CenterPoint Energy
Always There.

Customer Symposium

October 31, 2018

Mission

  

To foster enhanced communication and strengthen long-term relationships with high valued customers through a trusted energy partnership.

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Technologies for Energy Efficiency and Improved IAQ in Schools & Universities

Eric Burgis, Energy Solutions Center

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Topics

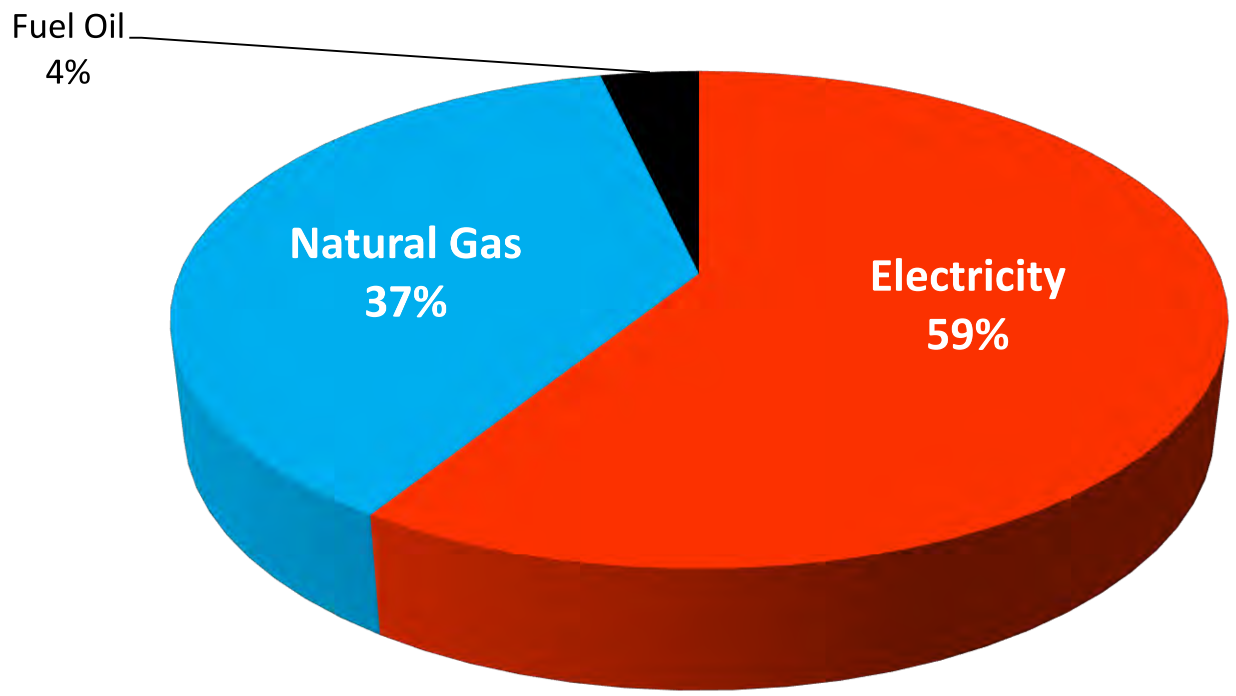
- Benchmarking your facility; the first step to saving energy
- Save energy and reduce absenteeism with proper humidity control
- Energy costs and seasonal demand comparisons; save money by reducing peak electric usage
- Interruptible electric rates and resiliency through back-up power systems and Combined Heat & Power

General Notes

- K-12 Schools, Secondary Schools, Colleges & Universities are places where people go to learn.
- Funding mechanisms and stake holders vary.
- Technologies covered in this presentation benefit all types of education.
- The priority of a K-12 school may be different than that of higher education when it comes to the solutions that will be presented.

Education Data & Statistics

Consumption by Energy Source for Education Market

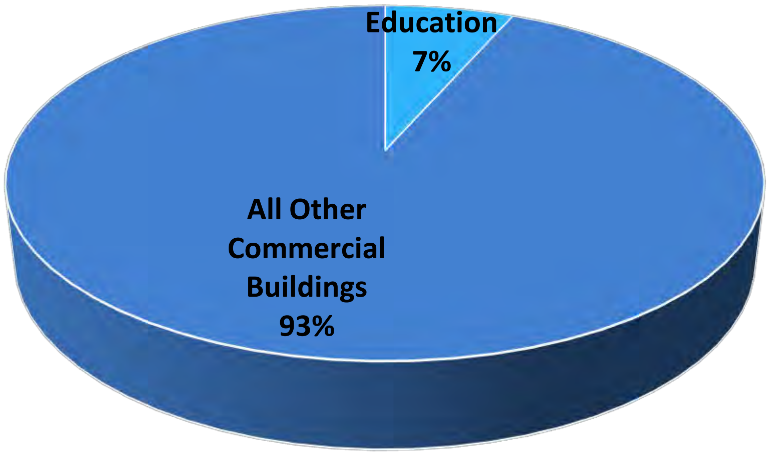


CBECS 2012 – Release date: March 18, 2016: Table 1 – Total Energy Source

Includes data for all education as defined by DOE

Market Overview - Statistics

% of Education Buildings vs. Other Commercial Buildings



Education Buildings makes up 7% of the commercial building Stock in the U.S.

Education uses ~12% of all energy used in the commercial market segment & has 14% of the floor space.

	Number of buildings	% of Commercial Buildings	Total Floor space (million Square Feet)	Total Energy Use (trillion Btu)	% of BTU's Consumed by Commercial Buildings
Education	**389,000**	7%	12,239	842	**12%**
Total all Commercial Buildings	5,559,000		87,094	6963	

84,000 Buildings are College or University campus or complex (22% of Education under EIA)

CBECS – Release date: March 18, 2016: Table 2 – Total Energy Source & Table B1 Summary table

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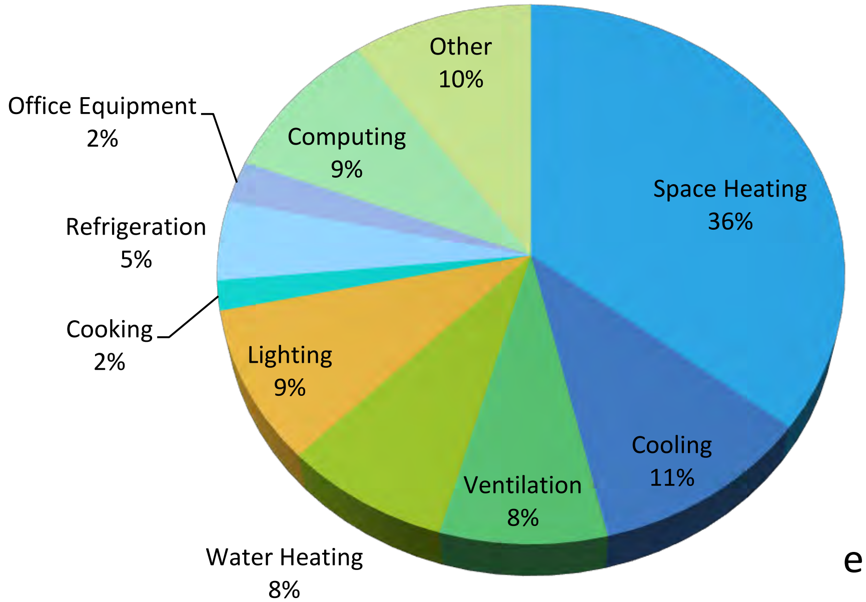
Market Overview - Statistics

Total Major Fuel Consumption
Education Market



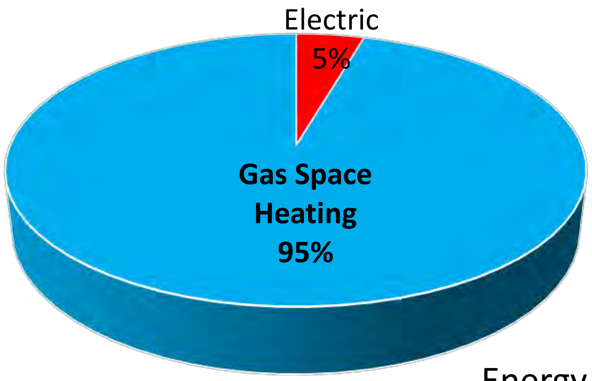
Includes data for all education as defined by DOE

Heating, cooling & ventilation account for more than 1/2 of all energy used.

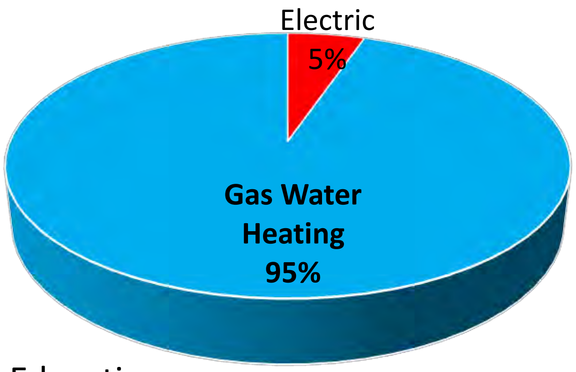
CBECS-Commercial Buildings Energy Consumption Survey – issued 2016, Table 5 – Major Fuel Consumption

General Education Energy Use

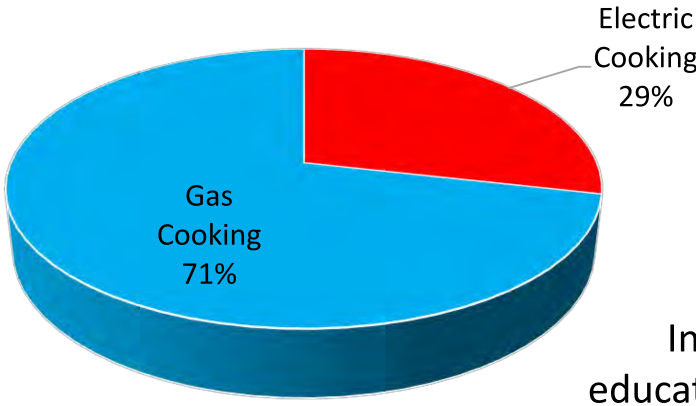
Energy Use for Heating in Education



Energy for Water Heating in Education



Energy Use for Cooking in Education



Includes data for all education as defined by DOE

CBECS-Commercial Buildings Energy Consumption Survey – issued 2016: Table 6 & 7

Energy Intensity

Energy Intensity - Use Per Square Foot

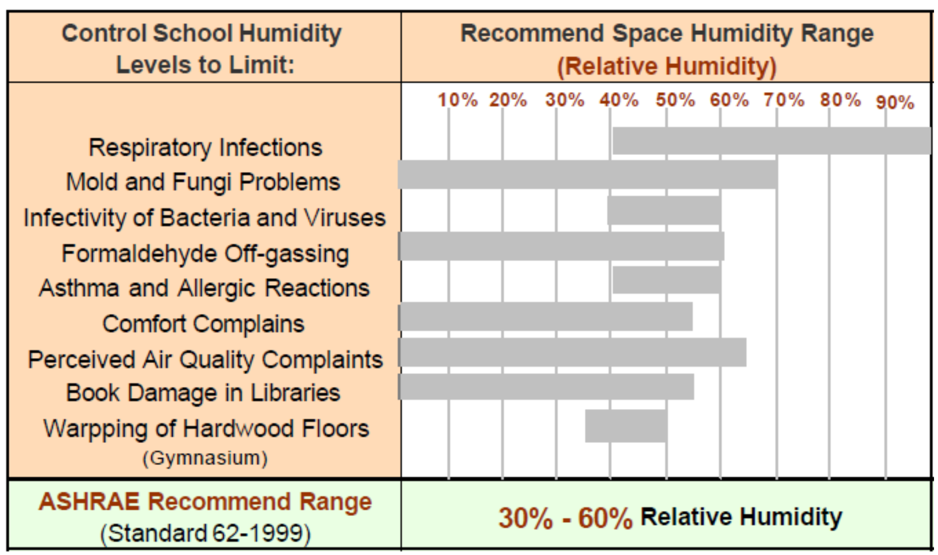
	Per Square Foot (Thousand Btu)
College/University	**130.7**
K-12	**123**
All Commercial Buildings	**80**
* Percentages are % of average for all commercial customers	

University buildings use ~ 63% more energy & K-12 use 54% more energy per square foot of space than the average commercial building

CBECS Data * E* Portfolio Manager

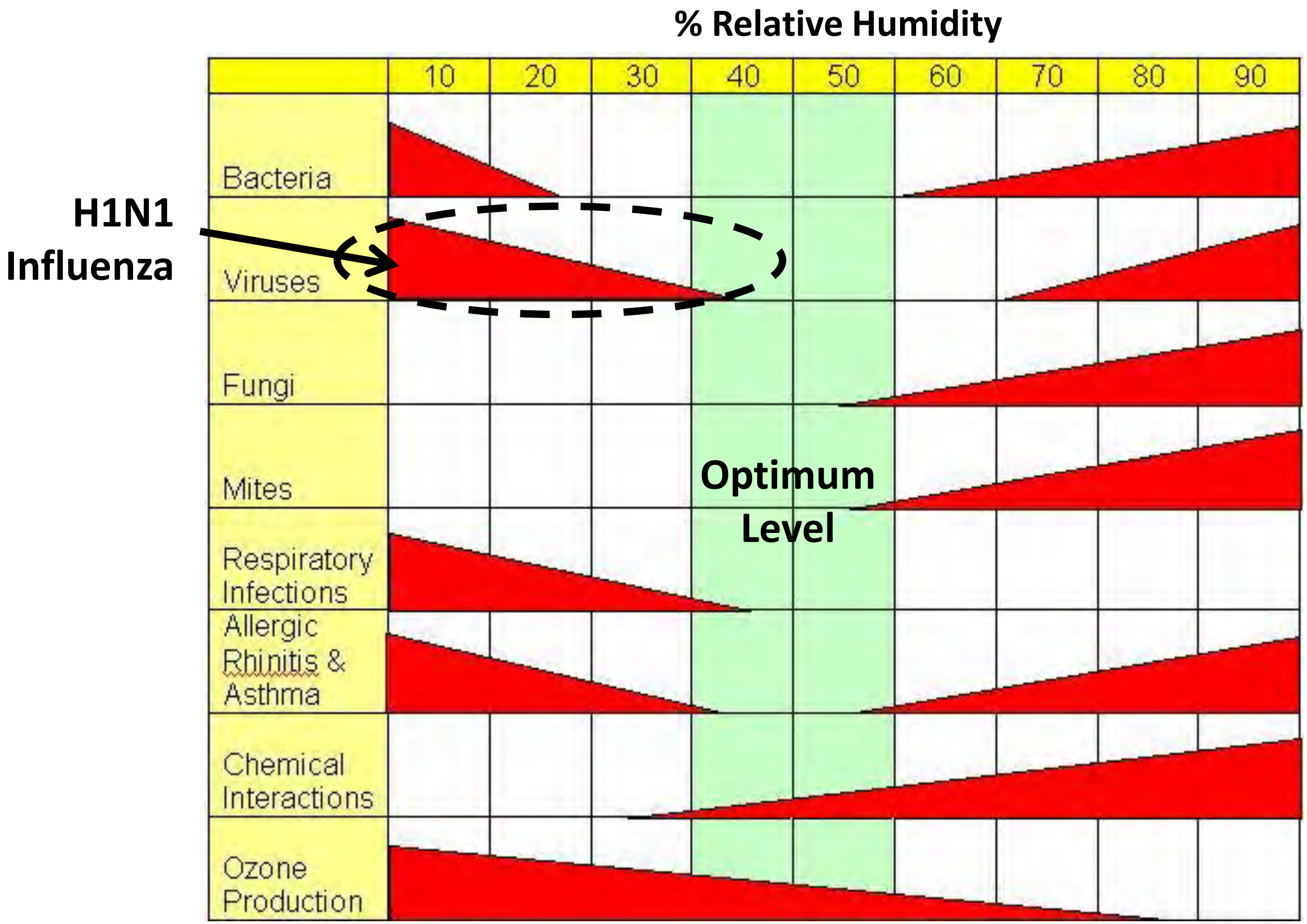
Humidity Control

- Schools struggle with maintaining proper humidity levels in schools while providing continuous ventilation.
- The impact of too much or too little humidity is significant to physical assets as well as health of staff & students.



“Humidity Control in School Facilities”, By John C. Fischer & Charlene W. Bayer, PhD.

Health Impact of Uncontrolled Humidity



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Impacts of Too Much or Too Little Humidity

High Humidity

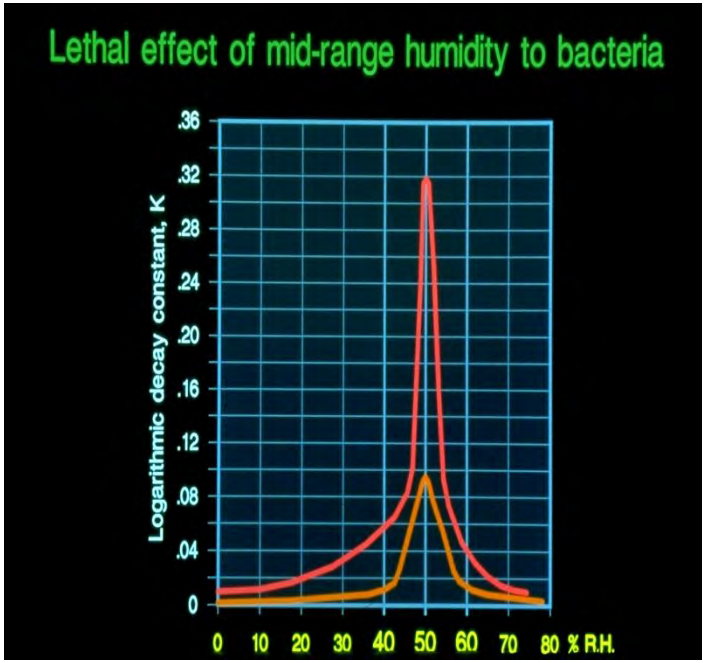
Higher cooling costs	Damage to stored dry foods
Condensate on Structures	In Summer you feel hotter
Oxidation	**Contribute to sick building syndrome**
Growth of Mold & Bacteria	**Aggravate allergies, asthma**

Low Humidity

Dry out wall coverings, floor and ceiling tiles, & furniture	**Aggravates asthma, allergies and other respiratory-related illnesses**
Increased static electricity	In Winter you feel colder
Leads to cracked lips, dry skin, and bloody noses	**Impacts employee productivity and absenteeism**

Influence of Humidity on Mortality of Pathogens

The bacteria mortality rate is greatest between 40 and 60% relative humidity.



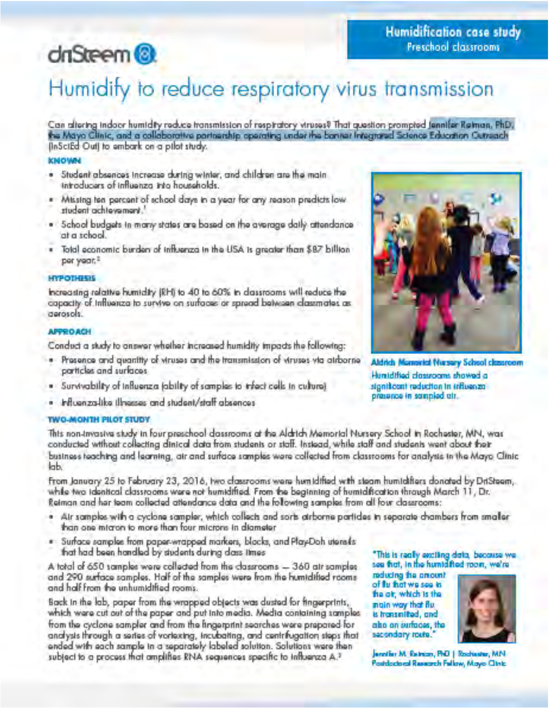
Research indicates that lab animals inoculated with influenza virus were dramatically effected by RH outside the mid range of 40%-50% RH.

- **Green range:** **The mice perished**
- **Orange range:** **Contracted virus and recovered**
- **Blue range:** **Mice didn't get infected**

http://www.plospathogens.org/article/info%3Adoi%2F10.1371%2Fjournal.ppat.0030151

Pre-School Humidification Study

- Conducted by Jennifer Reiman, PhD from the Mayo Clinic, in collaboration with Integrated Science Education Outreach
- Results released 2018
- Actual Test 2 months in 2016
- Location: 4 classrooms at Aldrich Memorial Nursery School classroom in Rochester, MN
  - 2 humidified, 2 not humidified
- **Hypothesis: Increasing relative humidity (RH) to 40 to 60% in classrooms will reduce the capacity of influenza to survive on surfaces or spread between classmates as aerosols.**
- 650 samples from air and surface collected



Humidification case study
Preschool classrooms

DriSteem

Humidify to reduce respiratory virus transmission

Can altering indoor humidity reduce transmission of respiratory viruses? That question prompted Jennifer Reiman, PhD, the Mayo Clinic, and a collaborative partnership operating under the banner Integrated Science Education Outreach (InSciEd Out) to embark on a pilot study.

