

- Critical to digital processes
- Delicate manufacturing equipment
- Sensitive testing and industrial processes

RULE OF THUMB
Keep Impact Loads
$\Delta VAR < 15\% \ VA_{short\_circuit}$

Failure Modes and Effects Analysis (FMEA)

Item	Failure	Cause	Local Effect	System Effect	Probability	Severity	Detection	Mitigation
Substation #2 Overcurrent device to Circuit #9	Overcurrent protection device opens on high load	High loads on Circuit 9 due to recent additional loads added	Circuit #9 automatically switches to supply from Substation #4	Added load on Substation #4 exceeds capacity and trips regional protection device for area-wide black-out	Moderate Recent load additions have increased this probability	HIGH Commercial customers value their operations at $15 million per outage.	Power readings at Substation #2 for Circuit #9.	Build more capacity into Circuit #9. Subdivide Circuit #9 with other feeds. Establish DR program.

- Identify ALL possible failures in every component, assembly and sub system of the system.
- Determine how to Mitigate the failure
- Prioritize list and take action

Probability					
5 Certain	Low	Moderate	High	Extreme	Extreme
4 Likely	Low	Moderate	High	High	Extreme
3 Possible	Low	Moderate	Moderate	High	High
2 Unlikely	Low	Low	Moderate	Moderate	Moderate
1 Rare	Low	Low	Low	Low	Low
	1 Insignificant	2 Minor	3 Significant	4 Major	5 [illegible]

Severity

Power System Reliability Engineering References:

- IEEE 3006 Series Power System Reliability (formerly IEEE gold Book)
- IEC 60812 Analysis techniques for system reliability - Procedures for FMEA

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Reliability Summary and Score

UT Austin Results

Reliability, Power Quality and Safety

Criteria		Max Points	Points
Sustained Interruptions		25	23.0
Momentary and Other Interruption Indices (bonus criteria)		10	0.0
Capabilities for Reliability		55	43.0
Power Quality Improvement (bonus criteria)		10	5.0
Risk Mitigation		20	14.0
Innovations (bonus criteria)		5	4.5
Core Points		**100**	**80.0**
Bonus Points	(Limited to 15 points)	**15**	**9.5**
Subtotal	(Limted to 100 points)		**89.5**

Highlights:

- 3 year average ASAI of 0.999982
- Distribution Looping and Alternative Feeds
- Islanding Capability
- Power Resiliency for Essential Services
- Risk Mitigation – Moved critical pumps above flood plain

Reliability Benefits – Ice Calculator

UT Austin:

- 50,000 residential customers
- 155 commercial customers
- SAIDI and SAIFI based on three year average

Reliability Savings		
	Baseline	**UT Austin**
SAIDI	**310.0**	**9.7**
SAIFI	**1.600**	**0.040**
LBNL Reliability Cost ($)	**$ 1,523,538**	**$ 48,278**
Reliability Savings ($)		**$ 1,475,260**

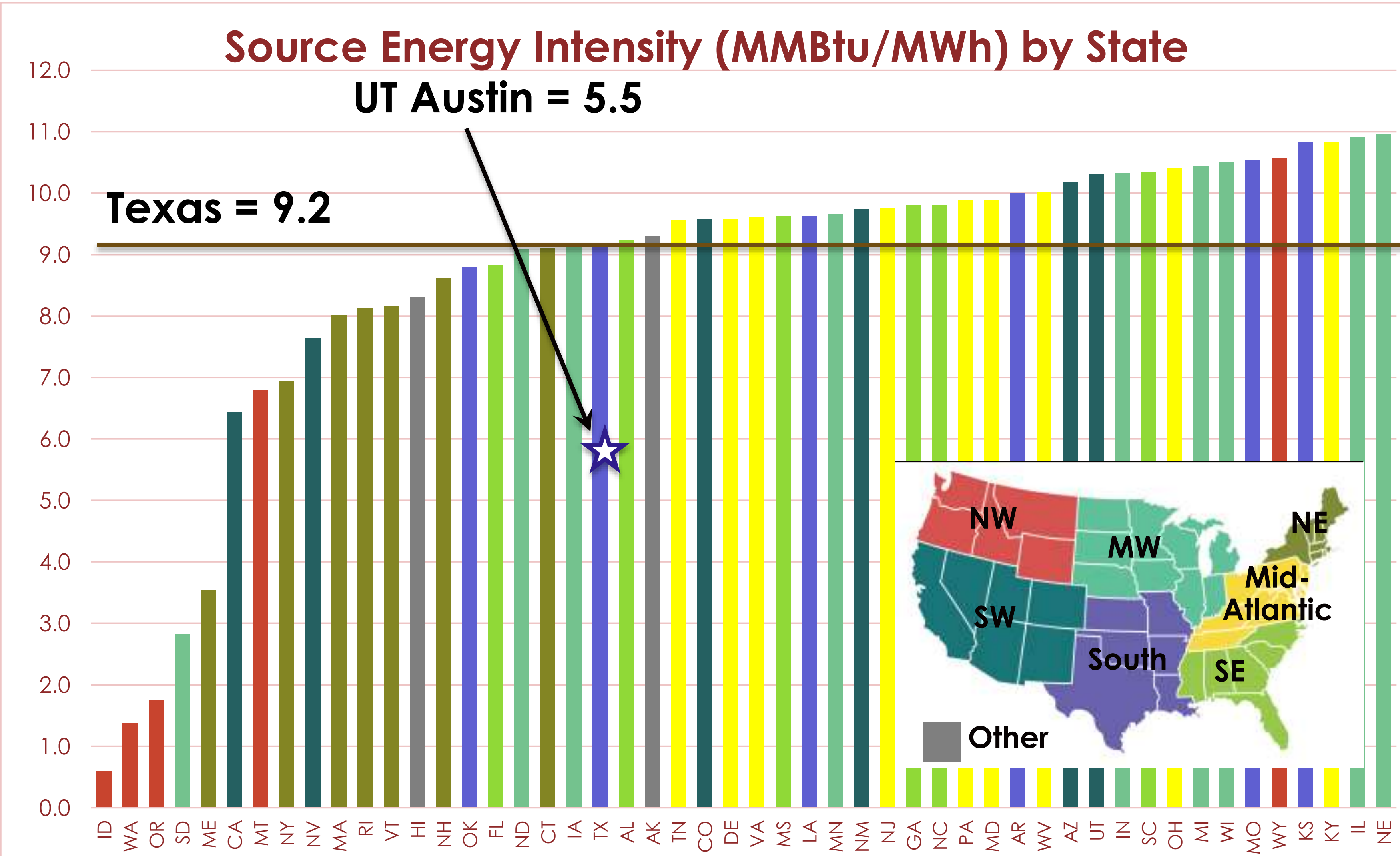
ENERGY EFFICENCY AND ENVIRONMENTAL Performance Criteria

