MI POWER GRID

Making the Most of Michigan's Energy Future

New Technologies and Business Models

Stakeholder Meeting 6: Combined Heat & Power

The meeting will begin promptly at 1:00 pm.

April 7, 2021

1PM – 5 PM

MPSC

Michigan Public Service Commission

MI POWER GRID

Making the Most of Michigan's Energy Future

New Technologies and Business Models: Welcome and Overview

Joy Wang

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Smart Grid Section

Michigan Public Service Commission

MPSC

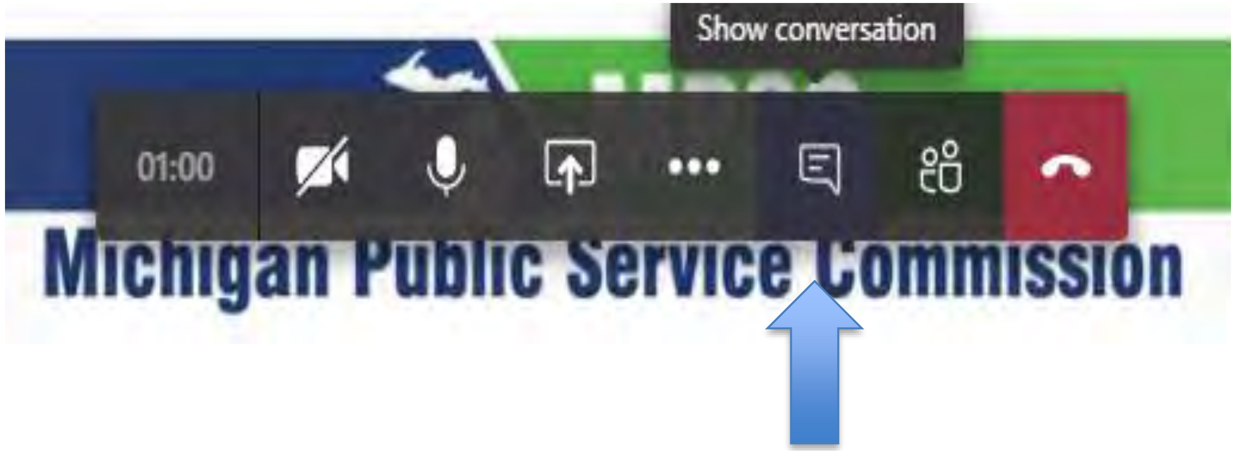
Michigan Public Service Commission

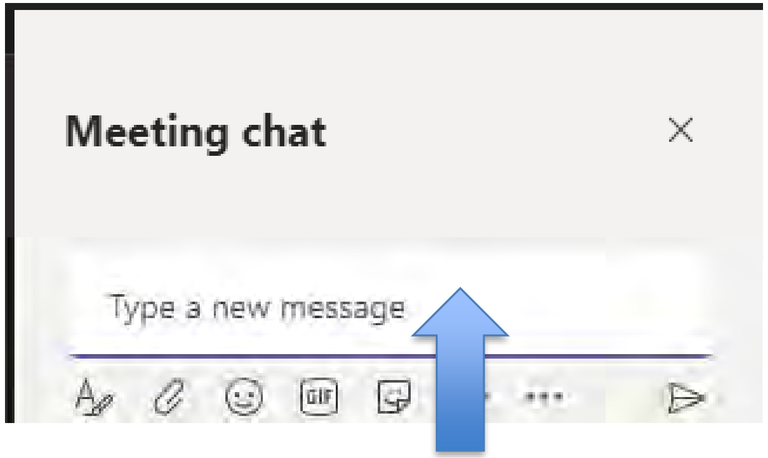
Agenda: Combined Heat and Power

1:00 pm	Welcome & Opening Statements	Joy Wang, MPSC Staff, and Dan Scripps, Chair, Michigan Public Service Commission
1:05 pm	The Potential for Combined Heat and Power in Michigan	Graeme Miller, University of Illinois at Chicago
1:40 pm	District Energy/CHP Systems for Resiliency & Sustainability	Rob Thornton, International District Energy Association
2:05 pm	Break	
2:15 pm	*Panel: The Power of CHP –* *Roadblocks to Harnessing Its Opportunity* James Leidel, DTE Gas Kevin O'Connell, Michigan CAT Chris Bixby, Clarke Energy	Moderator: Lynn A. Kirshbaum, Combined Heat and Power Alliance
3:00 pm	*Panel: Speaking from Experience –* *CHP Motivations, Barriers, & Realities* Timothy Lynch, Benton Harbor Saint Joseph WWTP Jeff Means, Department of Veteran Affairs Kathy Richards, Northern Michigan University	Moderator: Lynn A. Kirshbaum, Combined Heat and Power Alliance
3:45 pm	Break	
3:50 pm	Waste Heat to Power: An Overlooked Zero Emission Energy Resource for Michigan's Industrial Sector	Patricia Sharkey, Heat is Power Association & Midwest Cogeneration Association
4:15 pm	The Future of CHP: Reducing Emissions and Improving Resilience	Lynn A. Kirshbaum, Combined Heat and Power Alliance
4:40 pm	Aisin mCHP Development	Tom Miller, Aisin Technical Center of America
4:55 pm	Closing Statements	Joy Wang, MPSC Staff

Housekeeping

- This meeting is being recorded
- Slides available and recording will be posted on workgroup website within a week
- All audience members will be muted
- Please type questions into the chat box
    - To access chat box:





- Staff will ask chat box questions during Q&A

Housekeeping, cont.

- During the meeting, if clarification of your question is needed, we will ask you to unmute.
  - To unmute:
    - Phone: Press *6
    - Teams: Click mic button
  - Please mute yourself again after your clarification.
- Chat box may note when audience members enter/exit.
  - These notices are automatic:

- If you are not a session speaker, please turn off your video.
- If Teams via web browser is not working, try a different web browser.
  - All work except Safari
- Please share your thoughts on the meeting with us by filling out the survey.

MI POWER GRID

Making the Most of Michigan's Energy Future

Opening Remarks

Dan Scripps, Chair
Michigan Public Service Commission

Stakeholder Meeting 6: Combined Heat and Power
April 7, 2021

The Potential for Combined Heat and Power in Michigan

Graeme Miller

Senior Research Specialist

Distributed Generation

Energy Resources Center

University of Illinois at Chicago

The Potential for Combined Heat and Power in Michigan

Presentation to the Michigan Public Service Commission

April 7, 2021

US DOE Midwest CHP Technical Assistance Partnership

CHP Technical Assistance Partnerships

Introduction

Graeme Miller
Senior Research Specialist
Energy Resources Center
University of Illinois at Chicago

Assistant Director,
US DOE Midwest CHP TAP

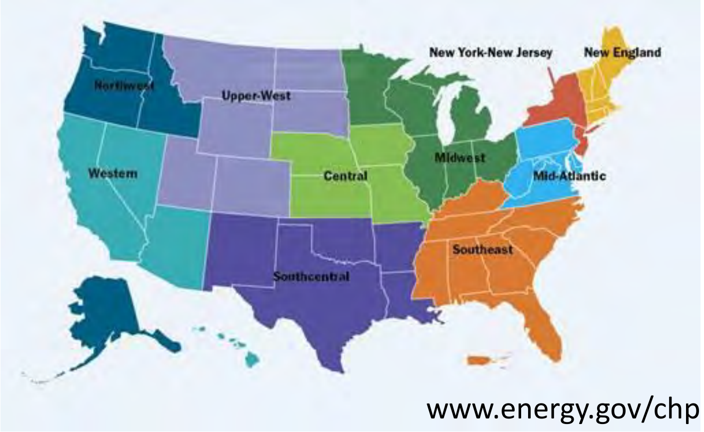
Agenda

- What is the USDOE CHP TAP Program?
- CHP Basics
- CHP Technical Potential in Michigan
- CHP Economic Benefit Potential
- CHP Potential in the Clean Energy Transition
- CHP Potential in Reduce Emissions

What is the US DOE CHP TAP Program?

U.S. DOE CHP Technical Assistance Partnerships (CHP TAPs)

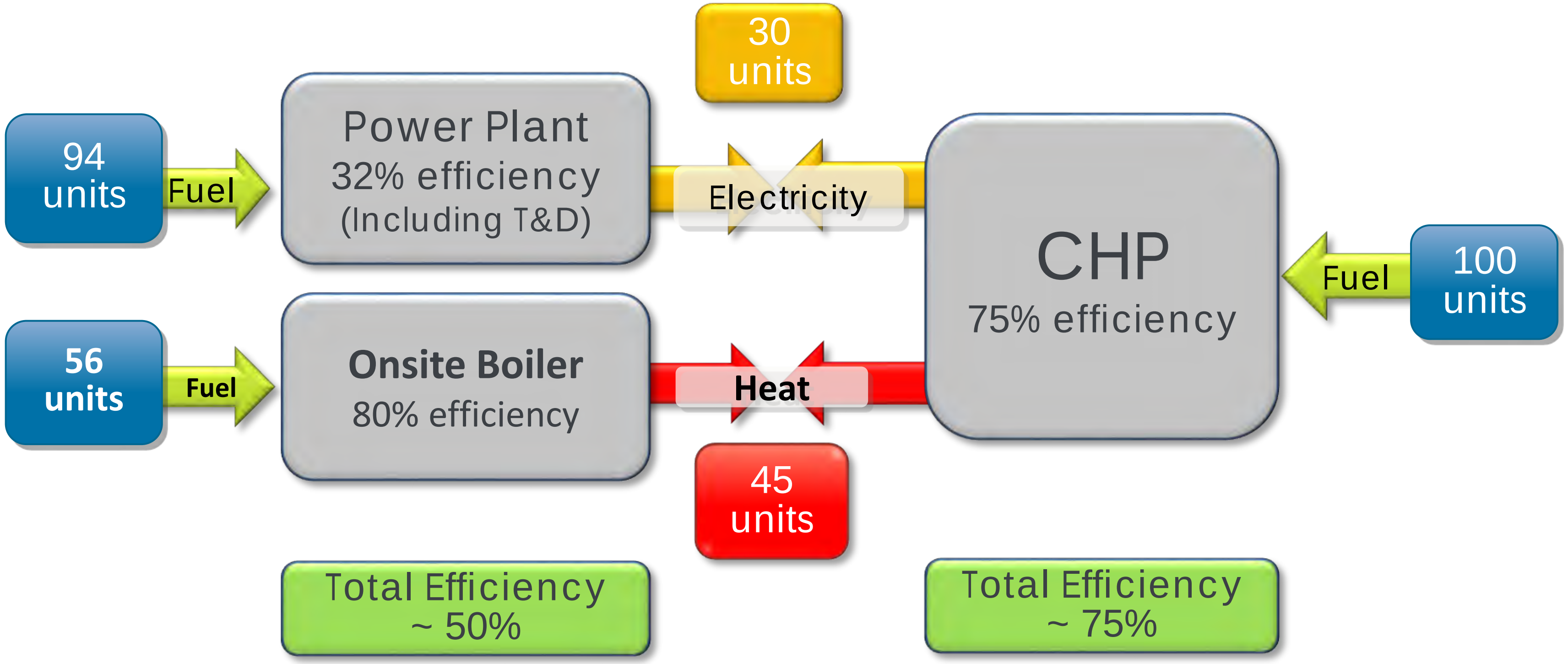
- **End User Engagement**
  Partner with strategic End Users to advance technical solutions using CHP as a cost effective and resilient way to ensure American competitiveness, utilize local fuels and enhance energy security. CHP TAPs offer fact-based, non-biased engineering support to manufacturing, commercial, institutional and federal facilities and campuses.
- **Stakeholder Engagement**
  Engage with strategic Stakeholders, including regulators, utilities, and policy makers, to identify and reduce the barriers to using CHP to advance regional efficiency, promote energy independence and enhance the nation's resilient grid. CHP TAPs provide fact-based, non-biased education to advance sound CHP programs and policies.
- **Technical Services**
  As leading experts in CHP (as well as microgrids, heat to power, and district energy) the CHP TAPs work with sites to screen for CHP opportunities as well as provide advanced services to maximize the economic impact and reduce the risk of CHP from initial CHP screening to installation.



National Manufacturing Day 2019 at the University of Illinois at Chicago

5

CHP Recaptures Heat of Generation, Increasing Energy Efficiency, and Reducing GHGs

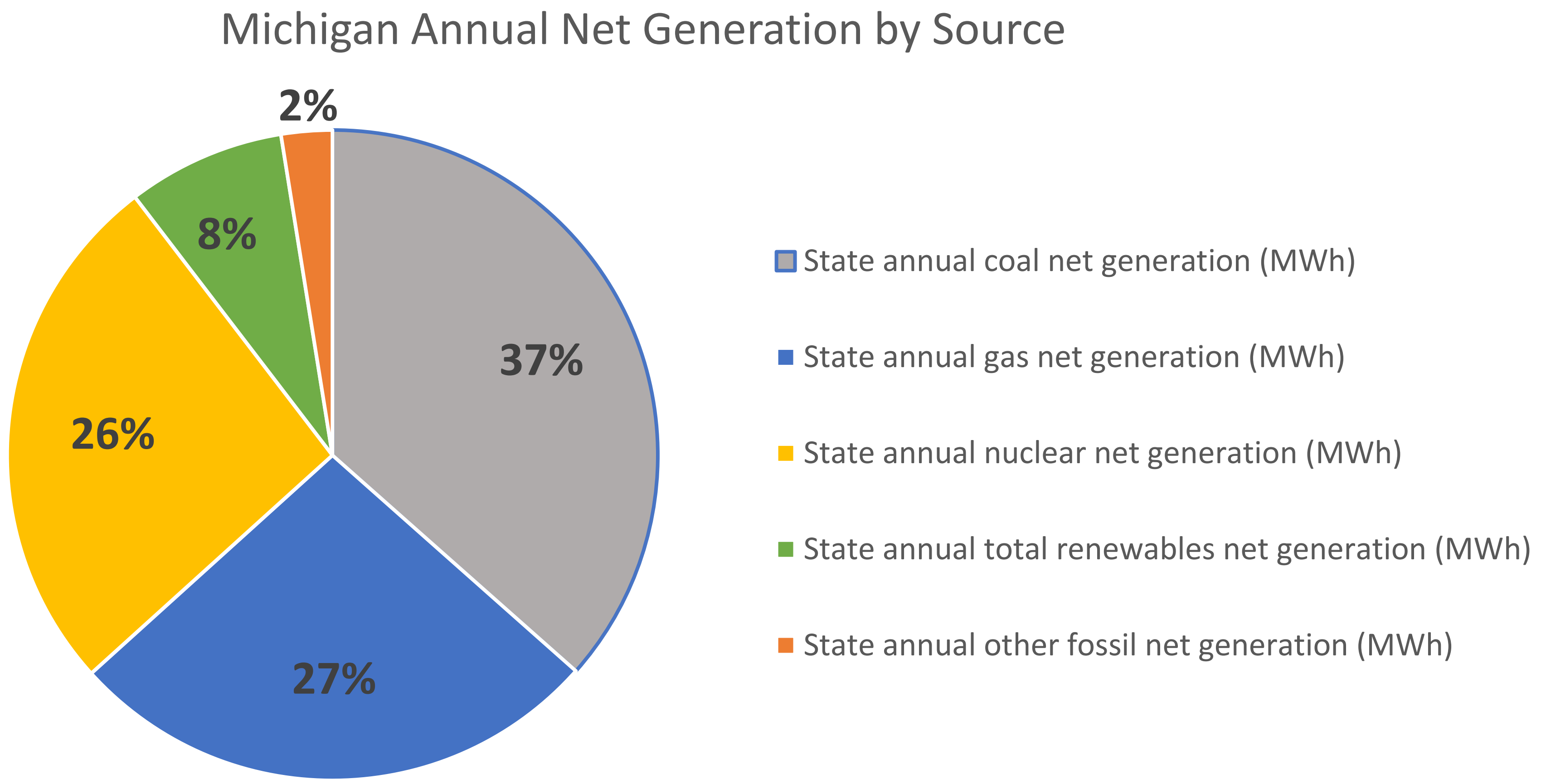


30 to 55% less greenhouse gas emissions

CHP Technical Potential in Michigan

Current Electricity Landscape
Annual Net Generation by Source

115,834,924 MWh
of
Net Generation

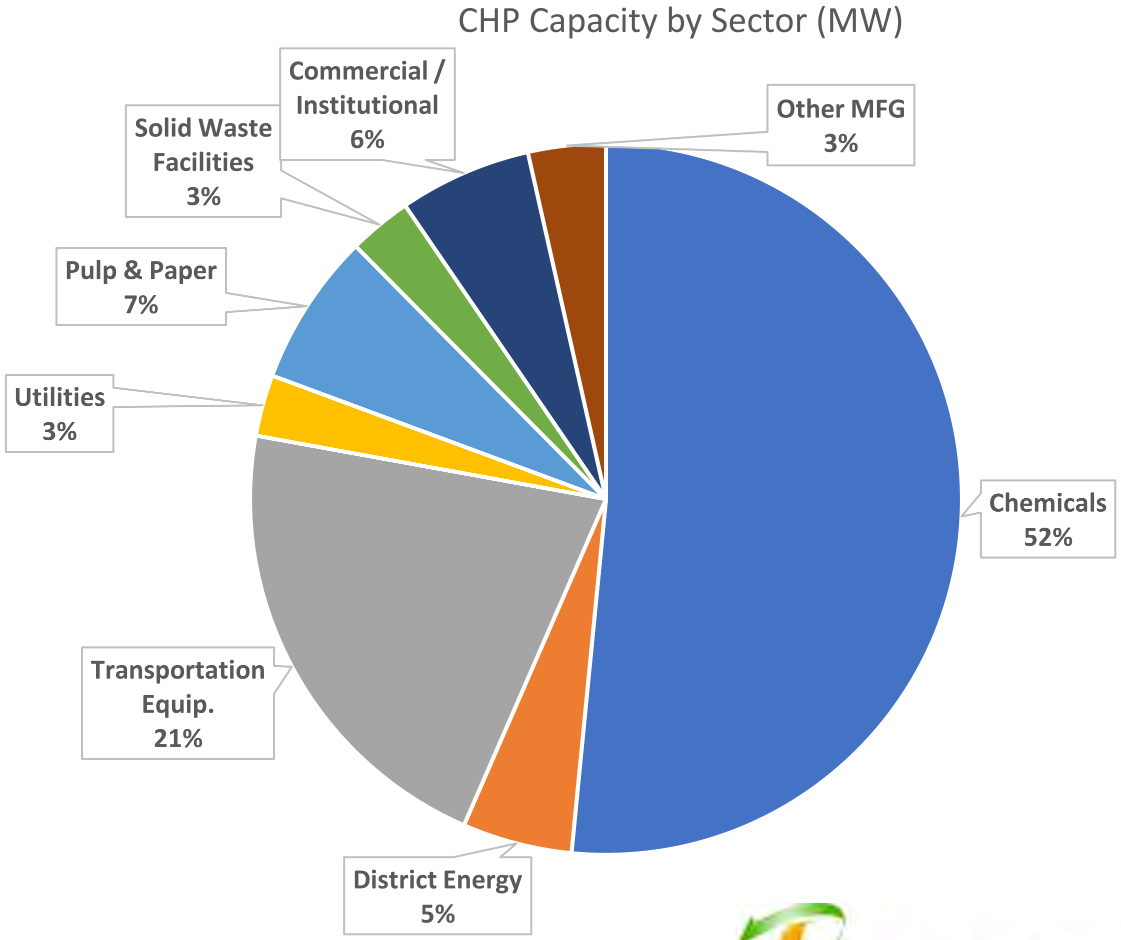


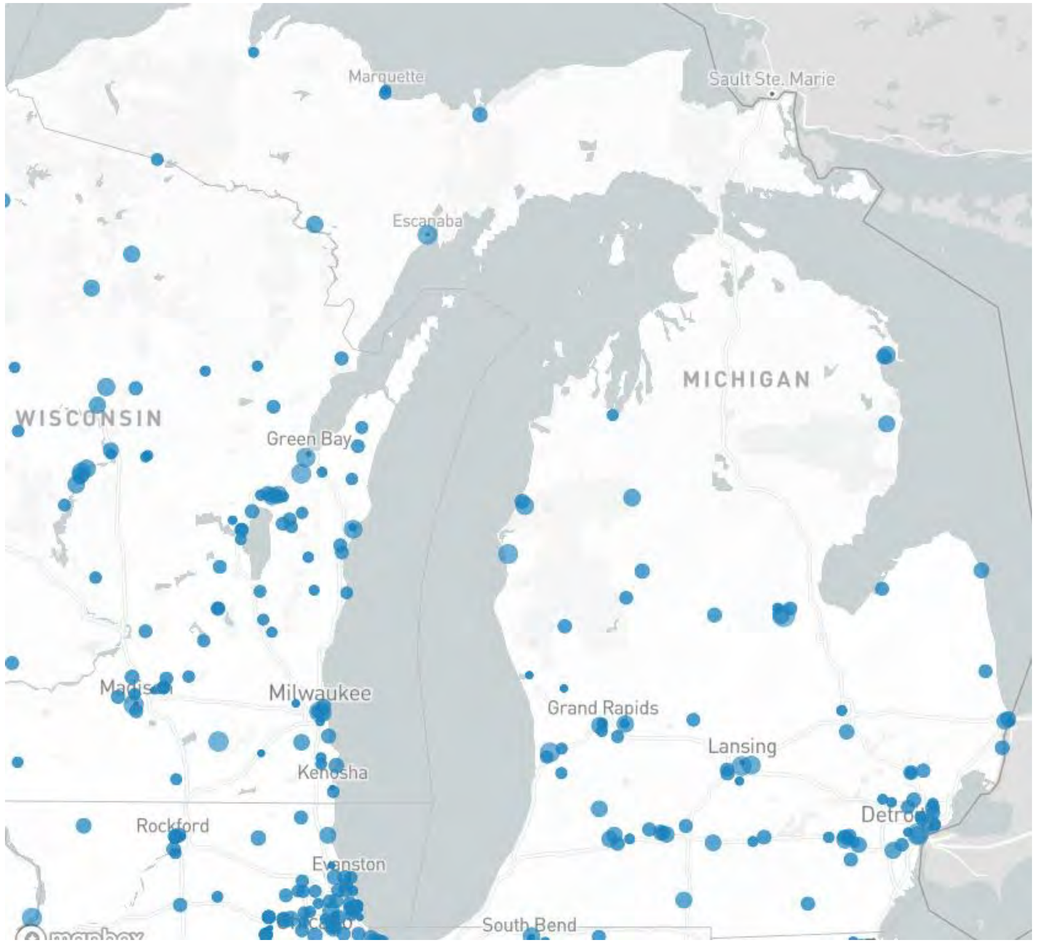
Source: eGrid 2020 (2018 Data)

CHP Technical Assistance Partnerships

Current CHP Capacity in Michigan

3,579 MW of Installed Capacity

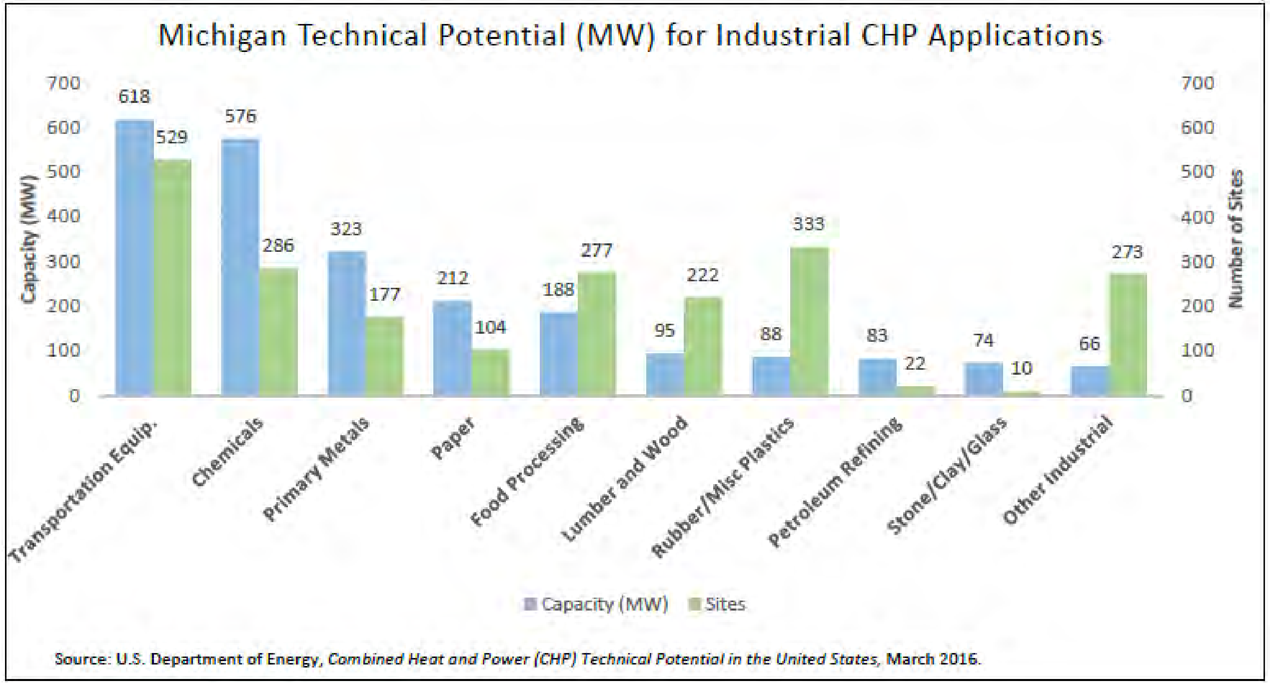


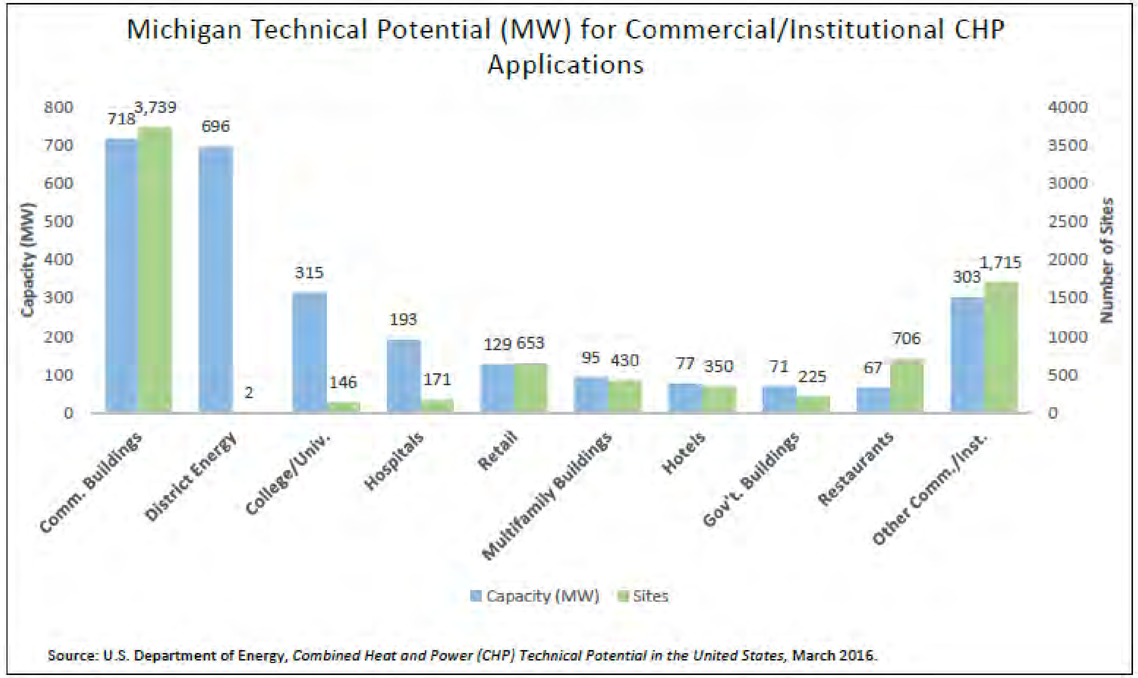


CHP Technical Assistance Partnerships

CHP Technical Potential in Michigan

Sector	*Potential Sites*	*Potential Capacity (MW)*
Industrial	2,233	2,324
Commercial/Institutional	8,137	2,664
Total	**10,370**	**4,987**