KNOWN

- Student absences increase during winter, and children are the main introducers of influenza into households.
- Missing ten percent of school days in a year for any reason predicts low student achievement.[1]
- School budgets in many states are based on the average daily attendance at a school.
- Total economic burden of influenza in the USA is greater than $87 billion per year.[2]

HYPOTHESIS

Increasing relative humidity (RH) to 40 to 60% in classrooms will reduce the capacity of influenza to survive on surfaces or spread between classmates as aerosols.

APPROACH

Conduct a study to answer whether increased humidity impacts the following:

- Presence and quantity of viruses and the transmission of viruses via airborne particles and surfaces
- Survivability of influenza (ability of samples to infect cells in culture)
- Influenza-like illnesses and student/staff absences

Aldrich Memorial Nursery School classroom
Humidified classrooms showed a significant reduction in influenza presence in sampled air.

TWO-MONTH PILOT STUDY

This non-invasive study in four preschool classrooms at the Aldrich Memorial Nursery School in Rochester, MN, was conducted without collecting clinical data from students or staff. Instead, while staff and students went about their business teaching and learning, air and surface samples were collected from classrooms for analysis in the Mayo Clinic lab.

From January 25 to February 23, 2016, two classrooms were humidified with steam humidifiers donated by DriSteem, while two identical classrooms were not humidified. From the beginning of humidification through March 11, Dr. Reiman and her team collected attendance data and the following samples from all four classrooms:

- Air samples with a cyclone sampler, which collects and sorts airborne particles in separate chambers from smaller than one micron to more than four microns in diameter
- Surface samples from paper-wrapped markers, blocks, and Play-Doh utensils that had been handled by students during class times

A total of 650 samples were collected from the classrooms — 360 air samples and 290 surface samples. Half of the samples were from the humidified rooms and half from the unhumidified rooms.

Back in the lab, paper from the wrapped objects was dusted for fingerprints, which were cut out of the paper and put into media. Media containing samples from the cyclone sampler and from the fingerprint searches were prepared for analysis through a series of vortexing, incubating, and centrifugation steps that ended with each sample in a separately labeled solution. Solutions were then subject to a process that amplifies RNA sequences specific to influenza A.[3]

"This is really exciting data, because we see that, in the humidified room, we're reducing the amount of flu that we see in the air, which is the main way that flu is transmitted, and also on surfaces, the secondary route."

Jennifer M. Reiman, PhD | Rochester, MN
Postdoctoral Research Fellow, Mayo Clinic

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Pre-School Study Results

Influenza-positive samples from air and surfaces			
Sample type	**Humidified rooms percent positive**	**Unhumidified rooms percent positive**	**Odds ratio***
Air	11.7	18.3	0.51
Surfaces (paper)	18.0	22.1	0.51

* Odds ratio less than 1 indicates a reduced likelihood of finding influenza-positive samples in humidified rooms compared to unhumidified rooms.

- The % of positive Influenza samples was greater in air and on surfaces in unhumidified rooms.
- 45 of influenza-positive samples were further tested for infectivity
  - **48% from unhumidified room were infectious**
  - **Only 17% from the humidified rooms were infectious**

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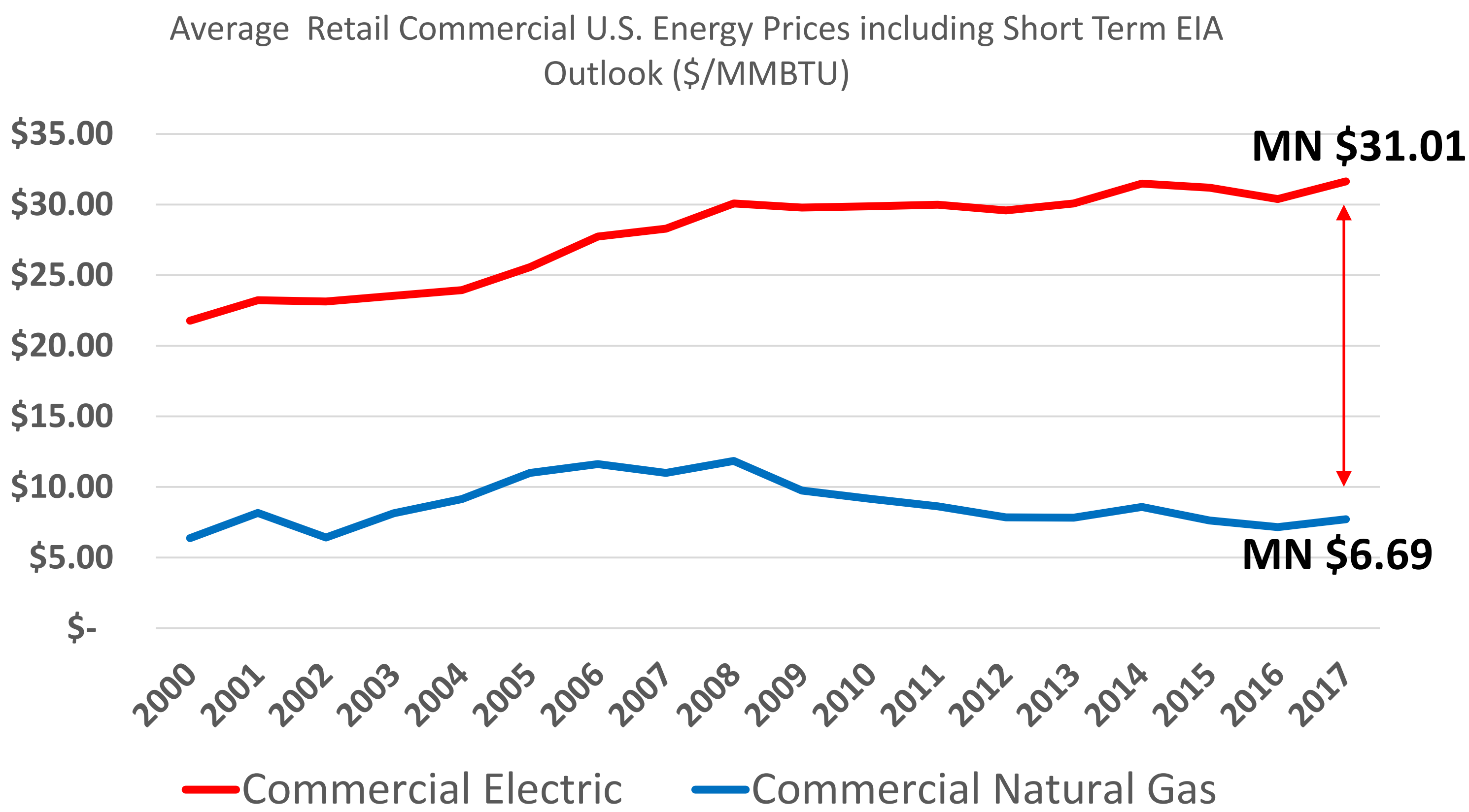
Options for Humidity Control

- Conventional sub-cool & reheat with conventional systems
  - Not very energy efficient
- Desiccant dehumidification
- Gas fired humidifiers

Energy Costs & Seasonal Demands

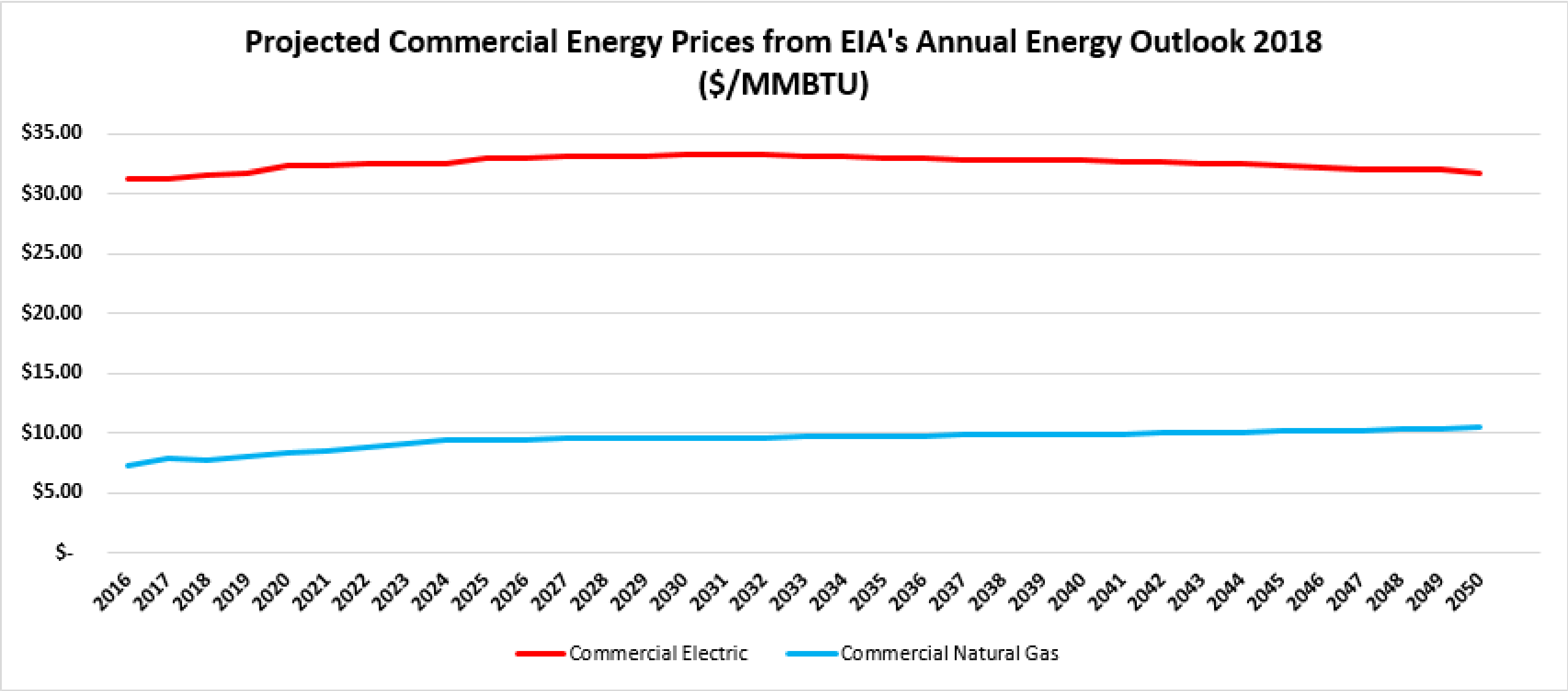


U.S. average electric cost is ~ 4X the price of natural gas.

In MN the cost of electric is 4.6 X that of gas.

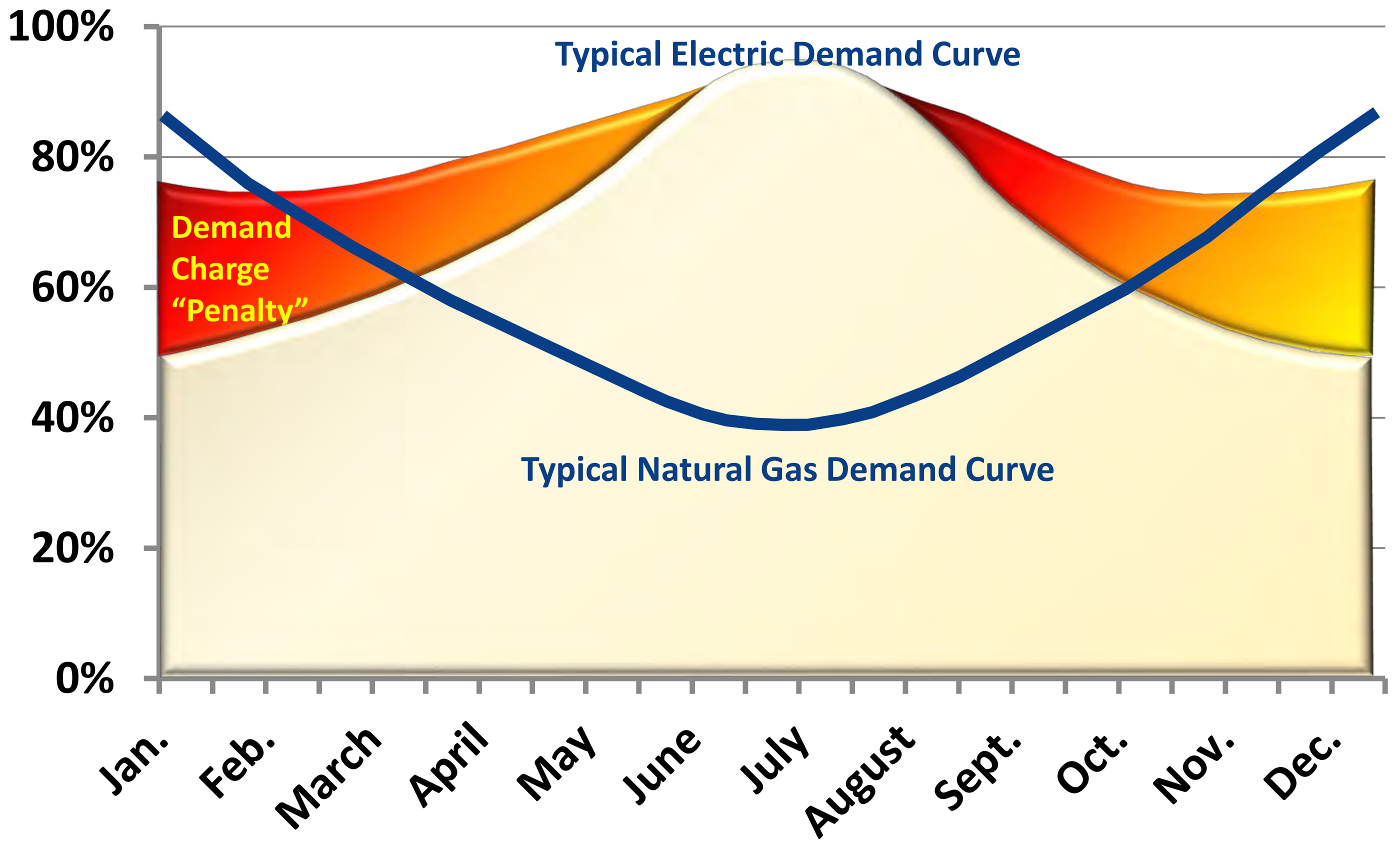
*EIA data. Uses 1032 BTU/CF Natural Gas and 3412 BTU/KWH Electric. (2016 &2017 are from EIA STEO)

Future Electric Pricing Projected to remain at >3X Natural Gas Price



EIA's 2018 Annual Energy Outlook

Typical Energy Demand Curves



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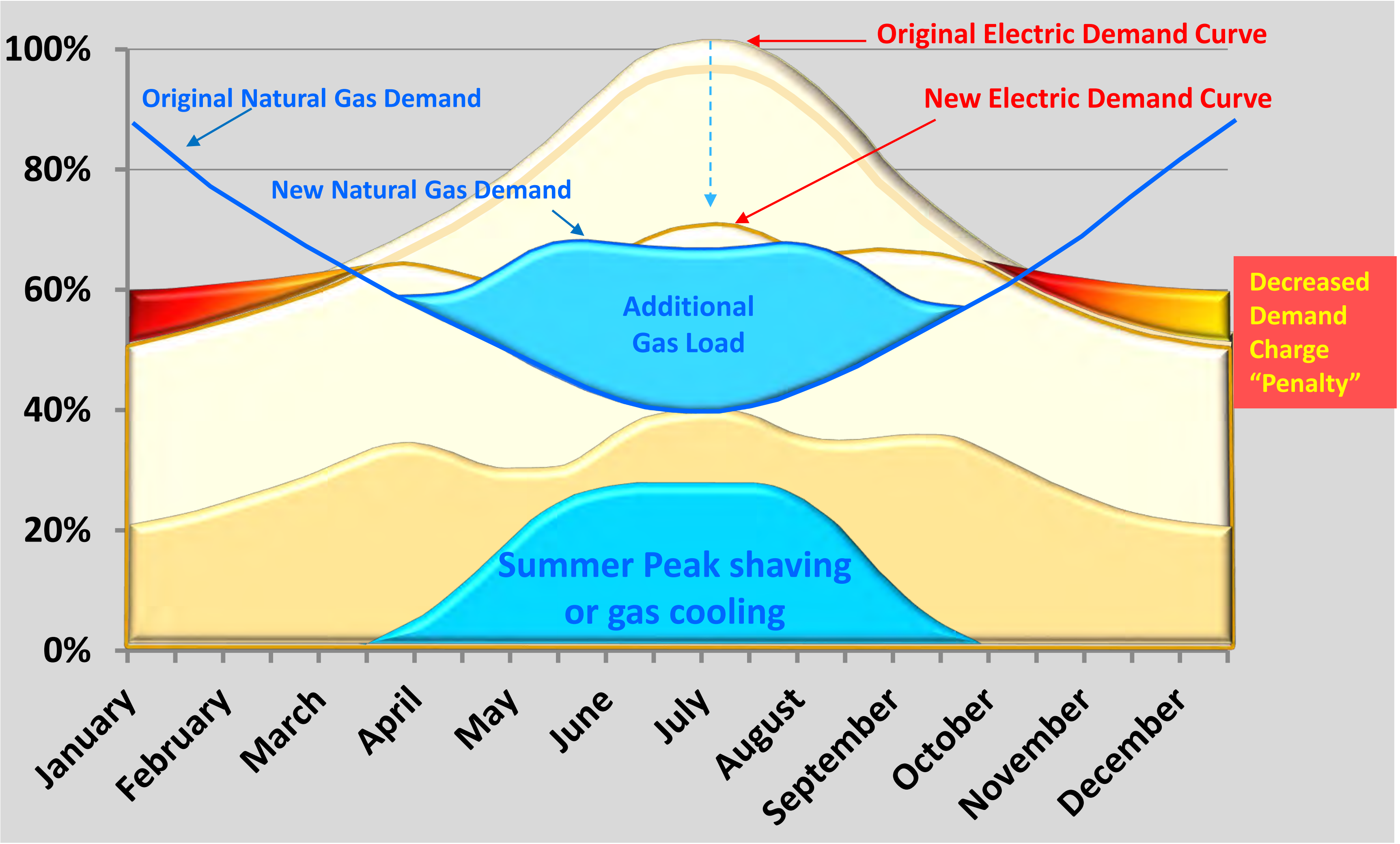
Using Natural Gas to Reduce Summer Peak Electric Demand Saves Money



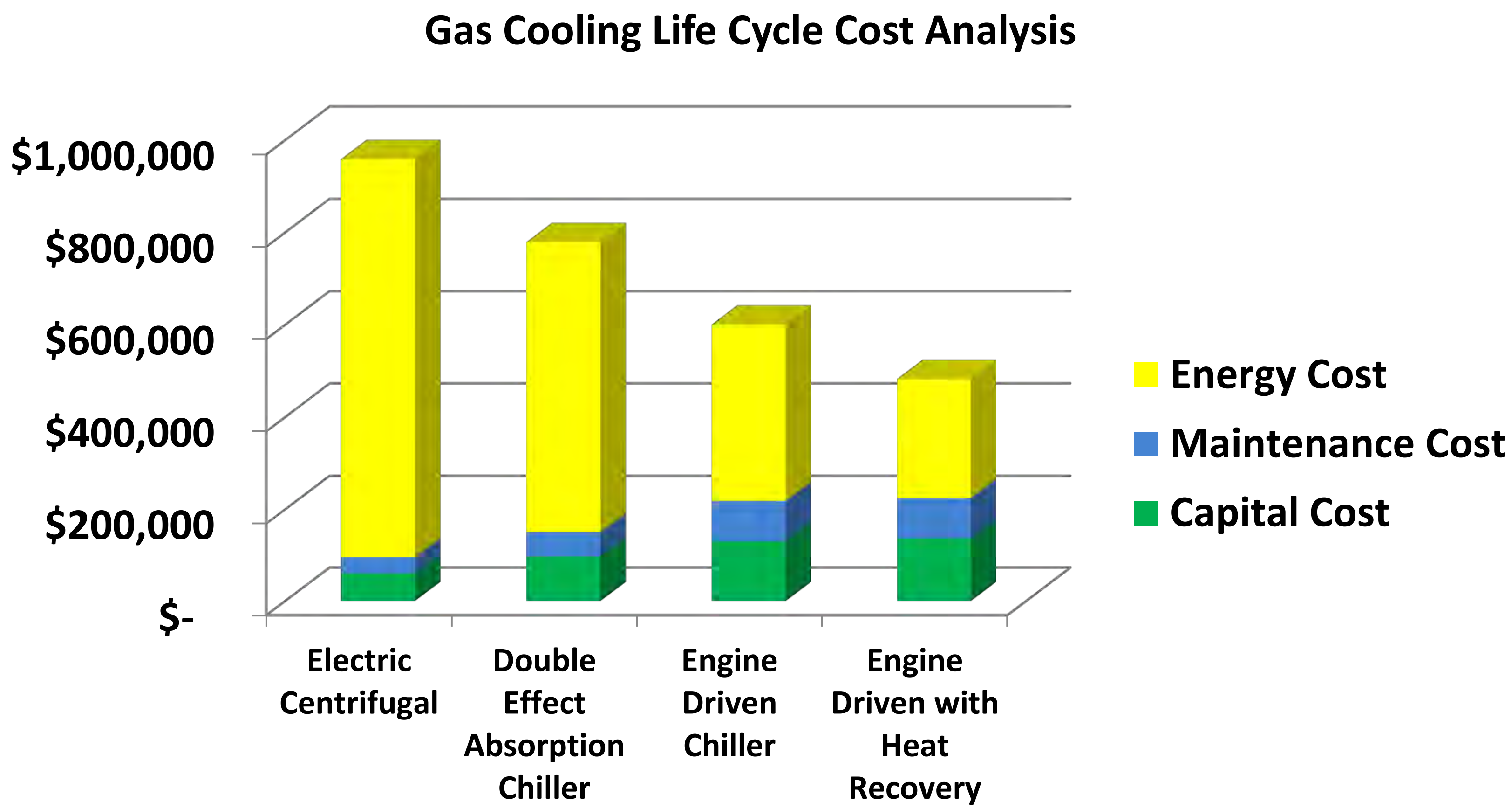
Natural Gas Cooling Options

Absorption Chillers

Gas Heat Pumps

Engine Driven Chillers

Large Chiller 20 Year Life Cycle Cost



Using ESC Cooling payback tool for 200 Tons running 2000 cooling hours per year with $7/MMBTU natural gas and $.014/KWH electric.