- Efficiency (SEI) *MMBtu/MWh*
- Emissions
  - CO_2e, NOx, SO_2 *lb./MWh*
- Water *gal/MWh*
- Solid Waste *% Recycled*

Capabilities:

- Local clean power (e.g. solar, cogeneration)
- Renewable energy credits, REC's
- Environment improvements (e.g. aesthetics)

Energy Efficiency



Environmental Metrics and Benefits

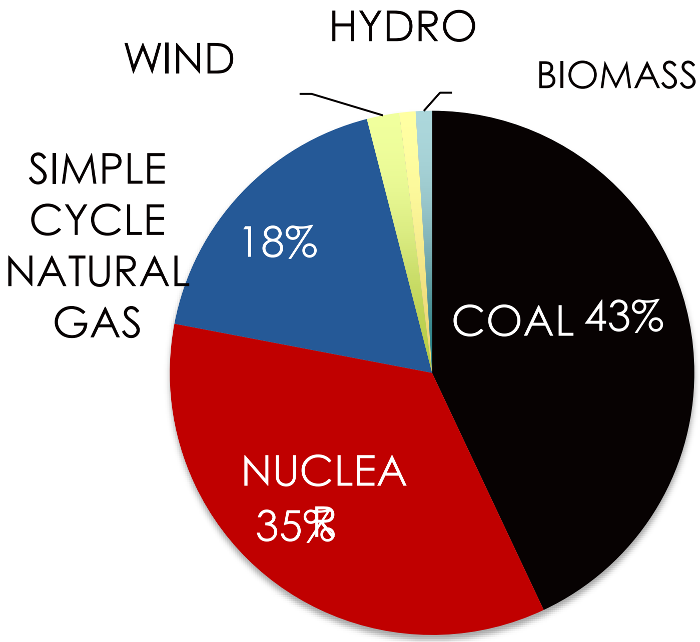
	United States	Texas (benchmark)	UT Austin
CO_2 Intensity (lb/MWh)	1391	1565	775
NO_x Intensity (lb/MWh)	1.37	1.12	1.29
SO_2 Intensity (lb/MWh)	2.77	2.18	0.02
Water Usage (gal/MWh)	487	332	106
Waste (% Recycle)	55.3	69.9	100

Benefits

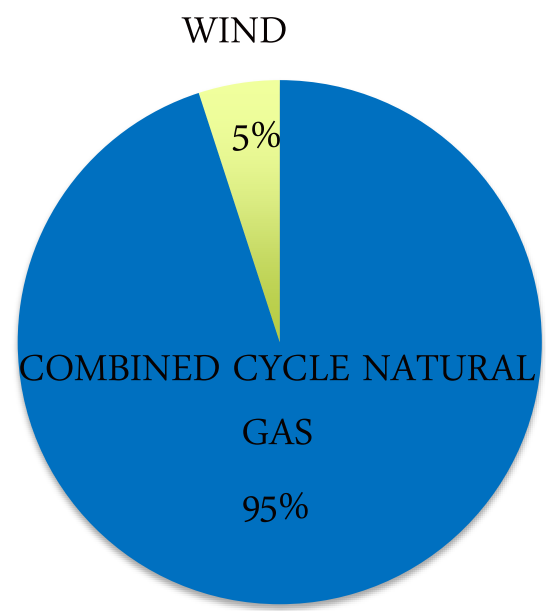
- Energy Efficiency Savings Equivalent to 12,000 Net Zero Homes
- CO_2 Savings Equivalent to taking 26,500 automobiles off the road

LEVERAGING PROCURMENT EXAMPLE

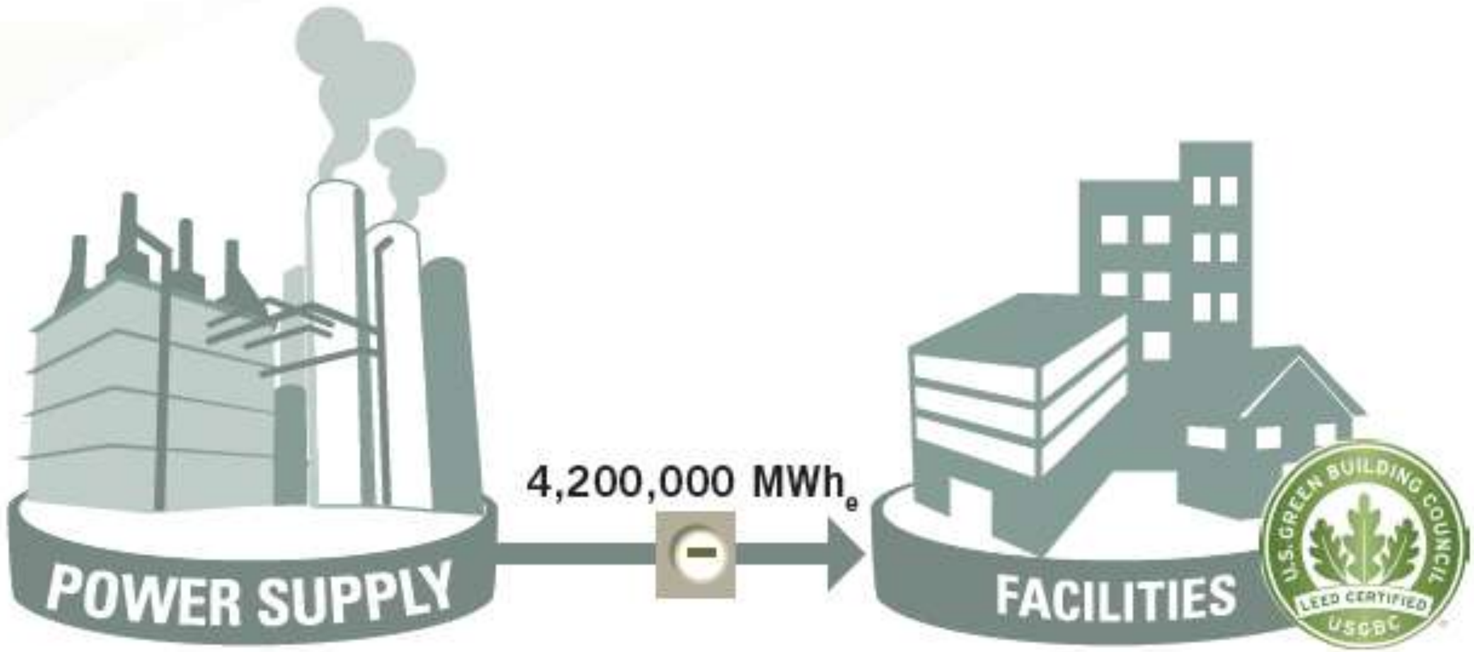
Illinois Power Agency Default Electricity Mix