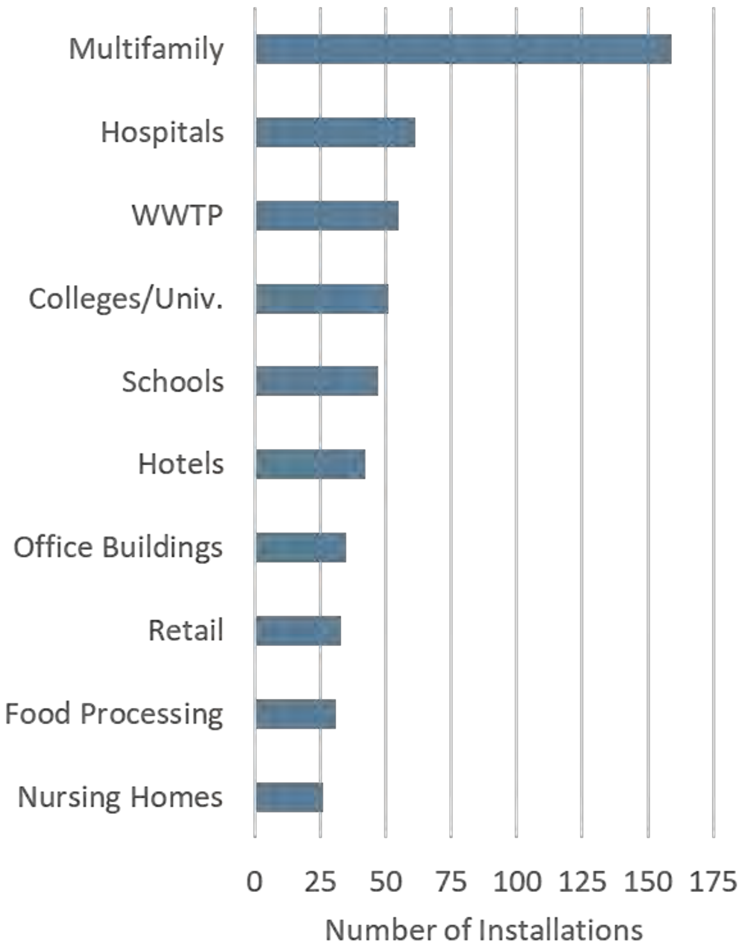


CHP Technical Assistance Partnerships

CHP Market Trends – The Last Five Years

- Significant capacity continues to be installed in industrial applications – 61% of capacity
- Growing activity in non-traditional CHP markets (light industrial, commercial, institutional, multi-family) – 88% of installs
- Move toward smaller CHP installations - recip engines and microturbines make up 77% of installs
- Increase in packaged CHP system offerings
- Natural gas continues to be the dominant fuel - 77% of new capacity
- Increasing interest in hybrid systems that integrated CHP with renewables and energy storage
- Prioritizing CHP for resilience with focus on critical infrastructure applications and microgrids

Top CHP Applications 2015-2019



Source: DOE CHP Installation Database (U.S. installations as of August 31, 2020)

CHP Technical Assistance Partnerships

CHP's Economic Benefit Potential in Michigan

CHP's Site Specific Economic Benefit

Comparative Economics between CHP and Boilers

Based on 8,000 hours of operation, 7 cents per kWh electricity price, and $6/MMBtu natural gas price. CHP system cost of $1,500/kWh, O&M costs of $0.009/kWh and 31 percent electrical efficiency. CHP availability of 95 percent and portion of electric price avoided by on-site generation of 90 percent are assumed values. Natural gas boiler estimated cost of $3.50/MMBtu input was provided by Worley Parsons. Net cash

	New Natural Gas Boilers	New Natural Gas CHP	Comparison
Peak Boiler Capacity, MMBtu/hr input	120	120	
Peak Steam Capacity, MMBtu/hr	96	96	
Avg Steam Demand, MMBtu/hr	76.8	76.8	
Boiler Efficiency	80%	NA	
CHP Capacity, MW	NA	14	
CHP Electric Efficiency	NA	31%	
CHP Total Efficiency	NA	74%	
Annual Steam Use, MMBtu	614,400	614,400	0
Annual Steam Use, MMlbs	558.6	558.6	0
Annual Power Generation, kWh	NA	106,400,000	106,400,000
Fuel Use, MMBtu/year	768,000	1,317,786	549,786
Annual Fuel Cost	$4,608,000	$7,906,719	$3,298,719
Annual O&M Cost	$729,600	$1,687,200	$957,600
Annual Electric Savings	0	($6,703,200)	($6,703,200)
Net Annual Operating Costs	$5,337,600	$2,890,269	($2,447,331)
Steam Costs, $/MMBtu	$9.56	$5.18	($4.38)
Capital Costs	$4,200,000	$21,000,000	$16,800,000
10 Year Net Cash Flow (output)	**$65,389,602**	**$54,138,850**	($11,250,752)
Incremental CHP Payback			6.9 years
10 Year IRR - CHP vs. Gas Boiler			10%
10 Year NPV – CHP vs. Gas Boiler			$2,411,765

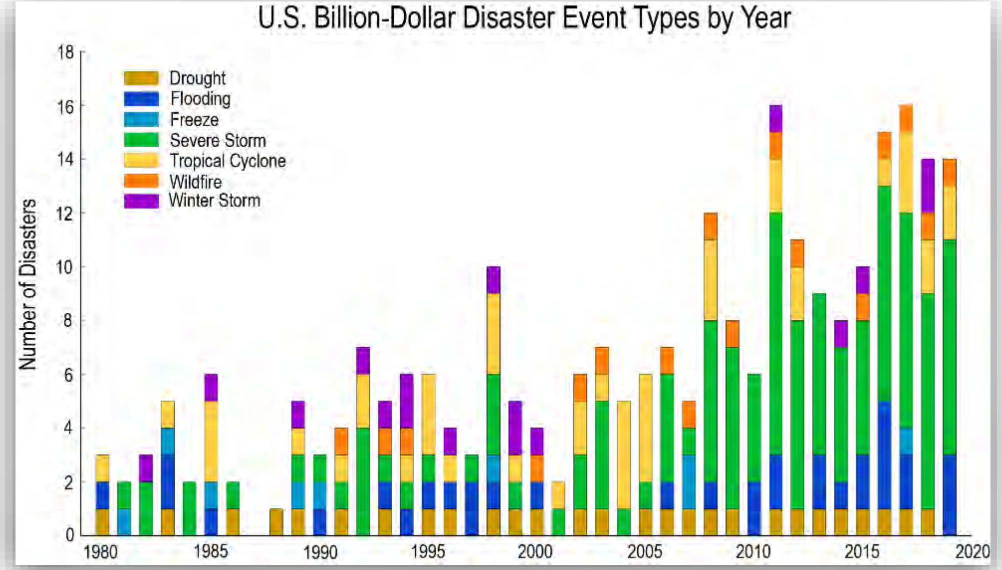
Source: ICF International

Source: ICF, "Guide to Using Combined Heat and Power for Enhancing Reliability and Resiliency in Buildings," 2013
Available at:
https://www.epa.gov/sites/production/files/2015-07/documents/guide_to_using_combined_heat_and_power_for_enhancing_reliability_and_resiliency_in_buildings.pdf

CHP Technical Assistance Partnerships

CHP Enhances Energy Resilience

- Higher reliability and power quality are needed to meet critical requirements
- Increased incidences of grid outages cause supply and production disruptions
- Consequences for health and safety of staff and clients, continuity of services, community support
- CHP can maintain power and heating/cooling during outages while providing financial benefits through operating savings every day



Source: NOAA

Ranking Criteria

Four basic criteria were used to estimate the vulnerability of a resource during each type of disaster event. They include the likelihood of experiencing:

1. *a fuel supply interruption,*
2. *damage to equipment,*
3. *performance limitations, or*
4. *a planned or forced shutdown*

○ *indicates the resource is unlikely to experience any impacts*

◒ *indicates the resource is likely to experience one, two, or three impacts*

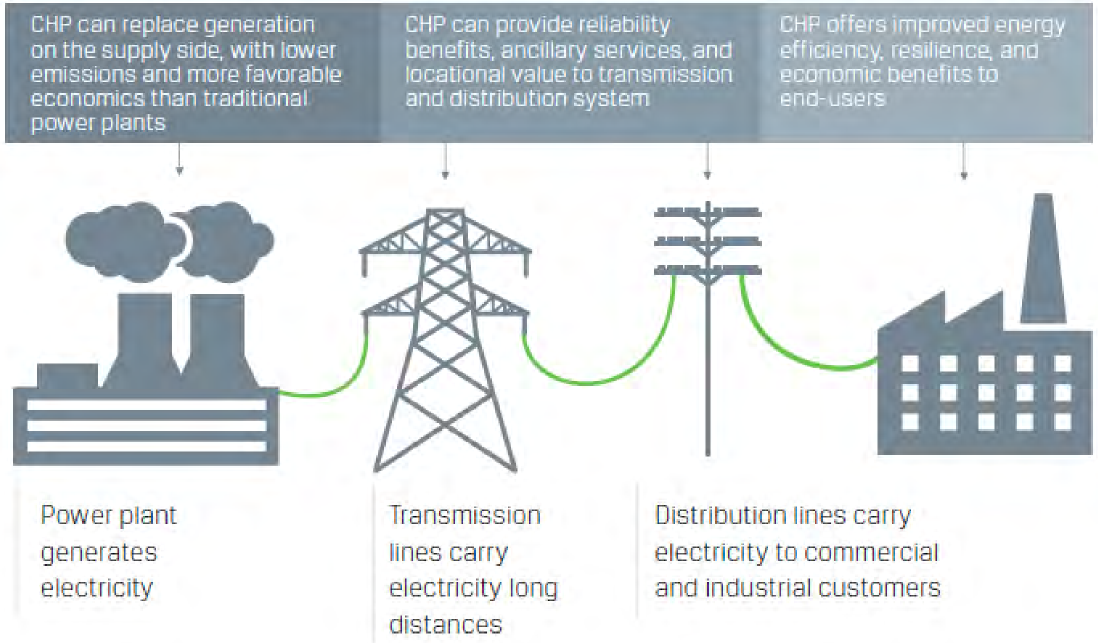
● *indicates the resource is likely to experience all four impacts*

Natural Disaster or Storm Events	*Flooding*	*High Winds*	*Earthquakes*	*Wildfires*	*Snow/Ice*	*Extreme Temperature*
Battery Storage	◒	○	◒	●	○	◒
Biomass/Biogas CHP	◒	◒	◒	●	○	○
Distributed Solar	○	◒	◒	●	◒	◒
Distributed Wind	○	◒	◒	◒	◒	◒
Natural Gas CHP	○	○	◒	◒	○	○
Standby Generators	◒	○	◒	●	◒	○

Source: https://betterbuildingssolutioncenter.energy.gov/sites/default/files/attachments/DER_Disaster_Impacts_Issue%20Brief.pdf

CHP's Benefit to the Grid

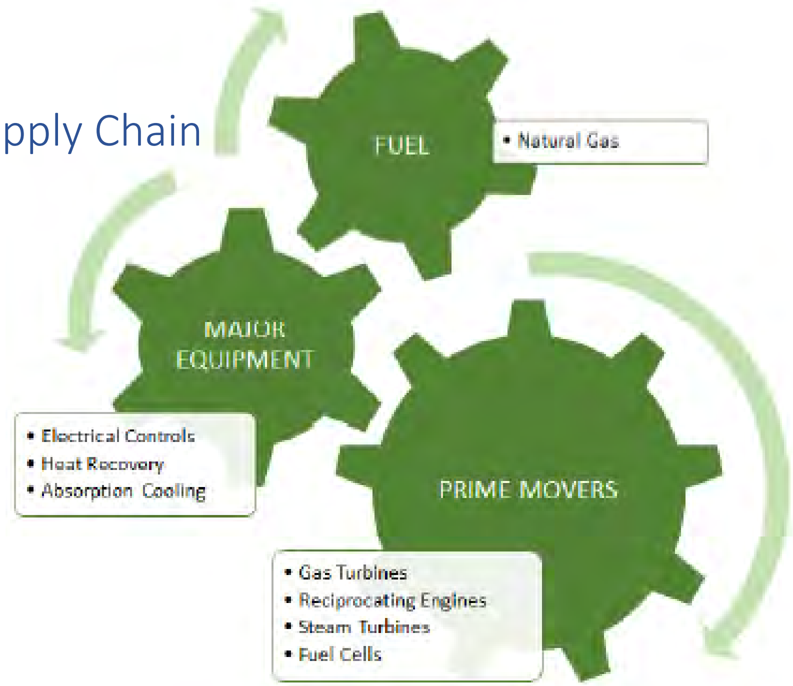
Grid Modernization Goal	How CHP Supports Goal
Grid Reliability	CHP installations can improve power quality, provide ancillary services, and relieve grid constraints
Customer Resilience	CHP systems can provide baseload power for microgrids, allowing critical loads to continue operation during grid outages
Energy Efficiency	CHP uses less fuel and is more efficient, which saves energy compared to conventional generation and separate heat production
DER Integration	CHP can help utilities integrate new renewable DER deployments and balance variable loads
Locational Value	CHP can be deployed at strategic locations on the system where it is needed most
Affordability	CHP can often meet system needs more cost-effectively than investments in traditional assets, thus lowering costs for ratepayers across the utility system
Emissions Reductions	Efficient CHP systems have lower emissions than conventional grid resources, and can be used to meet emissions reduction targets (ex: states w/ GHG goals)



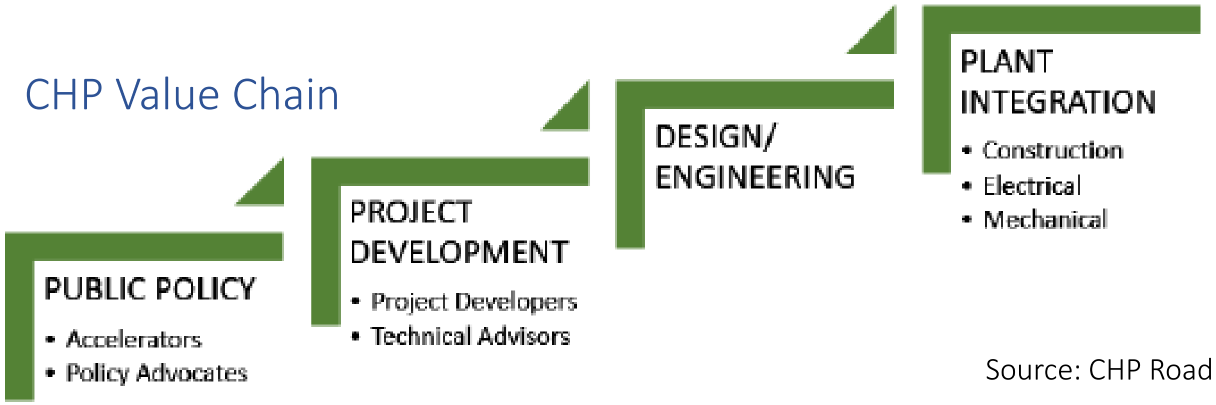
Source: Supporting Grid Modernization with Flexible CHP Systems, ICF, 2018
https://www.icf.com/-/media/files/icf/white-paper/2017/icf-supporting-grid-mod-with-flexible-chp-feb-2018.pdf

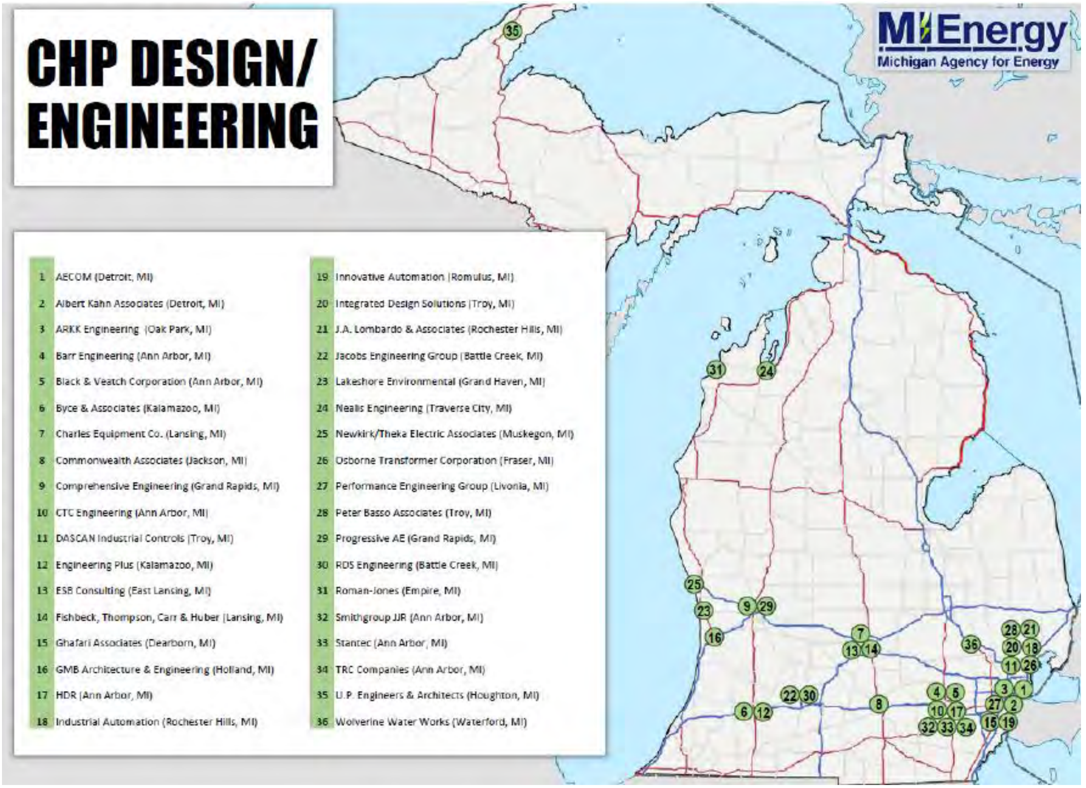
CHP and the Michigan Economy

CHP Supply Chain



CHP Value Chain



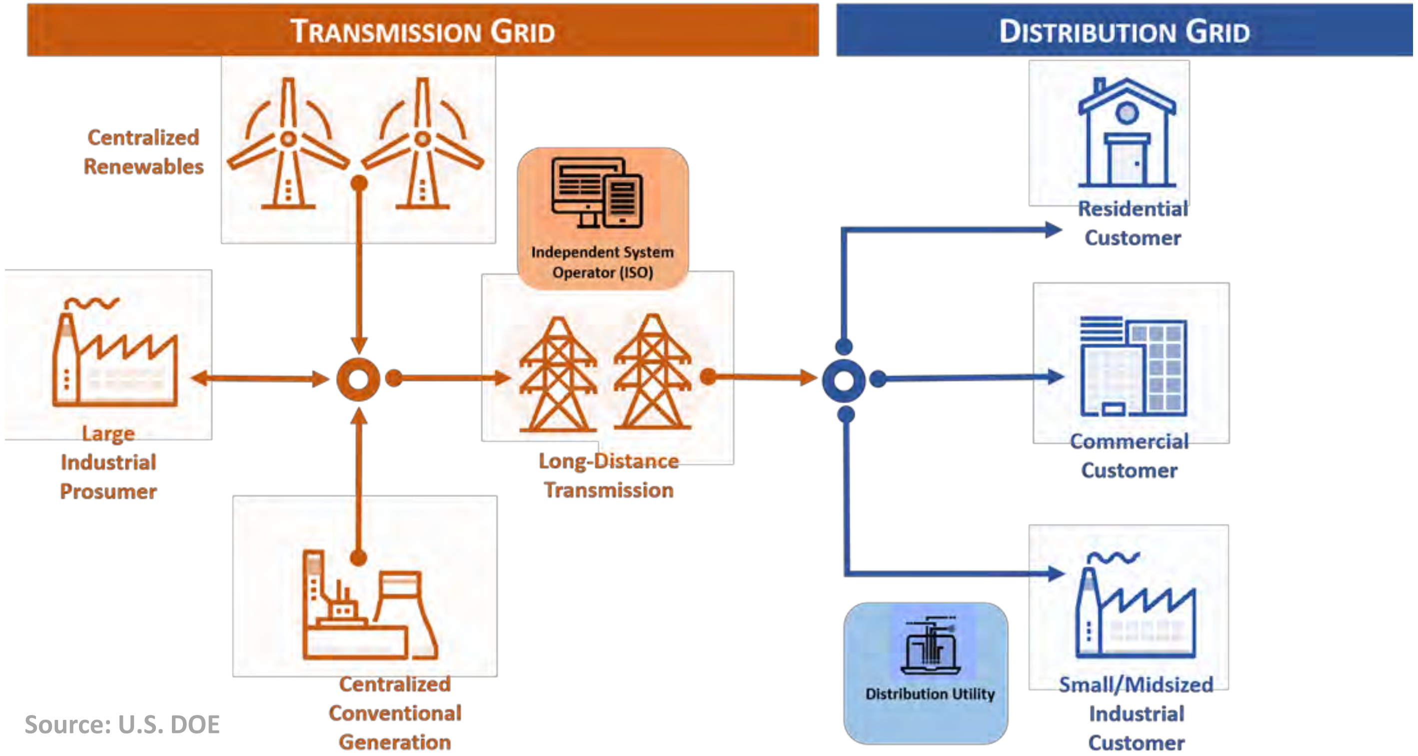


CHP Design/Engineering Firms in Michigan

Source: CHP Roadmap for Michigan, 2018

CHP's Potential To Help Michigan Transition to Clean Energy

Traditional Electric Grid

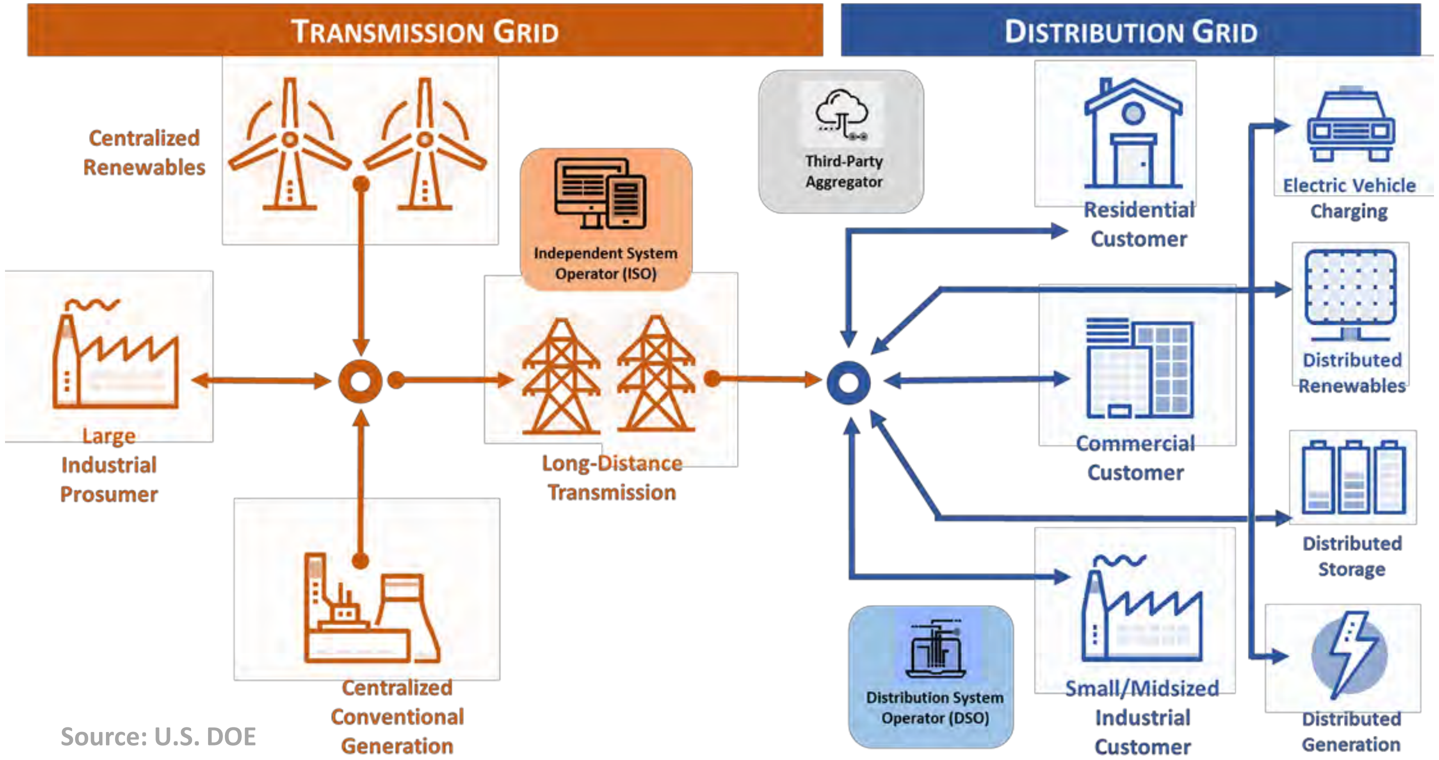


Source: U.S. DOE

In the traditional power grid, electricity is produced by centralized power plants and moved to the customer over a long-distance transmission network