Engine Driven Heat Pumps

- Similar to electric heat pumps
- Electric motor replaced with a natural gas driven engine
- Excellent part load efficiencies
- Multiple zone capable
- VRF capable
- **Heating efficiency equivalent to 140%**
- Cooling COP = 1.2

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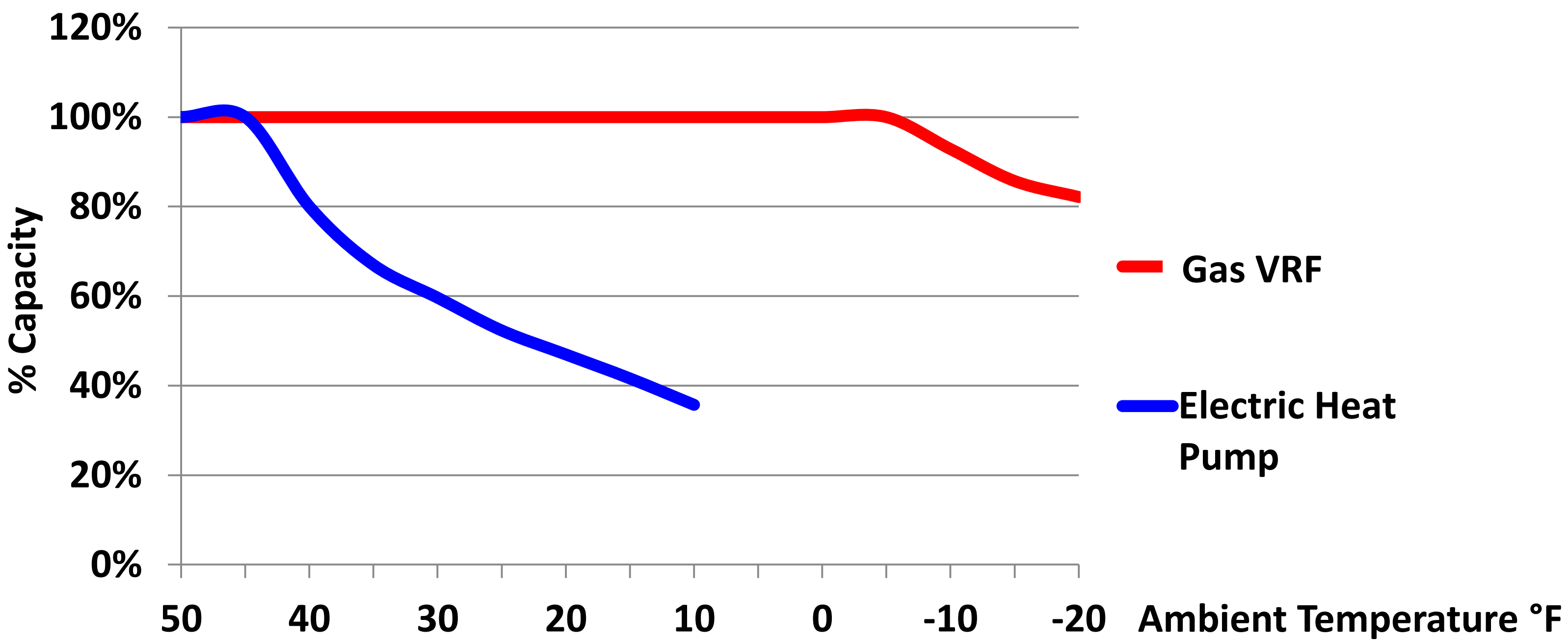
Gas Heat Pump
Low Temperature Performance



Typical of other Gas Heat Pumps

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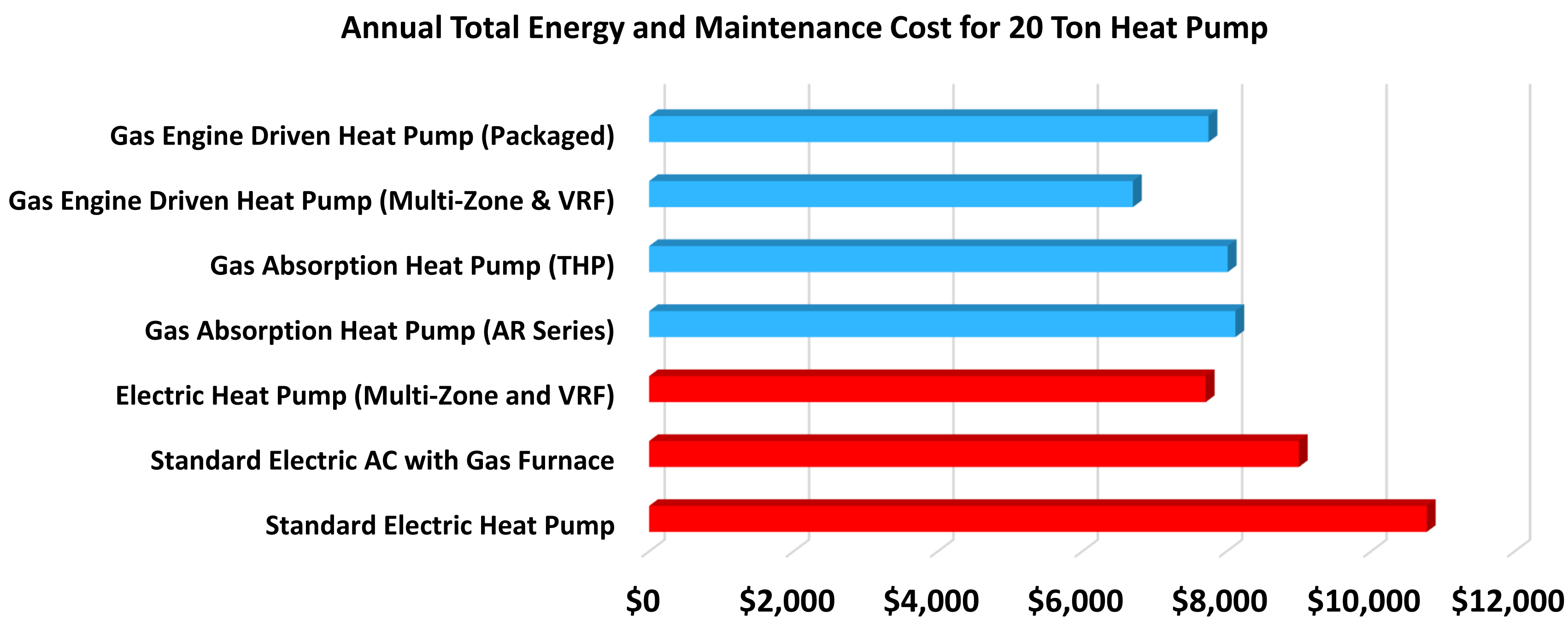
Small Tonnage Energy Analysis



Assumptions:

Electric - $.14/KWH, no demand charge, Gas = $.80/Therm

20 Tons of cooling for 6 months per year

1500 full load hours cooling & 1500 hours heating

Resiliency

Having the capability of generating electric on-demand allows a facility to take advantage of more favorable interruptible electric rates.

Power generation options include:

- Back-up Power
- Bi-Fueled Diesels
- Combined Heat & Power

Electric Reliability vs. Resiliency

- Reliability for the electric sector can be defined as the ability of the power system to deliver electricity in the quantity and with the quality demanded by users.
  - Reliability is generally measured by interruption indices.
  - Reliability means that lights are always on in a consistent manner.
- Resiliency is 'the ability to reduce the magnitude and/or duration of disruptive events. The effectiveness of a resilient infrastructure or enterprise depends upon its ability to anticipate, absorb, adapt to, and/or rapidly recover from a potentially disruptive event.'*
  - Reducing peak demands improves resiliency
  - Redundancy improves resiliency
  - Back-up power systems, Peak shavers, or CHP improve resiliency

* National Infrastructure Advisory Council

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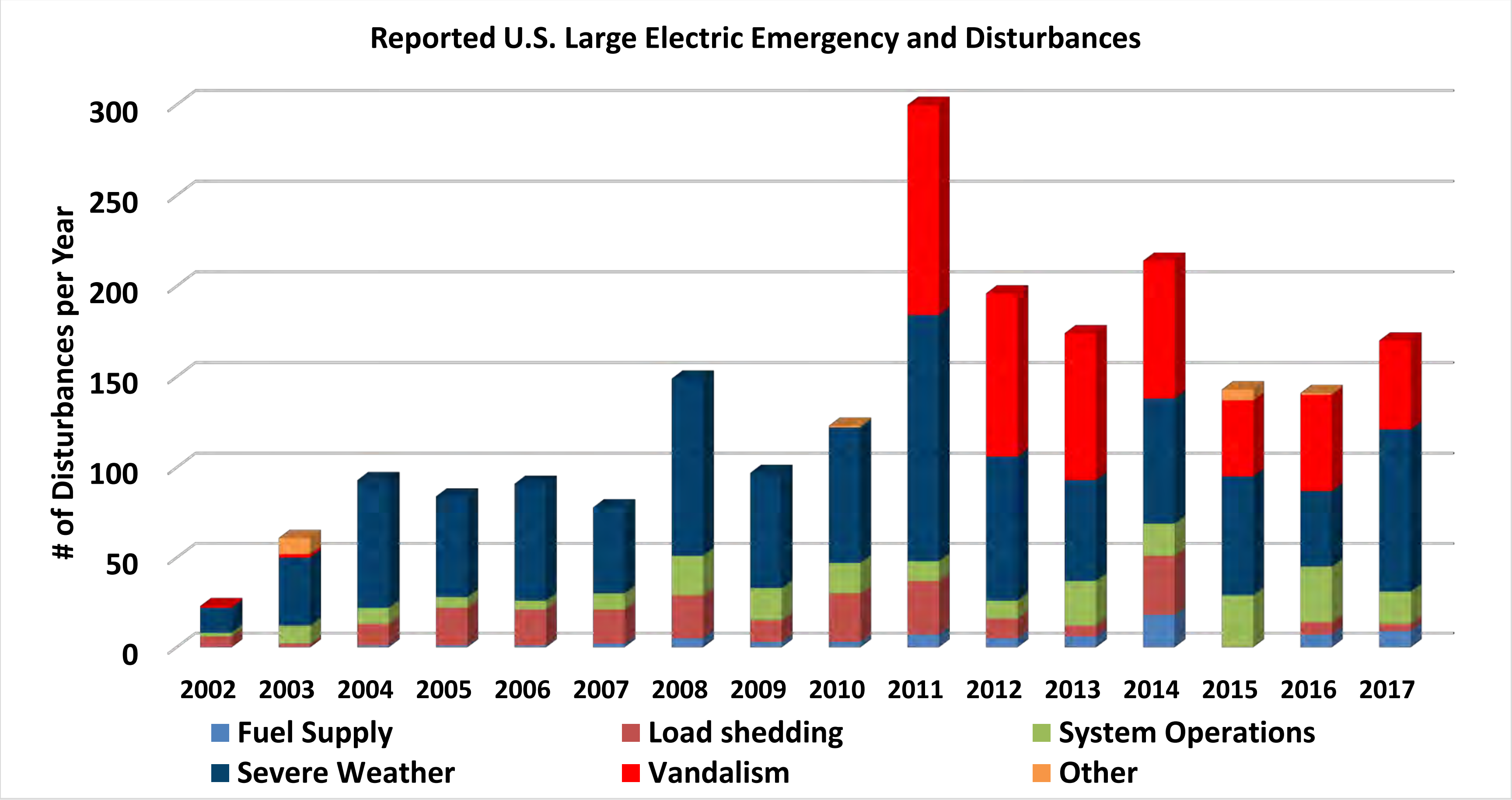
The Aged Electric Grid is Stressed with Congestion and Constraints

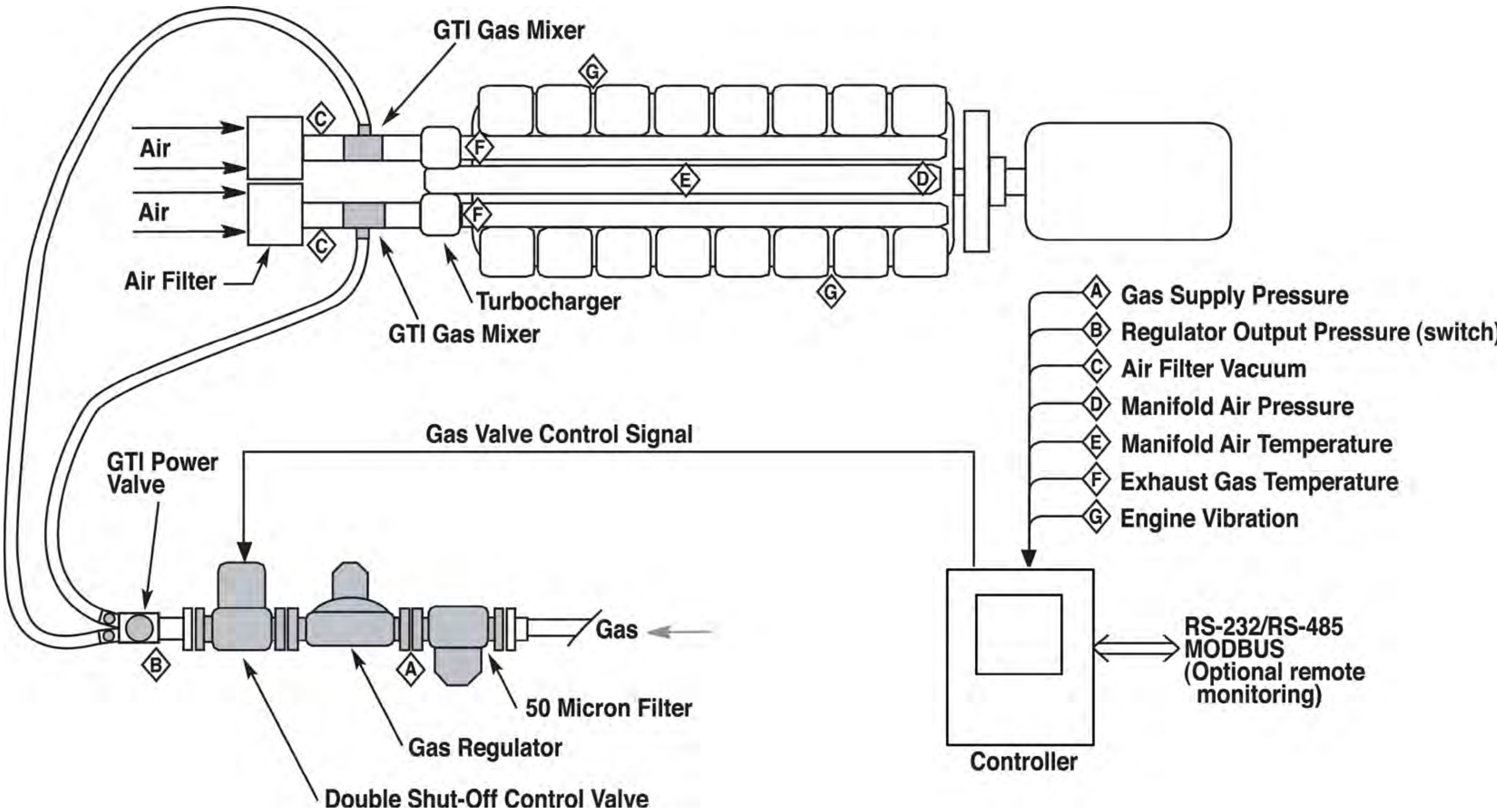


OE-417 Electric Emergency and Disturbance Reports

Back-Up Power

- Designed to turn on automatically whenever electric service is interrupted
- Transfers the electric load back to the utility once power is restored
- Equipped with controls to handle even brief electric interruptions

Bi-Fueling Diesel Generators



Engine Drives – Bi-Fuel Equipment

- Combust natural gas and diesel fuel
  - Diesel fuel acts as a “pilot” fuel – Starts the combustion process (Run a mix of roughly 75%-80% natural gas and the balance is diesel)
- No loss of power output
- Conversion kits available for existing diesel generator sets
- Adds dual fuel option to existing diesel power generation equipment

Combined Heat & Power (CHP)

Reciprocating Engines
(1 KW - 8 MW)

Fuel Cells
(10 – 200 KW)

Turbines
(1,000 KW – 40 MW)

Microturbines
(30 – 250 KW)

CHP for Colleges/Universities

- Similar to hospitals, colleges and universities have coincident power and thermal loads that are often optimal for CHP systems.
- The typical college or university campus has a high thermal load for conditioning dormitories, classrooms and research labs. These systems are often served by central utility plants with chilled water and steam or hot water distribution systems.
- The average college or university CHP system is about 10MW. The majority are fueled by natural gas.