Chicago Electricity Mix



Chicago CCA Energy Efficiency Benefit



ENERGY CONSUMED				SEI RATIO
BEFORE	~	13,000,000 MWh$_s$	(SEI 10.5)	3 : 1
AFTER	~	9,200,000 MWh$_s$	(SEI 7.5)	2 : 1
SAVINGS	~	3,800,000 MWh$_s$		

units of input fuel to deliver one unit of electricity

SEI Ratio = SEI / 3.4

MWh_{Source} = SEI Ratio * MWh_e

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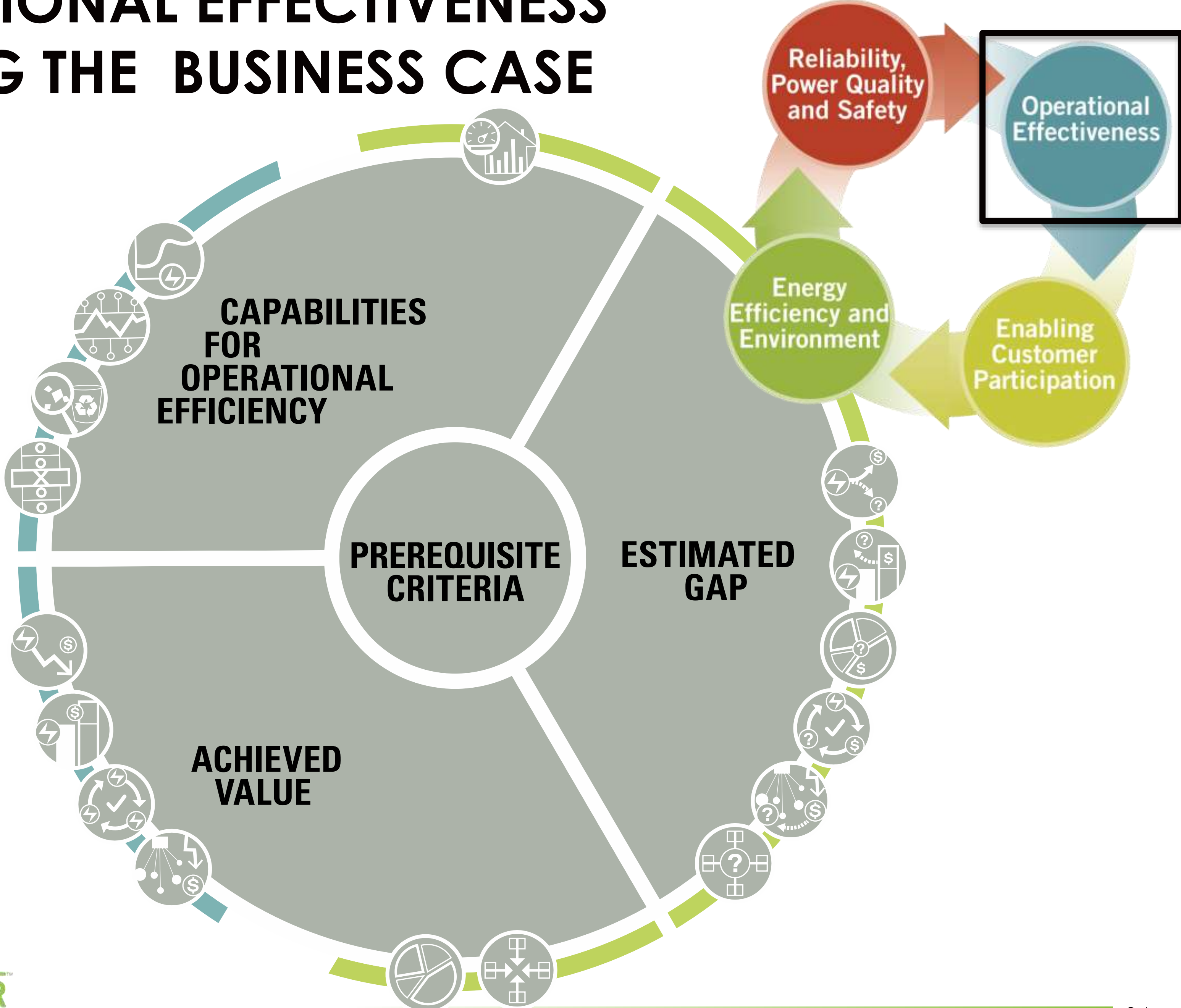
OPERATIONAL EFFECTIVENESS
MAKING THE BUSINESS CASE