- Power flows are generally one-way (from generator to customer)
- Large industrial customers can export power, but small and midsized industrial customers do not provide services to the electric grid
- Generation and load are separated, and coordination between customers and load-serving entities is limited

Transitional Electric Grid



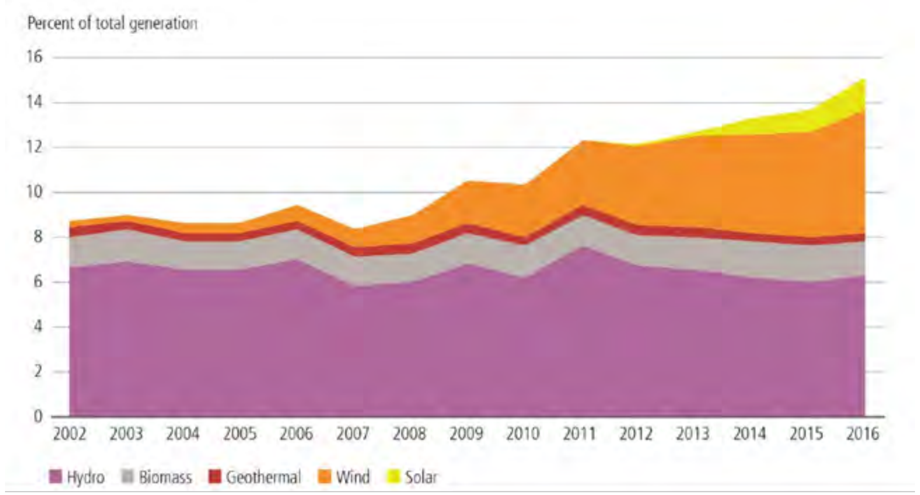
Source: U.S. DOE

In the future, electricity will be produced by a variety of resources, including renewable distributed energy resources with variable production that can export power to the distribution system

- Power flows are bi-directional and managed by interconnected information and control systems
- Customers are "prosumers:" they consume electricity but also generate power to satisfy their own loads as well as to provide services to the grid (including energy to other customers)
- Generation and load are closely coordinated to optimize the performance of the system and reduce infrastructure costs

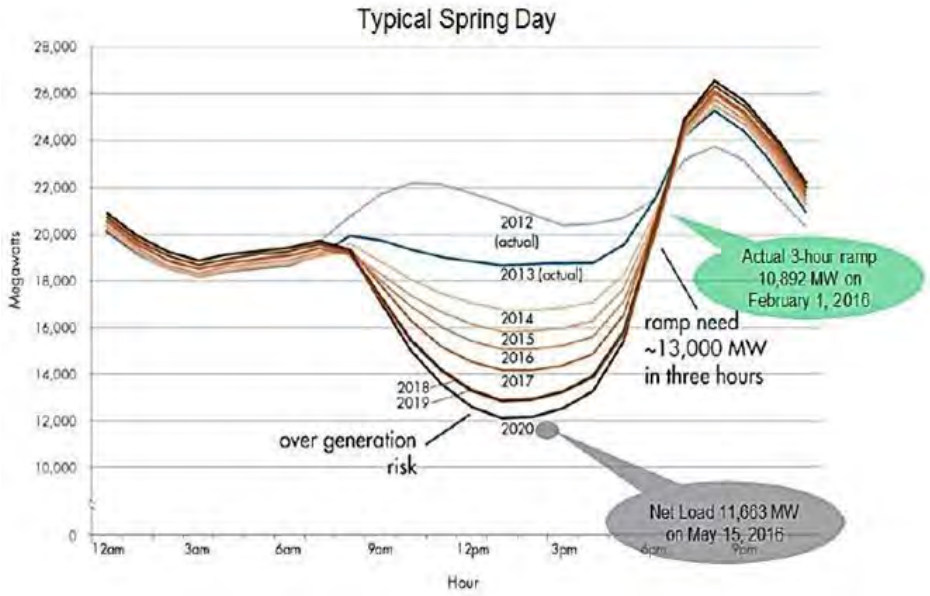
Two Key Issues and Challenges as Grid Resources Evolve

- Non-dispatchable renewables (particularly wind and solar) are increasing rapidly on the U.S. grid.
- The rapid increase of renewables exacerbates the load changes at peak demand periods requiring additional fast-reacting grid resources.
- CHP can be an important stabilizing factor in the transitional electric grid that supports intermittent renewable resources.



Source: U.S. DOE

Renewable Generation as a Percentage of Total U.S. Electricity Generation

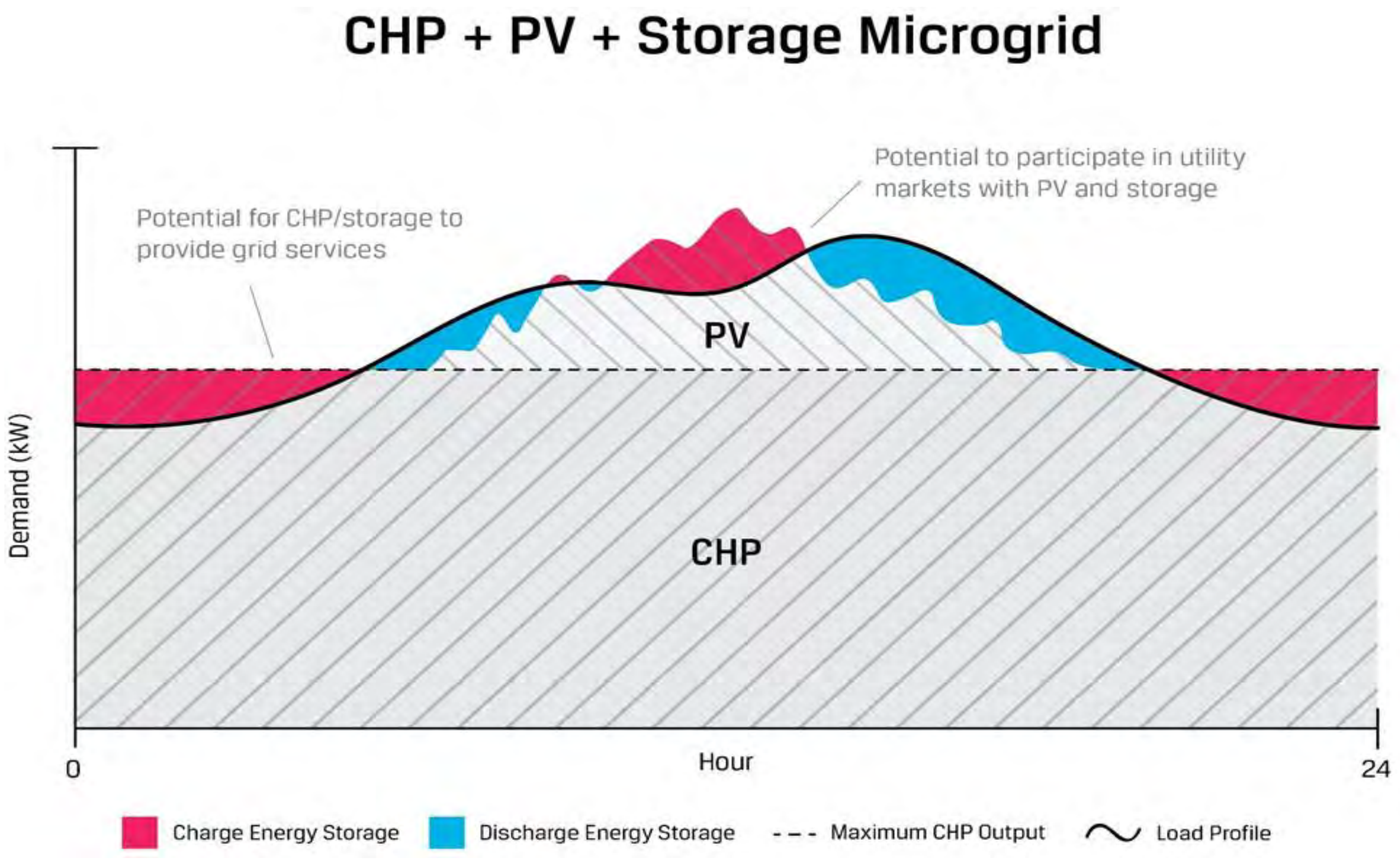


California's "Duck Curve"

CHP Technical Assistance Partnerships

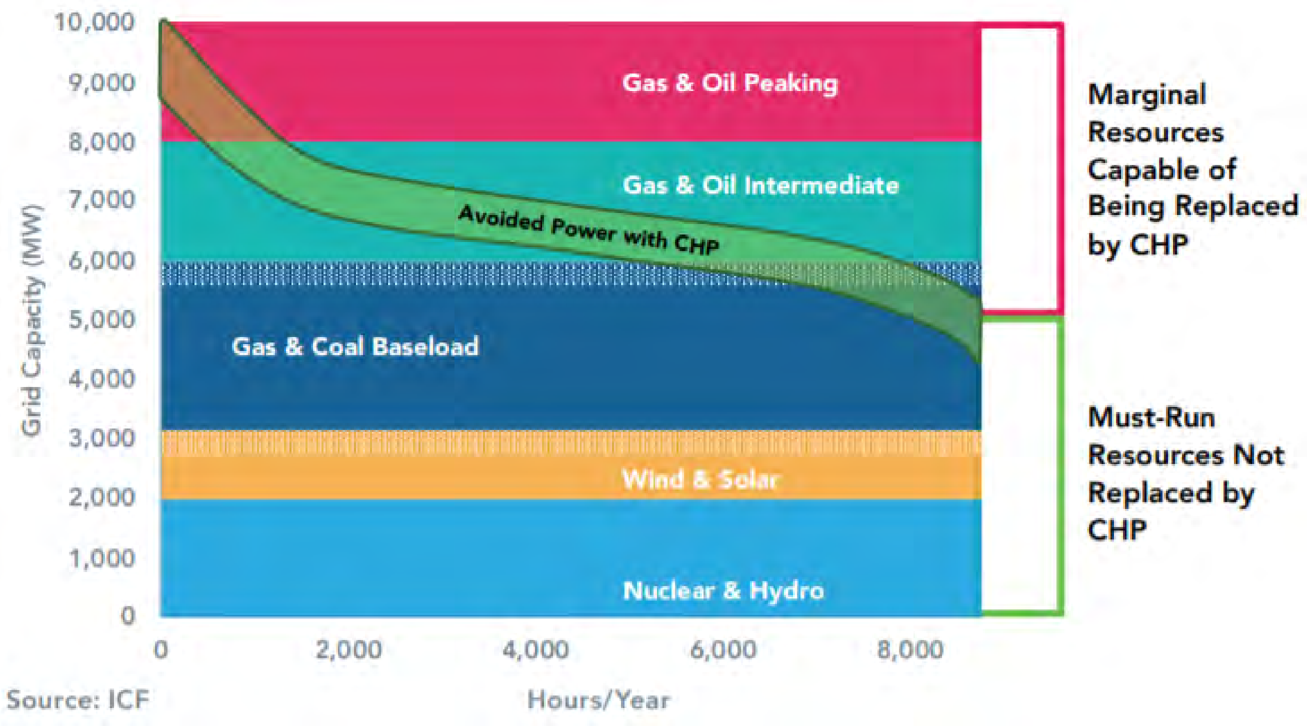
CHP Can Enable Other Microgrid Technologies

- An optimized combination of solar, storage, and CHP can provide long-duration, on-site energy for sites with high resilience needs with the least possible carbon emissions
- CHP provides efficient, resilient, baseload power and thermal energy
- PV reduces grid demand and related emissions in peak hours
- Storage provides additional flexibility, helping to “firm” solar to meet peak loads
- Adding photovoltaic (PV) and storage lowers the required CHP size and further improves emissions compared to the grid
- Thermal Storage can increase CHP efficiency



CHP's Potential To Reduce Emissions

Evaluating CHP Emission Impacts



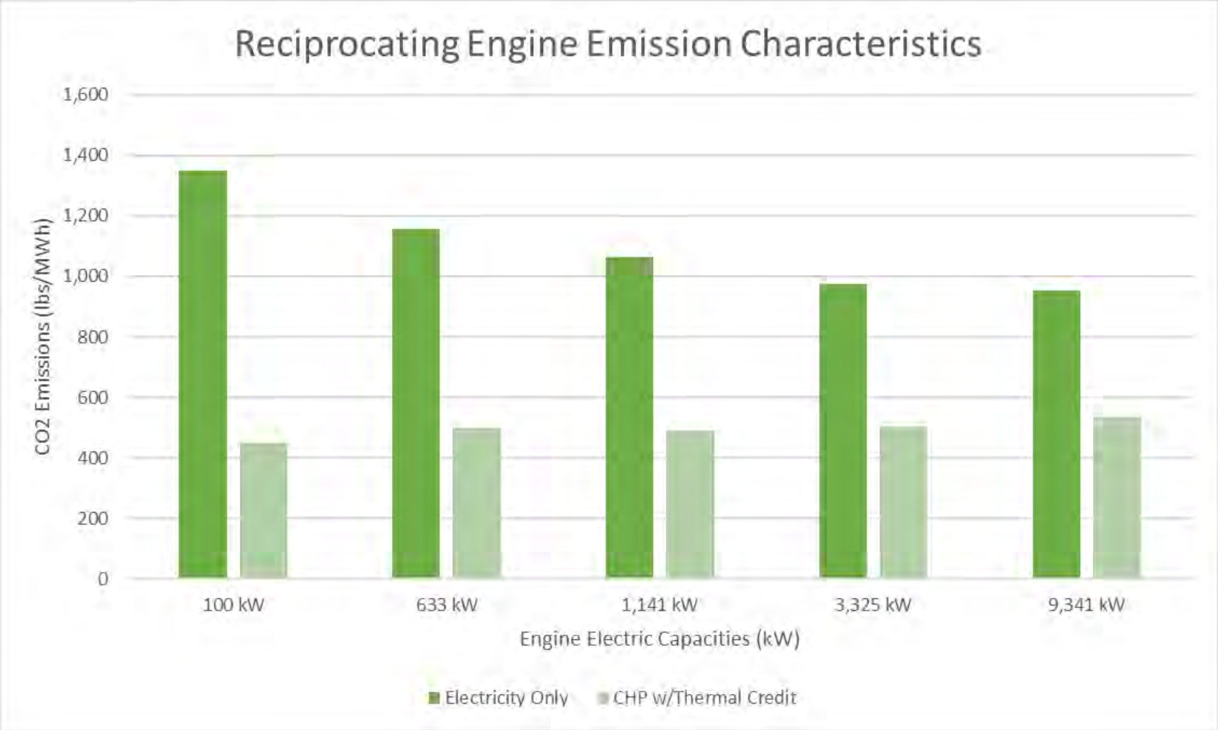
Source: ICF, "As the Grid Gets Greener, Combined Heat and Power Still Has a Role to Play," https://www.icf.com/-/media/files/icf/white-paper/2019/icf_chp_has_a_role_to_play_august_2019_web_wp.pdf

Displaced grid emissions for CHP are based on *marginal utility generation*

- Marginal units are those at the "top of the stack" that set the electricity price in real-time or day-ahead pricing
- Currently, marginal generation tends to be provided by units fueled by gas, oil, and in some cases coal
  - For CHP systems that operate 24/7, average *fossil fuel* emission factors from eGRID can be used
  - For CHP systems that operate during day/evening hours, average *non-baseload* emission factors from eGRID provide a better estimate

Limitations in accurately estimating marginal emissions with eGRID

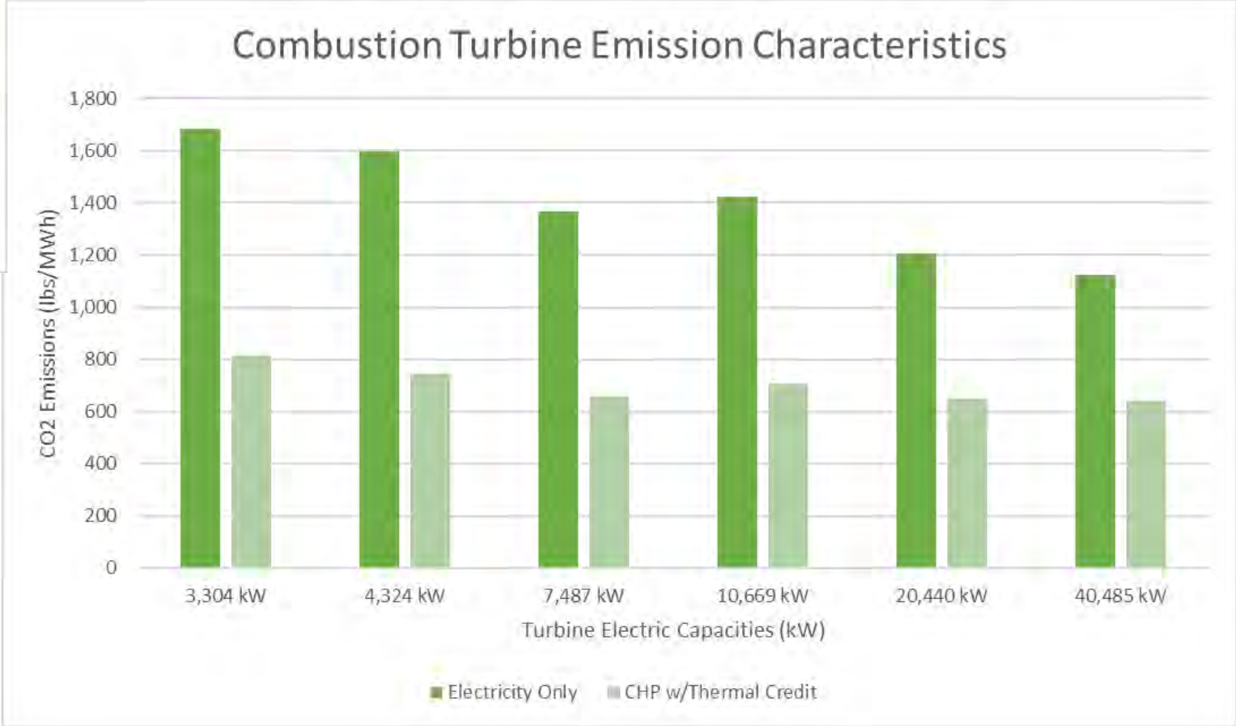
Carbon Emissions from CHP Systems



According to the EIA

Michigan Electric Sector:

- Avg. Carbon Dioxide: **1,108 lbs/MWh**
- Fossil Fuel CO2: **1,680 lbs/MWh**



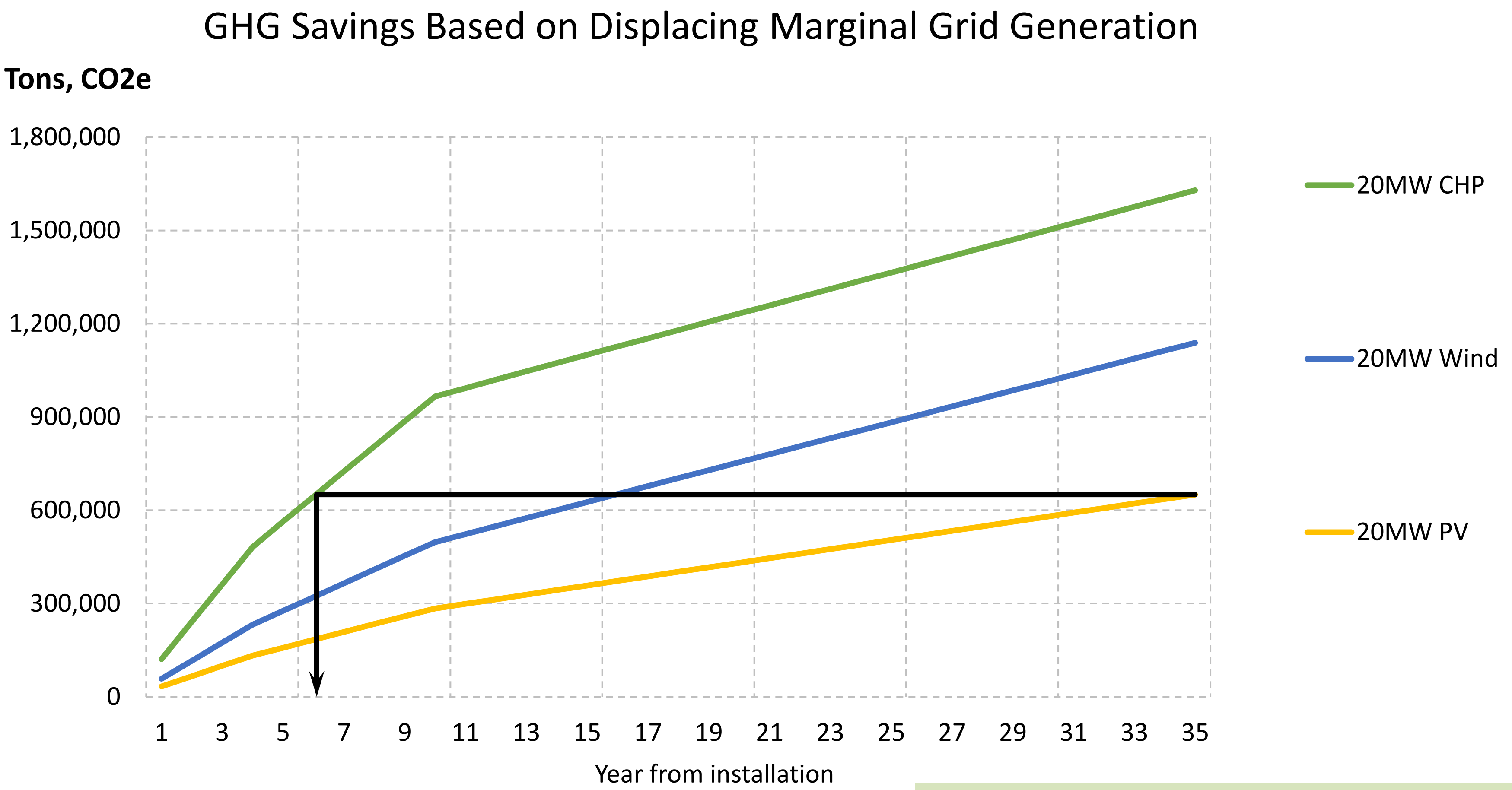
Source:
eGrid 2020 (2018 data)
DOE CHP Technology Fact Sheets

CHP's Higher Efficiency Results in Energy and Emissions Savings Compared to Michigan's Grid (Average Fossil Generation)

Category	10 MW CHP	10 MW WHP	10 MW PV	10 MW Wind	10 MW NGCC
Annual Capacity Factor	85%	85%	24.3%	34.3%	57.6%
Annual Electricity, MWh	74,460	74,460	21,287	32,762	50,458
Annual Useful Heat Provided, MWh_{th}	97,505	None	None	None	None
Capital Cost, $ million	$20.2 m	$15.0 m	$10.0 m	$11.0 m	$9.9 m
Annual Energy Savings, MMBtu	**313,352**	740,529	211,704	298,825	168,797
Annual CO_2 Savings, Tons	**40,787**	65,755	18,798	26,534	25,094
Annual NOx Savings, Tons	**37.2**	39.5	11.8	16.7	26.4