Table III-4: All On-Site U.S. Commercial CHP Technical Potential (Including Topping Cycle CHP and WHP CHP)

SIC	NAICS	Commercial Building	50-500 kW (MW)		0.5-1 MW (MW)		1-5 MW (MW)		5-20 MW(MW)		>20 MW (MW)		Total MW	
			# Sites	Capacity (MW)	# Sites	Capacity (MW)	# Sites	Capacity (MW)	# Sites	Capacity (MW)	# Sites	Capacity (MW)	# Sites	Capacity (MW)
8221	611	College/Univ.	2,944	534	399	264	1,369	3,580	541	5,041	132	4,513	5,385	13,932

Source: USDOE, "Combined Heat and Power (CHP) Technical Potential in the United States," March 2016

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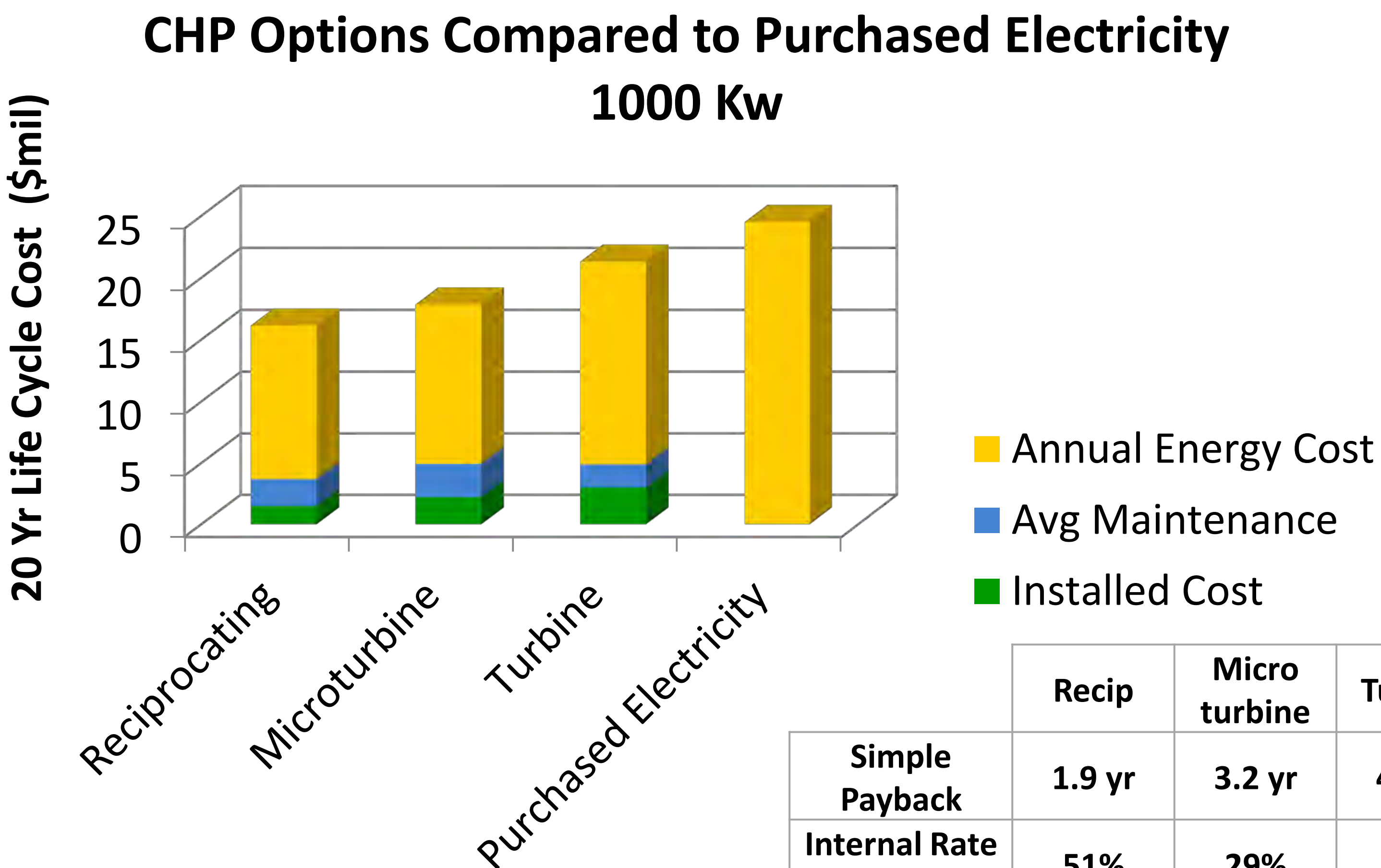
CHP Life Cycle Cost Analysis



	Recip	Micro turbine	Turbine
Simple Payback	1.9 yr	3.2 yr	4.4 yr
Internal Rate of Return	51%	29%	19%

<u>Example Only</u> – Values will vary by region and project

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Simple Payback Tool

www.UnderstandingCHP.com

Combined Heat & Power (CHP) Simple Payback Analysis Tool

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This tool provides a simple payback calculation for various CHP technologies based off the size and energy rates. The calculations use average pricing, efficiencies, & maintenance costs provided in the CHP Technology Catalogs available from the Combined Heat and Power partnership of the EPA.

The results produced by use of this tool are intended solely as a preliminary evaluation of a potential CHP installation. For a more detailed and exact evaluation you should seek the assistance of a qualified engineering firm with input from the appropriate manufacturers of power generation equipment.

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Analysis Assumptions




CHP Technology	Reciprocating Engine	Micro Turbine	Gas Turbine	Fuel Cell
Typical Size Range	75 kW - 10 MW	30 kW - 200 kW	.5 MW - 40 MW	1kW - 400 kW
Average Installed cost ($/kW)	$ 1,130 - $ 2,210	$ 2,440 - $ 2,970	$ 972 - $ 3,324	$ 6,310 - $ 9,100
Total Average CHP System Efficiency	74 - 79.0%	63.8 - 71.2%	66.3 - 72.1%	65.0 - 81.0%
Gas Input (MMBTU/Hr)	1.2 - 43.79	0.422 - 3.165	18.5 - 368.8	0.1 - 1.9
O&M Cost ($/kWH)	$ 0.009 - $ 0.022	$ 0.012 - $ 0.025	$ 0.0042 - $ 0.011	$ 0.033 - $0.038
Notes:	Less than a 75KW Engine is considered Micro-CHP	Can package multiple Micro turbines to reach 2 MW	Size starts at 1000KW	PEM: 1KW to 200 KW, PAFC: 250KW-400KW

Launch Calculator

CHP Tax Credit

Construction begins after	Construction begins before	Investment tax Credit (ITC)
12/31/2008	1/1/2022	10%

- A 10% investment tax credit (ITC) for CHP property, applicable to only the first 15MW of CHP property & systems must be less than 50MW.
- CHP system must be 60 percent efficient (on a lower heating value basis), producing at least 20% of its useful energy as electricity and at least another 20% as useful thermal energy.
- Construction must begin by 1/1/2022

Bipartisan Budget Act of 2018 (Page 211-214):
https://www.appropriations.senate.gov/imo/media/doc/Bipartisan%20Budget%20Act%20of%202018.pdf

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Bonus Depreciation

- Section 179 of the Tax code allows for 100% depreciation in the 1st year of capital expenses.
- Most for-profit institutions pay around 21% federal tax.
- For-profit institutions that earn more than the cost of the CHP system, you can write off the entire cost against income the first year and the net effect is you get ~21% of the cost back.
  - Add to that the 10% ITC for 31% of the cost returned in the first year.

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Case Studies

Case Study

Rowan University

- Glassboro, NJ
- Serve 72 buildings
- Project $1M/Year savings
- Expanded existing co-generation plant from 1.7 MW to 4.7 MW
  - New plant 1.2MW & 3.5 MW Turbines
- Hybrid Chiller Plant
  - Steam turbine driven Chiller

"Like quality programs and faculty, our facilities and infrastructure are key to creating a safe, cost-effective, educational environment for our growing student population," says John Imperatore, P.E., Director of Facilities, Resource Management at Rowan University. "By marrying high technology and compact development, we can accommodate future growth and successfully address sustainability, energy efficiency and cost control issues."

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Case Study

Georgia School

- Atlanta, GA
- 10,000 Sq. Ft.
- Natural gas-fired Integrated Active Desiccant Rooftop system

"It's working great," says the school district's HVAC Supervisor/Energy Manager. "We have experienced excellent IAQ and comfort conditions at all times. Most importantly, the teachers are very happy with the new system."

Facility Integrated Resiliency Model (FIRM)

How operational efficiency, security and reliability form the three pillars of resiliency.

October 31, 2018

Topics

- Who we are
- Resilience Definition
- What's driving the concern over resiliency?
- Trends and Convergence
- Three Pillars of Resilience
- Resilience Sequencing
- Case studies

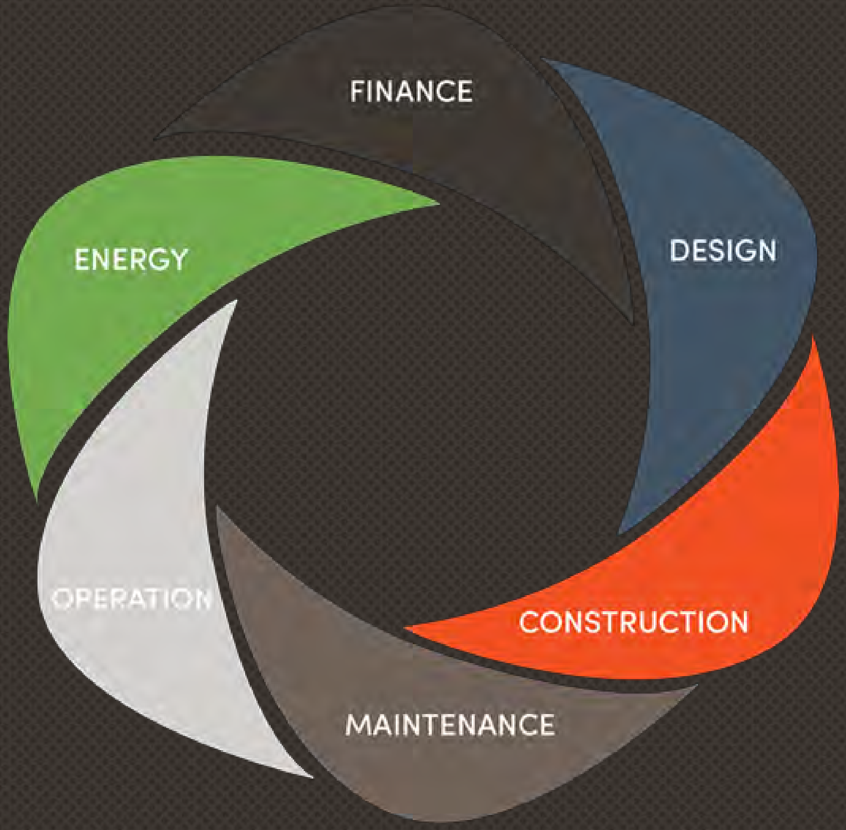
Who we are

CenterPoint Resiliency & Efficiency Program

Mission Meet the growing need for integrated resiliency and reliability solutions for our customers before and after the meter

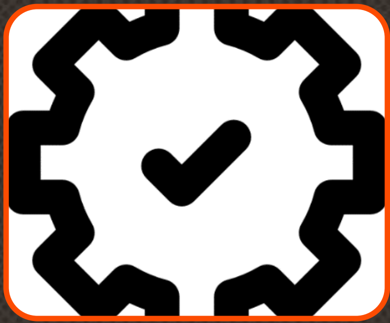
Offering Turn key solutions including funding options to deliver optimal energy resiliency and efficiency projects

Value Leverage our utility expertise to improve customers facilities and positively impact the communities we serve



Who we are

Southland Industries



Energy Efficiency

- Energy Master Planning
- Audits
- System Optimization
- Sustainability Planning
- Energy Simulations & Modeling

Energy Security

- Backup Generation
- Thermal Storage Systems
- Co-generation
- Redundancy Designs
- Cybersecurity (RMF)

Energy Reliability

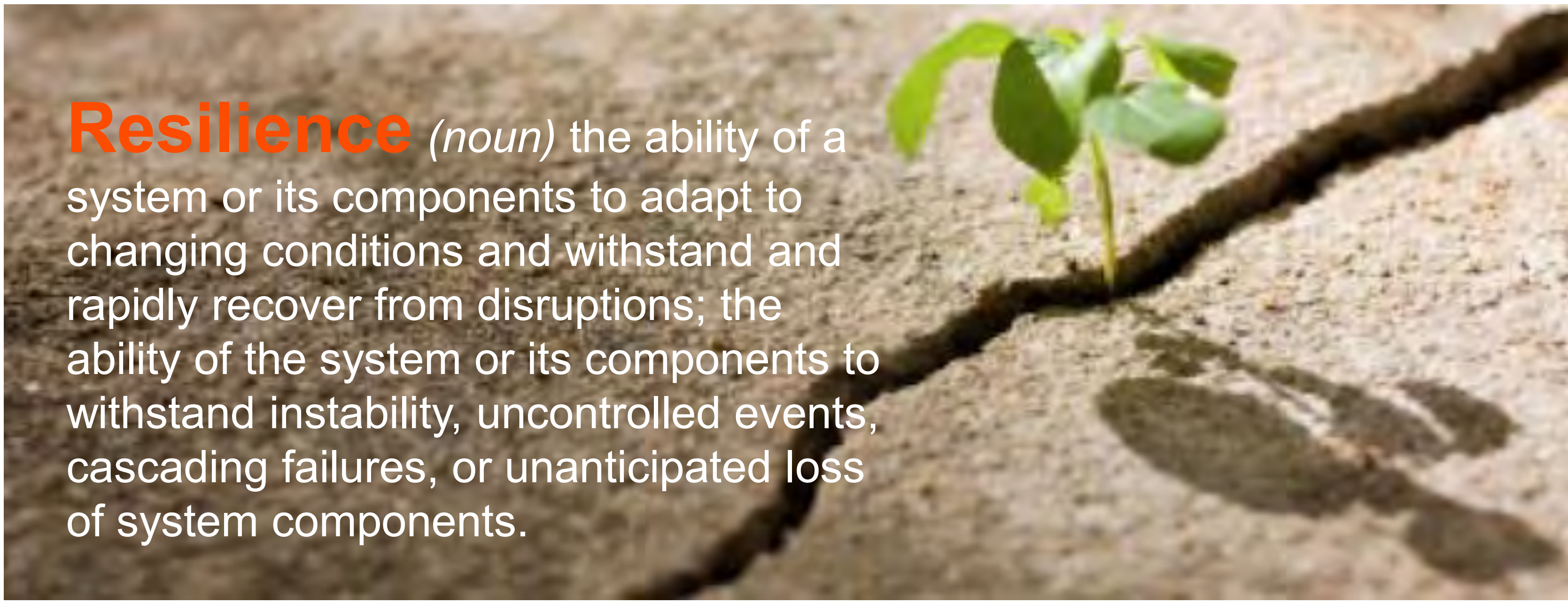
- Power Quality Analysis
- Building Metering
- Utility Analysis
- Measurement & Verification
- Performance Analysis
- Building Analytics

Operations & Maintenance

- Mechanical Service
- Building Automation Service
- Continuous Commissioning
- Repair & Replacement (R&R)

Resilience Definition

Efficiency, Reliability & Security



Resilience *(noun)* the ability of a system or its components to adapt to changing conditions and withstand and rapidly recover from disruptions; the ability of the system or its components to withstand instability, uncontrolled events, cascading failures, or unanticipated loss of system components.

What's driving the concern over resiliency?

The buzzword that everyone is talking about

The Military's realization that their operational capabilities hinge on their facilities – Mission Assurance through Energy Assurance

Extreme weather events (Polar vortex, tornadoes, mega-rain events) rendered schools, cities, state agencies all shut down for days or even weeks

Stuff is just plain old! - Shifts in generation sources, intermittent renewable sources, aging grid assets, system vulnerabilities to physical and cyber-attacks.

What's driving the concern over resiliency?

Global Weather Trends

Extreme weather events are becoming more common

- **Winter storms** have increased in frequency and intensity since the 1950s, and their tracks have shifted northward over the United States.
- **Heavy downpours** are increasing nationally, especially over the last three to five decades – more than 30% above the 1901-1960 average.
- There has been a **sizable upward trend** in the number of storms causing large financial and other losses.

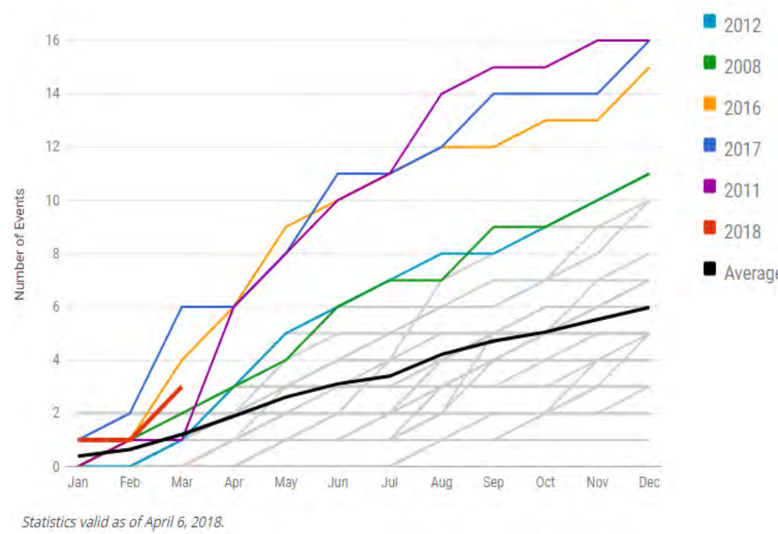


Figure 1- US Billion-Dollar Disaster Event Frequency over 10-Years (CPI-Adjusted) https://www.ncdc.noaa.gov/billions/

What's driving the concern over resiliency?

Increased reliability demands and increased capabilities

Commercial and industrial trends

- Increased customer capability and sophistication and demand for more reliable power
- Increased communication / interaction with utility providers

Advancements in technology are

- Enabling consumers to cost-effectively pursue energy resiliency
- Increasing grid energy resiliency as the demand grows

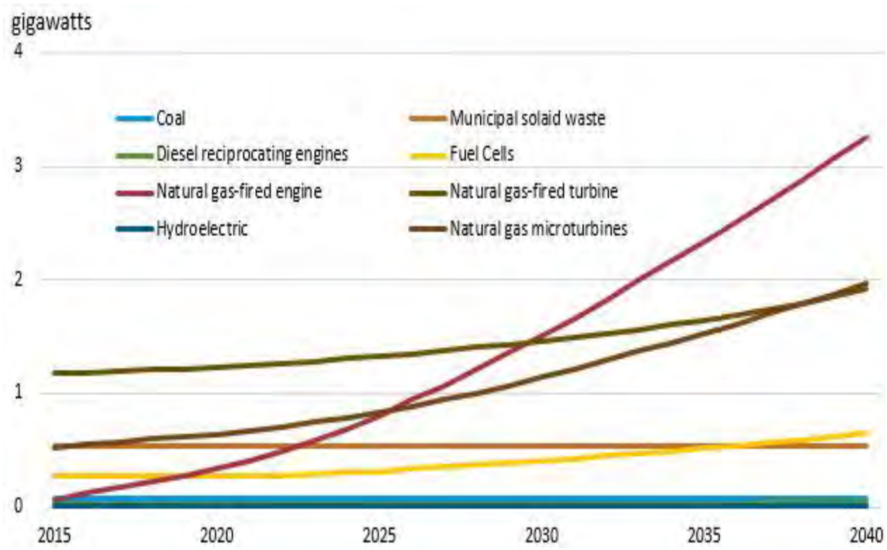


Figure 2 - Installed buildings sector non-renewable DG capacity forecast https://www.eia.gov/outlooks/aeo/nems/2017/buildings/

Trends and Convergence

As technology continues to advance…

Growing complexity in facility-level networking

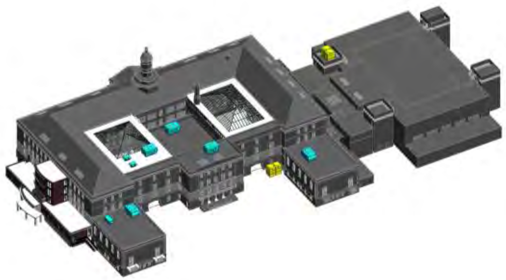
- Advanced BAS / Open systems
- Generation, demand response, battery storage, TES integration
- Programming platforms and network protocols manage data

Analytics are becoming more powerful

- Demand anticipation
- Equipment failure prediction
- Energy comparative benchmarking
- Real time pricing and client response

Trends and Convergence

All roads lead to efficiency and resiliency



Energy efficiency remains a high-priority policy for many clients

- Forms the basis of resiliency.
- Reduces cost
- Reduced energy use and emissions
- Deferred maintenance solutions

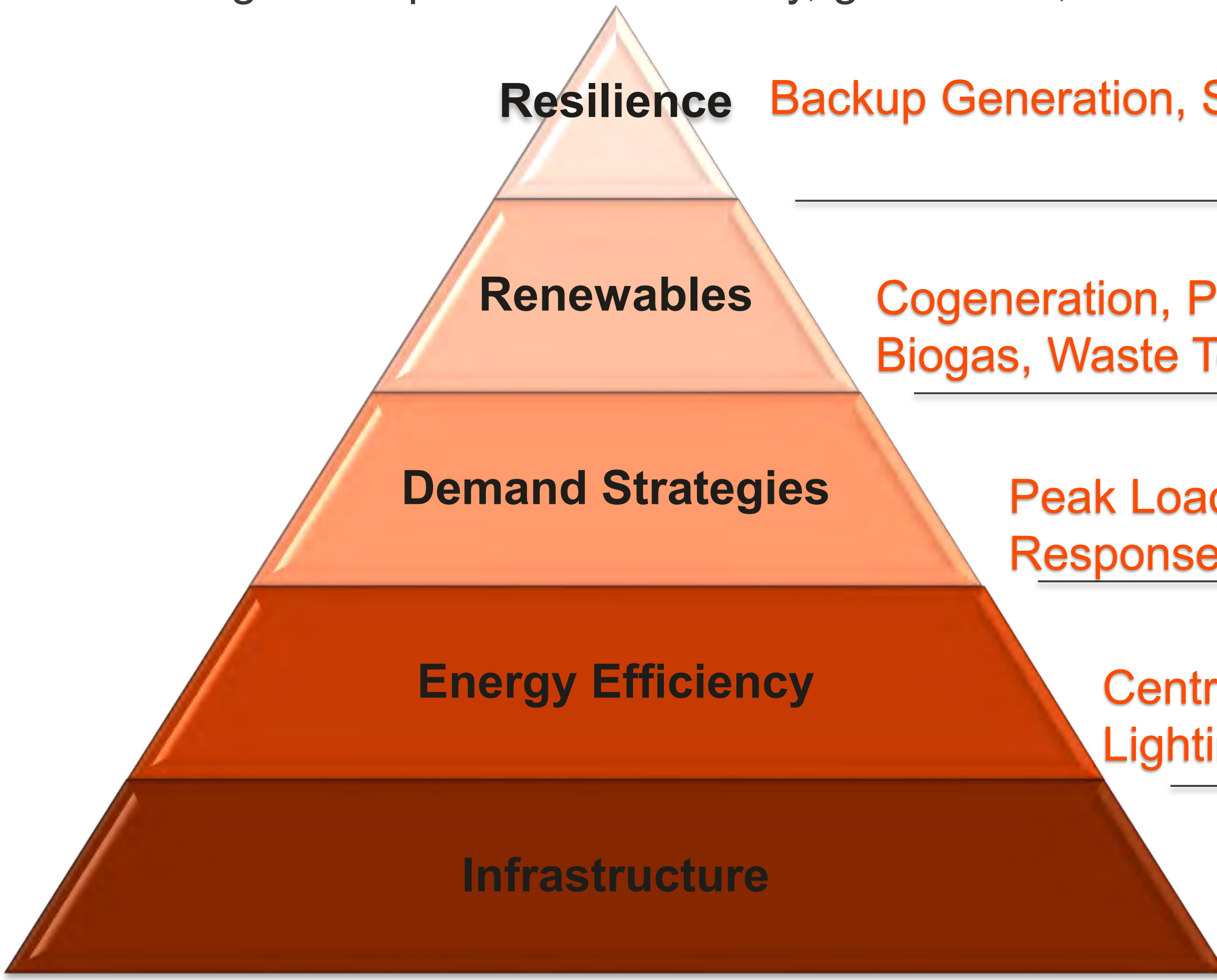
Resiliency / reliability of operations is increasingly important