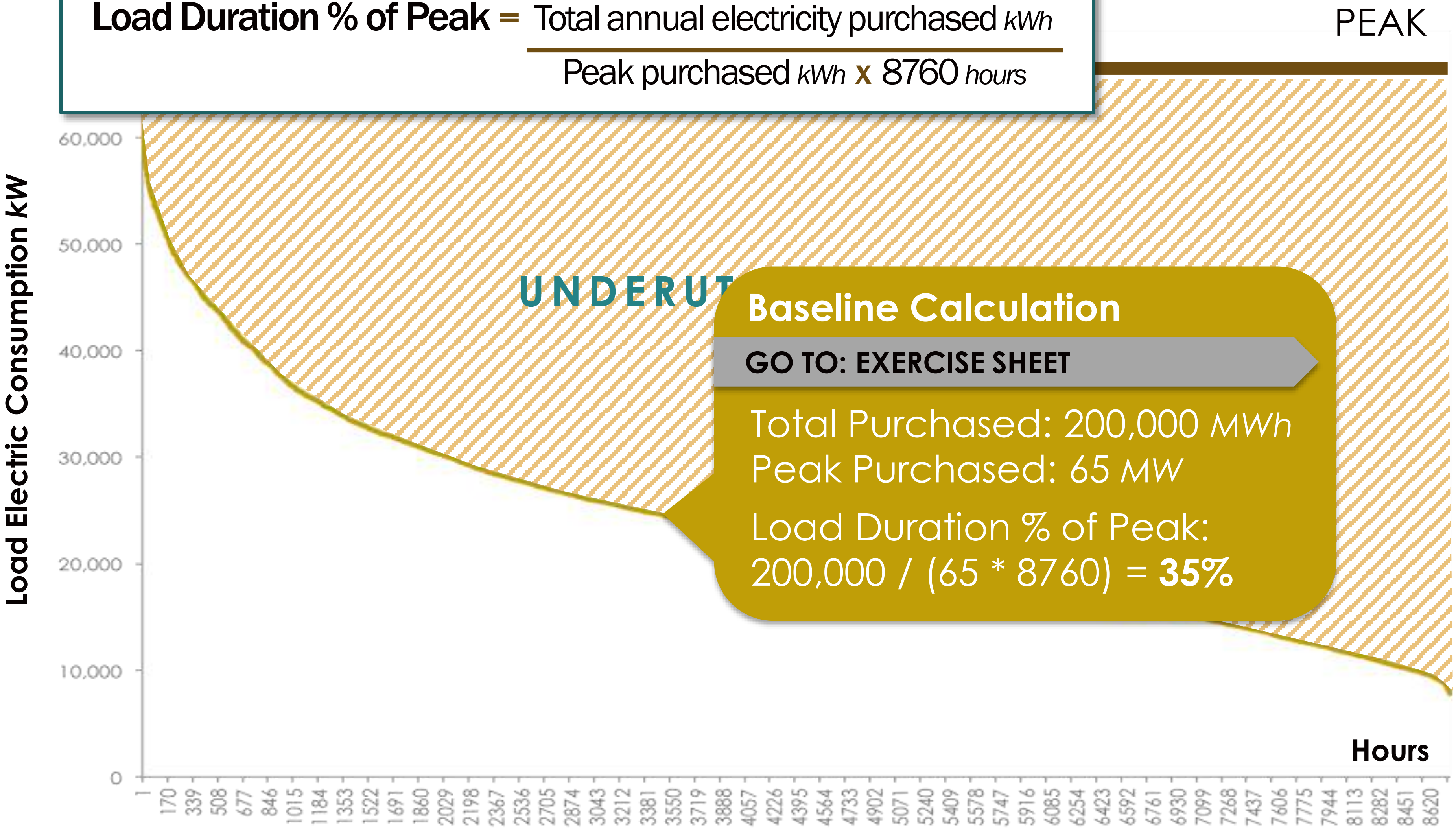
Capabilities

- Load Curve
- Demand Response
- Price Response



Load Duration Curve

$$\textbf{Load Duration \% of Peak} = \frac{\text{Total annual electricity purchased } kWh}{\text{Peak purchased } kWh \times 8760 \text{ hours}}$$



Baseline Calculation

GO TO: EXERCISE SHEET

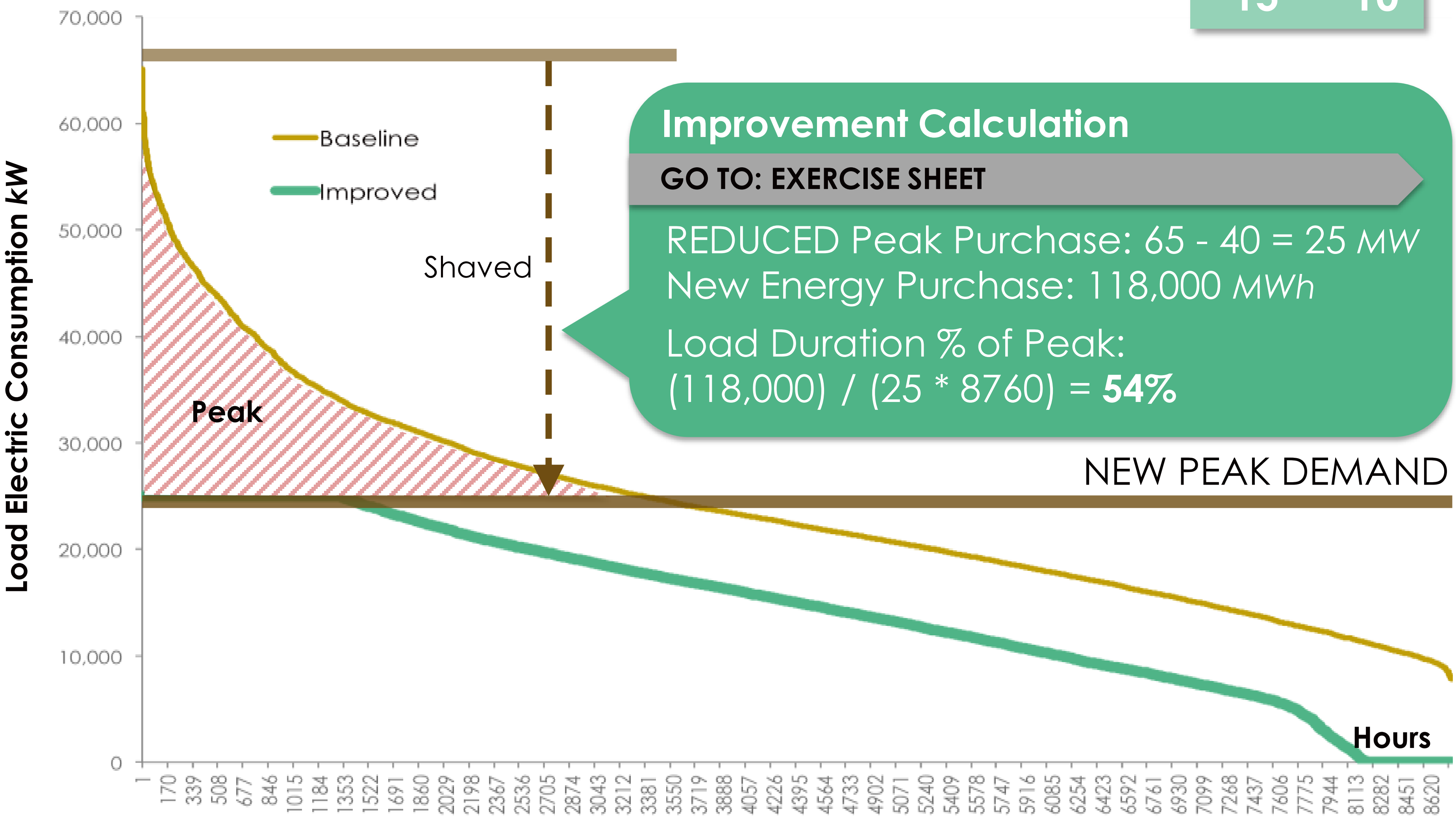
Total Purchased: 200,000 *MWh*
Peak Purchased: 65 *MW*