Source: Entropy LLC; eGrid 2020

CHP's Emissions Savings Are Significant



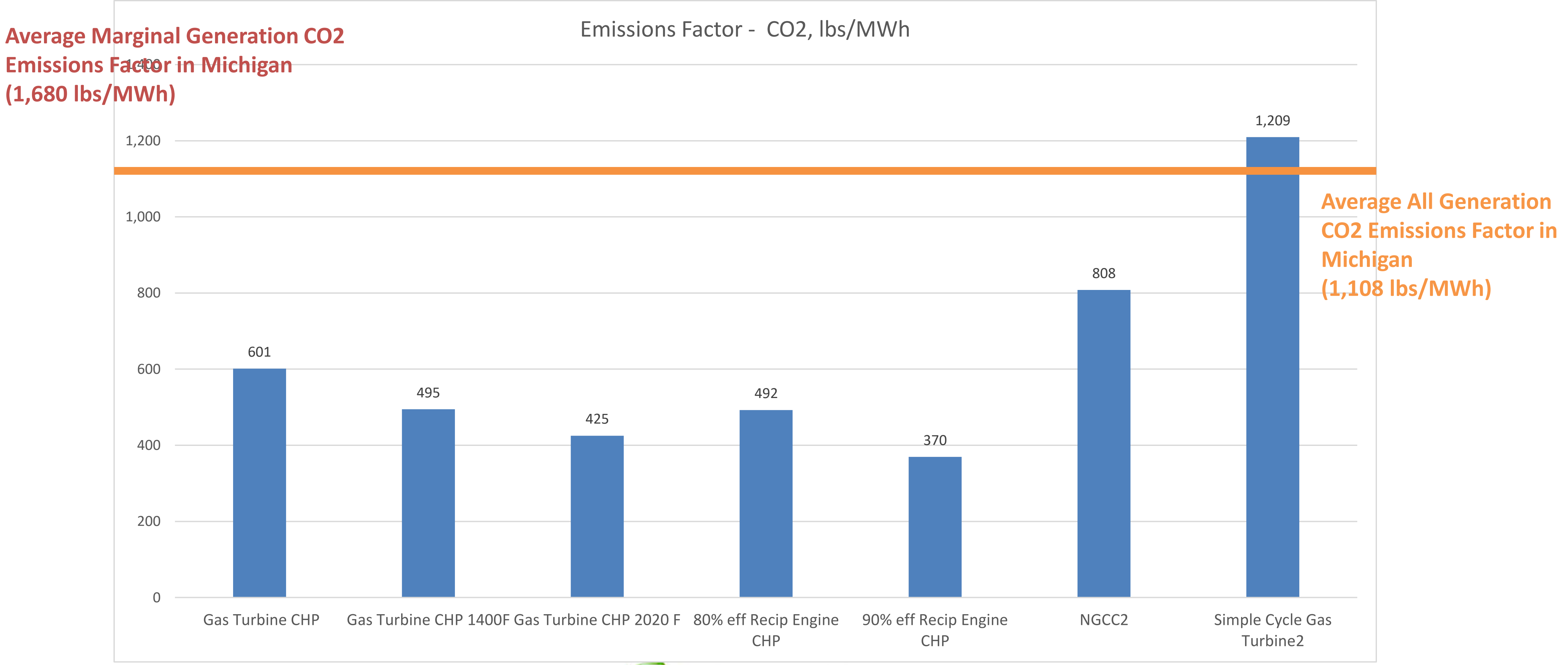
Base Case marginal grid offsets based on Long Term Dispatch Model of Regional Utility Generation Resources

- Y1-4 average 95% coal, ~1,900 lb CO_2e/MWh
- Y5-11 average ~55% coal, ~1,440 lb CO_2e /MWh
- Y12 on, 100% NGCC, ~840 lb CO_2e /MWh
- ~561 lb CO_2e /MWh (net FCP heat rate of 4800, including 4.1% T&D loss reduction credit)
- Capacity Factors: 95% for CHP, 20% for PV, and 35% for Wind

CHP saves more GHG emissions in 6 years as the same capacity of solar PV does in 35 years

Prepared by: Sterling Energy Group, LLC

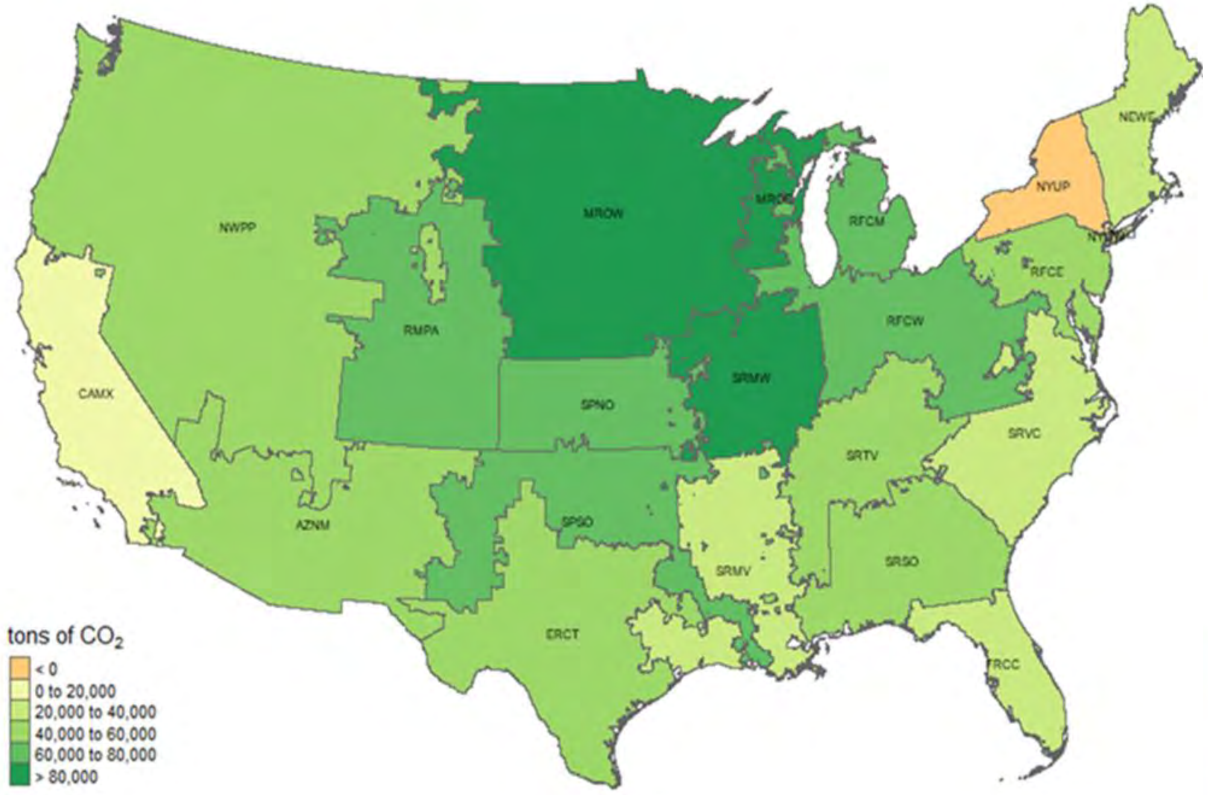
CHP's Higher Efficiency Results in Energy and Emissions Savings Compared to Michigan's Grid



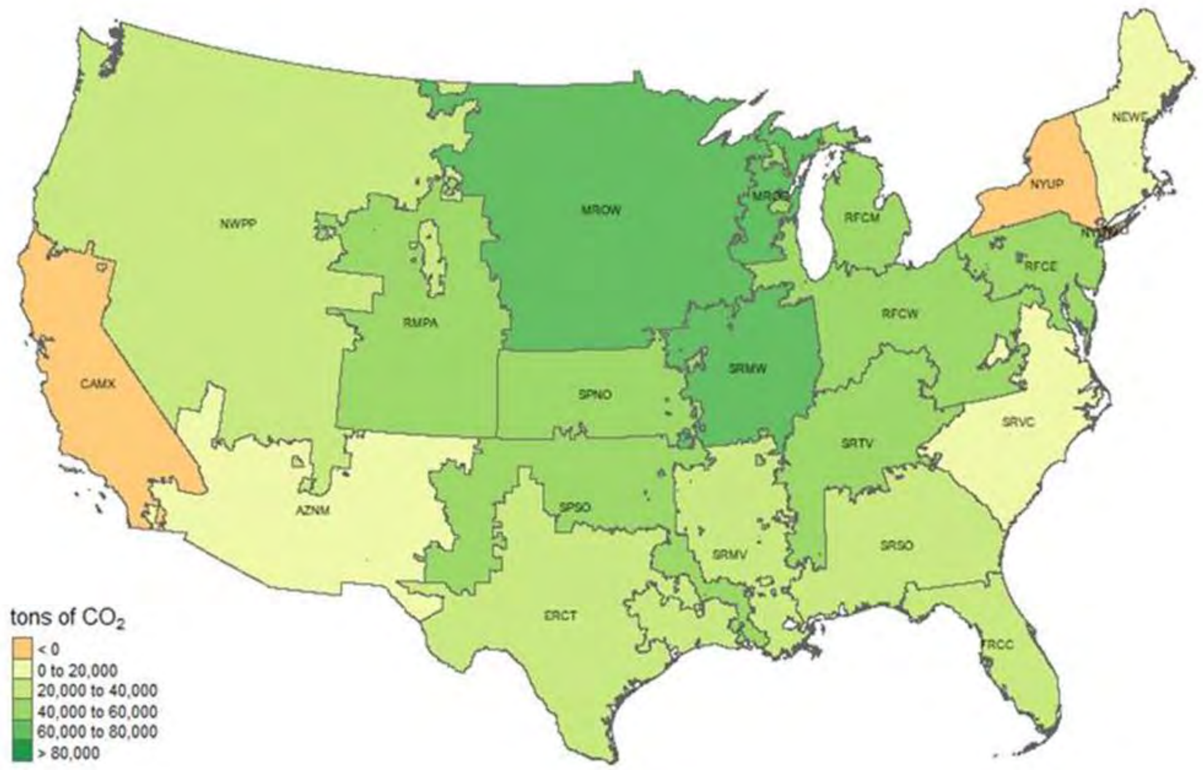
Source: ERC-UIC Internal Calculations

Estimating Future Emissions by eGRID Subregion Lifetime Carbon Emission Reductions for CHP Systems

2020-2035



2035-2050



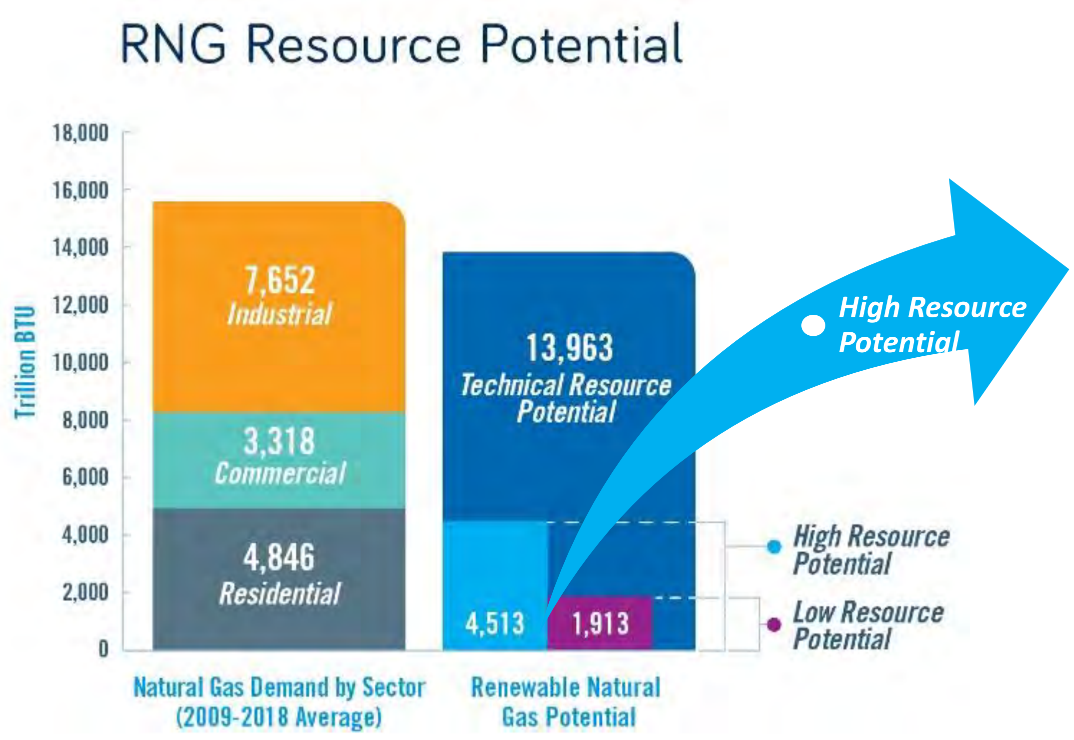
Source: ICF International, July 2020

CHP Technical Assistance Partnerships

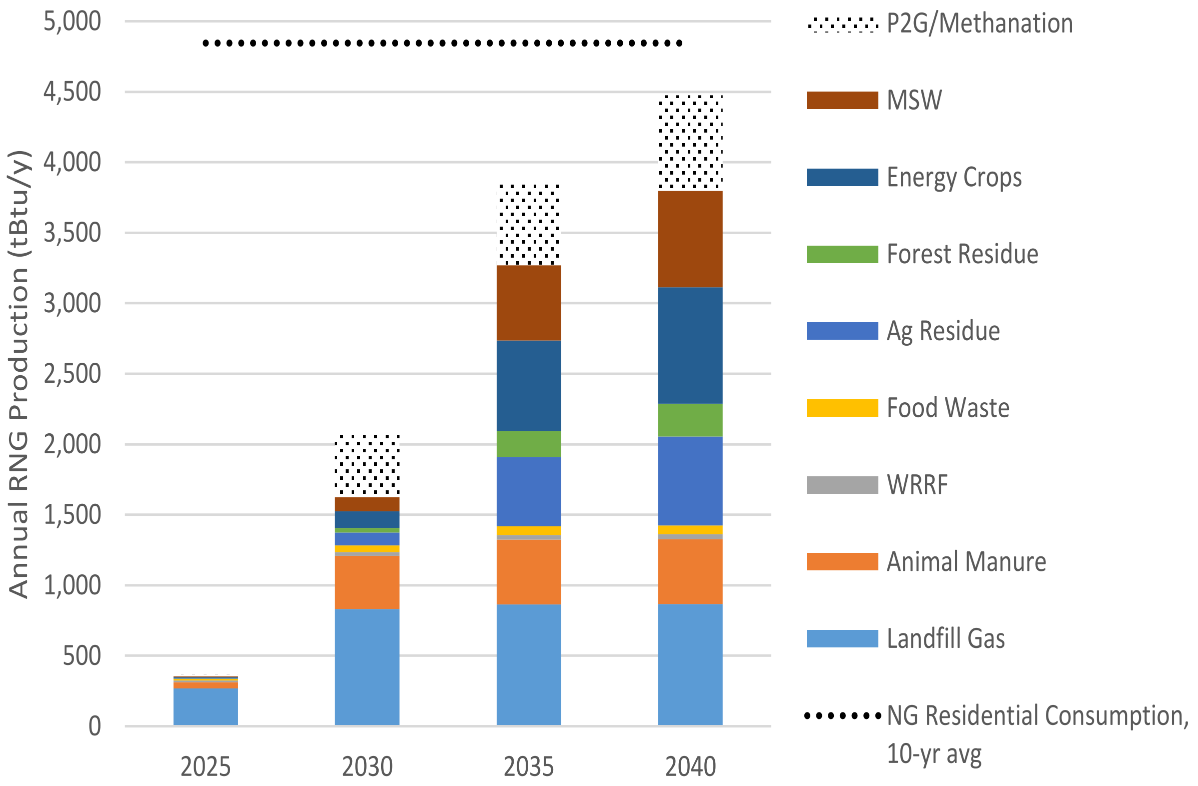
Renewable Gas Potential

AGA Key Findings

- RNG has the potential to offset natural gas demand equivalent to residential consumption
- Up to a **95% reduction** in residential GHG emissions from natural gas
- Cost competitive with other emission reduction strategies, $55-300/ton of GHG emission reductions



Estimated Annual Production



Source: AGA Foundation, Renewable Sources of Natural Gas: Supply and Emissions Reduction Assessment, 2019

Summary

- CHP is a proven technology providing energy savings, grid benefits, reduced emissions, and opportunities for resiliency
- There is ~5 GW of CHP Technical Potential in Michigan
- CHP integration works well in microgrids and can complement solar and other clean energy sources.
- CHP systems provide a direct pathway to decreasing emissions today and through minimal modifications, can run on renewable fuels providing a viable pathway to a no-carbon energy supply.

Contact Information

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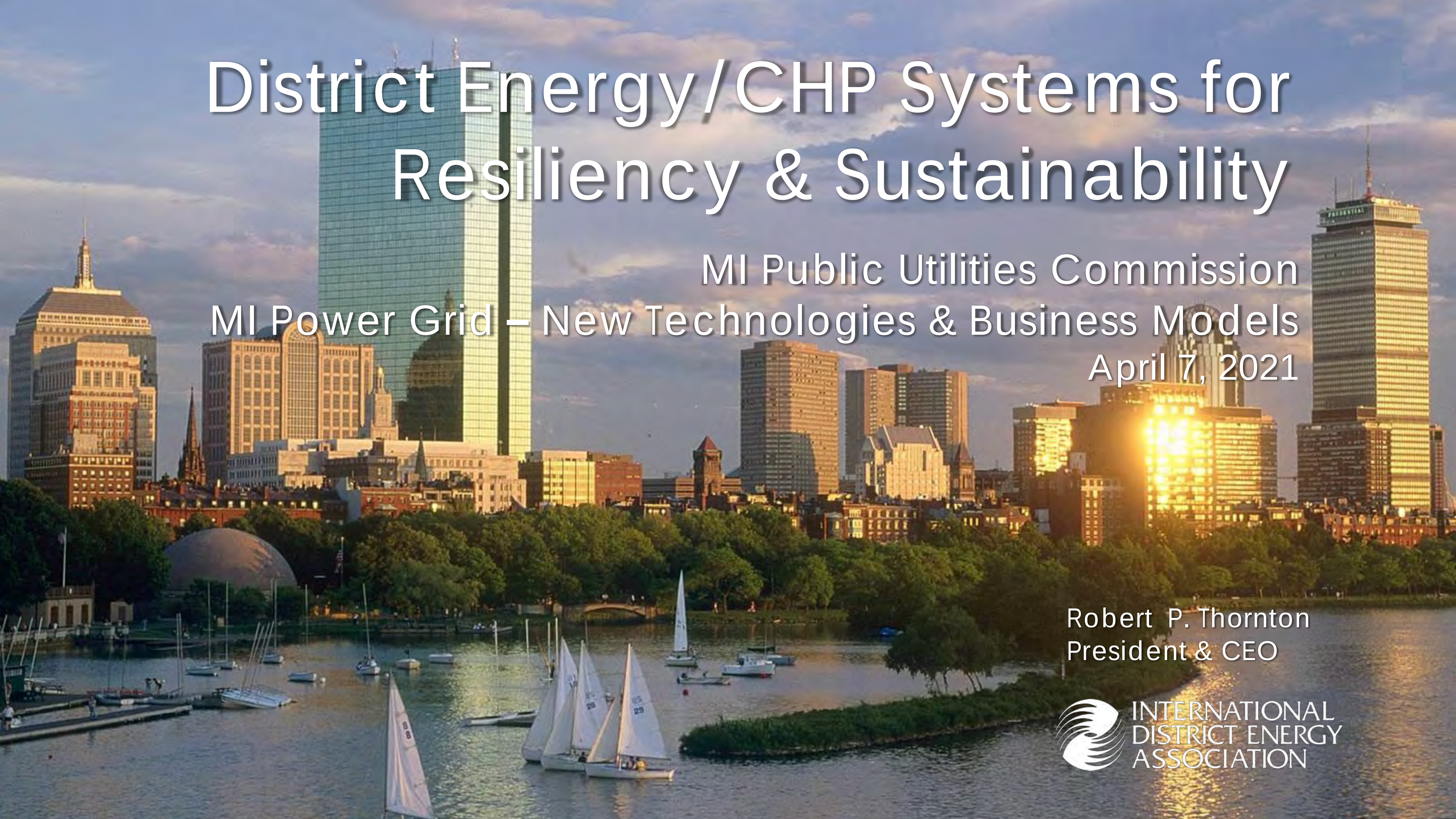
www.energy.gov/chp

District Energy/CHP Systems for Resiliency & Sustainability

Rob Thornton

President & CEO

International District Energy Association



District Energy/CHP Systems for Resiliency & Sustainability

MI Public Utilities Commission
MI Power Grid – New Technologies & Business Models
April 7, 2021

Robert P. Thornton
President & CEO

INTERNATIONAL DISTRICT ENERGY ASSOCIATION

ABOUT IDEA

INTERNATIONAL DISTRICT ENERGY ASSOCIATION

Formed in 1909: 112th year

501 (c) 6 industry association

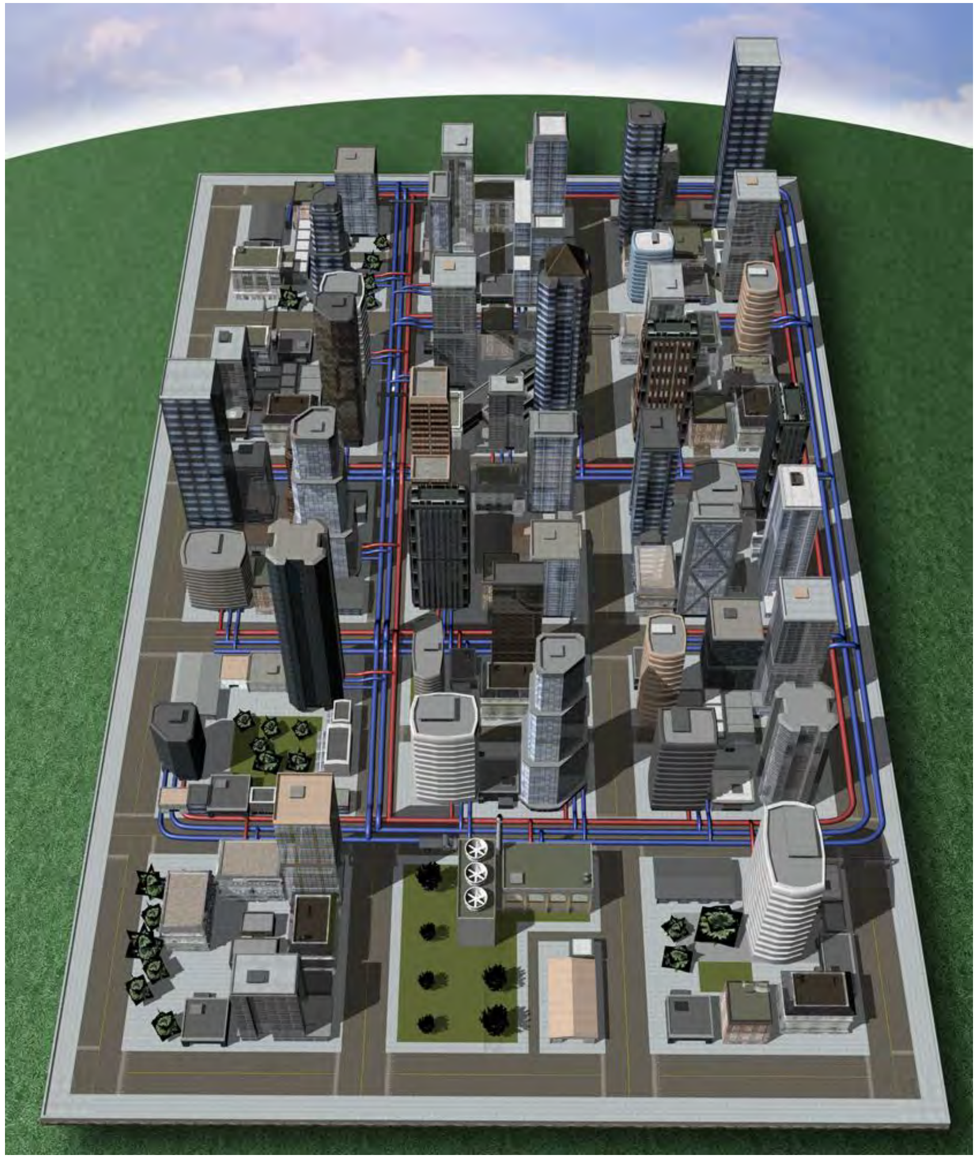
2500+ members – 26 nations

56% end-user systems, majority in North America: 48 states, 6 provinces

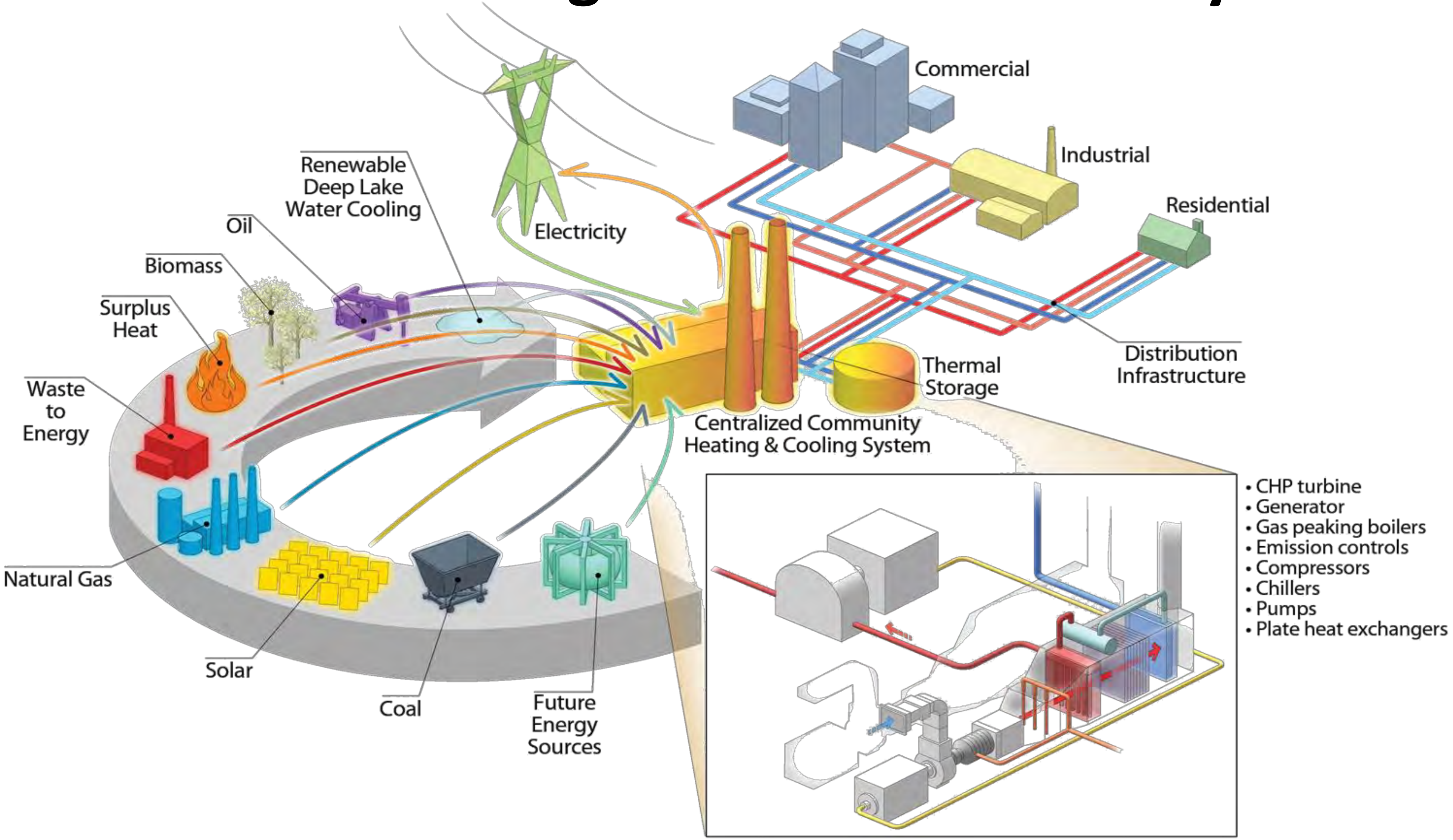
Major urban utilities, public and private universities & colleges, healthcare, pharma, airports, military bases, etc.