- Extreme weather jeopardizes core mission
- Grid stability is a growing concern
- Cybersecurity affects power
- Acute awareness of resiliency issues

Result - Customers are maturing from simple energy efficiency to energy resiliency as cost-effective generation opportunities present themselves

Trends and Convergence

The logical sequence of efficiency, generation, demand response & resiliency



Backup Generation, Storage and Microgrid

Cogeneration, PV, Solar Thermal, Biogas, Waste To Energy

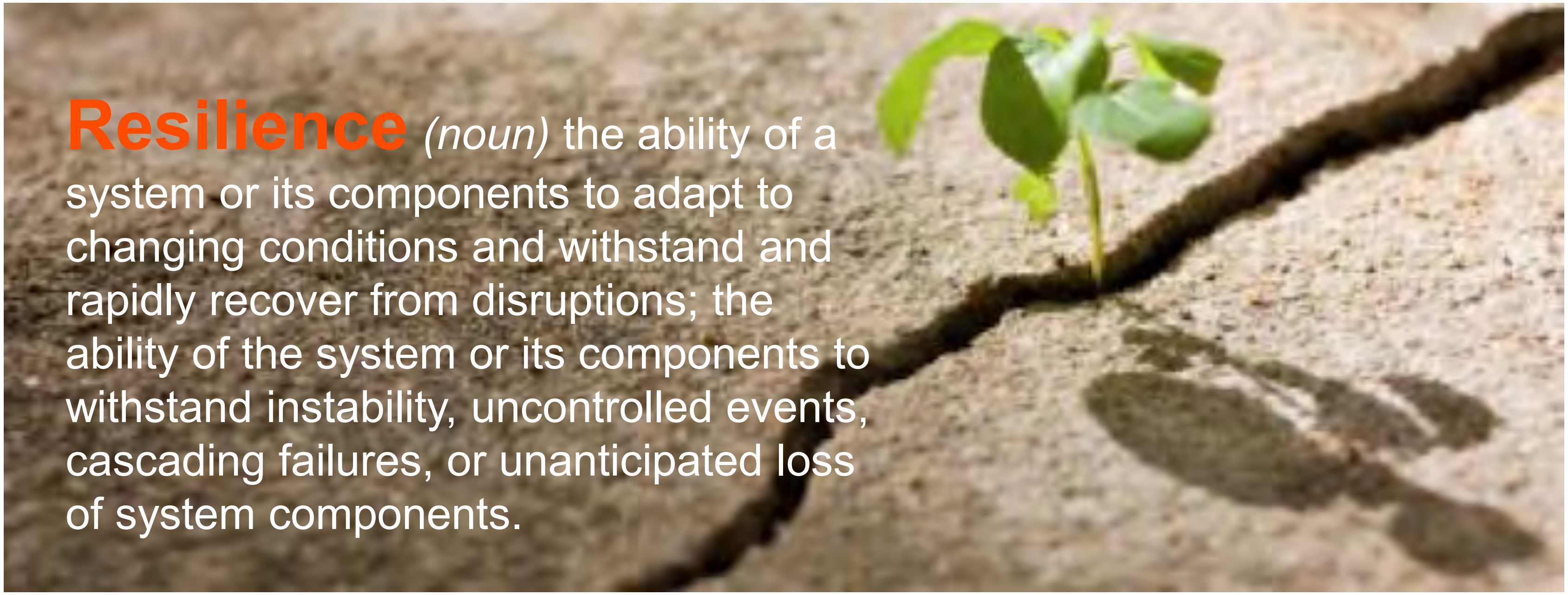
Peak Load Control, Demand Response (DR) & Automated DR

Central Plants / HVAC / Lighting / Envelope

IT / BMS / Electrical / Mechanical

Resilience Definition

Efficiency, Reliability & Security



Resilience *(noun)* the ability of a system or its components to adapt to changing conditions and withstand and rapidly recover from disruptions; the ability of the system or its components to withstand instability, uncontrolled events, cascading failures, or unanticipated loss of system components.

Three Pillars of Resilience

Efficiency, Reliability & Security

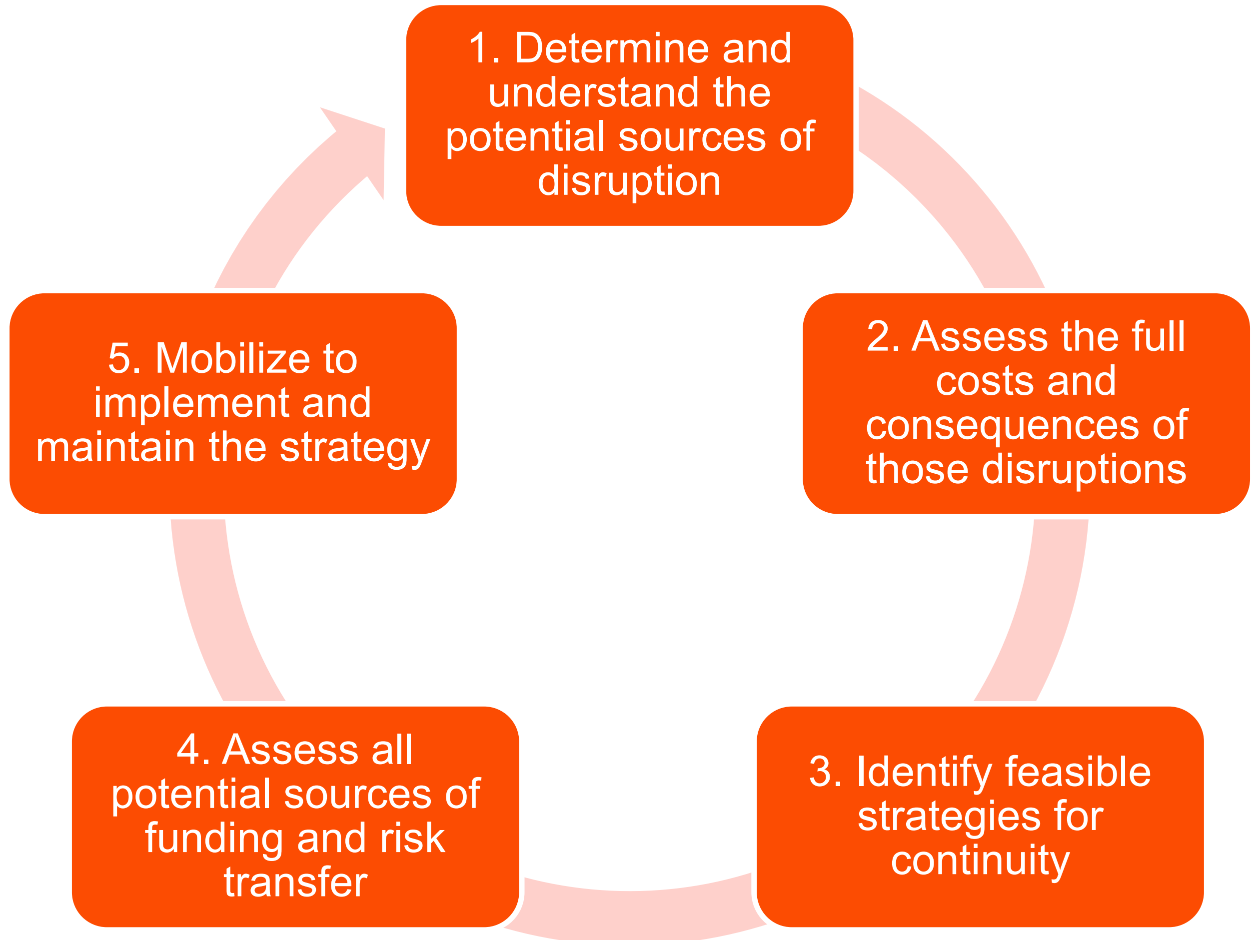
Efficiency is the state or quality of being efficient, or able to accomplish something with the least waste of time and effort; competency in performance.

Security the uninterrupted availability of energy sources at an affordable price. The ability of a system or its components to withstand attacks (including physical and cyber incidents) on its integrity and operations.

Reliability is the ability of an apparatus, machine, or system to consistently perform its intended or required function or mission, on demand and without degradation or failure.

Resilience Sequencing

Reliability Facility Operations Solutions Flow



Resilience Sequencing

1. Determine and understand the potential sources of disruption.

External Loss of Service

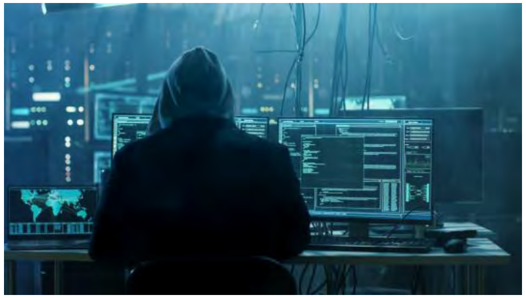
- Potential failures are all beyond direct control.
- Loss of grid electricity from extreme weather.
- Utility shutdown or loss of a generation or transmission.

Power Quality

- Sags and swells over 10%
- Transient voltages "spikes"
- Equipment failures motors, transformers
- Increased cost, more power is delivered than is used.
- Power Factor
- Frequency and voltage harmonics (VFDs)

Resilience Sequencing

1. Determine and understand the potential sources of disruption.



Cyber attacks

- Facility digital control or monitoring systems not typically targeted.
- Utility system attacks are extremely common and increasing.

On site failures

- Failure of equipment on-site.
- Interconnect to utility not have been upgraded over time to match growth or function.
- Transformers and switch gear maintenance or power quality issues such as transients.

Local system failure

- Full or partial loss of refrigeration, domestic water, thermal control, etc.
- Mitigate risk through Modern Best Practices in system design, redundancy, monitoring, maintenance and planned upgrades.

Resilience Sequencing

2. Assess the full costs and consequences of those disruptions

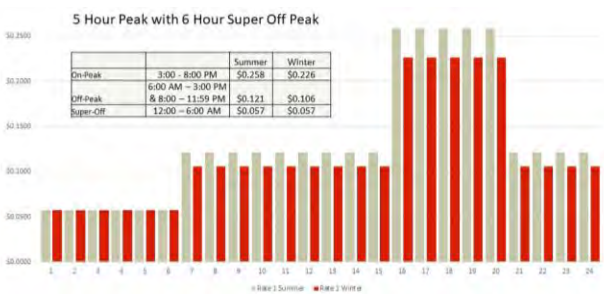
Determine the impact of failure

- Determine mission critical needs.
- Identify risks, assess likelihood, and identify costs.
- Determine and address safety concerns
- Determine regulatory or contractual penalties for failing to provide agreed services or products - School failures result in students being sent home.
- Determine equipment repair / replacement costs for at risk systems. Premature or unexpected failure of on-site systems are typically repaired out-of-budget and on an expedited basis at higher than normal costs.

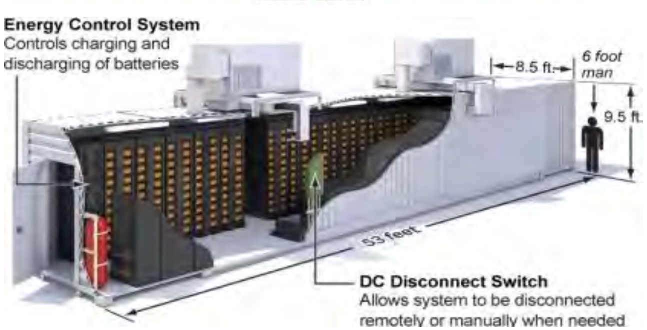
Low Med	Medium	Med Hi	High	High
Low	Low Med	Medium	Med Hi	High
Low	Low Med	Medium	Med Hi	Med Hi
Low	Low Med	Low Med	Medium	Med Hi
Low	Low	Low Med	Medium	Medium

Resilience Sequencing

3. Develop strategies for continuity



		Summer	Winter
On-Peak	3:00 - 8:00 PM	$0.258	$0.226
Off-Peak	6:00 AM – 3:00 PM & 8:00 – 11:59 PM	$0.121	$0.106
Super-Off	12:00 – 6:00 AM	$0.057	$0.057



On-site generation and load management - Provide power to critical loads in the event of grid outage.

Backup from Cogeneration or CHP - Operate continuously and in conjunction with incoming grid power.

Load shedding / demand response - manage demand cost but also mitigate partial loss of service

Uninterruptible Power Supply (UPS) Critical loads such as network servers Inherently provides a power conditioning

Power conditioning equipment - Determined as part of a power quality audit.

Number of feeders and loop redundancy - A single connection is also a single point of failure. Large sites are often fed by two or more feeders.

Energy Efficiency - Decreasing energy demand increases the level of redundancy of existing central systems.

Resilience Sequencing

4. Assess all potential sources of funding and risk transfer.

- Identify plausible risks / failures.
- Quantify the costs of such failures if they were to occur.
- Evaluate the likelihood of failures using statistical models.
- Develop one or more prevention/mitigation strategies for each failure.
- Identify the costs of these prevention / mitigation strategies.

- Evaluate the cost of a failure occurring vs the cost of the strategy to prevent or mitigate it.
- Identify all potential funding sources - traditional capital, operating budgets, energy efficiency upgrades, grants, government funding, and other similar mechanisms.
- Identify potential means of risk transfer - outside operation of energy infrastructure assets can transfer risk and cost to an outside party. Contractual mechanisms can also be employed to compensate in the event of loss of service as agreed.

Resilience Sequencing

5. Mobilize to implement the strategy

1. Determine baseline needs and patterns

- Assess infrastructure
- Gather all utility records
- Survey equipment
- Identify critical loads
- Identify energy needs
- Determine reliability needs

2. Implement efficiency measures

- Use energy as efficiently as possible; smallest load
- Reducing load lowers the cost of serving that load
- Reducing load improves the ability of installed equipment to serve it reliably

3. Determine on-site generation needs

- Cogeneration
- Solar / battery storage
- “Exotics” (waste-to-energy)
- Target appropriate level of redundancy (N+1) for major equipment.
- Determine generation assets, electrical feeders / transformers and other mission-critical items
- Ensure assets are physically secure

Resilience Sequencing

5. Mobilize to implement the strategy

4. Integrate installed and existing assets

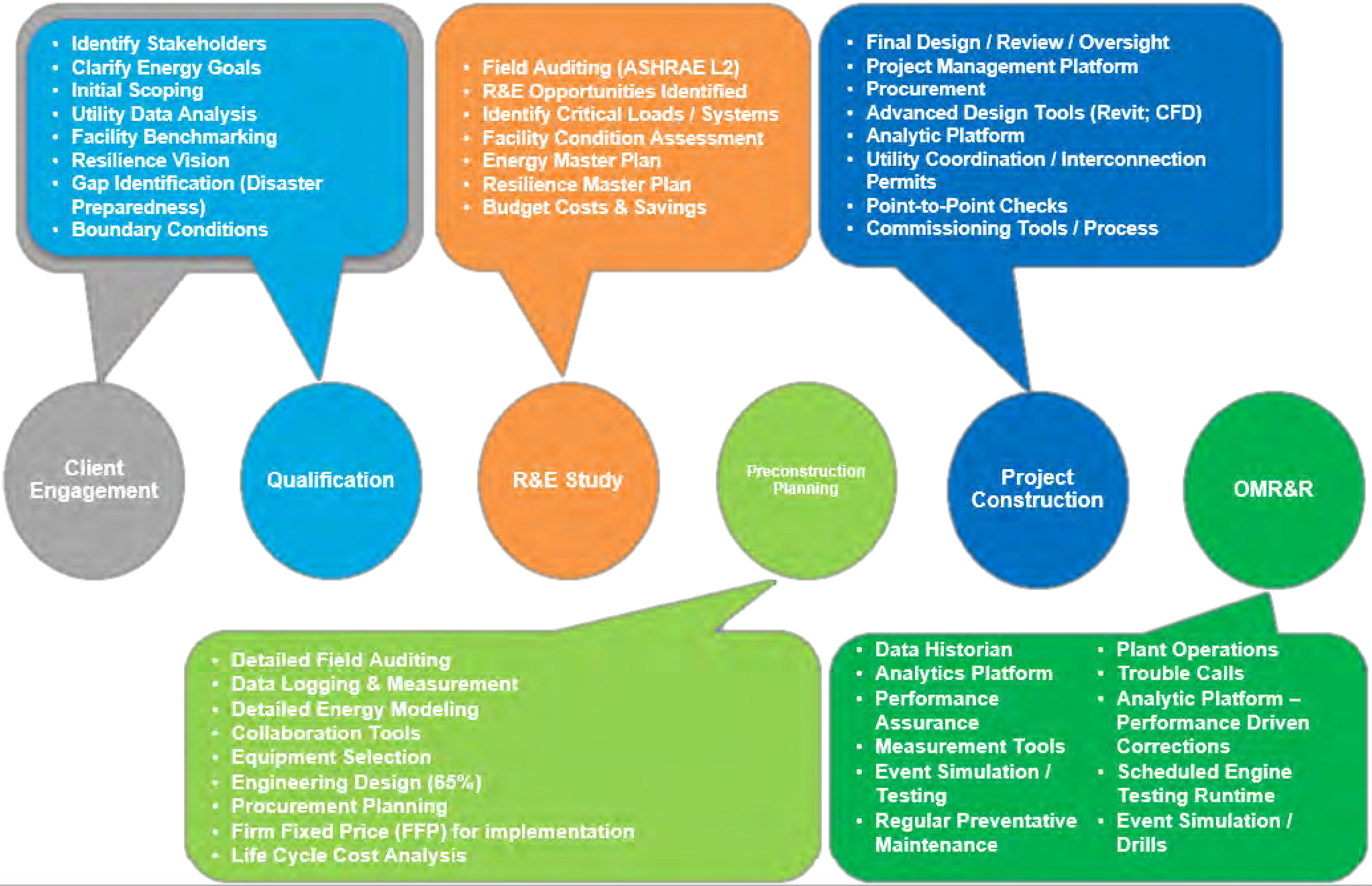
- Facility automation, generation controllers, storage, switchgear
- Ensure systems are electronically secure

5. Operate, Maintain, Repair and Replace

- Maintaining your primary mission remains Job 1
- Integrate predictive analytics into maintenance strategies
- Staff training and/or outsourcing of OMRR

Resilience Sequencing

The logical sequence of efficiency, generation, demand response & resiliency



Southland

Case Studies

Golden West Community College – Huntington Beach, CA

Project Highlights

- Retro-commissioning of 18 existing campus buildings included HVAC, Electrical, Plumbing, Ceiling and energy efficiency upgrades
- Developed strategic phasing plan where building upgrades were performed in blocks of 2-3 buildings to minimize downtime and disruption to operations
- New central utility plant with 1400-tons cooling / 16.8 million BTUs heating with complete new plumbing service including: sewer, storm drain, make-up water, and natural gas
- Installation of 26,000 linear feet of chilled and hot water piping underground completed in three months, tying new central plant to 18 campus buildings
- New campus-wide Energy Management System
- Minimal impact to the college with no incidents or injuries
- Implemented innovated energy solutions for the campus generating over $500,000 in CCC / IOU Partnership rebates
- Through California Legislature Government code 4217, Southland acted as prime contractor for this design-build project
- Project was completed within budget and ahead of schedule

Randolph-Macon Academy – Front Royal, VA

Project Highlights

Southland Energy provided energy auditing, development, and financing, as well as mechanical, electrical, and plumbing design services prior to the project's construction phase. Completing these services beforehand allowed Southland to develop a bundled energy and facility renewal program that replaced over $1.5 million in end-of-life equipment. By teaming with the school's finance, facilities, and operations staff Southland Energy offered a financial and technical solution to address the school's needs, as well as find savings and subsidies to fully fund the project.