Load Duration % of Peak:
200,000 / (65 * 8760) = **35%**

Load Duration Curve – Improved

SCORING
PEER CORE

CAMPUS	CITY
15	10



Improvement Calculation

GO TO: EXERCISE SHEET

REDUCED Peak Purchase: 65 - 40 = 25 *MW*

New Energy Purchase: 118,000 *MWh*

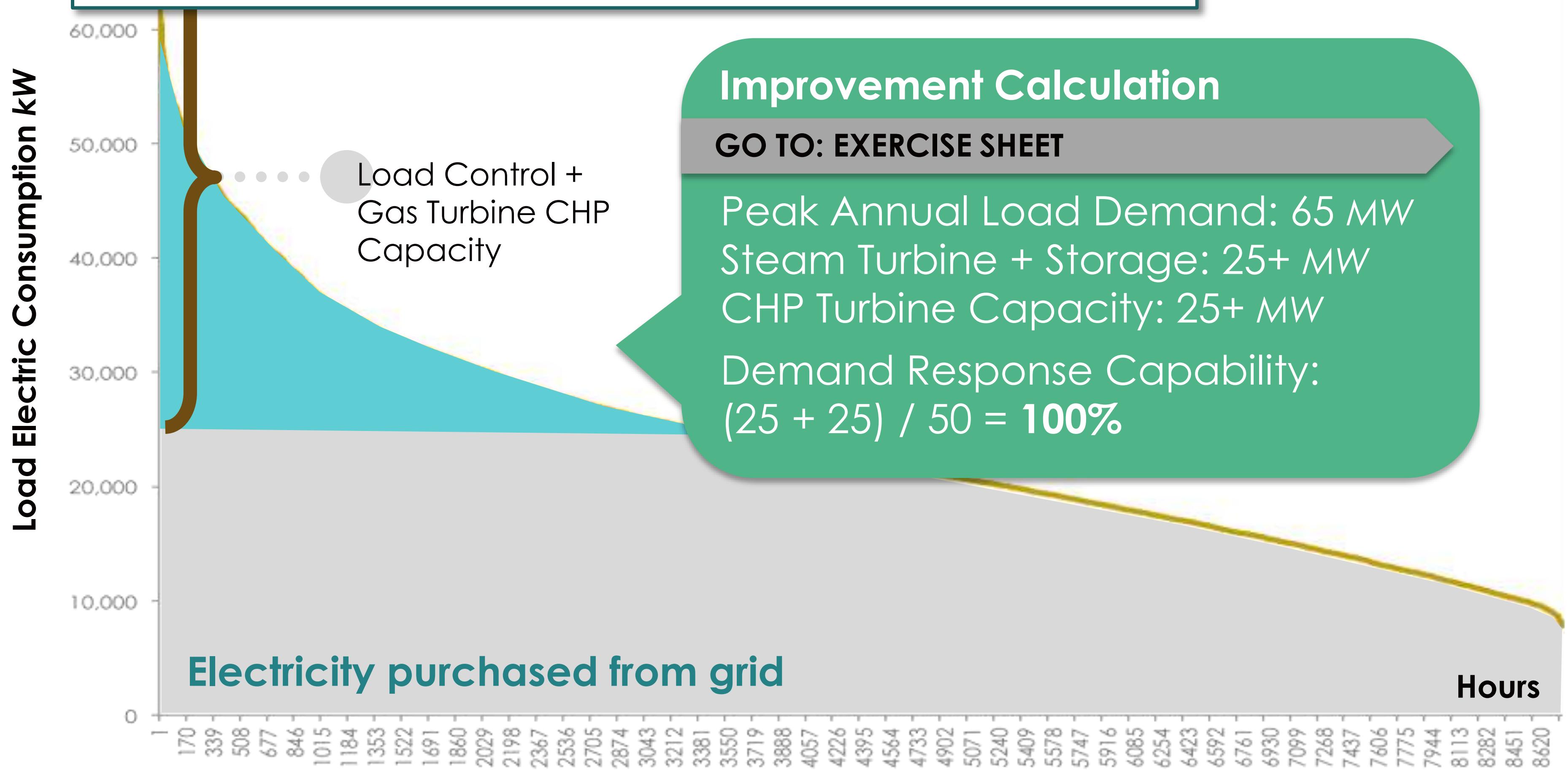
Load Duration % of Peak:
(118,000) / (25 * 8760) = **54%**

Demand Response Capability

SCORING
PEER CORE

CAMPUS	CITY
15	5

Demand Response Capability (%) = $\frac{\text{Total DR capacity } MW}{\text{Peak annual demand } MW}$



Improvement Calculation

GO TO: EXERCISE SHEET

Peak Annual Load Demand: 65 *MW*
Steam Turbine + Storage: 25+ *MW*
CHP Turbine Capacity: 25+ *MW*

Demand Response Capability:
(25 + 25) / 50 = **100%**

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Operations Summary and Score