District Energy/CHP – Community Scale Energy Solution

- Underground network of pipes "combines" heating and cooling loads of multiple buildings
- Aggregated thermal loads creates scale to apply technologies not feasible on single-building basis
- Creates a "market" for valuable thermal energy
- Fuel flexibility & distributed generation improves energy security, resiliency and strengthens local economy

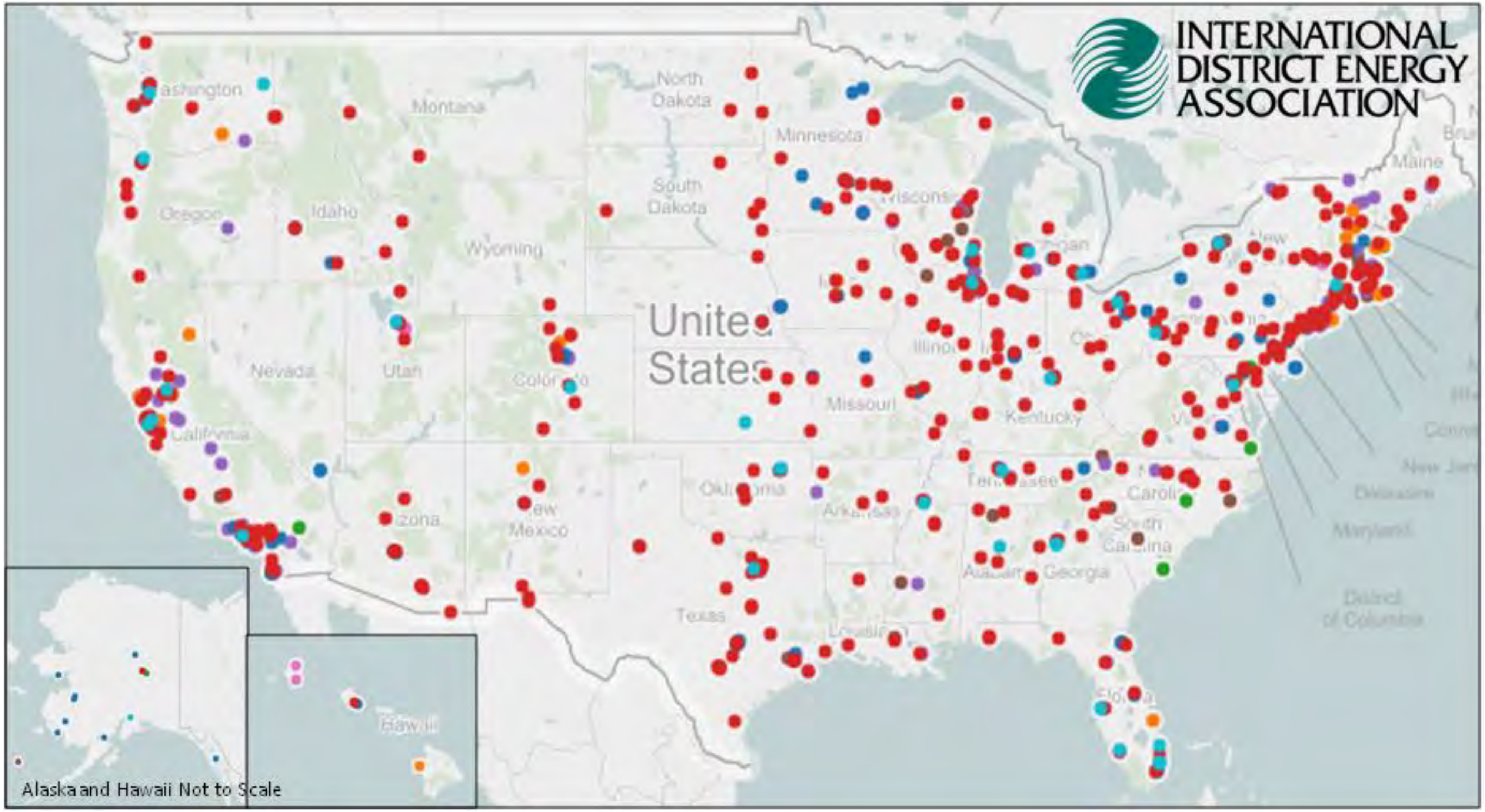


Future Proofing A More Resilient City



Illustration, copyright AEI / Affiliated Engineers, Inc.

US District Energy Systems 2020

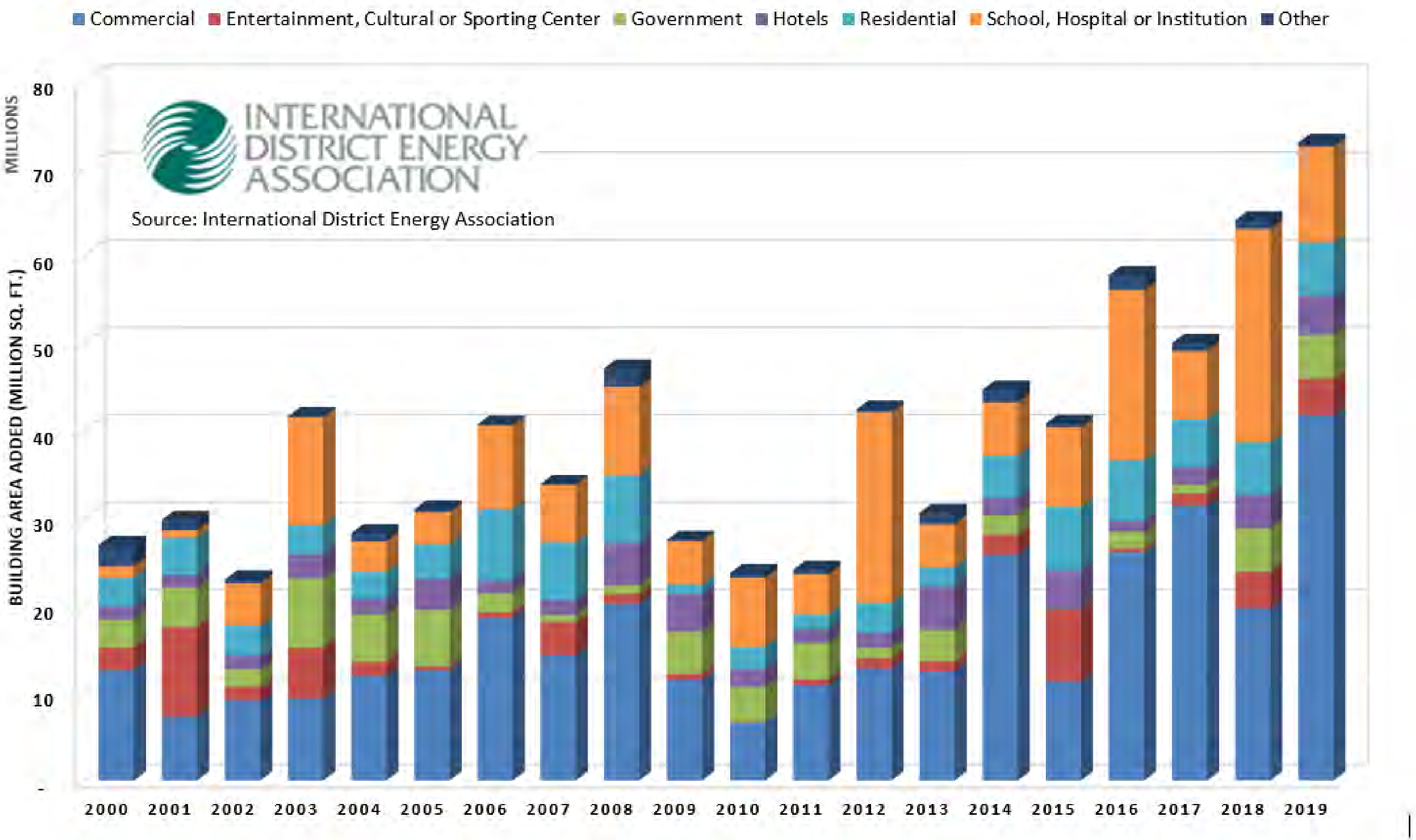


INTERNATIONAL DISTRICT ENERGY ASSOCIATION

https://www.districtenergy.org/resources/resources/system-maps

District Energy Space Growth: North America

Annual Customer Space Committed by Building Type
Building Area Added: 2000-2019 (million Sq. Ft.)

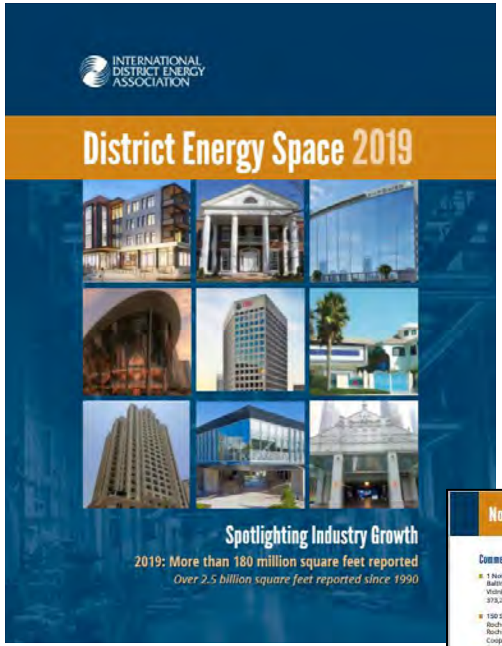


INTERNATIONAL DISTRICT ENERGY ASSOCIATION

https://www.districtenergy.org/resources/publications/district-energy-space

IDEA District Energy Space - 2019

- Annual tracking new customers added to IDEA member systems
- In 2019:
  - Over **72 million SF** North America
  - Over **108 million SF** Beyond North America (Middle East, Asia Pacific)
- Since 2000, **over 2.5 billion SF reported!**
- Report indicates building location; size; type (commercial, arena, hotel, etc); end use (heating, cooling, dhw, etc)



https://www.districtenergy.org/resources/publications/district-energy-space

Why District Energy/CHP?

- CHP use of thermal improves energy efficiency, economics, environment
- Aggregated customer scale creates options for local resources; fuel flexibility
- Generate or buy power based on economics and/or carbon intensity
- Reduce both energy *use* and peak *demand;* avoid costly MW & fuel spikes

- Enables integration of thermal and power generation, thermal storage, renewables, balancing capacity to enhance grid & energy security

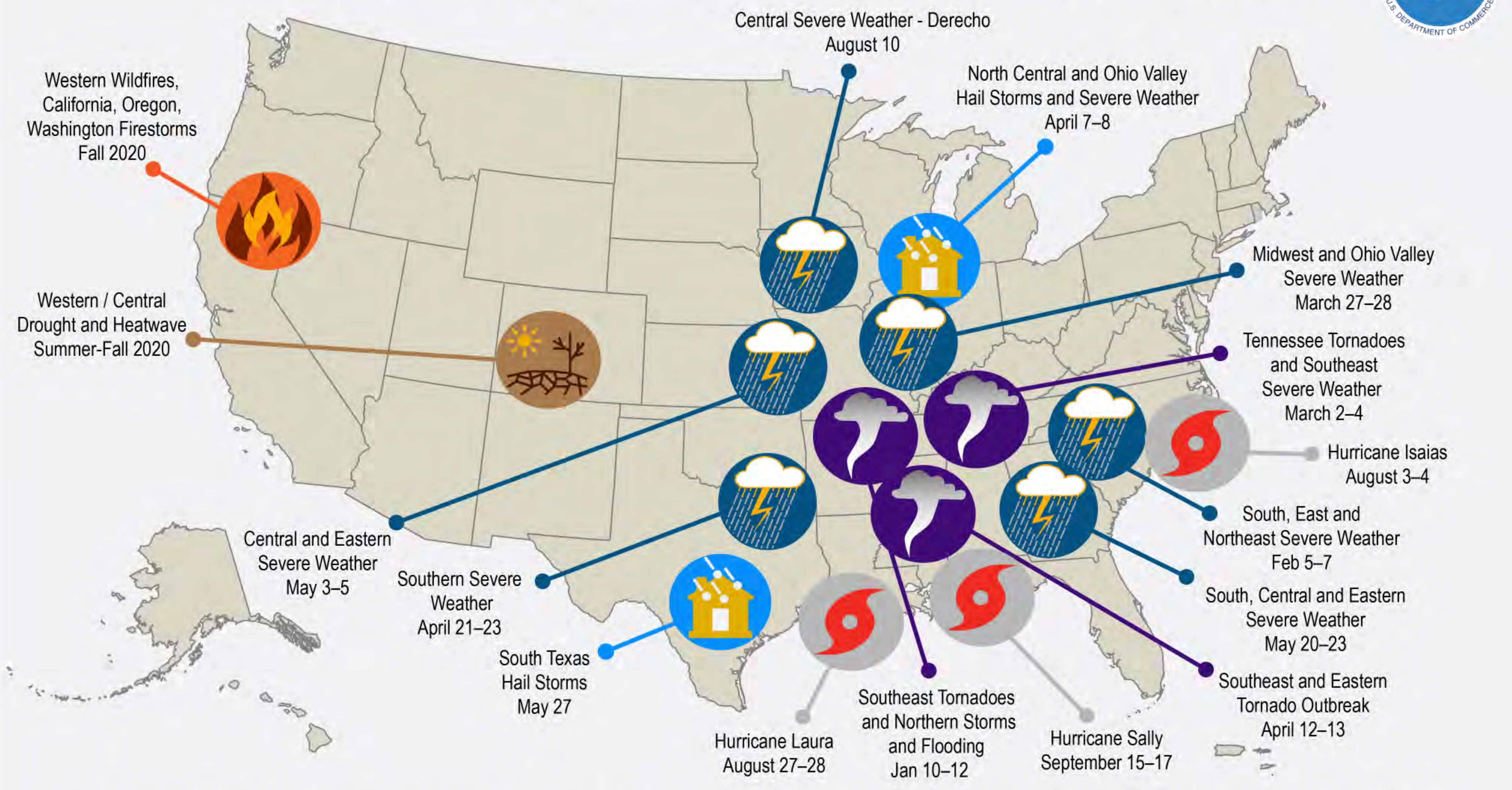
- Provides self-sufficiency, resiliency and areas of refuge during extreme weather emergencies; support local grid and “mission-critical” customers by islanding


PARADIGM
SHIFT

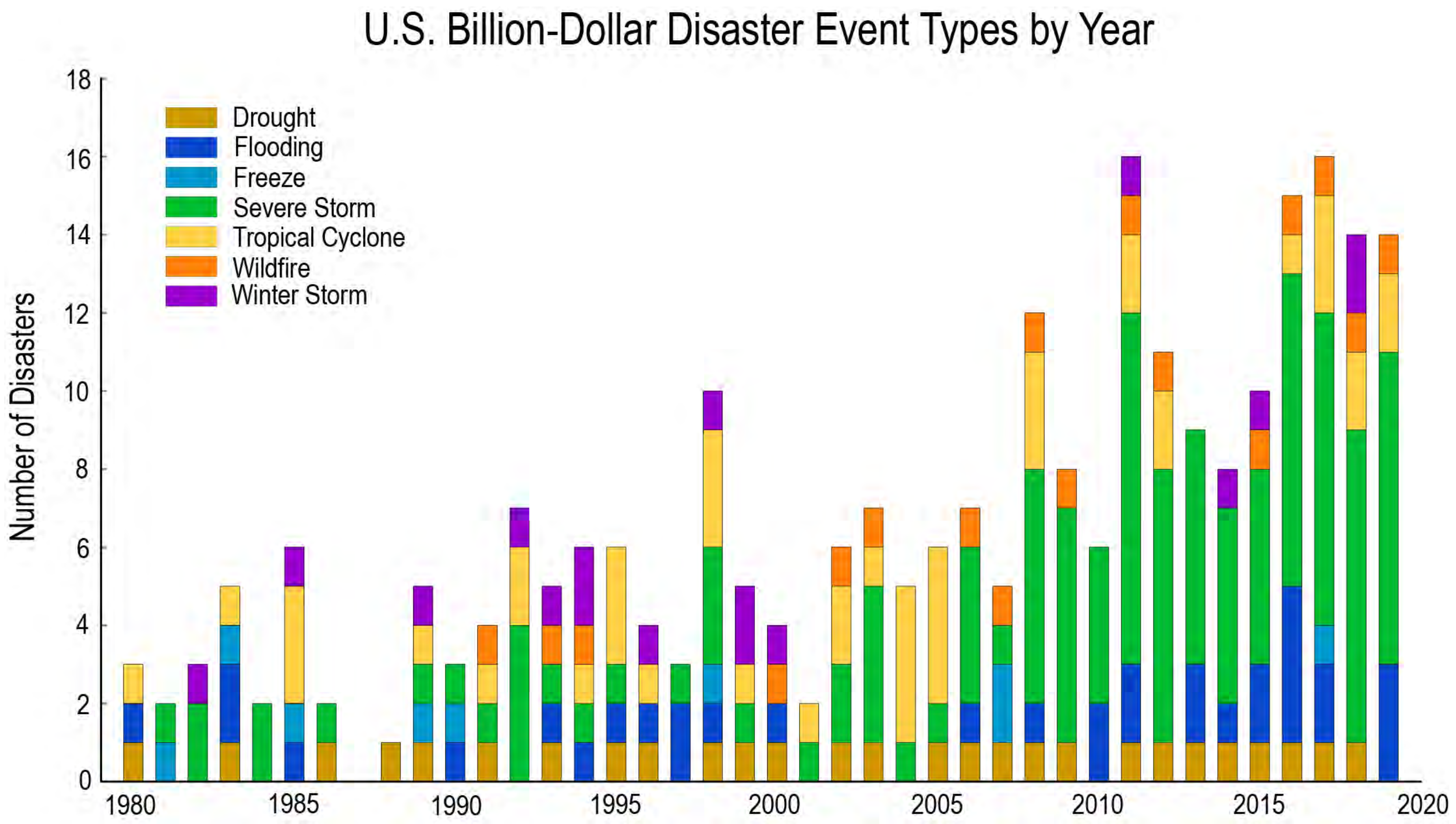
Opportunity: Generate Local Heat and Power

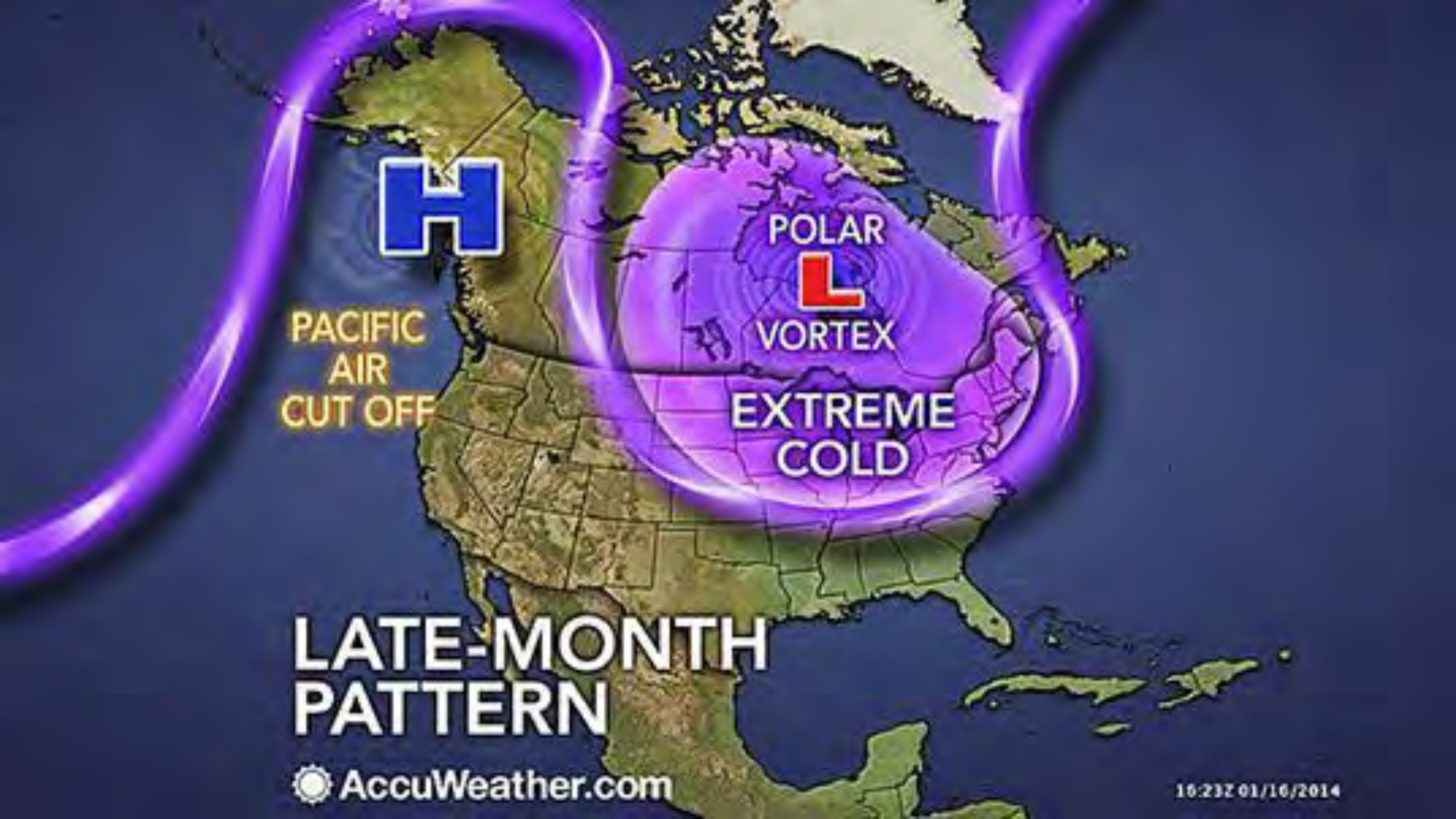
Source: NREL http://www.nrel.gov/dtet/about.html

U.S. 2020 Billion-Dollar Weather and Climate Disasters



This map denotes the approximate location for each of the ***16 separate billion-dollar weather and climate disasters*** *that impacted the United States* ***from January–September 2020****.*


U.S. Billion-Dollar Disaster Event Types by Year
Number of Disasters
0
2
4
6
8
10
12
14
16
18
1980
1985
1990
1995
2000
2005
2010
2015
2020
Drought
Flooding
Freeze
Severe Storm
Tropical Cyclone
Wildfire
Winter Storm


H
POLAR
L
VORTEX
PACIFIC
AIR
CUT OFF
EXTREME
COLD
LATE-MONTH
PATTERN
AccuWeather.com
16:23Z 01/16/2014

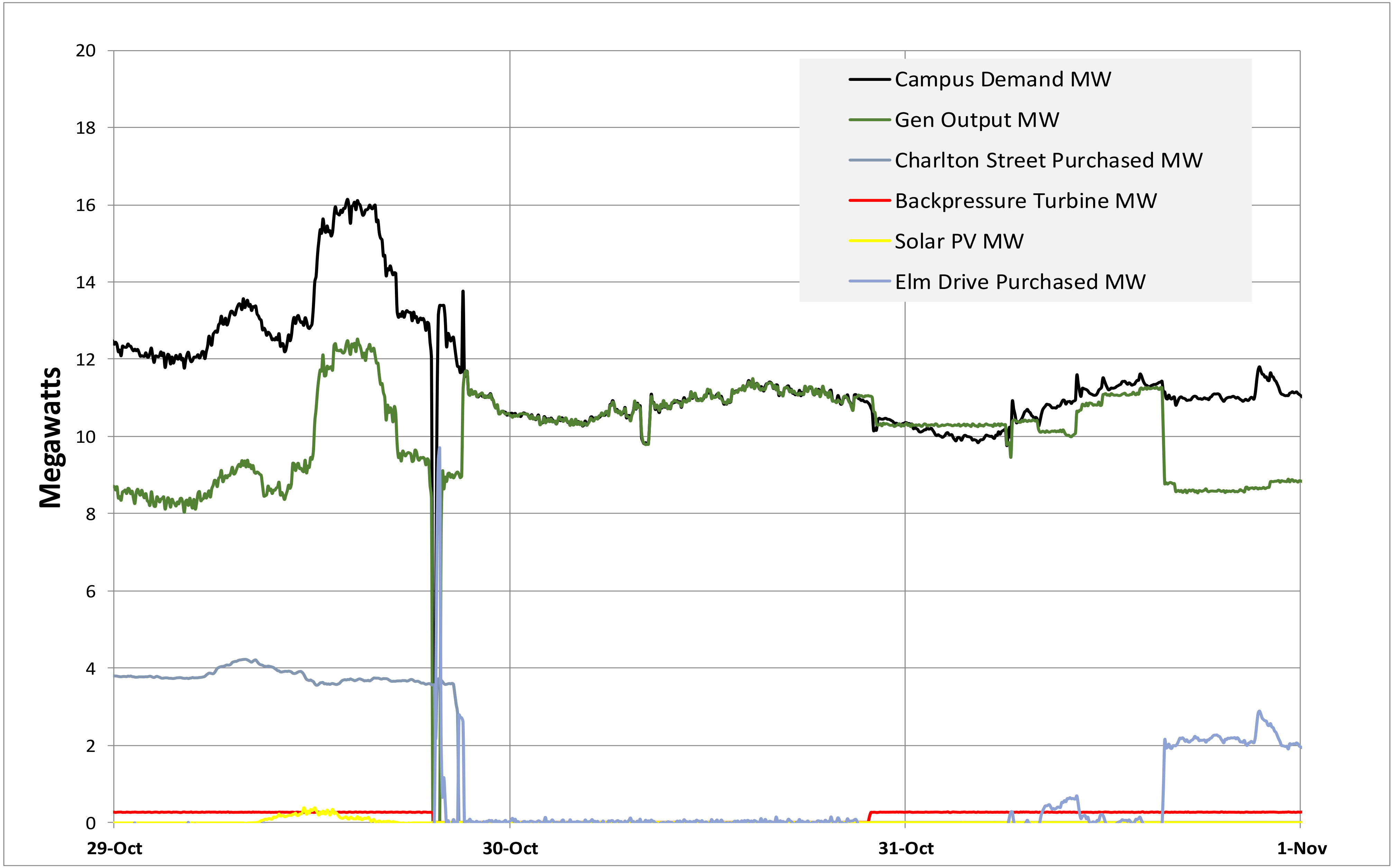
PRINCETON UNIVERSITY
15 MWe District Energy/CHP