Project Savings:

- Campus carbon reduction: 35%
- Electricity savings: 1,086,149 kWh/year
- Gas savings: 56,000 therms/year
- Water/sewer savings: 589,000 gallons/year
- VirginiaSAVES subsidiary value: $1,000,000
- Cost savings over project life: $5,500,000

St. Anne's-Belfield School – Charlottesville, VA

Project Highlights

This project was the first award under VirginiaSAVES, a new program designed to reduce the cost of qualified energy efficiency projects and provide low or no-cost long-term financing. By teaming with the school's finance, facilities, and operations staff, Southland developed a holistic energy and facility solution to reduce cost and address the school's aging infrastructure. The project is fully self-funding (annual savings exceed annual debt service costs) and reduces the school's carbon footprint by 28%.

Project Savings:

- Electricity savings: 805,427 kWh/year
- Natural gas savings: 23,078 therms/year
- Water savings: 1,015,000 gal/year
- VirginiaSAVES subsidy value: over $390,000
- Utility rebates: $15,240
- Carbon reduction: 730 metric tons of CO_2/year
- Cost savings over project life: $4,486,805

Longfellow Elementary School – Pasadena, CA

Project Highlights

Southland's team of engineers worked with the District to design and build a new Central Plant. The scope of work includes:

- Complete replacement of the central chilled water (CHW) and heating hot water (HHW) plants.
- Installation of a high efficiency, all variable speed, water-cooled CHW system utilizing a chiller with Turbocor compressors.
- Increased central plant footprint (by 70%) to accommodate redundant pumps, chiller and cooling tower for improved CHW system reliability.
- Complete replacement of the central plant controls including integration with the school's existing building automation system and the District's central server.

Work was completed during the two-month summer break when the school was unoccupied. This was a very tight schedule for the scope of work and Southland stayed on schedule and completed the project on time.

Project Savings:

- Electrical energy savings: 135,500 kWh/year (76% reduction)
- Electric cost savings: $25,300/year

Riverside County Regional Medical Center

Riverside County Regional Medical Center installed two new 750KW co-generation units that produce 1.5MW of electricity. The 10,000 ton-hour thermal storage system adjacent to the new co-generation equipment yard. The thermal storage system is charged during off-peak periods when energy costs are low and cools the hospital during peak hours when energy costs are highest.

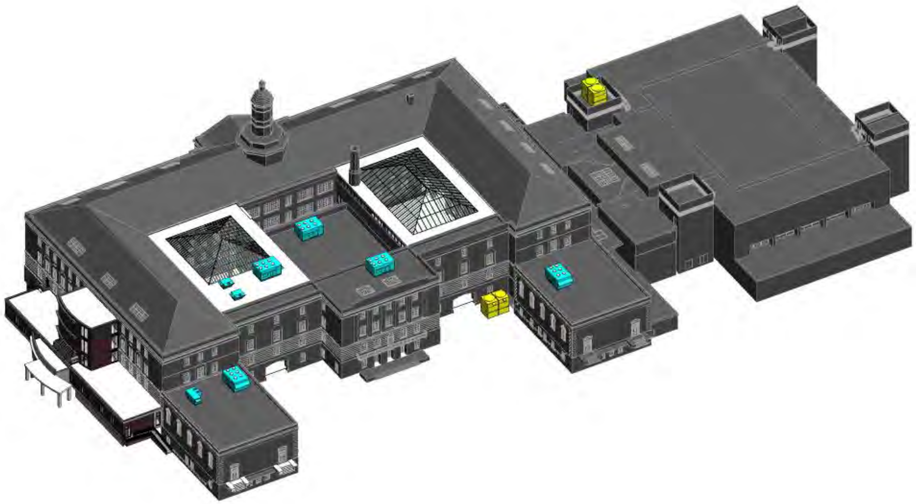
Project Highlights

- Two 750kw co-generation units providing 1,500 KW.
- 10,000-ton/hour thermal storage system.
- Installed an automatic revolving door system at the north east exterior entrance location located between the emergency wing and the main hospital provides improved occupant comfort and energy savings.

Coolidge High School – Washington, DC

Project Highlights

- Southland developed a SIP Schedule to be used for the construction schedule by the project team.
- Opportunity to expand scope with a renovation and scrub of the neighboring gymnasium complex.
- Southland drove the BIM and coordination process for all MEP trades through the use of BIM 360 Glue. This glue allows all trades to coordinate with “real-time” changes and can help prevent clashes.
- Project includes a water sourced VRF system, rather than the more common aircooled VRF system.
- Support and maintenance for the occupied swing space serving as temporary classrooms during the school year.
- 20,000+ injury-free man hours thus far on fast tracked project located in a congested metropolitan area.



Carl R. Darnell Army Medical Center – Fort Hood, TX

Project Highlights

- Received “Lonestar and US Army Corps of Engineers” awards for outstanding safety.
- 100% dedicated outside air HVAC system in all patient care areas to achieve superior indoor air quality and exceptional energy efficiency.
- Remote 5,220-ton CUP with high efficiency heating and cooling including heat recovery chillers, high efficiency centrifugal chillers, and boiler stack economizers.
- Exceeds the 30% minimum energy reduction over ASHRAE Standard 90.1.
- An Energy Independence Security Act (EISA) compliant building that achieves a 55% reduction in energy use over the existing hospital.
- Water efficient design that achieves a 30% reduction in domestic water use.
- Biosafety Laboratory level 2 and 3 spaces integrated into the facility.
- 30,000 square foot radiant cooling/heating system embedded into the atrium floor.

Innovation

- Southland’s ability to minimize water usage by 30% and maximize energy conservation proved to be a critical element due to the severe droughts Fort Hood is susceptible to from the dry and hot climates.

Chabot Las-Positas Community College District – Hayword, CA

Chabot Las-Positas installed two new energy efficient thermal ice storage central plants with chilled and hot water underground loop piping for two campuses. The Chabot included three Ajax natural gas fired high-efficiency hot water boilers, two 650-ton high-efficiency Trane chillers, 36 CalMac ice storage tanks with 6,840 ton-hours of cooling, and two Evapco cooling towers with VFDs located in a new central plant.

Las Positas included a new 3,600sqft CUP with two 300-ton high-efficiency Trane chillers, 21 CalMac ice storage tanks with 3,040 ton-hours of cooling, and two Ajax natural gas fired high-efficiency boilers with future capacity.

Project Highlights

- 1,661,189 kWh/yr and 122, 304 therm/yr in central plant savings, $653,884 energy rebate from utility.
- Upgraded DDC provides real-time monitoring and control saving 287,141 kWh/yr and 24,400 therm/yr, $78,226 energy rebate from utility.

Los Angeles Pierce College – Woodland Hills, CA

The Near Net-Zero design uses solar thermal power to generate heating and cooling for the new O&M building and horticultural buildings, which house the a gardening area, offices, administrative space, and electrical, plumbing, and carpentry shops. The infrastructure design provides for future solar thermal evacuated tube collectors and expansion provisions.

Project Highlights

- Energy efficiency: lighting and lighting controls, water conservation, HVAC, demand response, building controls, central plant, waste, and building envelope.
- Reliability: Two 2,000 MBH boilers as backup for the solar thermal system when hot water is not being generated with a 42,000 gallon underground solar hot water storage tank.
- Renewable: 189 kW of solar photovoltaic.

SSA National Support Center – Urbana MD

SSA National Support Center constructed a 285,000 square foot data center facility that contains 55,000 square feet of white space, an office building, and an access control center. The Tier III data center supports approximately 10 MW of IT load and replaces the administration's previous data center in Woodlawn, Maryland.

Project Highlights

- Uptime Tier III certified central utility plant equipment, computer room air handlers (CRAH), and chilled water distribution with N+2 redundancy requirements.
- Active chilled water thermal energy storage system to provide at least 15 minutes of chilled water capacity when switching from utility to generator power.
- Cooling tower basin design provides 72 hours of makeup water storage for cooling tower operation in the event of a water main failure.
- Largest installed single zone system in the United States.

Dallas VA Medical Center

Project Highlights

- Combined Heat and Power (CHP) plant with tie-in to the existing central steam plant for the Veterans Affairs Medical Center (VAMC) in Dallas, Texas.
- High pressure, natural gas turbine style generator that produces 4.5 MW of electricity.
- Heat is recovered through a 35,000 PPH heat recovery steam generator (HRSG) with a tri-fuel (bio-diesel, natural gas or fuel oil) duct burner to produce high pressure steam.
- Interconnection of high pressure steam (125-psig) into an existing building heating, cooling and domestic water systems without impacting ongoing facility operations
- To enhance energy security, the design-build solution incorporated the capability for the gas turbine to operate in an “island mode” configuration. This included a new 500 kW black-start diesel engine generator to provide start-up power to the CHP in a case of a loss of utility power.

CEO Update

Scott Prochazka

President and CEO

CenterPoint Energy

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Topics

- Who is CenterPoint Energy?
- 2017-2018 Accomplishments at a Glance
- Key Influences on the Energy Industry
- Our Proposed New Renewable Natural Gas Program
- CenterPoint Energy's Investments for Growth, Reliability, Safety, Sustainability and Customer Satisfaction
- Our Value Proposition: to be Your Trusted Energy Partner

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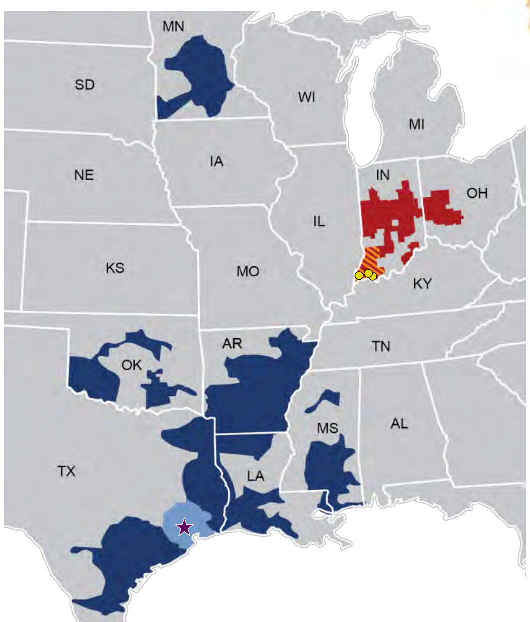
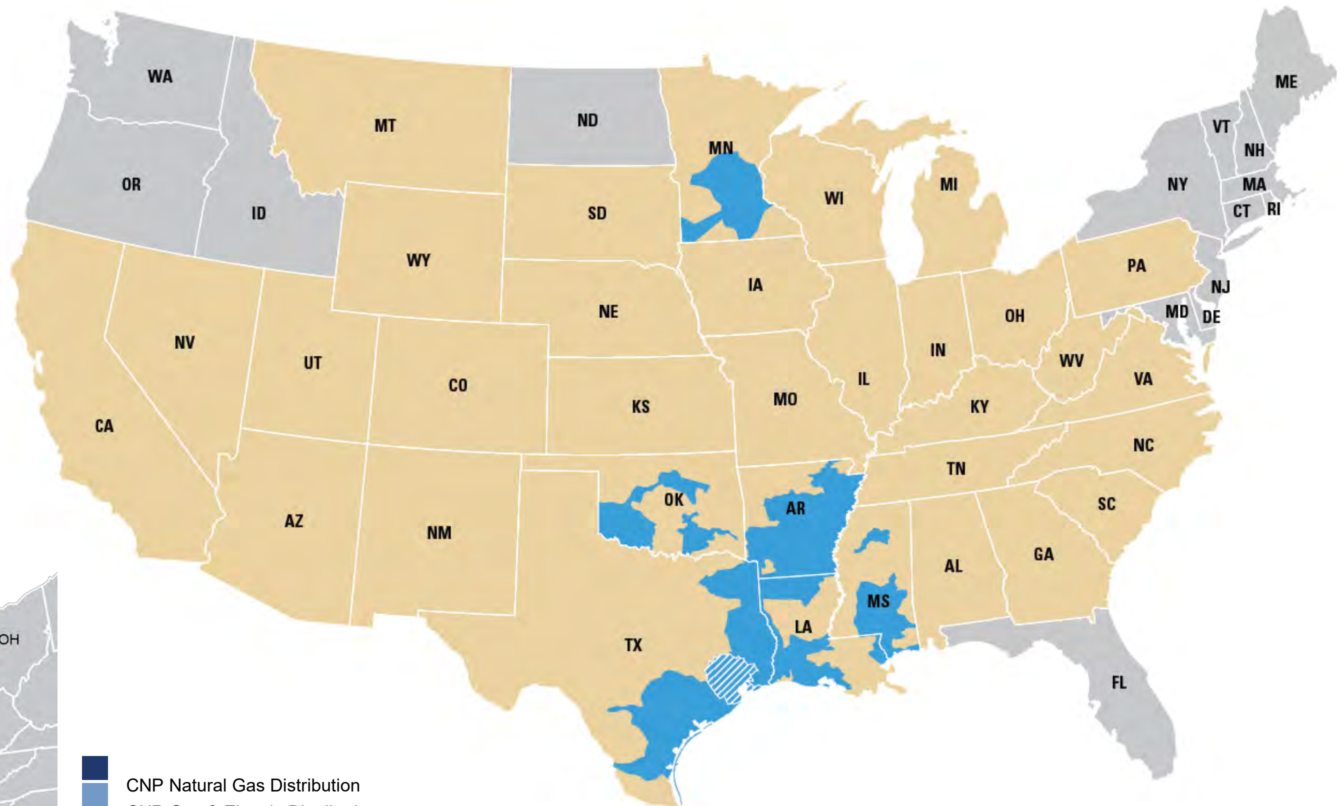
Who is CenterPoint Energy?

Post-merger



- CNP Natural Gas Distribution
- CNP Gas & Electric Distribution
- VVC Natural Gas Distribution
- VVC Gas & Electric Distribution
- Regulated Generation
- Corporate HQ



- CenterPoint Energy Services
- Natural Gas Distribution
- Electric Transmission & Distribution
- No Presence

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2017-18 Accomplishments at a Glance

- **Operate**
  - Completed cast-iron pipeline replacement in Minnesota and Texas
  - Filed to introduce new renewable natural gas program in Minnesota
- **Serve**
  - Reduced carbon footprint through energy conservation programs
  - Awarded a historic energy conservation rebate for $2 million to the University of Minnesota for installation and construction of its Main Energy Plant, a high-efficiency natural gas combined heat and power plant (CHP).
  - Launched our Corporate Responsibility Report following Global Reporting Initiative standards to disclose environmental, social and governance performance
  - Showed value of technology investments during Hurricane Harvey restoration
  - Contributed crews to historic power restoration in Puerto Rico after Hurricane Maria and in Florida following Hurricanes Irma and Michael
- **Grow**
  - Added more than 70,000 natural gas and electric customers
  - Invested nearly $1.5 billion in capital expenditures on behalf of customers
  - Pending merger with Vectren advances our vision to lead the nation in delivering energy, service and value

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An Award-Winning Company

Customer Satisfaction

Natural Gas
Residential Gas Customer Champion 2017, 2018
Most Trusted Brand 2017, 2018

#1 Investor Owned Utility in U.S. 2018

#1 among Large Southern Gas Utilities 2017 & 2018

CenterPoint Energy Services (CES)
Exceeded industry benchmark in a 2017 Natural Gas Marketer Customer Value / Loyalty Benchmarking Study.

Energy Efficiency

Home Service Plus®
Energy Efficiency Partner Award from Xcel Energy

Environment

Environmental Champion - Midwest

Community

Key Energy Industry Influences

Customers

Technology

Natural Gas and Electric Vehicles

Backup/ Distributed Generation

Data Analytics

Picarro Leak Detection

Drones

Renewable Energy

Power-Sensitive Equipment

Environmental Stewardship

Microgrids

Battery Storage

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Renewable Natural Gas

- CNP proposed program to Minnesota Public Utilities Commission, for
  - Residential CNP customers
  - Commercial & Industrial customers receiving firm sales service
  - C&I customers receiving interruptible sales service
- **Renewable natural gas lowers GHG emissions by 40-100%**
- Sources of renewable natural gas
  - **Landfills** – methane emissions from decomposed waste
  - **Digesters** – micro-organisms consuming biomass such as manure and cornstalks, which produces methane and CO_2
  - **Gasifiers** – biomass (e.g. wood and crop residue) converted to combustible gas by heat and pressure in low-oxygen environment
- CNP estimates cost of renewable natural gas to be slightly < $4/therm
- Pending MPUC approval, enrollments could begin in spring 2019

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CNP is Improving Customer Satisfaction While Reducing Carbon Emissions

New, improved gas leak detection systems

Drive-by Advanced Meters

Pipeline replacement programs

Predictive Analytics

Smart Grid

CenterPoint Energy

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Energy Delivery of Tomorrow

Rising Customer Expectations

Regulated and Competitive Services

Trusted Energy Partner

- **Deliver Energy**
  - Natural gas and electricity delivery
  - Power generation (natural gas-fired, renewables)*
  - Competitive natural gas supply
  - Continued focus on safety, reliability and sustainability
- **Deliver Service**
  - Customized products and self-service capabilities
  - Enhanced energy management and reliability solutions
  - Underground pipeline construction and repair*
  - Energy performance contracting – renewable, distributed generation and combined heat and power projects*
  - Proactive communications (curtailment, outage)
- **Deliver Value**
  - Customer engagement is proactive, enterprise-wide and seamless
  - Focus on financial and operational improvements for customer
  - Allows customers to focus on core competencies/skills
  - Move customers from satisfaction to loyalty

*Post-merger

Natural Gas Reliability

Trey Kuchar

Vice President, Gas Engineering and System Integrity

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Minnesota Gas Operations

- Operate 14,000 miles of main serving 860,000 customers in over 400 communities
- Eight propane-air peak shaving facilities, one liquefied natural gas (LNG) storage facility and one underground storage facility
– Home Service Plus (CenterPoint Energy's non-regulated business) provides residential appliance repair, maintenance and equipment replacement in MN
– CenterPoint Energy Services (CES) provides competitive energy services for commercial and industrial customers across the state

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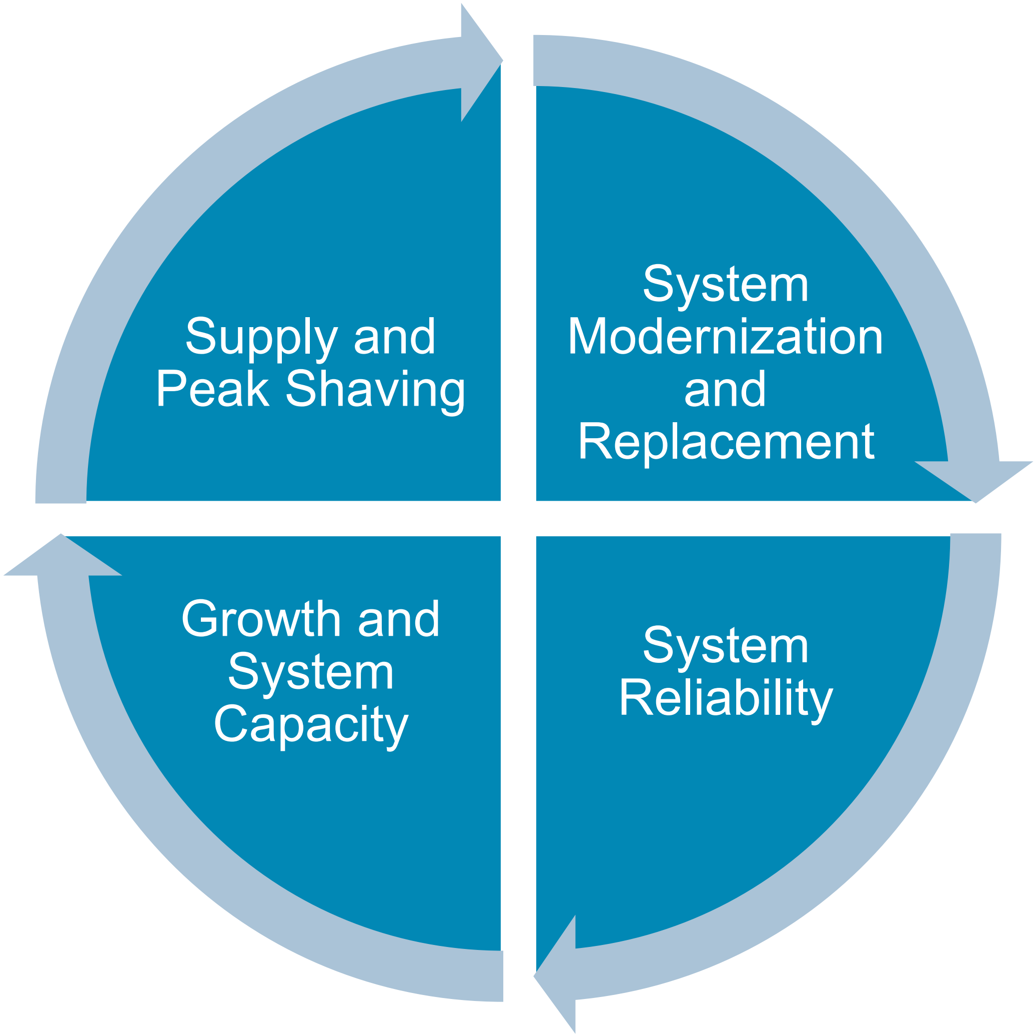
Holistic Approach to Reliability