UT Austin Results

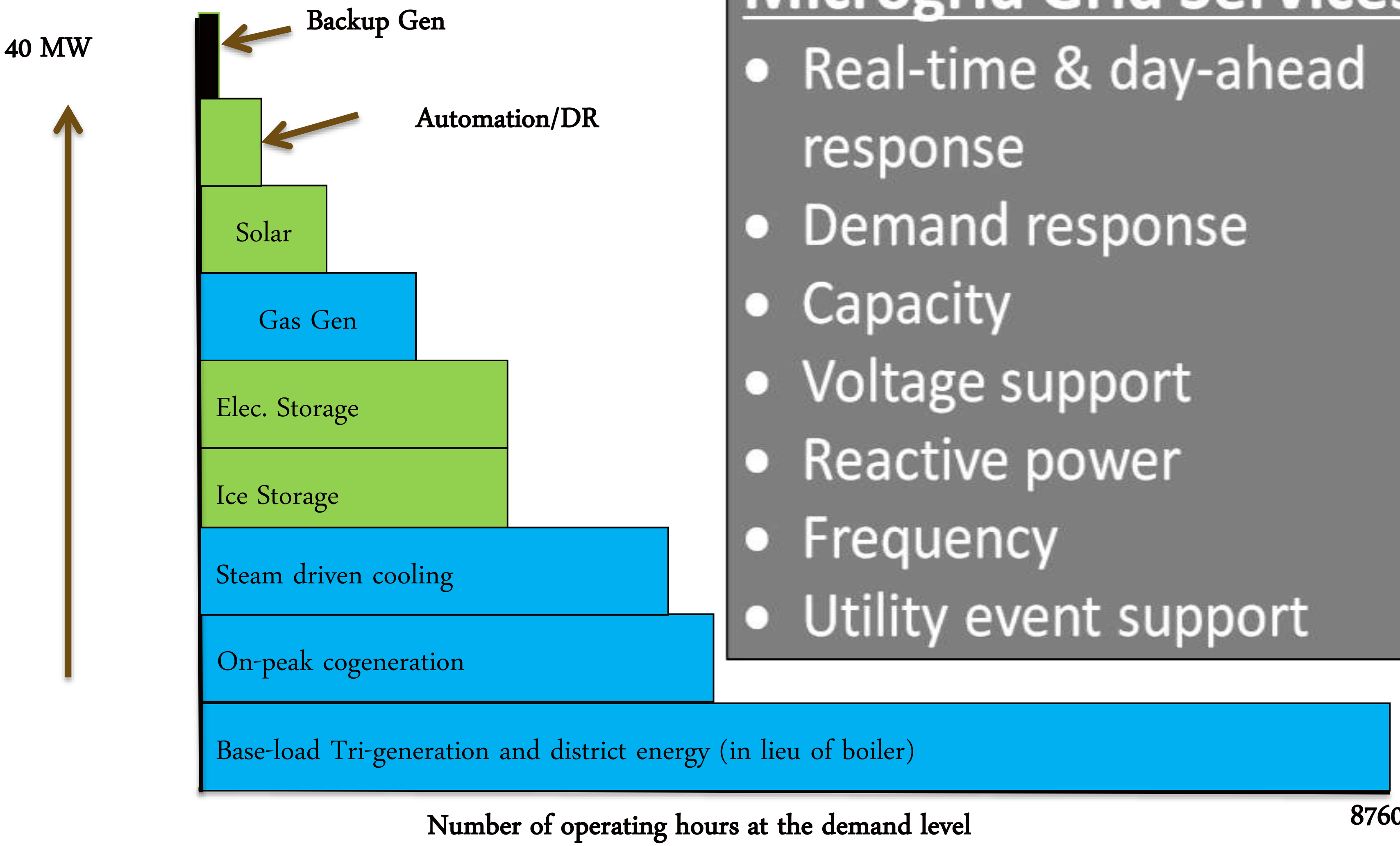
Operational Effectiveness

Criteria	Max Points	Points
Operational Capability (Load Curve & DR)	83	62.0
Actual Estimated Value	26	23.0
Estimated Gap (bonus criteria)	8	4.0
Innovations (bonus criteria)	5	4.3
Core Points	100	79.0
Bonus Points	22	14.3
Total (Limited to 100 points)		93.3

Highlights:

- 78% Load Duration Percent of Peak
- 88% System Energy Efficiency
- Substantial Value in Demand Charge savings and Reliability
- Primary Opportunity Cost is associated with increasing local renewables

Customer Capability = Grid Support



Microgrid Grid Services

- Real-time & day-ahead response
- Demand response
- Capacity
- Voltage support
- Reactive power
- Frequency
- Utility event support

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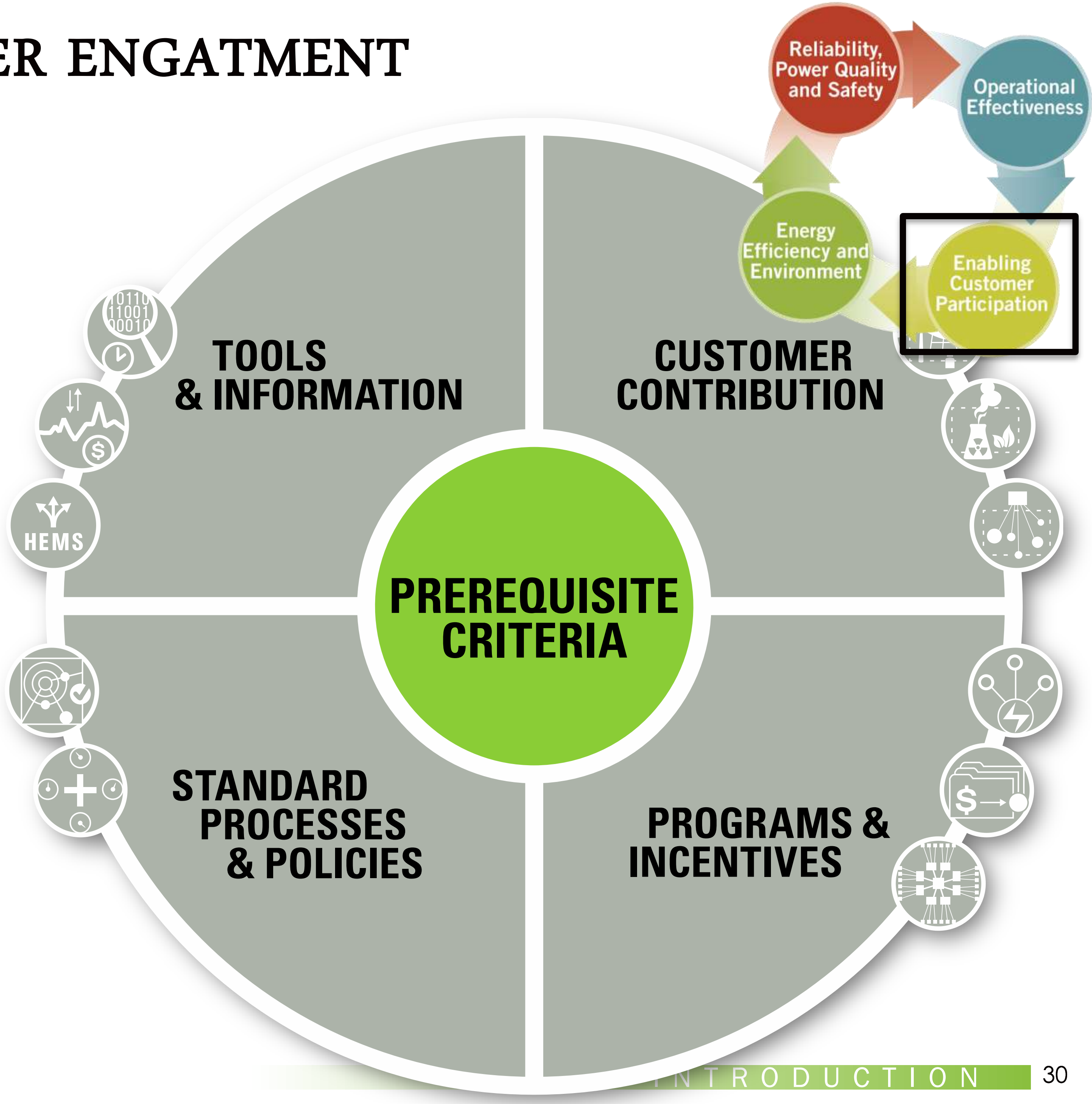
CUSTOMER ENGATMENT

- AMI -Access to data
- Dynamic pricing
- Interconnect
- Net metering
- Incentives