Stood up to Super Storm Sandy

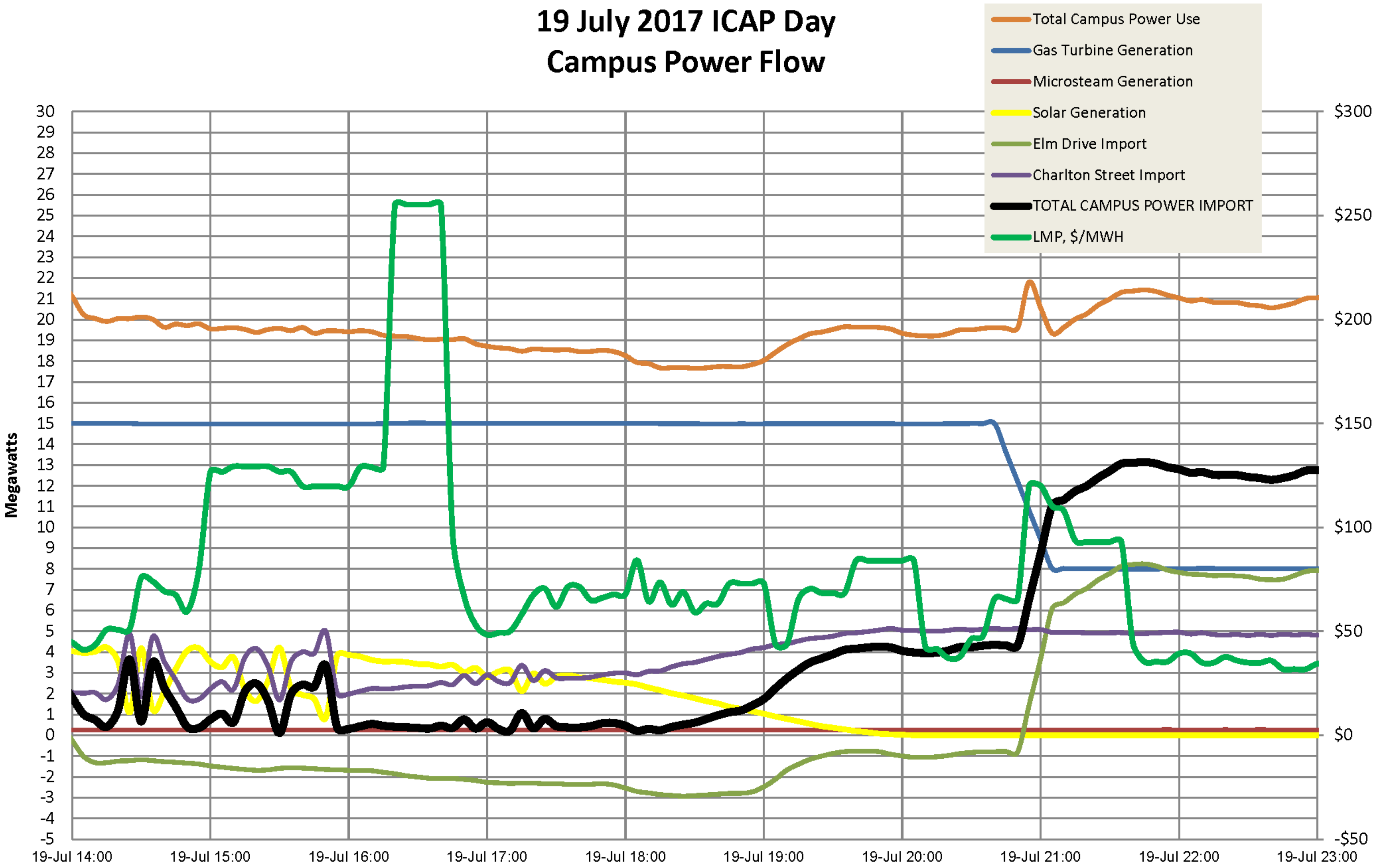
Facilities
Engineering

		Campus Peak
Gas Turbine Generator	15 MW	27 MW
Solar PV Farm	5.4 MW	
Steam Generation		
(1) Heat Recovery Boiler	180,000 #/hr	
(2) Auxiliary Boilers	300,000#/hr	240,00#/hr
Chilled Water Plant		
(3) Steam-Driven Chillers	10,100 Tons	
(3) Electric Chillers	5,700 Tons	
Thermal Storage		
(2) Electric Chillers	5,000 Tons	
(1) Thermal Storage Tank	40,000 Ton-hours	11,800
*peak discharge	10,000 tons (peak)	

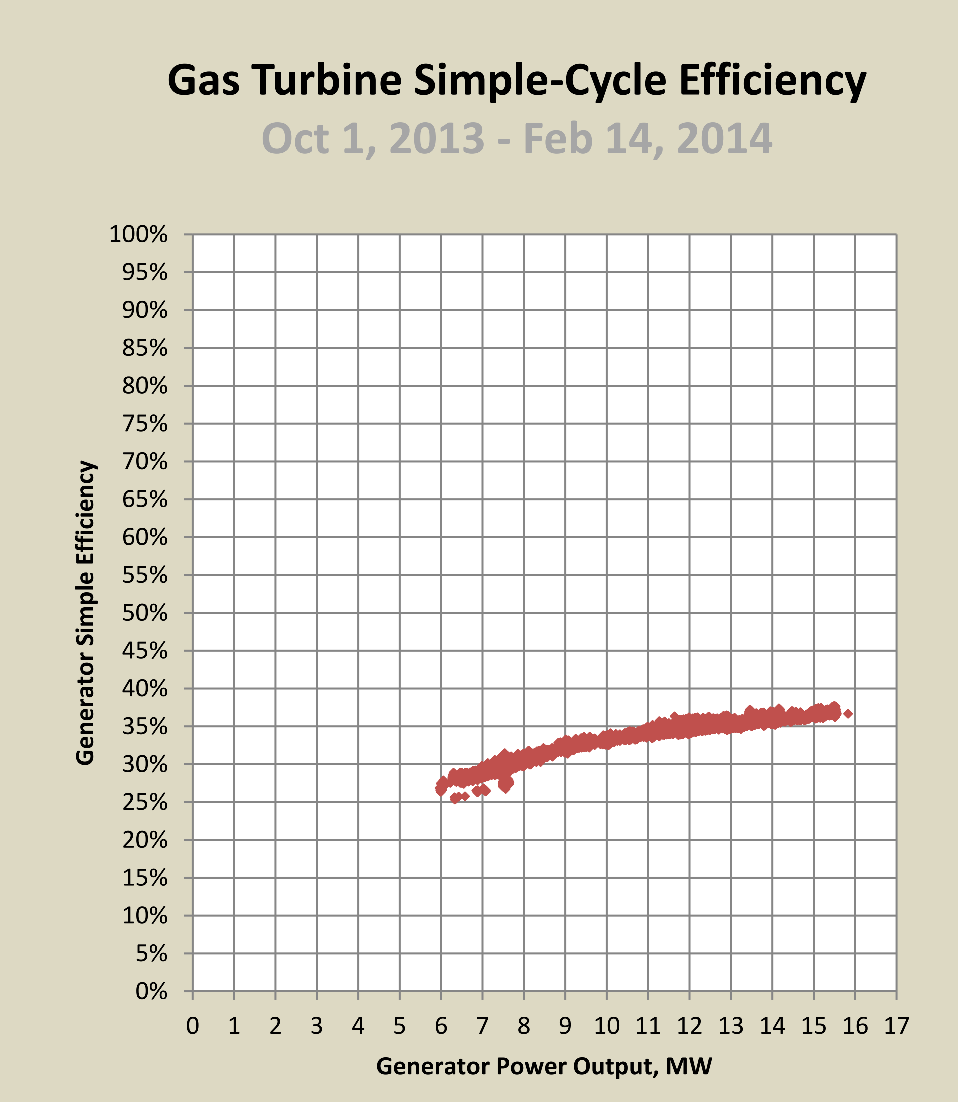
Campus Power During Super Storm Sandy

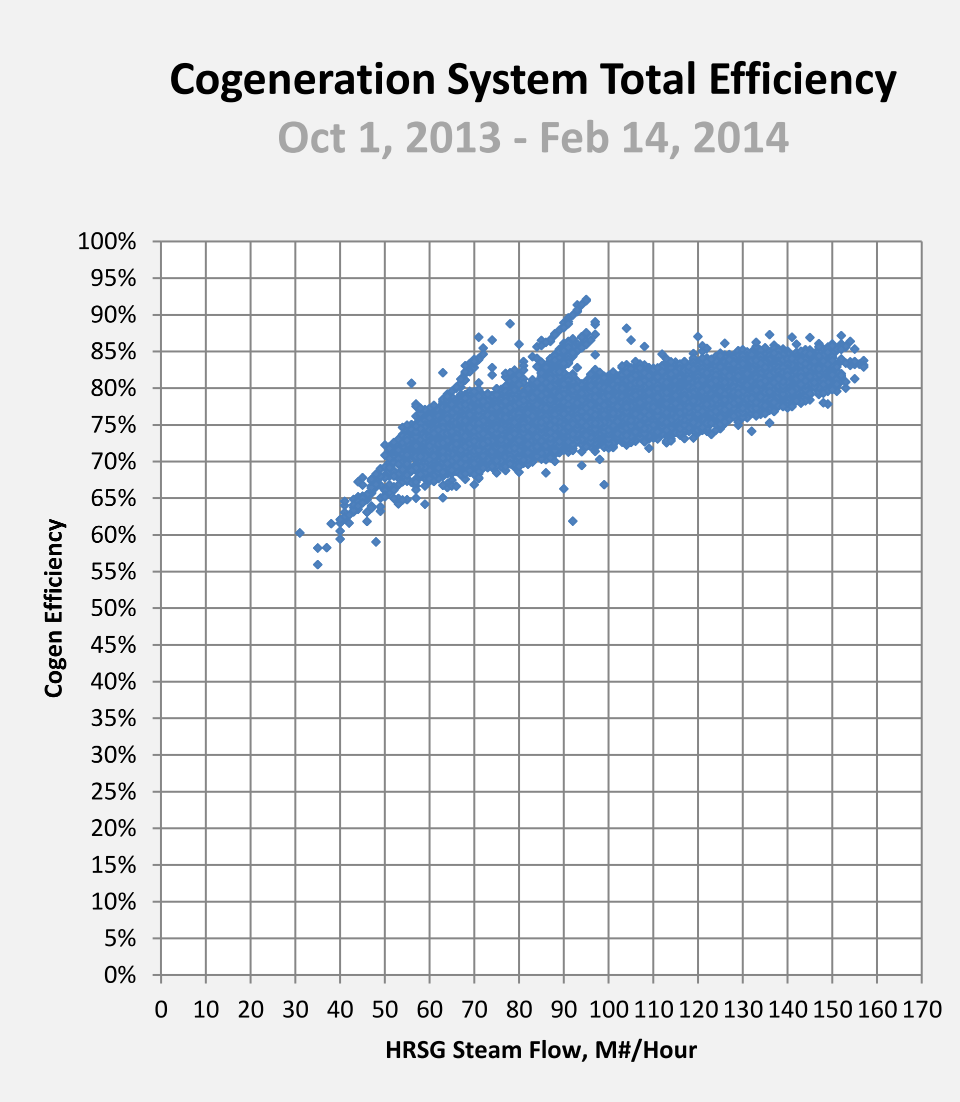


Princeton University – Blue Sky



How Much More Efficient is Combined Heat & Power?





Last month in Texas…

WINTER STORM 2021Texas was "seconds and minutes" away from catastrophic monthslong blackouts, officials say – The Texas Tribune 18 Feb, 21

Photo courtesy LA Times.com

Photo courtesy of VT.com

Photo courtesy of Chicago Tribune

TECO currently serves
50 buildings
16 different institutions
22.7 million sq. ft of space

Texas Medical Center – Mission Critical

- **TEXAS MEDICAL CENTER**
- **10 million** patients annually
- **110,000** employees
- **8th largest** business district in U.S.
- **180,000+** surgeries annually
- **10,500** patient beds
- **$2.5 billion** in annual life science research

tecothermalenergy.com

Thermal Energy Corp (TECO) – Houston, TX

- 48 MWe CHP provides efficiency to 80%+
- 16 MW of emergency power generation
- 980,000 Lbs per hour steam capacity
- 120,210 Tons chilled water capacity
- 8.8 million-gallons CHW TES tank
- Will save $200 million over 15 years
- Reduced CO^2 by 302,000 tons per year
    - equivalent to displacing 52,000 cars
    - or planting 83,000 acres of new forest

TEXAS
The University of Texas at Austin

- Began Microgrid operations in 1928 – 100% of power load
- 134 MW CHP, 1.2 MLbs steam capacity; 60,600 Tons CHW
- 18 Million SF; 150+ buildings; 71,000 daily population
- 99.9998% availability over 35+ years
- Water reclaim from AHU's yields over 66 M gal/yr
- Cut CO_2 emissions by > 90,000 tons/year
- Now serve twice buildings SF (18M), with same volume fuel and carbon emissions as 1976 (9 M SF)

FIGURE 5.1

Effects of Utility Improvements

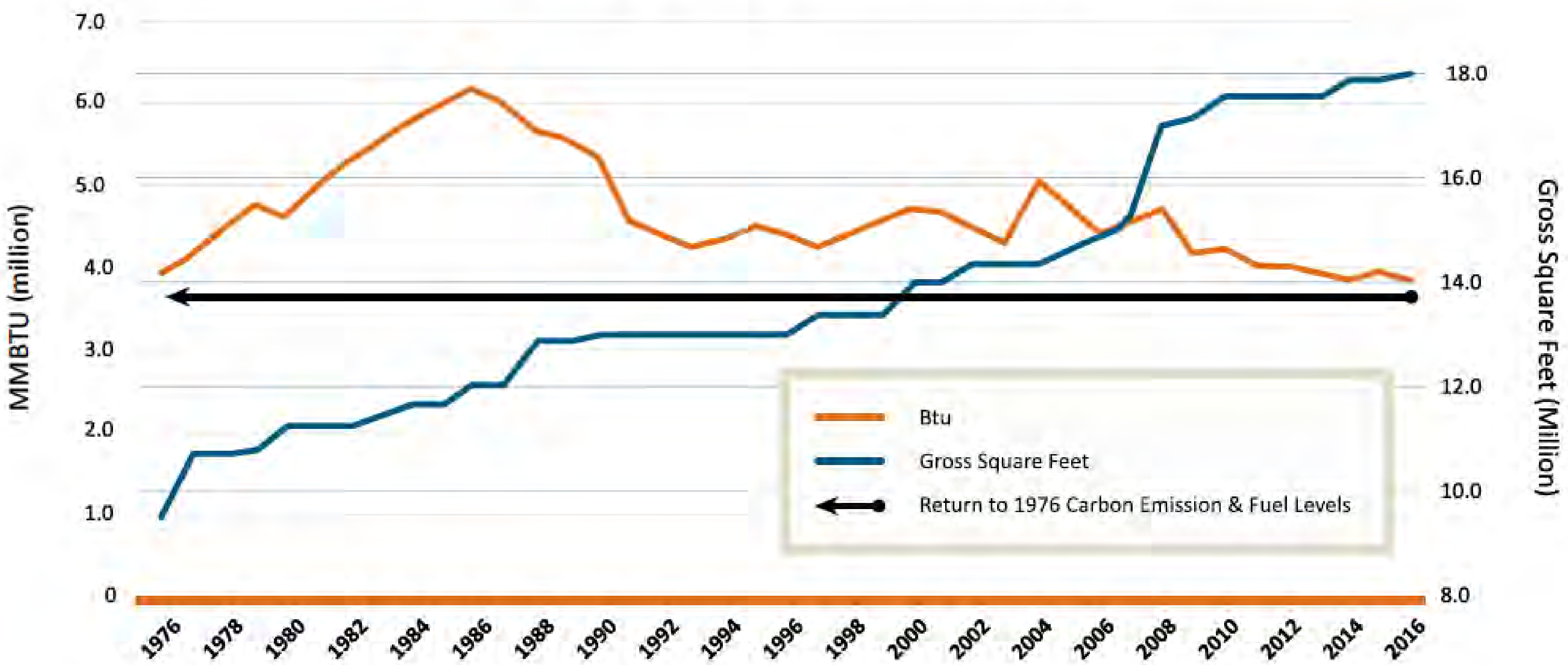
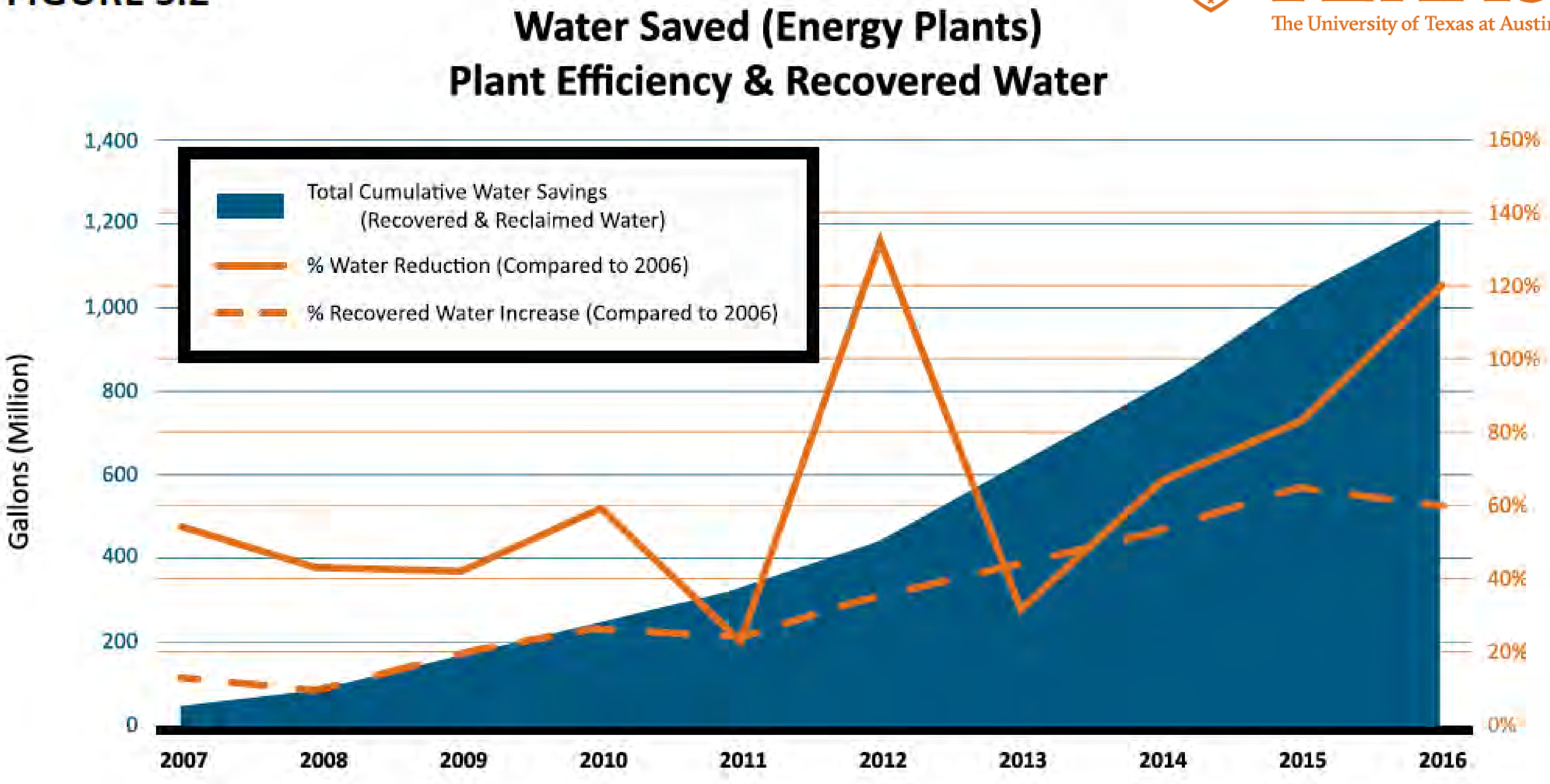


FIGURE 5.2



TEXAS
The University of Texas at Austin


Aging Infrastructure
The Washington Post
'No excuse': Atlanta airport power outage strands travelers in darkness for nearly 11 hours Dec 17, 2017
The New York Times
Power Failure at Airport Snarls Air Traffic Nationwide Dec 17, 2017

Capitol Hill District Energy – Washington, DC

Capitol Power Plant, Washington, DC - 7.5 MW CHP

HUDSON YARDS, NYC

Related Companies

13 MW CHP Microgrid in two plants

Provides electricity, hot and chilled water to $17B community

First-of-its-kind microgrid, with Con Edison allowing a commercial property to island from grid w/o manual intervention

image courtesy of related / oxford properties

MIT CHP - 2020

- Doubled CHP capacity from 22 to 44 MW; currently in commissioning
- Grid interruptions in 2012; concerns about resiliency
- Higher energy efficiency to offset 10% growth in energy demand from new buildings and research
- **Critical to MIT's commitment to reducing campus GHG emissions at least** 32% by 2030.

Harvard University District Energy CHP

Blackstone (orig 1902) – 5 MW backpressure turbine; 8 MW combustion turbine in 2015

New District Energy Facility 2019 – 5.2 MW Allston Campus Development

Kendall Station

Cambridge, MA

- 256 MWe plant reconfigured for CHP; 1.2 MLbs steam
- **Recovered heat previously "wasted" into Charles River**
- Infrastructure piping to interconnect Boston DH network
- Mission-critical customers include health care; life sciences

Green Steam Reducing Boston's Carbon Footprint

Cuts carbon emissions by 475,000 tons/year, equivalent to:

- **Removing 80,000 cars from the streets annually**
- **Installing 600 football fields of solar PV**

Veolia Completes the Sale of Its District Energy Assets in the United States for USD 1.25 Billion to Antin Infrastructure

December 30, 2019

VICINITY

DISTRICT SYSTEMS

- Atlanta, GA
- Baltimore, MD
- Boston-Cambridge, MA
- Grand Rapids, MI
- Kansas City, MO
- Morgantown, WV
- Oklahoma City, OK
- Philadelphia, PA
- Tulsa, OK
- Trenton, NJ
- Watergate (Washington DC)

Brookfield Infrastructure agrees to sell Enwave for $4.1bn

3 February 2021

enwave

- Chicago, IL
- Houston, TX
- Seattle, WA
- Los Angeles, CA
- New Orleans, LA
- Portland, OR
- Las Vegas, NV
- Toronto, ON
- London, ON
- Windsor, ON
- Charlottetown, PEI

Enwave Toronto

- **Deep Lake Water Cooling commissioned in 2004**
- **75,000 TR capacity and expanding w/ 2M gallon thermal storage**
- **Electricity use for cooling reduced by up to 90%**
- **61MW demand & 85M kWh consumption reduced each year**
- **CO_2 emissions reduced by 79,000 Tonnes / Year**
- **Eliminates ozone depleting refrigerants, reduces harmful NO_x and So_x**
- **Environmental benefits equivalent to removing 15,800 cars from the road**

Corporations deploying district energy

On the horizon…

- Headwinds for natural gas in some states
- Utility investment/P3 strategies – infrastructure aggregation
- Enhanced value of resilience, business continuity

- Energy can be local in a circular economy
- Adapt central plant to future fuels (RNG; H2; SMR)
- Scale matters. Carbon matters. Experience matters.

Emerging Trends in District Energy/CHP

- Institutions investing carbon neutral 2030; fossil free 2050
  - Campuses evaluate steam to HW, integrate geo-exchange
- Industry attracting $ billions private capital
  - Acquisitions, concession agreements; corporate campuses
- IDEA 2021 District Energy project inventory - aggregate
  - Federal funding support (80+ projects; $ 3+ Billion)
- Value of Resilience (VOR) gaining as metric; dispatchable
- Scale provides adaptive flexibility – RNG; H2; CCS
- Carbon intensity market signal (by ISO's) - (i.e. LMP 5 min interval price signal)

INTERNATIONAL DISTRICT ENERGY ASSOCIATION

THANK YOU

Questions?

Rob Thornton
rob.idea@districtenergy.org
www.districtenergy.org
+ 1 508 366 9339

Connect at www.districtenergy.org

CampusEnergy2021
BRIDGE TO THE FUTURE
Feb. 16-18 | CONNECTING VIRTUALLY

Over 800 attendees; 100 speakers; 80+ technical sessions & panels recorded – still available to purchase access to content.