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System Modernization

- Gas company was founded in Minneapolis in 1870
- Use state-of-the art pipe and installation methods for the distribution system

Wood

- Low pressure gas carried in wooden pipe

Cast Iron

- 1890 - 1930's
- Long lifespan
- Brittle and difficult to repair
- All cast iron was replaced in MN in 2017

Uncoated or Bared Steel

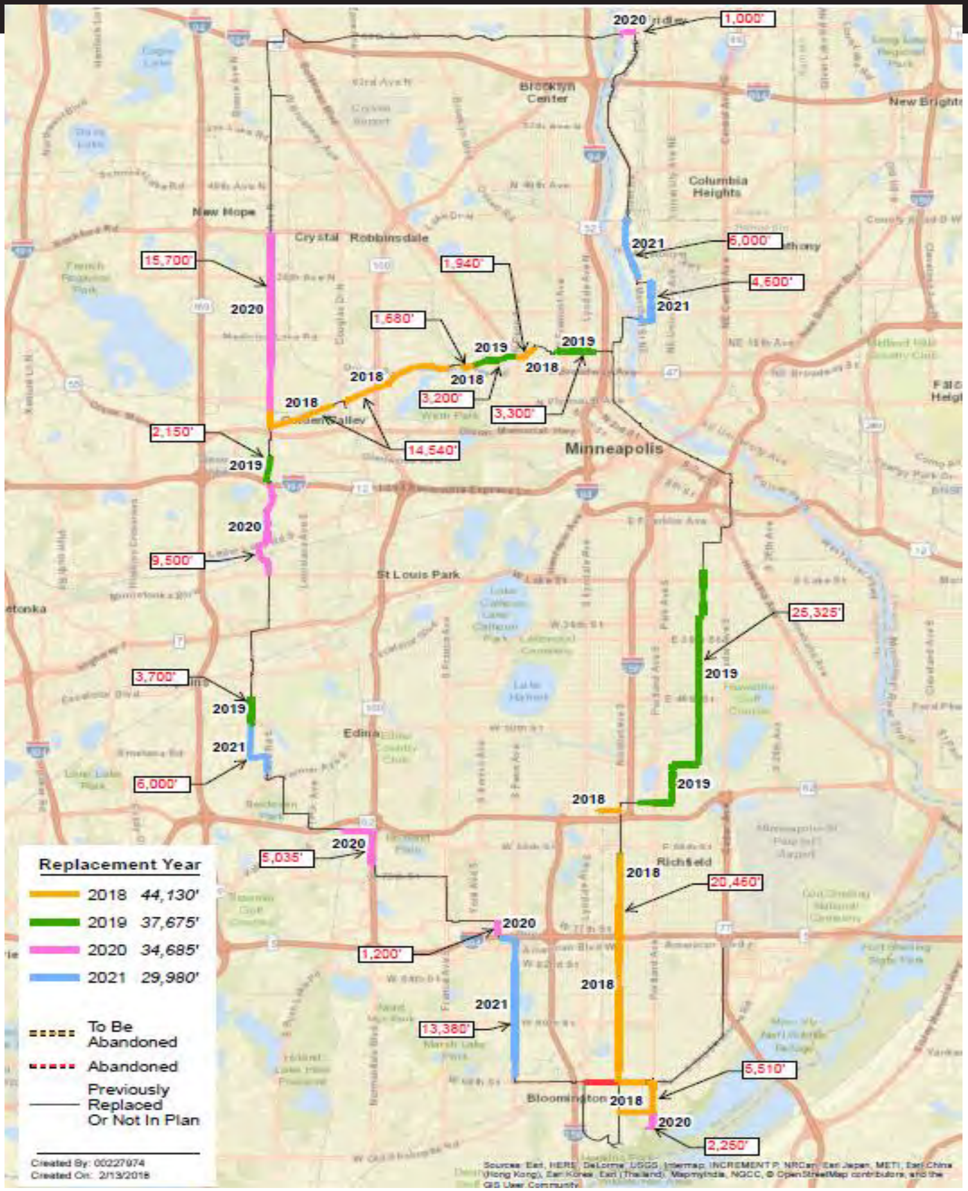
- 1940-1950's
- Corrosion can be an issue in certain soils

Plastic & High Strength Coated Steel

- Used in recent decades
- Each has a extremely long life expectancy

System Modernization- Beltline Replacement

- Replacement projects to enhance reliability
- Modernizes 20” and 24” pipelines
- Involves 74 miles in urban and suburban areas
- Major financial undertaking $121M
- Main supply lines



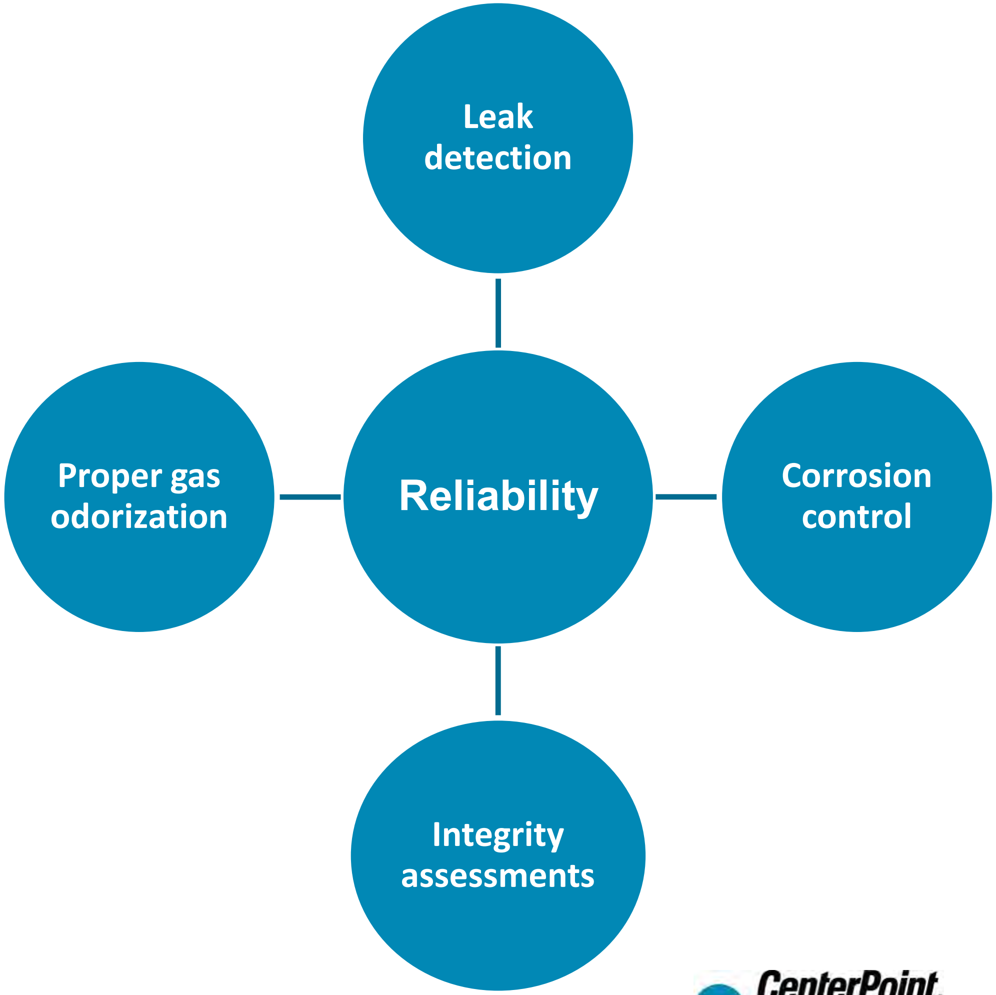
System Modernization-
Beltline Replacement

System Modernization-Beltline Replacement

System Modernization
Cast Iron Replacement

System Reliability

- Extensive maintenance programs
- Distribution system is monitored in real-time through a SCADA (Supervisory Control Data Acquisition) system
- Committed to reliable service



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System Reliability
Leak Detection

- Picarro is an innovative technology used for leak detection
- Full deployment of Picarro technology happened this year
  - Picarro / Cavity Ring-Down Spectroscopy (CRDS) Vehicle
  - Anemometer (top) measures wind speed

Typical Picarro Vehicle

System Reliability
System Security

- Physical security – CenterPoint Energy partners with our main interstate transmission supplier to provide on-site security at critical facilities
- Security consists of fencing, cameras and detection monitored 24/7
- Cyber security – protecting our facilities and our customer data

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Growth & System Capacity

- CNP projects growth through the use of city planning departments as well as Metropolitan Council's seven-county data for the next 20 to 30 years
- CNP monitors system pressures to determine when growth is affecting system pressures
- CNP models system capacity and pressures using flow modeling software to anticipate when and where system up grades are required

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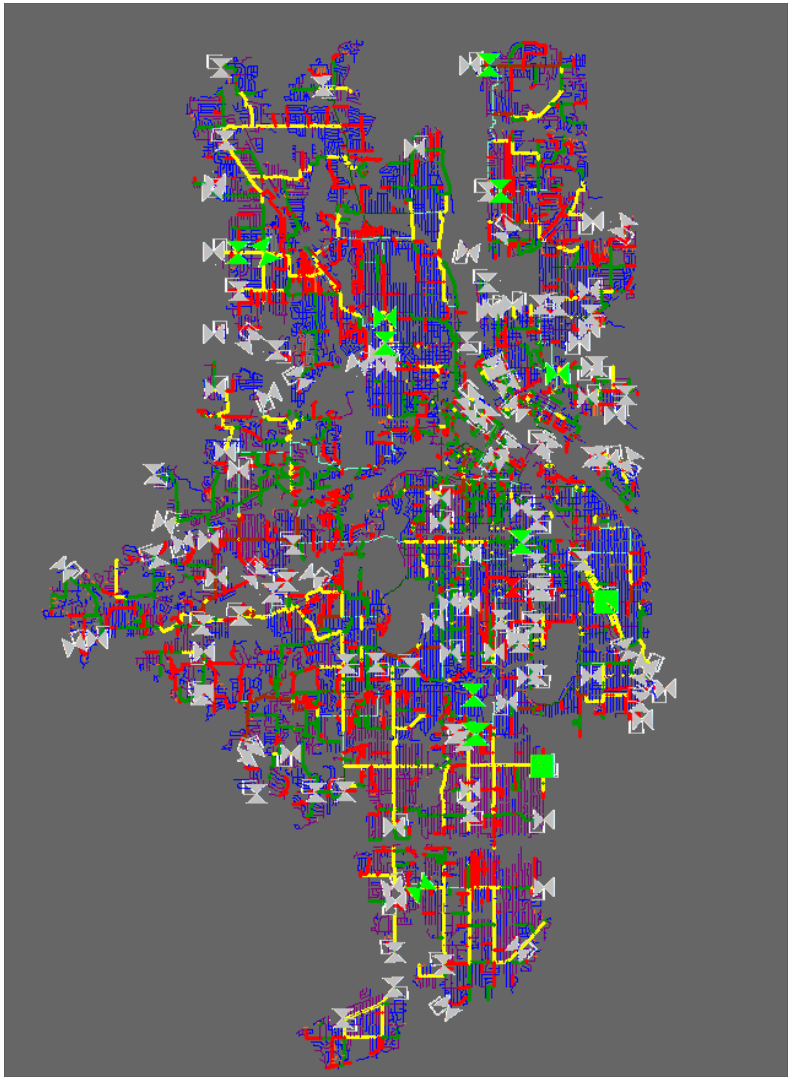
Growth & System Capacity
Synergi Flow Modeling – Metro Area



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Growth & System Capacity
8" Plastic Main

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Supply & Peak Shaving

"Design Day" calculations are performed every year

Sufficient firm gas supplies contracted by CNP gas supply to serve forecasted design day

Interstate pipeline transportation supply points are matched to CNP town border stations

Interstate pipeline storage is used for supply management and balancing

Supply & Peak Shaving

During extreme cold weather, a significant portion of our firm design day requirements can be produced and delivered from local storage facilities

Local CNP Storage and Production

❖ Propane-Air	~160,000 DT/Day
❖ Liquefied Natural Gas (LNG)	~72,000 DT/Day
❖ Underground Storage	~50,000 DT/Day

Supply & Peak Shaving
Mankato Propane-Air

Production System Replacements

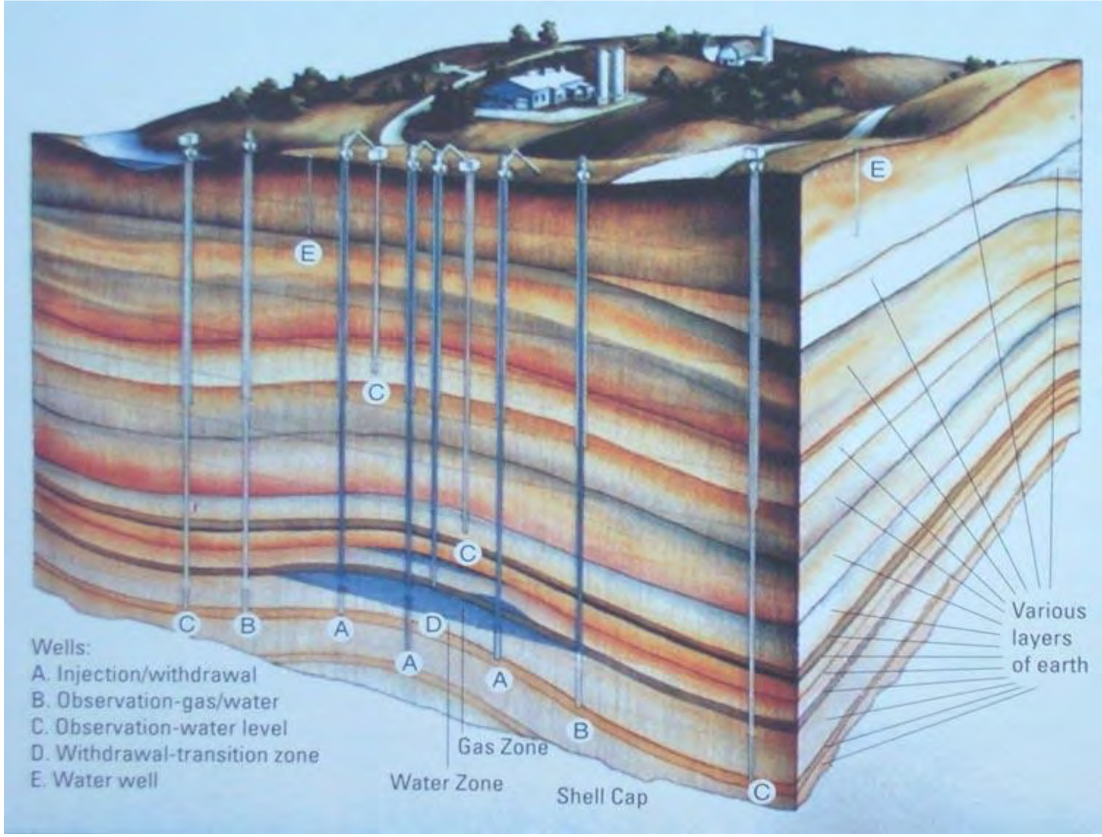
- New Compressors, New Vaporizer, New Blender, New Gas & Fire Detection

Supply & Peak Shaving Dakota Station

Largest Facility – Ongoing Facility Investment for Reliability and Safety

Supply & Peak Shaving
Underground Storage – Waterville, MN

- Flexible Reliable Gas Supply
- Investments in Storage Integrity Management Program
- 5 Year Gathering Line Replacement
- 2018 Compressor Upgrade



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Natural Gas Market Update

Scott Doyle

Senior Vice President, Natural Gas Distribution

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Benefits of Natural Gas

Domestic & Abundant

- Large percentage of the energy in the US is generated by natural gas
- Increased supply and abundance has increased exportation to other countries and provided 9.8 million jobs.

Comfortable & Convenient

- Easy to use and putting heat and hot water at your fingertips

Safe & Reliable

- Federal statistics show that pipelines are the safest modes of transportation.
- High level of reliability during natural disasters compared to other forms of energy delivery.

Affordable & Efficient

- Highly efficient, clean and affordable

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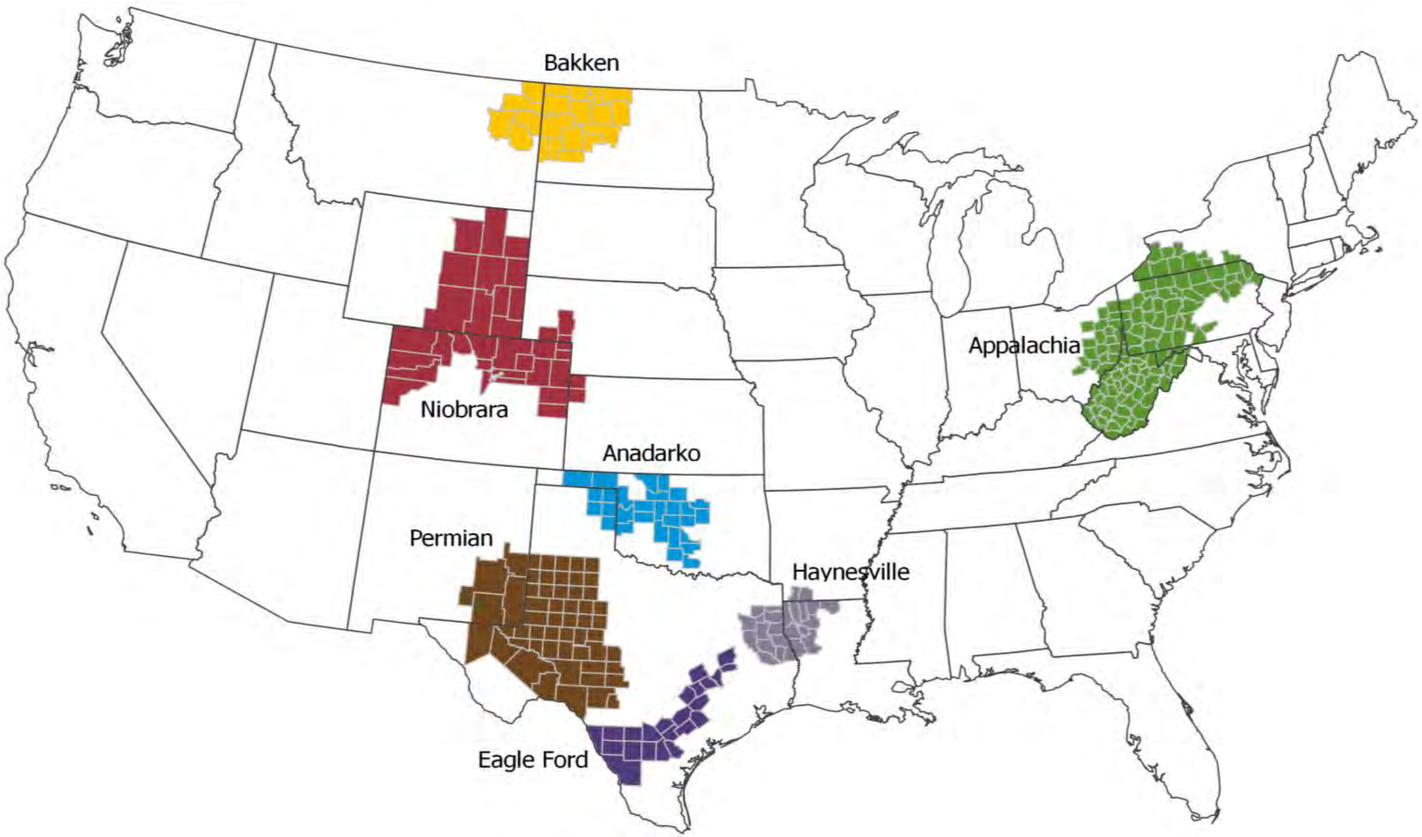
Major Production Regions