- Contribution
  - DR
  - Local Gen
  - Services



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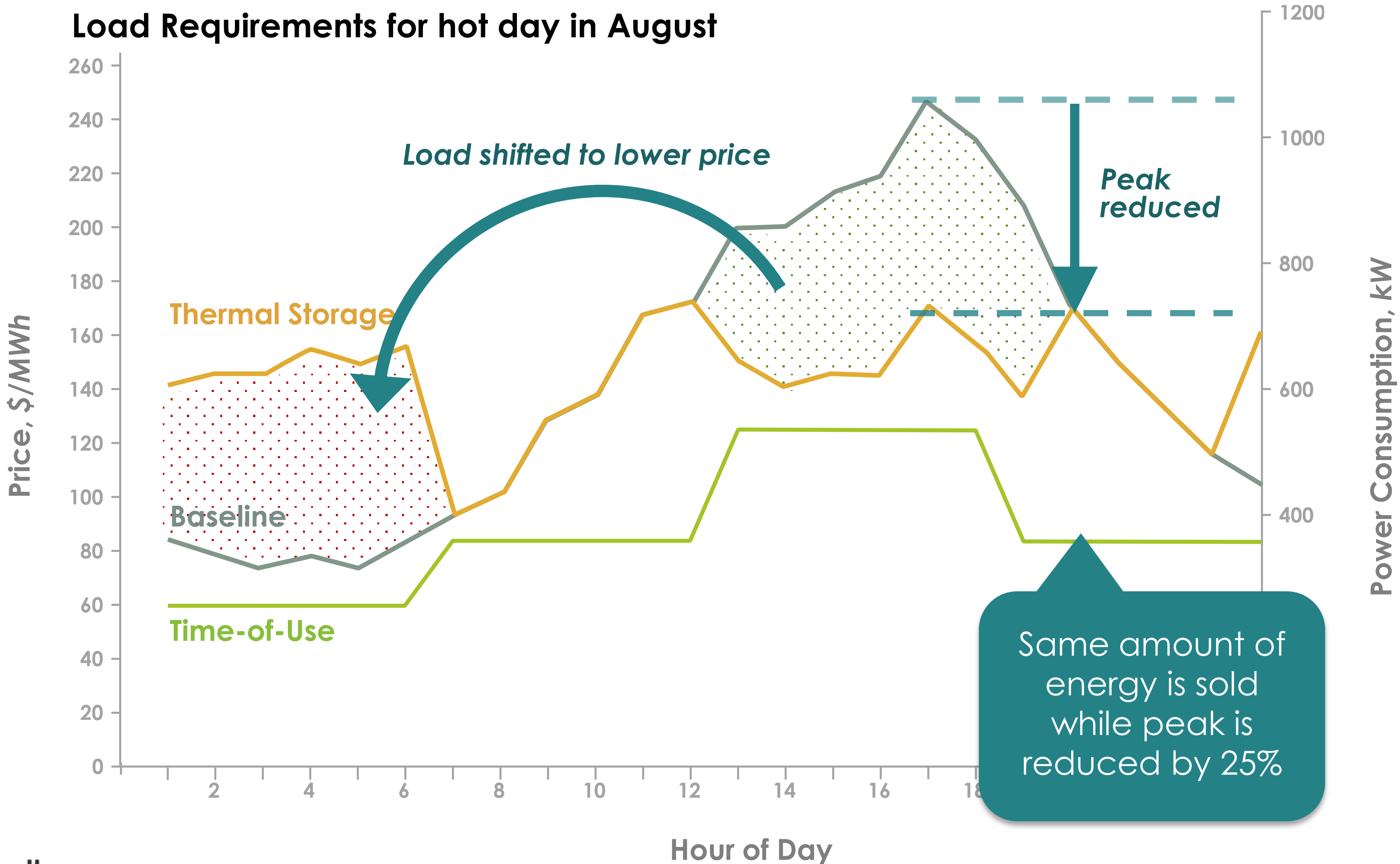
Managing Demand with Storage



Perfecting Power at University of Texas

87% System Efficiency

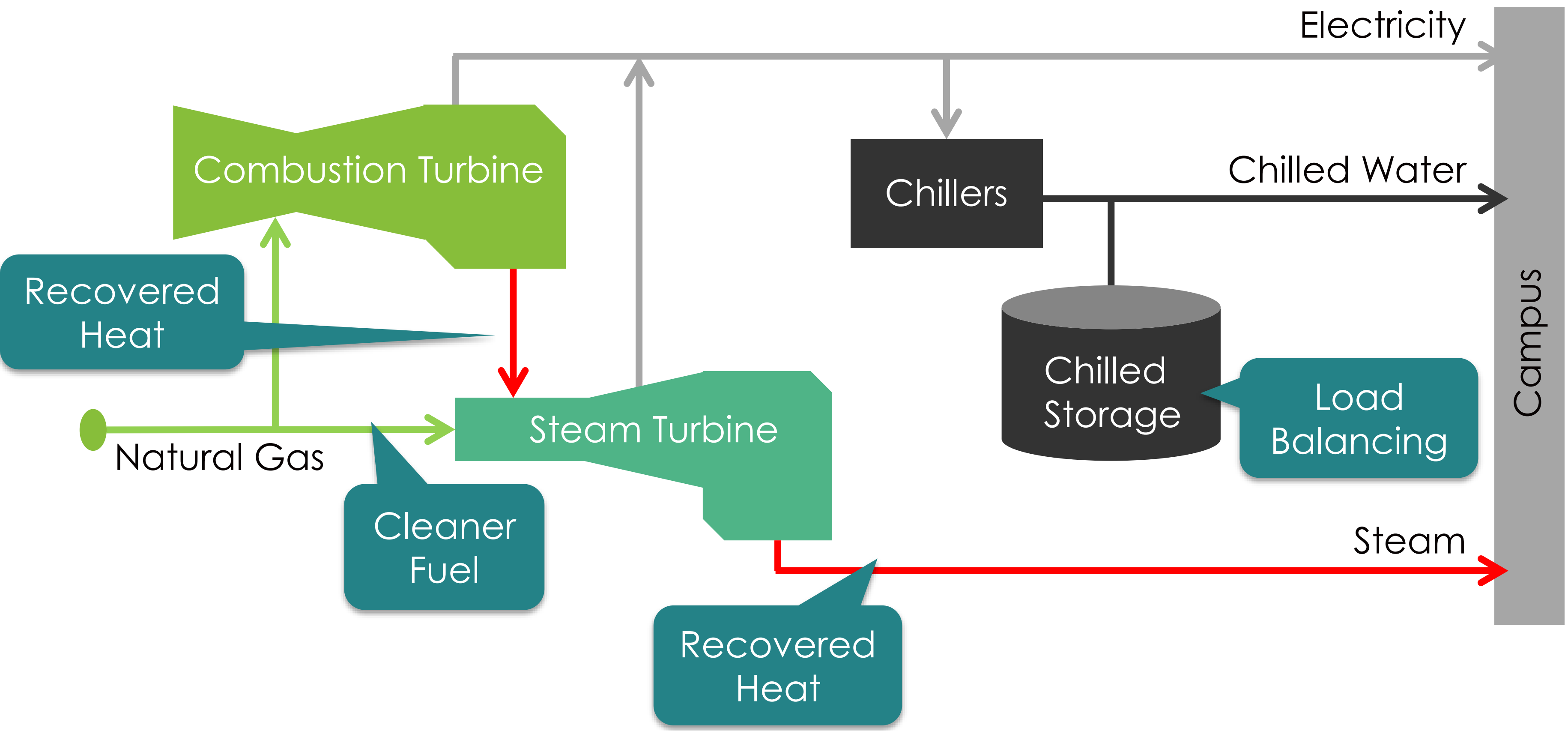


Image source: http://www.cj-philosophy.com/wp-content/uploads/2012/10/austinCT.jpg