34th Annual IDEA Campus Energy Conference

IDEA2021
Powering the Future: District Energy/CHP/Microgrids
Sept. 27-29 | Austin Convention Center | Austin, Texas

Dates moved to September, planning for in-person event – TBD. Exhibits & Sponsors still available. Abstracts for program over-subscribed

112th Annual Conference & Trade Show

Rob.idea@districtenergy.org +1-508-366-9339 www.districtenergy.org

MI POWER GRID

Making the Most of Michigan's Energy Future

New Technologies and Business Models

Break: 2:05 – 2:15 PM

Stakeholder Meeting 6: Combined Heat & Power

April 7, 2021

MPSC

Michigan Public Service Commission

Panel: The Power of CHP – Roadblocks to Harnessing Its Opportunity

Moderator

Lynn A. Kirshbaum
Deputy Director
Combined Heat and Power Alliance

Chris Bixby
Sales Engineer
Clarke Energy USA

James Leidel
Principal Markets
Technical Consultant, DTE Gas

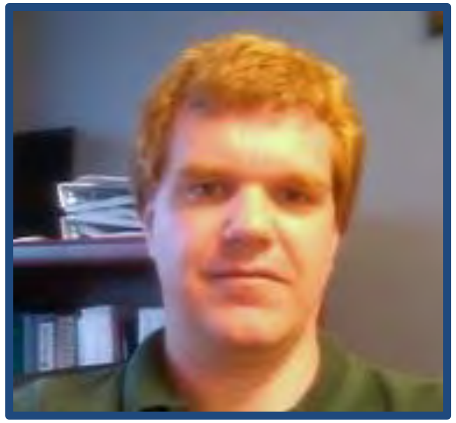
Kevin O'Connell
Advanced Energy Systems Manager
Michigan CAT &
MacAllister Machinery

Panel: Speaking from Experience - CHP Motivations, Barriers, & Realities

Moderator

Lynn A. Kirshbaum
Deputy Director
Combined Heat and Power Alliance

Tim Lynch
Plant Manager
Benton Harbor-St. Joseph Joint Wastewater Treatment Plant



Jeff Means
Energy Manager
Veteran Affairs Medical Center
Department of Veteran Affairs

Kathy Richards
Associate Vice President
Engineering & Planning/Facilities
Northern Michigan University

BENTON HARBOR - ST JOSEPH WASTEWATER TREATMENT PLANT

producing clean water for the environment

COMBINED HEAT & POWER - 2021

Tim Lynch, Plant Manager

April 7, 2021

BENTON HARBOR – ST. JOSEPH WWTP

FACILITY INFORMATION

TREATMENT CAPACITY	15.3 MGD
AVERAGE DAILY FLOW	9.0 MGD
OPERATING BUDGET	$3,057,240
CAPITAL BUDGET	$4,440,000
INSURABLE VALUE	$61,631,000
PERSONNEL	18 FULL TIME
POPULATION SERVED	58,000

ANAEROBIC DIGESTION

Outside Resources / CHP Project

- Currently in design phase of CHP Improvement Project to fulfill most if not all electrical and thermal needs of facility
- DOE Combined Heat and Power Technical Assistance Partnerships (CHP TAPs)
- Conducted a CHP Feasibility Analysis . Grant funds from Michigan Energy Office
- Construction costs of $6 Million. CHP approximately $4 Million

VA Ann Arbor

MI Power Grid New Technologies & Business Models

Combined Heat and Power

Natural Gas Fired Turbines

Purpose

- To comply with the Energy Independence and Security Act of 2007 and other relevant legislation and Executive Orders
  - Reduce Energy Intensity
  - Reduce Green House Gas Emissions
- To Save Energy and Operational Dollars
  - Every dollar saved on utilities (Electricity, Natural Gas and Water) is a dollar that can be spent of capital improvements, salaries, improvements in VA care for Veterans

Project

- Located at VA Ann Arbor
  - 1.2 Million gsf Tier 1A Medical Facility
  - OR's, ICU's, MRI's, Linear Accelerators, Clinical Research
- 5 – 200 kW natural gas turbines in parallel with a waste heat recovery to generate steam
- Installed in facility Energy Center utilizing a pad set aside for a future boiler.

Natural Gas Fired Turbines

Performance

- Energy Production
  - 8,400,840 kwh/yr
  - 27,094,680 lbs steam/yr
  - 64,757 MMbtu/yr

    Source generation credit (defined by the Department of Energy)
- Fiscal
  - $373,315 savings per year
- Energy Goal
  - 25,469 MMbtu reduction/yr

    ~ 2 avg month of natural gas consumption

    ~ 45% of electric consumption
  - 2,628 MtCO2e reduction/yr

    571 equivalent to vehicles off the road

- Risk Management
  - Utility cost fluctuations impact net savings $$$
  - Need a maintenance contract for the system to keep it operational
  - Our installation was an early version and reliability is an issue.

Final analysis

- Take aways
  - PROJECT WAS SUCCESSFUL IN REDUCTION OF OUR ENERGY FOOTPRINT
  - PROJECT WAS SUCCESSFUL IN REDUCTION OF GREENHOUSE GAS FOOTPRINT
  - PROJECT HAS GENERATED A SIGNIFICANT NET ANNUAL COST SAVINGS.

JEFF MEANS

ENERGY MANAGER

VA ANN ARBOR, VA SAGINAW

NORTHERN MICHIGAN UNIVERSITY

Presentation-MI Power Grid
Panel: Speaking from Experience – CHP Motivations, Barriers, & Realities
April 7, 2021

CHP Presentation

Ms. Kathy Richards
Associate Vice President
Engineering and
Planning/Facilities
kathrich@nmu.edu, 227-1237

Objective: Share experience with existing CHP plant design, construction and operation along with considerations of potential future CHP project.

Ripley Energy Plant

CHP Plant Addition

Original Plant

Experience Highlights

CHP Plant Facts

- Completed July 2013
- $17 Million project
- 42,000 lb/hr hybrid fire/water tube boiler
- 750 kW back pressure steam turbine/generator
- Capable of burning wood chips or natural gas
- Can meet 87% of campus thermal and 16% of electric needs
- 400 psig in and 85 psig out

Ripley Energy Plant

Boiler Water Tube Section & Economizer

Boiler Fire Tube Section

Ripley Energy Plant

Entry

Backpressure Steam Turbine Generator

MI POWER GRID

Making the Most of Michigan's Energy Future

New Technologies and Business Models

Break: 3:45 – 3:50 PM

Stakeholder Meeting 6: Combined Heat & Power

April 7, 2021

Waste Heat to Power: An Overlooked Zero Emission Energy Resource for Michigan's Industrial Sector

Patricia Sharkey

Executive Director, Heat is Power Association

Policy Director, Midwest Cogeneration Association

Waste Heat to Power: An Overlooked Zero Emission Energy Resource for Michigan's Industrial Sector

Patricia F. Sharkey
Executive Director
Heat is Power Association

Policy Director,
Midwest Cogeneration Association

MI Power Grid New Technologies & Business Models Workgroup
Workgroup Meeting #6 – April 7, 2021
Michigan Public Service Commission

HEAT IS POWER
LET'S CAPTURE IT

The **Heat is Power Association** is the industry-led organization focused exclusively on advancing waste heat to power (WHP) through outreach, education and advocacy.

- Advocates in Congress for parity for WHP with other sources of clean energy
- Supports state efforts to incorporate WHP into their clean energy policies and programs
- Advocates for appropriate inclusion of WHP into DOE, EPA and other agencies' policies and programs
- Educates companies and industry groups about WHP opportunities
- Connects waste heat generators with solution providers
- Collaborates with clean energy organizations to

Waste Heat is an Energy Resource

- Solar and geothermal are “natural” heat energy resources that can be captured and converted to electric energy with appropriate technology

- “Waste heat” is the term used for heat energy that is generated as a by-product of a man-made activity, such as an industrial process, power generation, or a comfort heating system

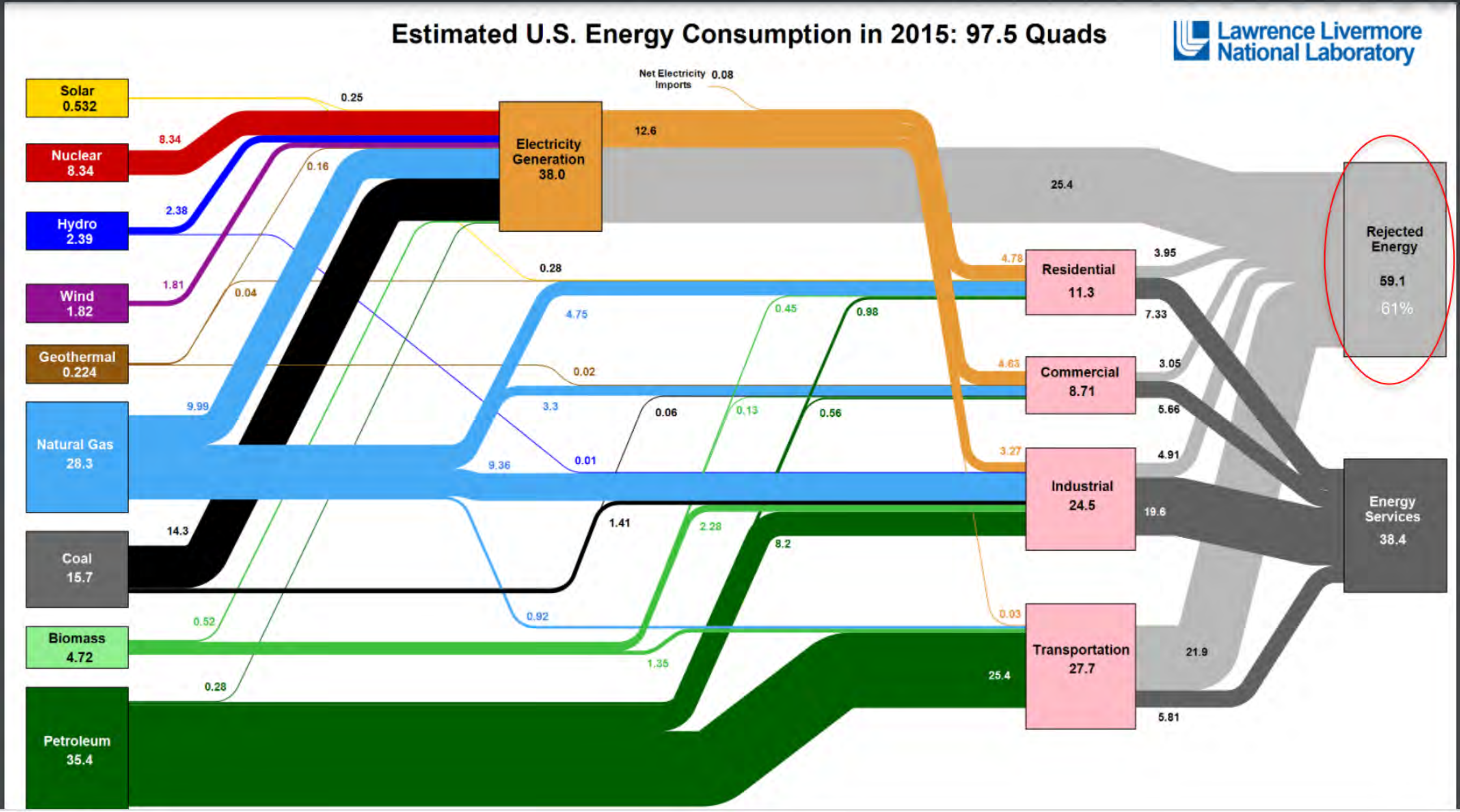
How does WHP differ from CHP?
Both Capture and Utilize a Waste Heat Resource

Combined Heat & Power

CHP systems generate electricity first and then capture the waste heat from the electric generation process for useful thermal purposes, e.g. as heat for industrial processes or building HVAC systems.

Waste Heat to Power

WHP systems capture waste heat first, e.g. from industrial processes or commercial building heating systems, and then convert it to electricity


Estimated U.S. Energy Consumption in 2015: 97.5 Quads
Lawrence Livermore National Laboratory
Solar 0.532
Nuclear 8.34
Hydro 2.39
Wind 1.82
Geothermal 0.224
Natural Gas 28.3
Coal 15.7
Biomass 4.72
Petroleum 35.4
Net Electricity Imports 0.08
Electricity Generation 38.0
Residential 11.3
Commercial 8.71
Industrial 24.5
Transportation 27.7
Rejected Energy 59.1 61%
Energy Services 38.4
0.25
8.34
2.38
1.81
0.16
0.04
12.6
25.4
0.28
4.75
0.45
0.98
0.02
3.3
0.06
0.13
0.56
9.99
9.36
0.01
14.3
1.41
2.28
8.2
0.92
0.52
1.35
0.28
25.4
4.78
4.63
3.27
0.03
3.95
7.33
3.05
5.66
4.91
19.6
21.9
5.81

WHP Opportunity:
Decarbonizing the Industrial Sector

- 30% of all energy consumed in the US is consumed by industry
- 20% to 30% of this energy is lost as waste heat, ~ 5-13 quadrillion BTU/yr at a cost of $20B-$60B/year

Waste Heat Recovery: Technology and Opportunity in US Industry, Report for US DOE, BCS, 2008

Total WHP opportunity = 15 GW

ORNL Waste Heat to Power Market Assessment March 2015

Source

WHP Is Emission Free

"Zero Emission" because "waste heat" is excess energy - the heat will be generated anyway regardless of whether the wasted portion is captured

- Every quantum of wasted heat recovered, increases the energy output of the fuel used and thus reduces its carbon intensity

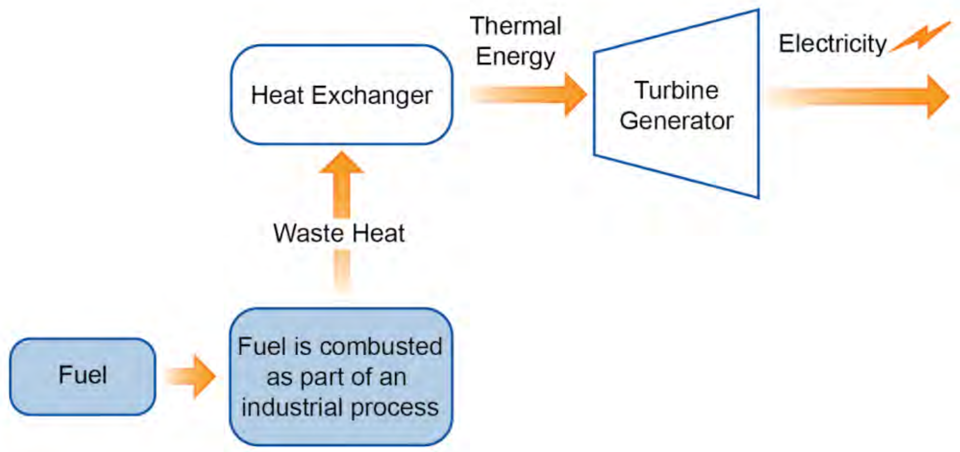
- Another way of thinking about it:

  Less fuel is needed to produce the same quantum of product

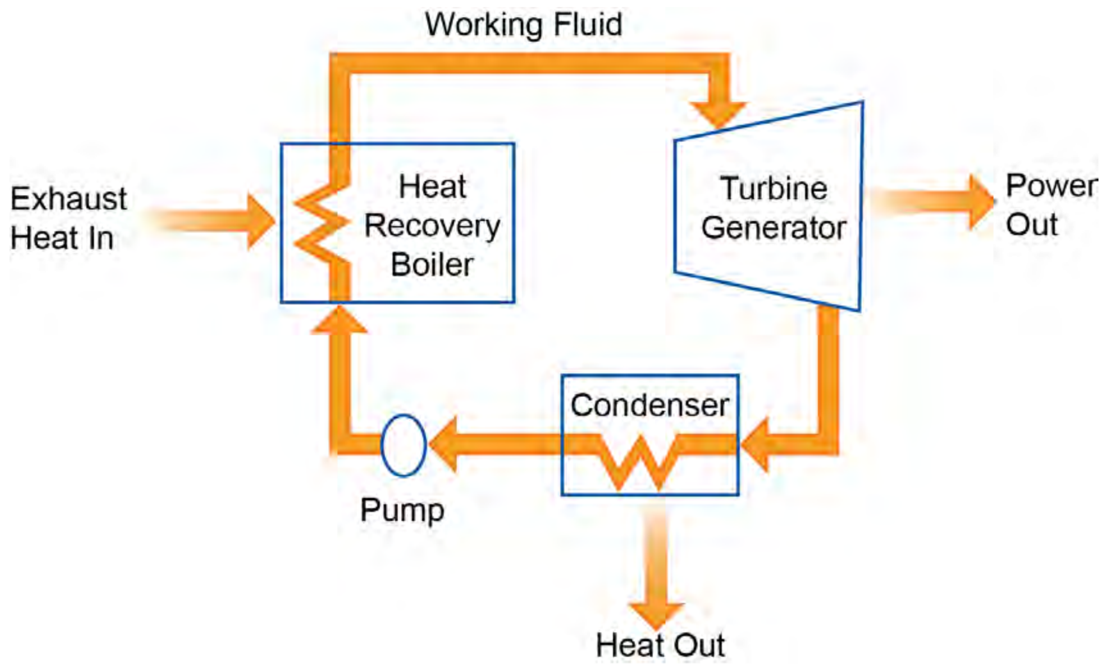
- Thus, process or heating fuel costs are reduced and emissions (including conventional pollutants, not just CO2e) are reduced

WHP is a variety of technologies that capture waste heat and convert it to electricity.

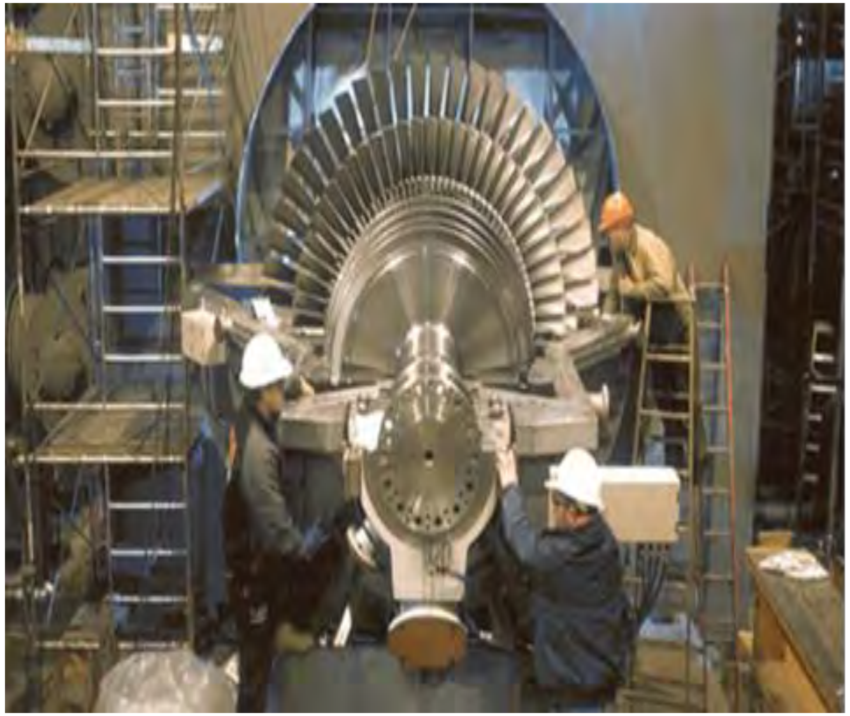
Bottoming Cycle Cogeneration



Rankine Cycle WHP



Steam Turbine Technology



- Primary Energy's North Lake Energy LLC steam turbine WHP facility produces up to 90 MW of electricity, providing more than 20% of ArcelorMittal's electricity requirements.
- Increasing reliability of the plant electric supply, substantially reduces energy costs, and produces 215,000 fewer tons of carbon dioxide.
- 1500 °F exhaust heat from blast furnace gas recovery boilers

Organic Rankine Cycle (ORC)

- More than 90% of America's waste heat is generated at lower temperatures than steam turbines can economically capture.
- ORC technology captures heat from lower temperature heat sources.
- ORC is a heat exchanging process that utilizes a refrigerant for its working fluid rather than water, as used with steam turbines

Low Temperature WHP

ARPA-e

Advanced Research Projects Agency – Energy

U.S. Department of Energy

1000 Independence Ave SW

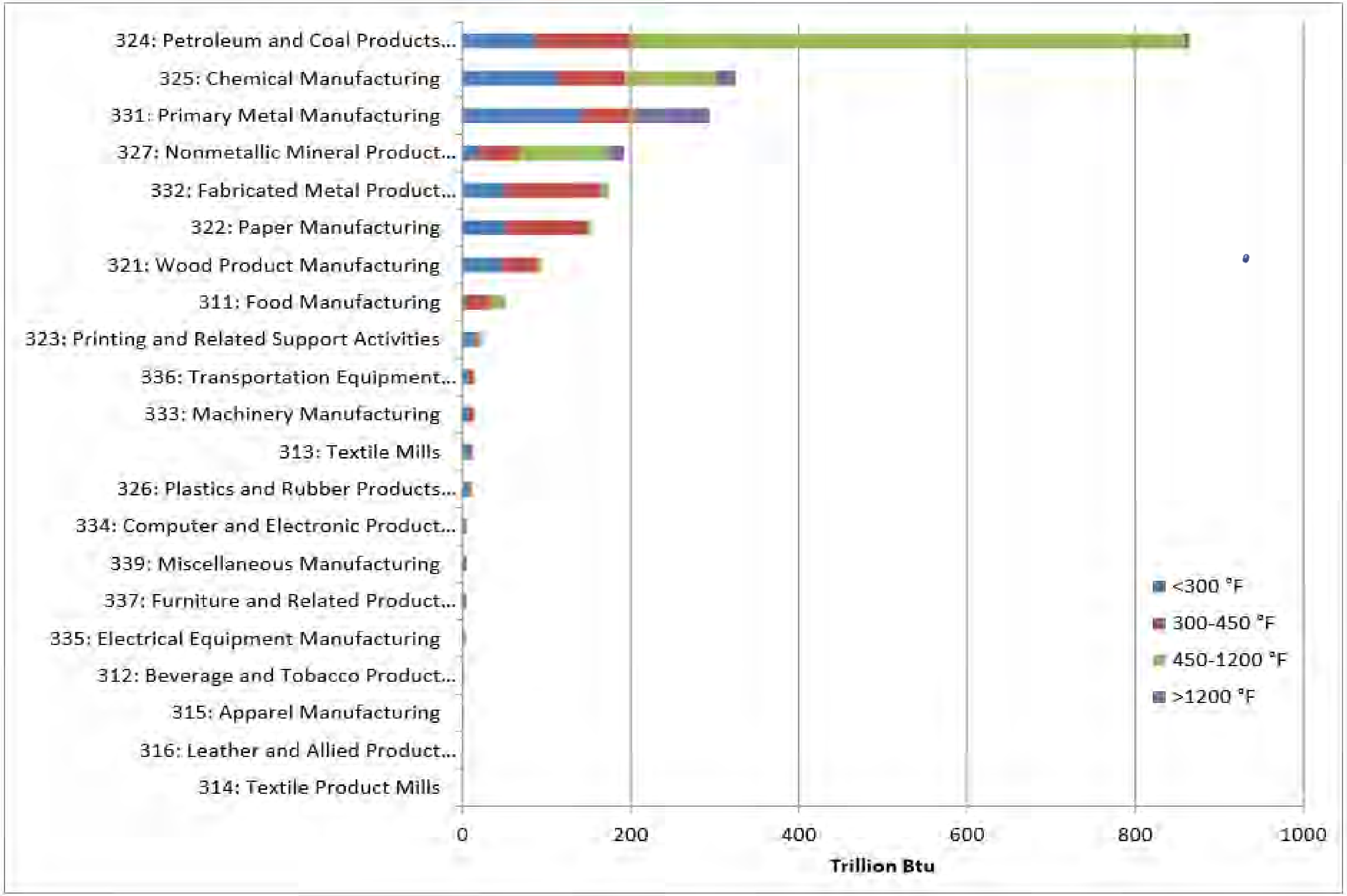
Washington, DC 20585

"Around 60% of all energy in the U.S. is lost as waste heat; 90% of this waste heat is at temperatures less than 200°C and termed low grade because of the inability of most heat-recovery technologies to operate effectively in this range."

"The capture of low-grade waste heat, which turns excess thermal energy into useable energy, has the potential to provide consumers with billions of dollars in energy savings per year."

Also see ARPA-e *Lower Grade Waste Heat Workshop* December 13 - 14, 2016 San Francisco, CA https://arpa-e.energy.gov/sites/default/files/Joseph%20King%20Opening%20-Overview%20Waste%20Heat%20-%20For%20Posting_Revised.pdf

Figure 10. Manufacturing Sector Waste Heat Inventory by Industry and Temperature Range
(reference temperature at 120 °F)



Examples of Emerging Low Temp WHP Technologies

Thermoelectrics

Nanoantennas fabricated onto flexible material in tightly packed arrays and placed near heat sources, such as condensers or heat exchangers, harvest low grade radiant heat to produce DC power.

Thermoaccoustics

Uses low-grade waste heat from factory exhaust to generate acoustic waves that power a turbine providing a 20% thermal to electric conversion.

Shape Memory Alloys

Stretched wire made of shape memory alloy is heated and then shrinks back. Require as little as a 10°C temperature difference to convert low-grade waste heat to drive an electric generator.

Pressurized Hydrogen

System cycles between heating and cooling a metal hydride at small temperature differences to produce a flow of pressurized hydrogen that is routed to a turbine.

Examples of New and Developing Waste Heat to Power Technologies and Applications

- **Improving efficiency and reducing costs of ORC utilizing low temperature heat**
  - https://www.sciencedirect.com/science/article/pii/S136403211731198X)
- **ORC applications at higher heat temperatures**
  - https://www.energy.gov/sites/prod/files/2019/06/f63/1912-ElectraTherm%20ORC-041019_compliant_0.pdf
- **ORC utilizing supercritical CO2 as working fluid**
  - https://www.siemens-energy.com/global/en/news/magazine/2020/waste-heat-to-power-with-sco2-turbines.html
- **Nanotechnologies and thermoelectric generation systems**
  - https://cfpub.epa.gov/ncer_abstracts/index.cfm/fuseaction/display.abstractDetail/abstract/9006/report/F
  - https://www.futurity.org/carbon-nanotubes-waste-heat-recycling-solar-energy-2105802/

Estimated Waste Heat to Power Capital and O&M Costs*

Technology	Cost Type	Electric Capacity Cost for 2 Major WHP Technologies				
		50-500 kW	500-1,000 kW	1-5 MW	5-20 MW	>20 MW
Steam Rankine Cycle	Installed Capital Cost, $/kW	$3,000	$2,500	$1,800	$1,500	$1,200
	O&M Costs, $/kW h	$0.013	$0.009	$0.008	$0.006	$0.005
Organic Rankine Cycle	Installed Capital Cost, $/kW	$4,500	$4,000	$3,000	$2,500	$1,900
	O&M Costs, $/kWh	$0.018	$0.014	$0.012	$0.011	$0.009

New Federal Investment Tax Credit for WHP Helps Reduce Cost

- Investment Tax Credit (ITC) – 2021, Consolidated Appropriations Bill (Enacted Dec. 2020)

- U.S. Internal Revenue Code Section 48(a) and (c)(5)

  "Waste Energy Recovery Property" eligible for:
  - "…generates electricity solely from heat from buildings or equipment..."
  - 26% tax credit – Commence Construct Jan. 1, 2021 to Dec. 31, 2022
  - 22% tax credit - Commence Construct Jan. 1, 20213 to Dec. 31, 2023*

This the same level of ITC that is available to wind and solar energy!