These 7 key producing regions make up +60% of total US production

Sources: EIA

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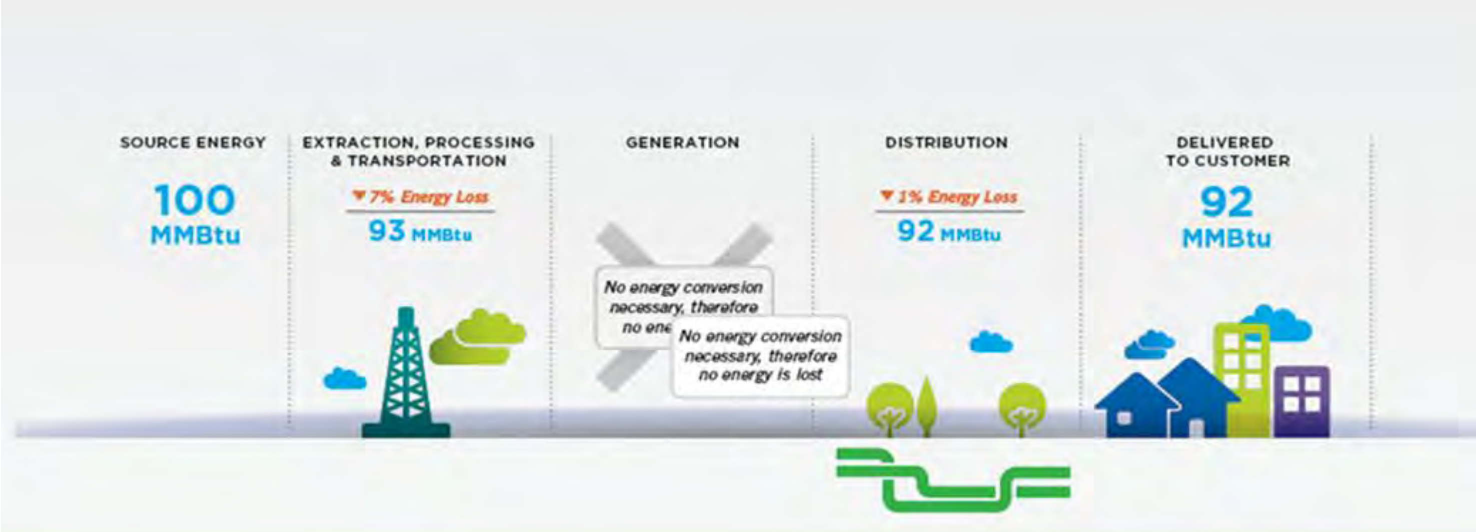
Natural Gas Efficiency



*Based on most recent actual generation mix of all energy sources from 2012

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A Confluence of Factors are Driving Changes to the Provision & Consumption of Energy and Energy Services

Proliferation of Information & Communications Technologies

Low-cost information, communications technologies and advanced metering enable more cost reflective prices and charges for electricity services that animate the "demand side" of the power system

Technological Innovation

Technological innovation has driven dramatic cost declines in a number of technologies. The cost of wind and solar PV (the leading non-hydro renewable energy technologies) have decreased by 25 and 70% respectively between 2010 and 2017. The trend is expected to continue as renewables increasingly become economically viable

Electric Vehicles

Electric vehicles represent a new type of electricity user that is expected to increase, creating a class of electricity demand that can be charged in a controlled or price-responsive manner to reduce the impact of EV charging on power systems or provide electricity services.

Consumer Choice & Preferences

Customers increasingly have an unprecedented level of choice regarding how they receive power and manage energy consumption through distributed generation, smart appliances and energy efficiency improvements

Generation Resource Mix is Changing in Type and Location

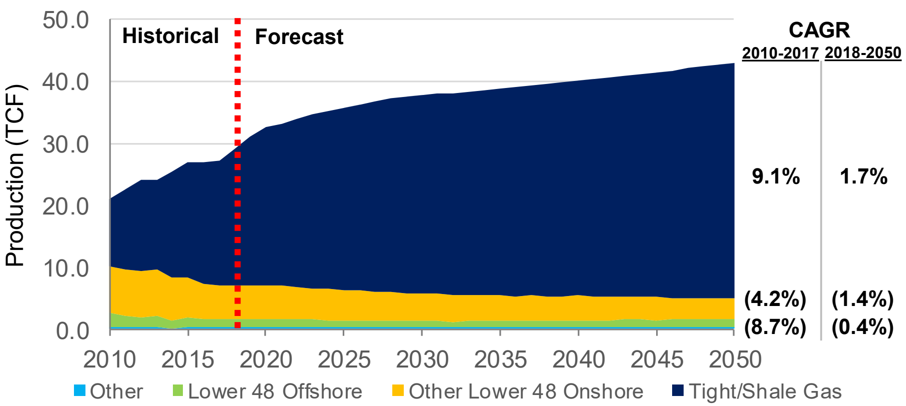
Power systems are becoming less centralized as the resource mix integrates various forms of distributed energy resources, such as demand response, rooftop solar, energy storage and energy control devices

Regulatory Reform

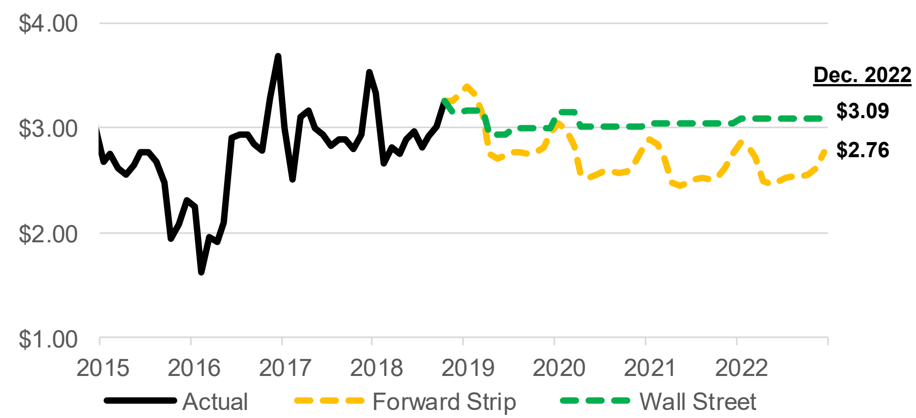
Improved utility incentives that reward cost savings, performance improvements, and long term innovation while simultaneously reevaluating the power sector's structure to incorporate the growing penetration of renewables and resources with non-traditional features (i.e. intermittent vs. dispatch)

Cheap and Abundant Natural Gas Will Drive Demand Growth in the Industrial and Electric Power Sectors

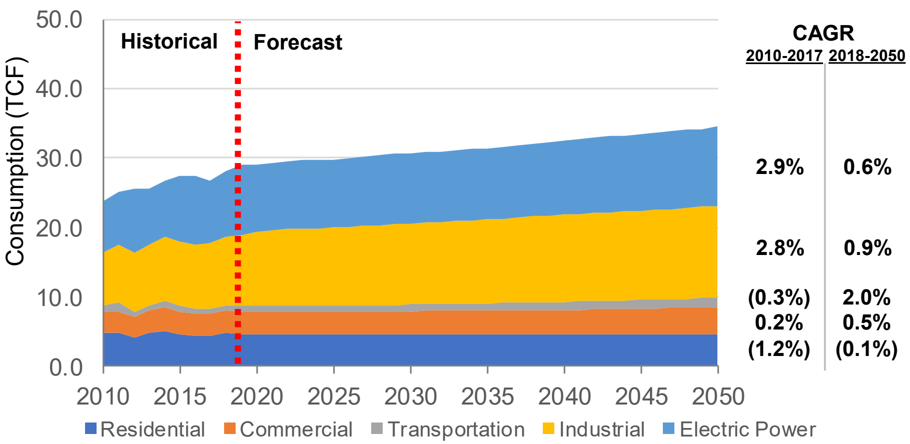
Natural Gas Production Increasingly Unconventional



Prices Projected to Stay Relatively Low



Demand Driven by Electric Power & Industrial Sectors



Key Assumptions of EIA Base Forecast

Near Term

- Low prices continue to fuel growing demand from gas intensive chemical projects and liquefaction export terminals

After 2020

- Drilling expands into less prolific, more expensive areas (partly counterbalanced by continued improvements in technology) leading to increase natural gas prices
- Demand further driven by the chemical industry (for use as a feedstock), industrial heat and power, and liquified natural gas export facilities
- Shale / tight gas continues providing accessible supply from over 500,000 square miles of associated resources

Source: Annual Energy Outlook 2018, EIA; EIA defines Industrial customers as all facilities and equipment used for producing, processing or assembling goods, includes manufacturing, agriculture, forestry, fishing and hunting, mining and construction where energy is used primarily for process heat and cooling and powering machinery

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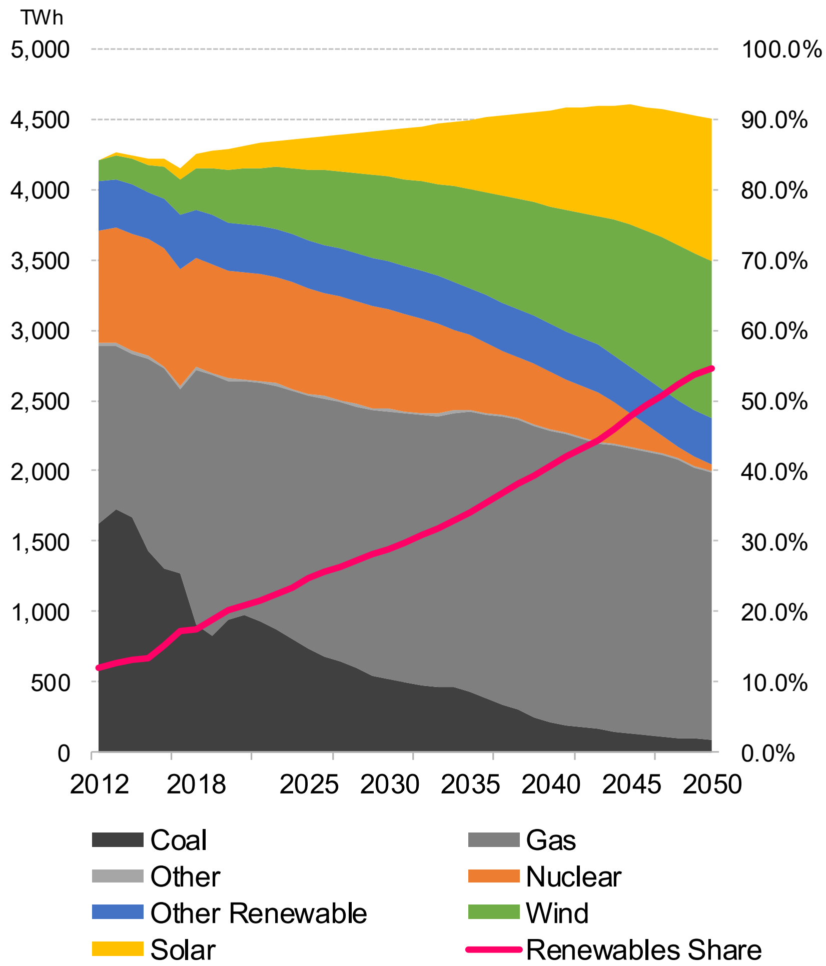
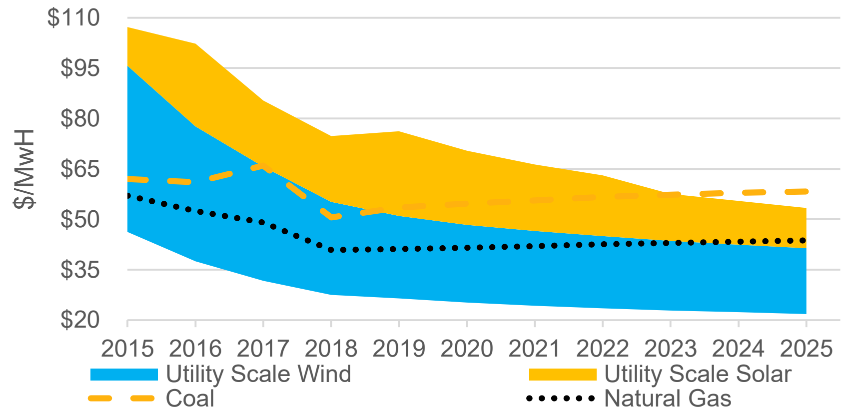
Electricity Generation is Changing in Type and Location, Driven by the Declining Cost of Renewables

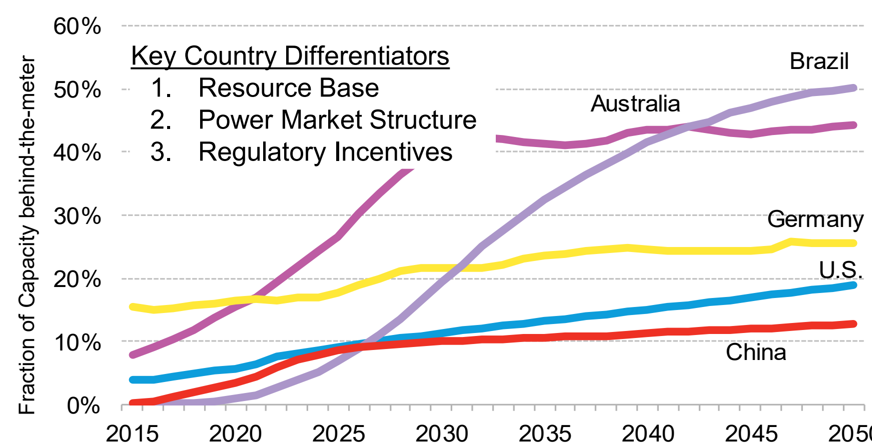
Coal to Continue Decline Replaced with Gas and Renewables



U.S. Renewables' LCOE is Expected to Decline



Decentralization of Generation Resources Expected to Grow



Source: *"New Energy Outlook 2018", Bloomberg New Energy Finance, June 2018*

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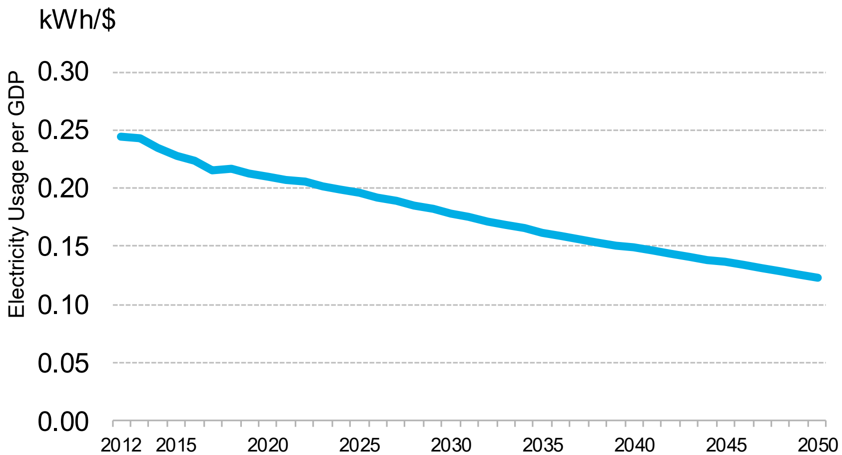
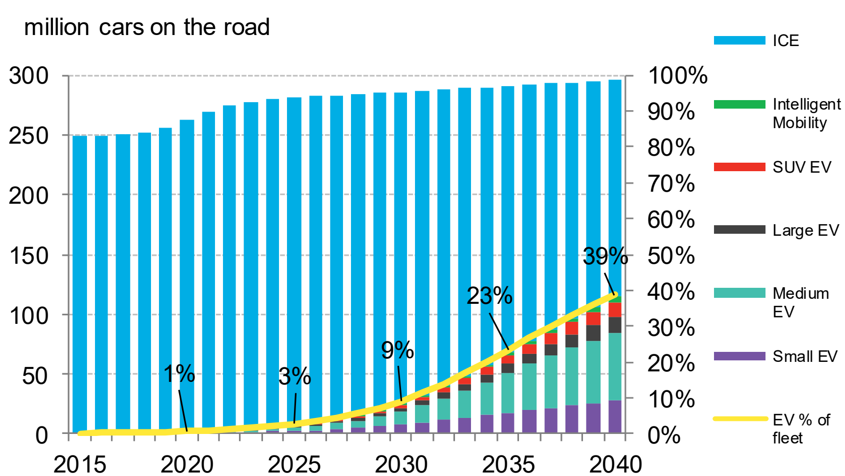
Energy Demand from Electric Vehicles Will Help Offset Efficiency-Driven Declines in Demand

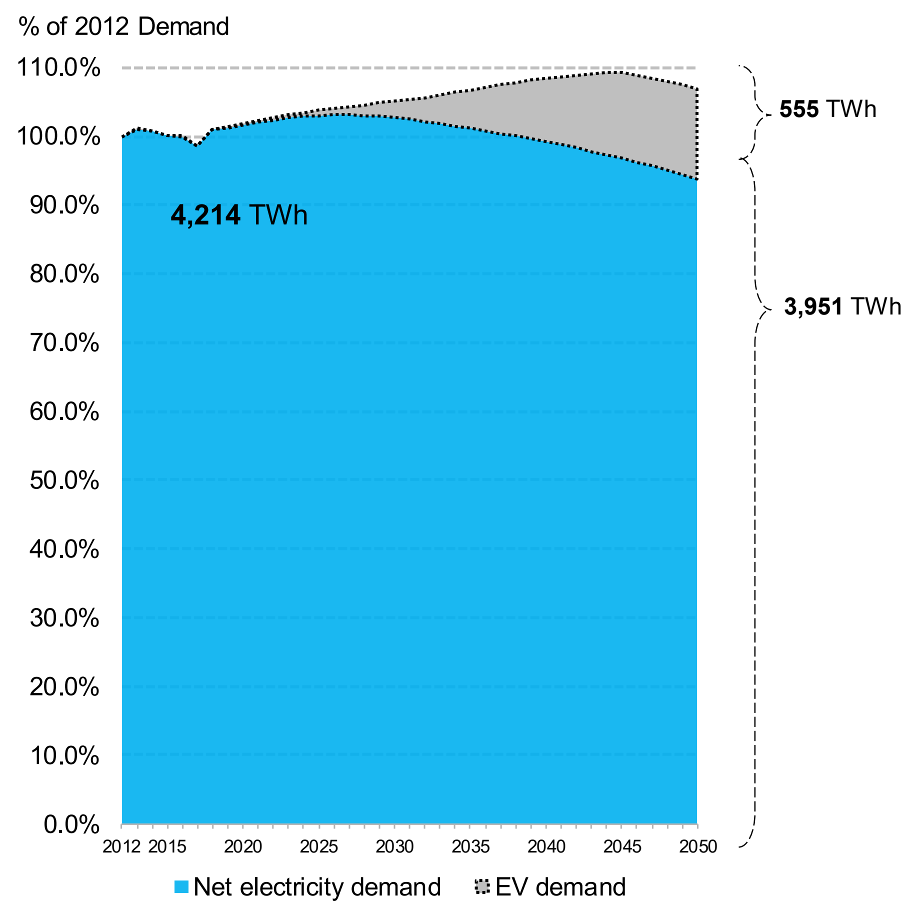
Declining Electricity Intensity of GDP



U.S. Penetration of Electric Vehicles to Rise



U.S. General Electricity Demand Declines as EV Load Expands



Source: "New Energy Outlook 2018", Bloomberg New Energy Finance, June 2018

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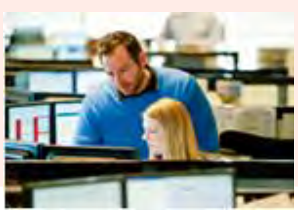
Drivers of Natural Gas Pricing

Natural Gas Price Component	Description	Drivers
 Commodity	The physical supply of natural gas; the largest component of delivered supply.	• Supply & demand • Economic activity • Market volatility • Weather • Geopolitical events
 Transportation	Interstate pipeline companies own, operate and maintain the pipelines that transport gas across state lines. This is the cost associated with moving gas from production fields to supply hubs to a utility distribution system.	• Geographic location • Pipeline tariffs • Available capacity • Federal Regulation
 Utility	Utilities own, operate and maintain the infrastructure that make up the utility distribution system. This is the cost associated with moving gas from the utility's supply purchase point to customer meter.	• Rate base • Utility rates • Rate class • Weather • Regulatory environment
 Marketer	Marketers arrange for the procurement of natural gas on behalf of customers, handle the transportation and storage of gas, and often assume financing and price risk.	• Trading activity • Billing systems • Credit • Transaction costs • Pipeline capacity

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Thank You

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