Customer Summary and Score

UT Austin Results

Enabling Customer Action

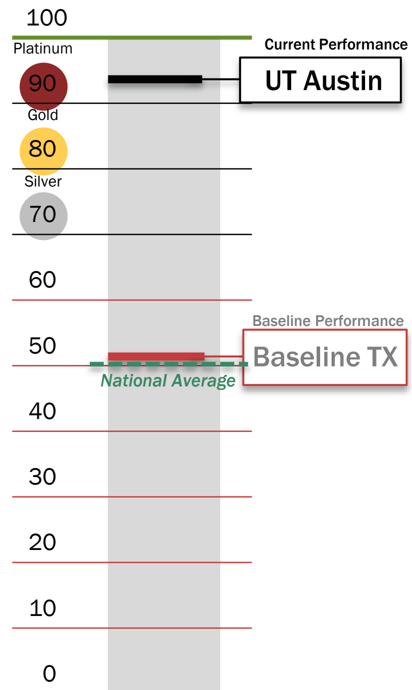
Criteria	Max Points	Points
Tools and Information	10	0.0
Standard Processes and Policies (N/A for campus)	0	0.0
Programs and Incentives	5	0.0
Customer Contribution	85	60.0
Innovations (bonus criteria)	20	19.0
Core Points	**100**	**60.0**
Bonus Points	**20**	**19.0**
Subtotal (Limted to 100 points)		**79.0**

Highlights:

- Local Clean Generation from high efficiency CHP
- Local Demand Response Capability from excess local generation capacity
- Several innovations including lighting reduction program and software that maximizes chiller and generation efficiency

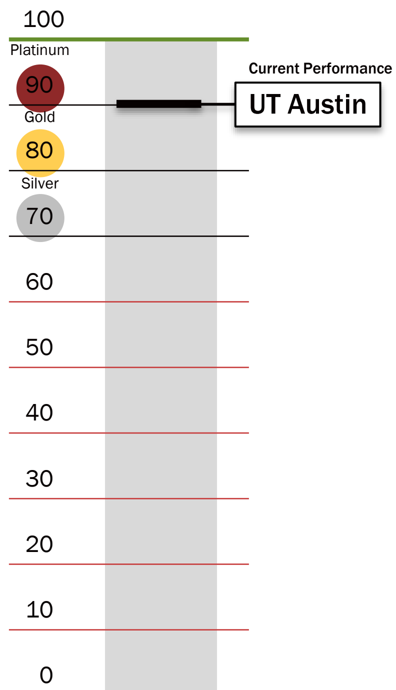
Total Score

Overall UT Austin Score: 356 / 400



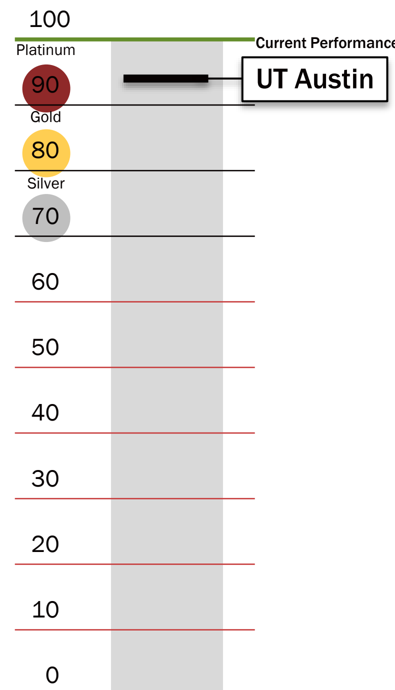
Energy Efficiency and Environmental

94



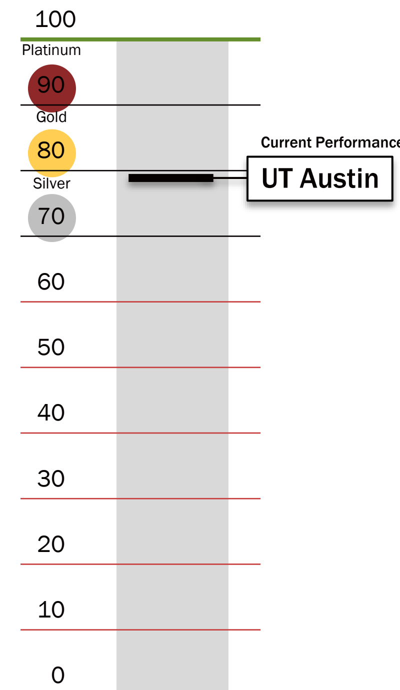
Reliability, Power Quality and Safety

90



Operational Effectiveness

93



Enabling Customer Action

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LEVERAGING VALUE/GAP TO VERIFY/MAKE THE BUSINESS CASE

Site Characteristics	Baseline
Facility Demand	51 MW
Facility Usage	355,000 MWh
Electricity Supply/T&D	$75/MWh
Demand Charge	$14/kW/month

UPPER LIMIT

Total Gap =	**$3,850,000**
Reliability OC	$50,000
Energy Waste OC	$3,630,000
Demand Charge OC	$170,000
Real Time Price OC	$0

Current State

Total Value =	**$13,400,000**
Reliability Value	$1,500,000
Energy Efficiency	$6,500,000
Local Generation Savings	($3,100,000)
Demand Charge	$8,500,000

BASELINE

Performance Indicators	Baseline	Current	Upper Limit
SEI, MMBtu/MWh	9.2	5.3	3.0
Local Generation, MWh	0	348k	355k
Demand Charge/ MWh	$25	$0.50	$0
SAIDI, min	310	9.7	0

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PEER USES

- ✓ Build a **common language** and shared vision
- ✓ Make the **business case** for investment
- ✓ **Promote** great performance **and reveal hidden value**

- ✓ **Benchmark** to an industry standard
- ✓ Create innovative **conceptual designs**
- ✓ Develop **performance based specification and policy**
- ✓ Measure and **verify benefits/financial projections**
- ✓ Establish a **competitive differentiation**

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