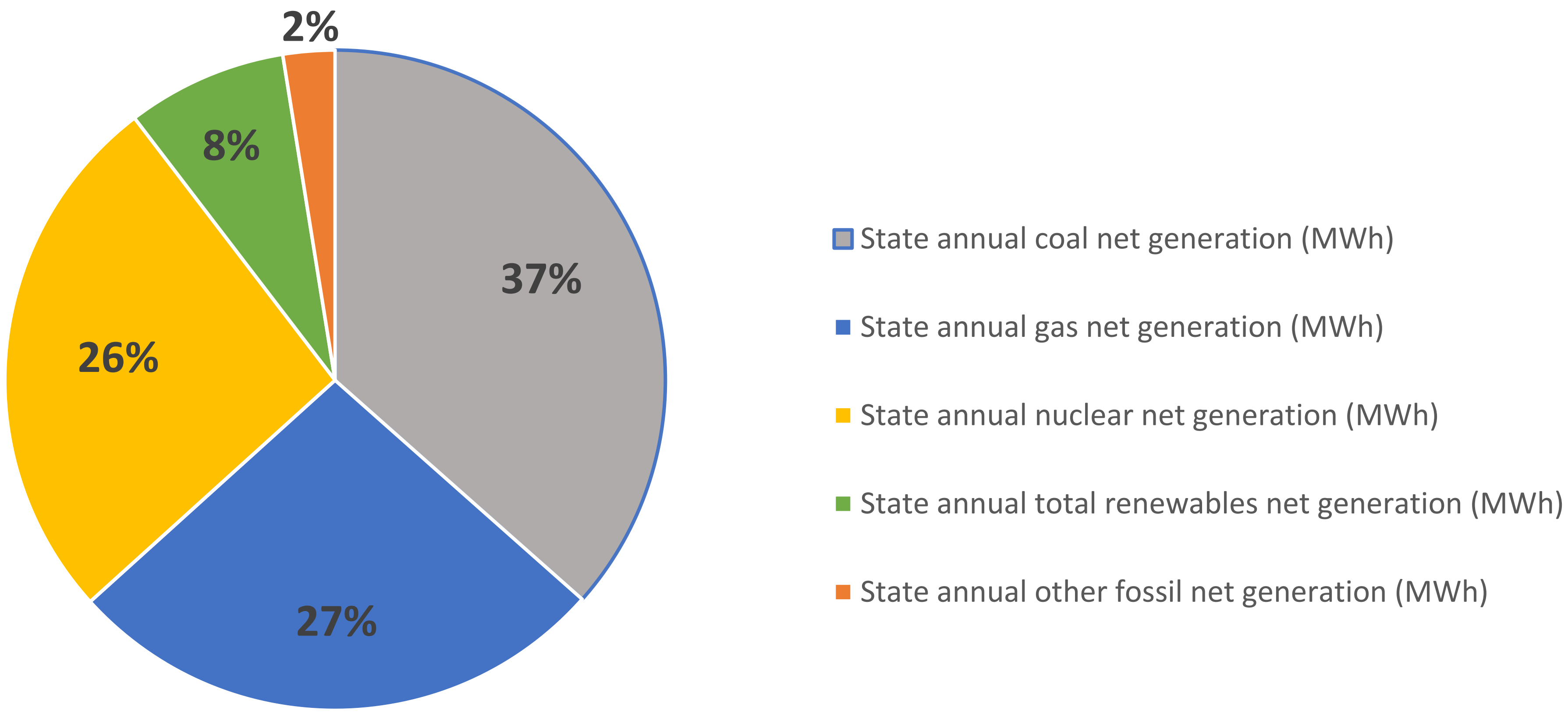
*Biden Infrastructure Bill expected to extend this credit

CHP and WHP in Michigan: Opportunity and Policy Barriers

Current Electricity Landscape in Michigan

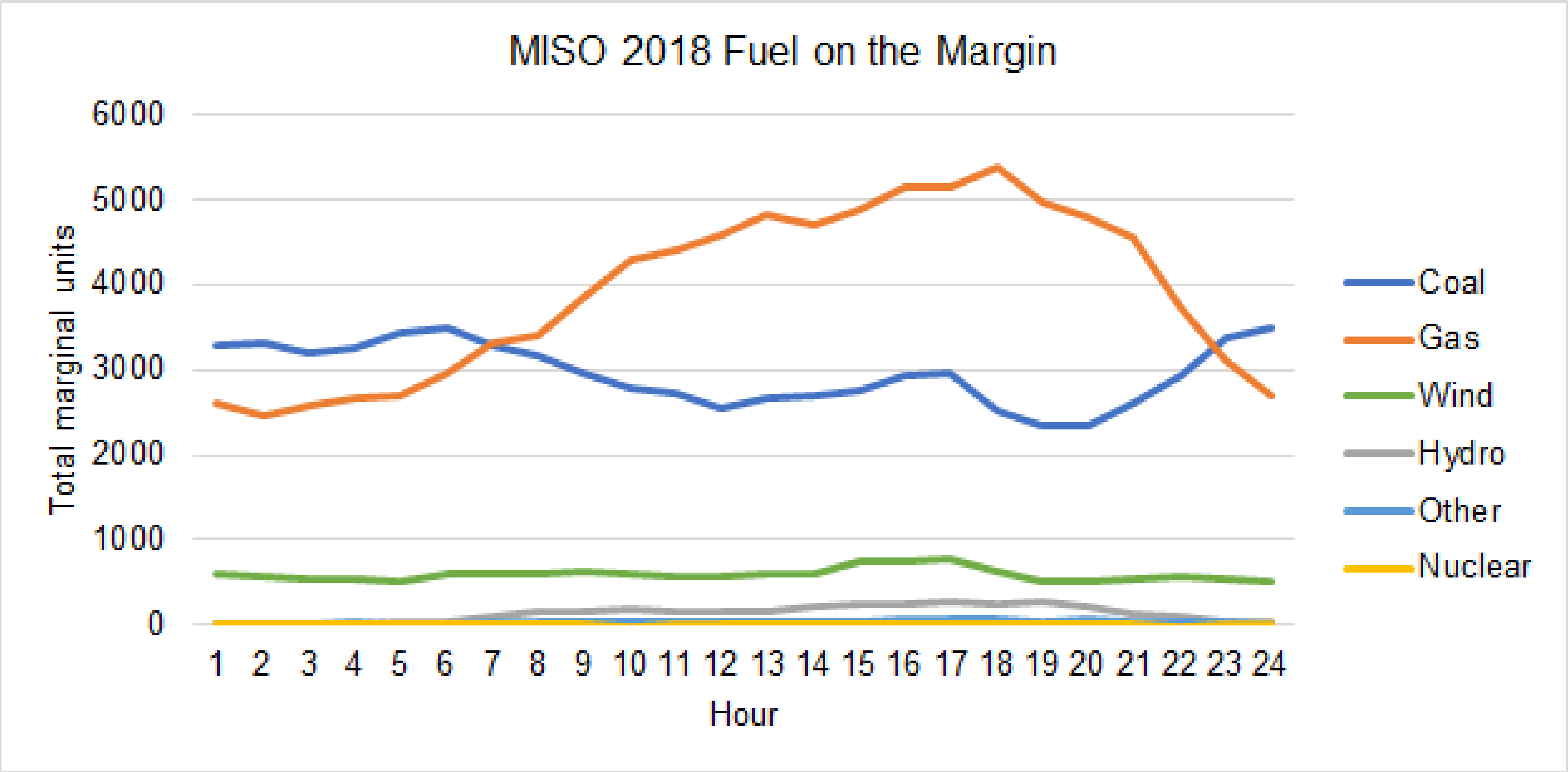
2018 Data

115,834,924 MWh
of
Net Generation



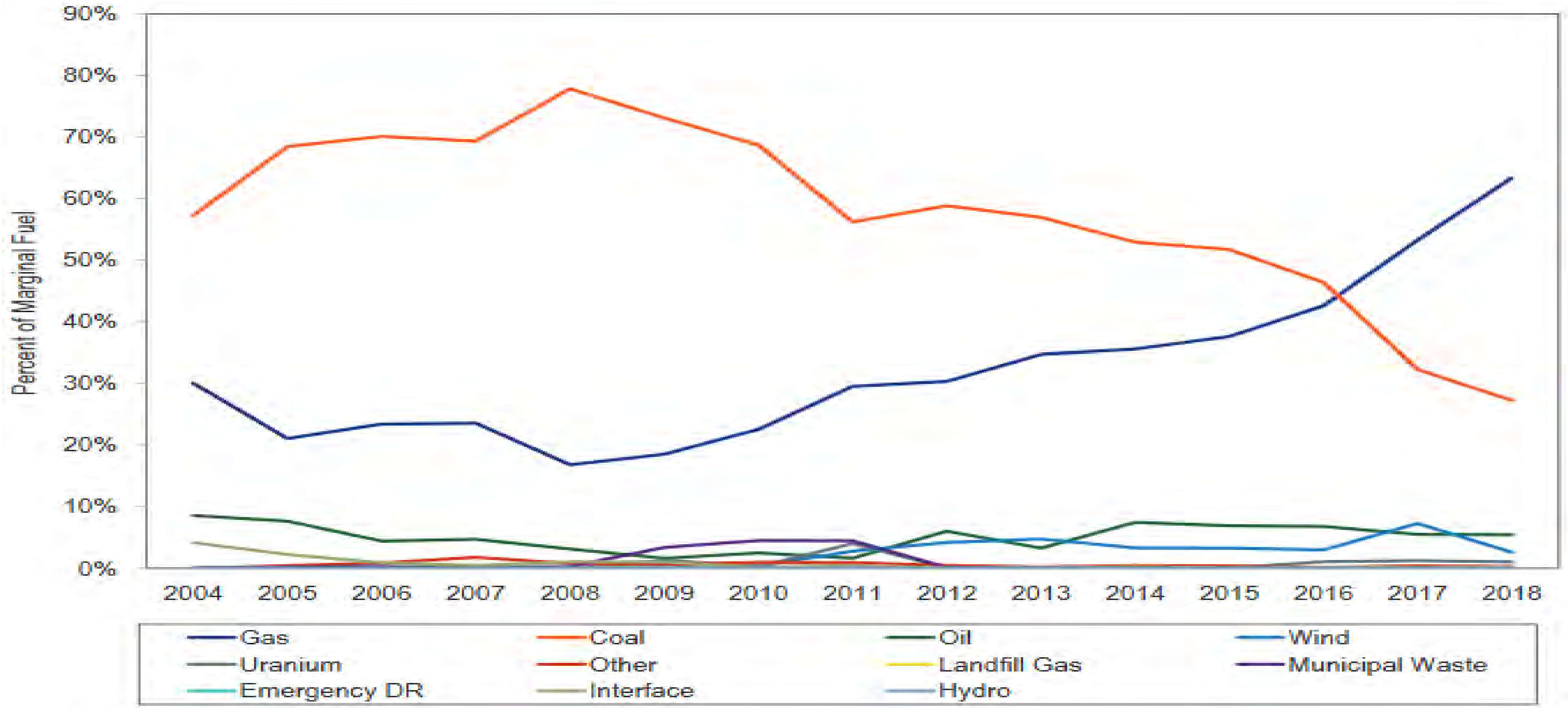
Source: eGrid 2020 (2018 Data)

Slide from Graeme Miller Presentation


MISO 2018 Fuel on the Margin
Total marginal units
6000
5000
4000
3000
2000
1000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour
Coal
Gas
Wind
Hydro
Other
Nuclear

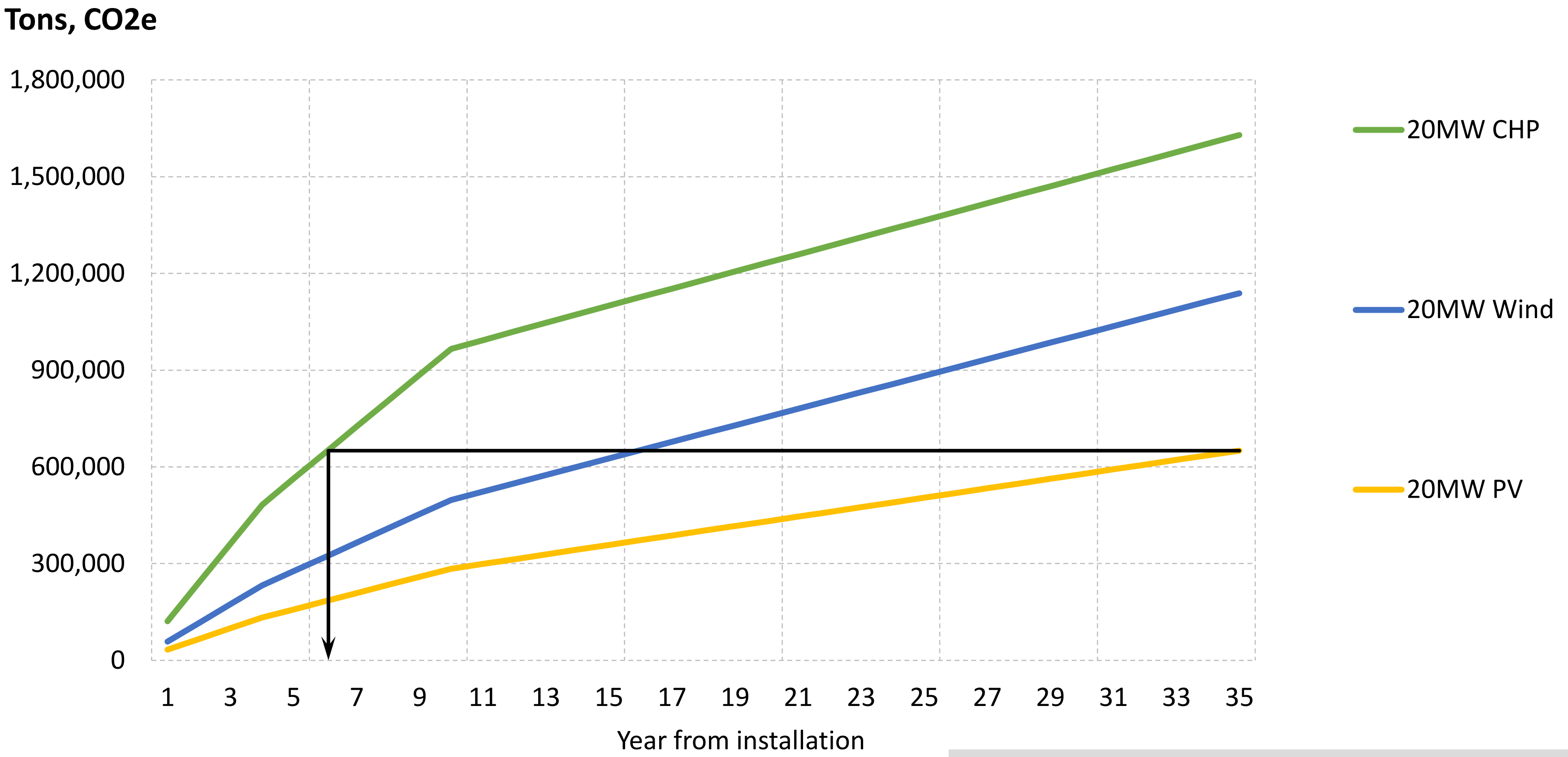
PJM Historic Fuel on the Margin

PJM



CHP & WHP's Carbon Reductions Exceed Those of Renewables Based on Load Factor

GHG Savings Based on Displacing Marginal Grid Generation



Base Case marginal grid offsets based on Long Term Dispatch Model of Regional Utility Generation Resources

- Y1-4 average 95% coal, ~1,900 lb CO_2e/MWh
- Y5-11 average ~55% coal, ~1,440 lb CO_2e /MWh
- Y12 on, 100% NGCC, ~840 lb CO_2e /MWh
- ~561 lb CO_2e /MWh (net FCP heat rate of 4800, including 4.1% T&D loss reduction credit)
- Capacity Factors: 95% for CHP, 20% for PV, and 35% for Wind

CHP saves more GHG emissions in 6 years as the same capacity of solar PV does in 35 years

Graph and Analysis Prepared by: Sterling Energy Group, LLC ©2020

Slide from Graeme Miller's presentation

CHP's Higher Efficiency Results in Energy and Emissions Savings Compared to Michigan's Grid (Average Fossil Generation)

Category	10 MW CHP	10 MW WHP	10 MW PV	10 MW Wind	10 MW NGCC
Annual Capacity Factor	85%	85%	24.3%	34.3%	57.6%
Annual Electricity, MWh	74,460	74,460	21,287	32,762	50,458
Annual Useful Heat Provided, MWh_{th}	97,505	None	None	None	None
Capital Cost, $ million	$20.2 m	$15.0 m	$10.0 m	$11.0 m	$9.9 m
Annual Energy Savings, MMBtu	**313,352**	740,529	211,704	298,825	168,797
Annual CO_2 Savings, Tons	**40,787**	65,755	18,798	26,534	25,094
Annual NOx Savings, Tons	**37.2**	39.5	11.8	16.7	26.4

Slide from Graeme Miller presentation

WHP is a Zero Emission, Fuel Neutral, Baseload Energy Resource Displacing Fuels on the Margin

- WHP is a zero emission resource reducing more CO2e than solar and wind
- Because WHP provides baseload power (24/7)
  - It displaces marginal fossil fuel resources that must be used when Michigan's intermittent solar and wind are not available.
- Fuel Neutral. Whenever baseload RNG, battery and/or CCS technologies become available, WHP technologies will still be making Michigan businesses more competitive by reducing fuel or stored energy consumption

Michigan Energy Policy Disincentivizes CHP and WHP

→Michigan provides Renewable Energy Credits (RECs) for renewable resources and energy waste reduction credits (EMRs) for energy conservation

→However, Michigan provides no incentives for CO2e reductions that can be achieved through distributed CHP and WHP generation

→This disincentivizes the development of clean distributed generation resources in Michigan's large C&I Sectors

Michigan energy policy is tilting the economics of clean energy in favor of "renewables", regardless of CO_2e reductions.

Michigan's Renewables Only Policy:

- Discourages private investment in CHP and WHP – which can leverage public $$ spent on generation resources

- Ignores value of baseload resources that can supplement utility owned generation, stabilize grid resources and complement renewable energy resources

- Ignores large CO_2e reductions that can be achieved today in the C&I Sectors with available CHP and WHP technologies and available fuels

- Misses an opportunity to make Michigan's industrial sector more competitive

HiP's Michigan Policy Prescription

Michigan should revise its energy policies to incentivize CHP and WHP along side Renewables.

Specific Proposals:

→Create **"tech neutral" incentives** based on actual carbon reductions, rather than labels

→Alternative:

→**Add WHP to Michigan RPS** (as eligible technology for Michigan RECs)

→Include CHP in an "**Advanced Clean Energy" Portfolio Standard**

→Provide robust incentives for other Industrial Energy Efficiency Projects

Patricia F. Sharkey

Executive Director, Heat is Power Association

Pat@heatispower.org

Policy Director, Midwest Cogeneration Association

The Future of CHP: Reducing Emissions and Improving Resilience

Lynn A. Kirshbaum

Deputy Director

Combined Heat and Power Alliance

The Future of CHP:
Reducing Emissions and Improving Resilience

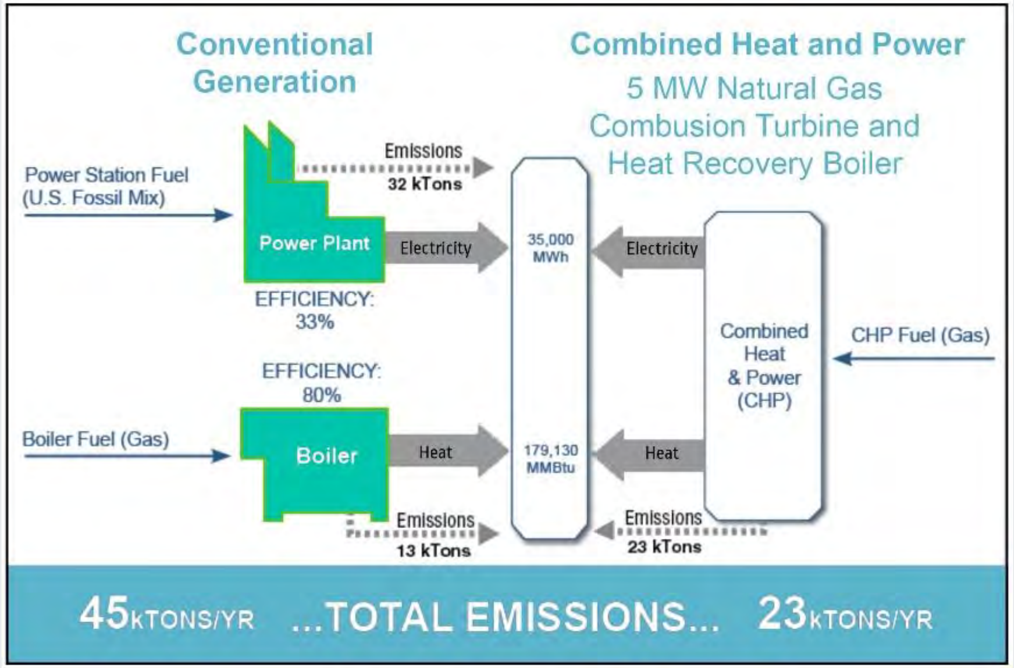
Lynn A. Kirshbaum
Deputy Director, CHP Alliance
April 7, 2021
MI Power Grid Workgroup Presentation

Overview of CHP: Emissions

- CHP uses a single fuel source to generate both heat and electricity. CHP's key advantage is efficiency – more than twice the energy efficiency of the average power plant.
- CHP uses less fuel to provide the same energy services, so it can reduce all emissions including criteria pollutants and GHG emissions.

35% Reduction of CO_2 Emissions

CO_2 Emissions – 5 MW CHP Versus 5 MW of Separate Heat and Power Production



Source: U.S. EPA, 2015, https://bit.ly/2E2IByK.

Overview of CHP: Emissions

- CHP systems reduce emissions because they:
  - Are highly efficient
  - Displace higher-emitting marginal grid resources
  - Have a high capacity factor
  - Enable intermittent renewable resources
  - Can use lower-carbon fuels
  - Can be paired with carbon capture

Case Study: Eastern Michigan University

- Location: Ypsilanti, MI
- Size:
  - 7.8 MW
- Facility Type: University
- Facility Size: 800 acre campus
- Emissions Benefits: CO_2 annual savings of approximately 48,800 metric tons, equivalent to removing more than 10,700 passenger vehicles from the road
- Estimated annual cost savings of $2.8 million

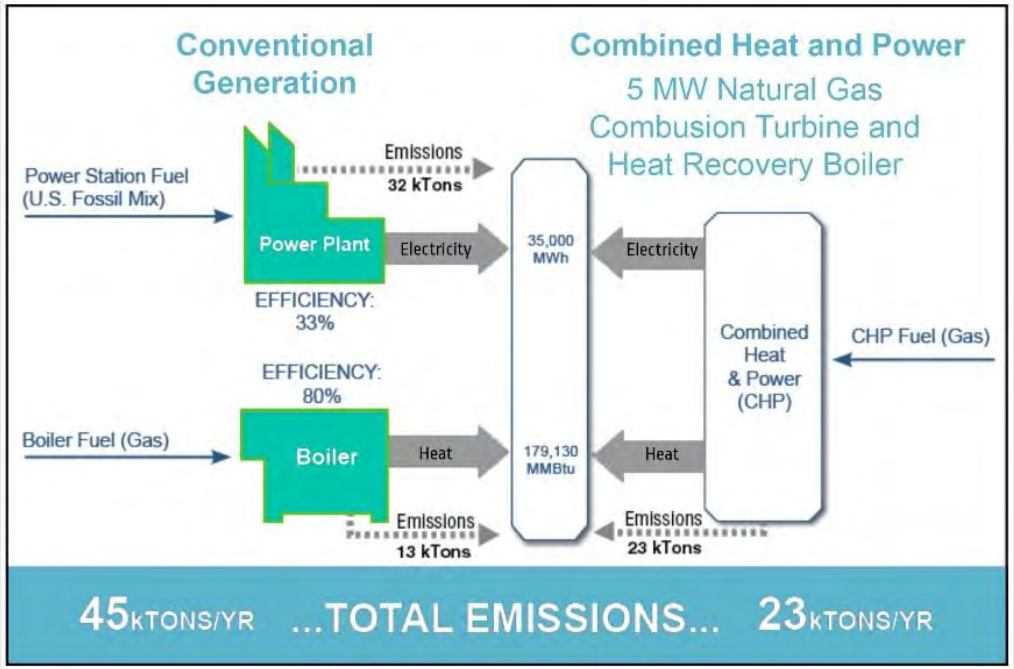
For additional information, see: https://chptap.lbl.gov/profile/65/EasternMichiganUniversity-Project_Profile.pdf

CHP and Lower-Carbon Fuels

- CHP units can be fueled by renewable and lower-carbon fuels such as biogas, RNG or biomethane, and hydrogen, or “CHP 2.0.”
- Use of these fuels can allow CHP systems to reduce emissions even further.
- Using existing gas pipeline infrastructure could be a low-cost option for delivering these fuels.

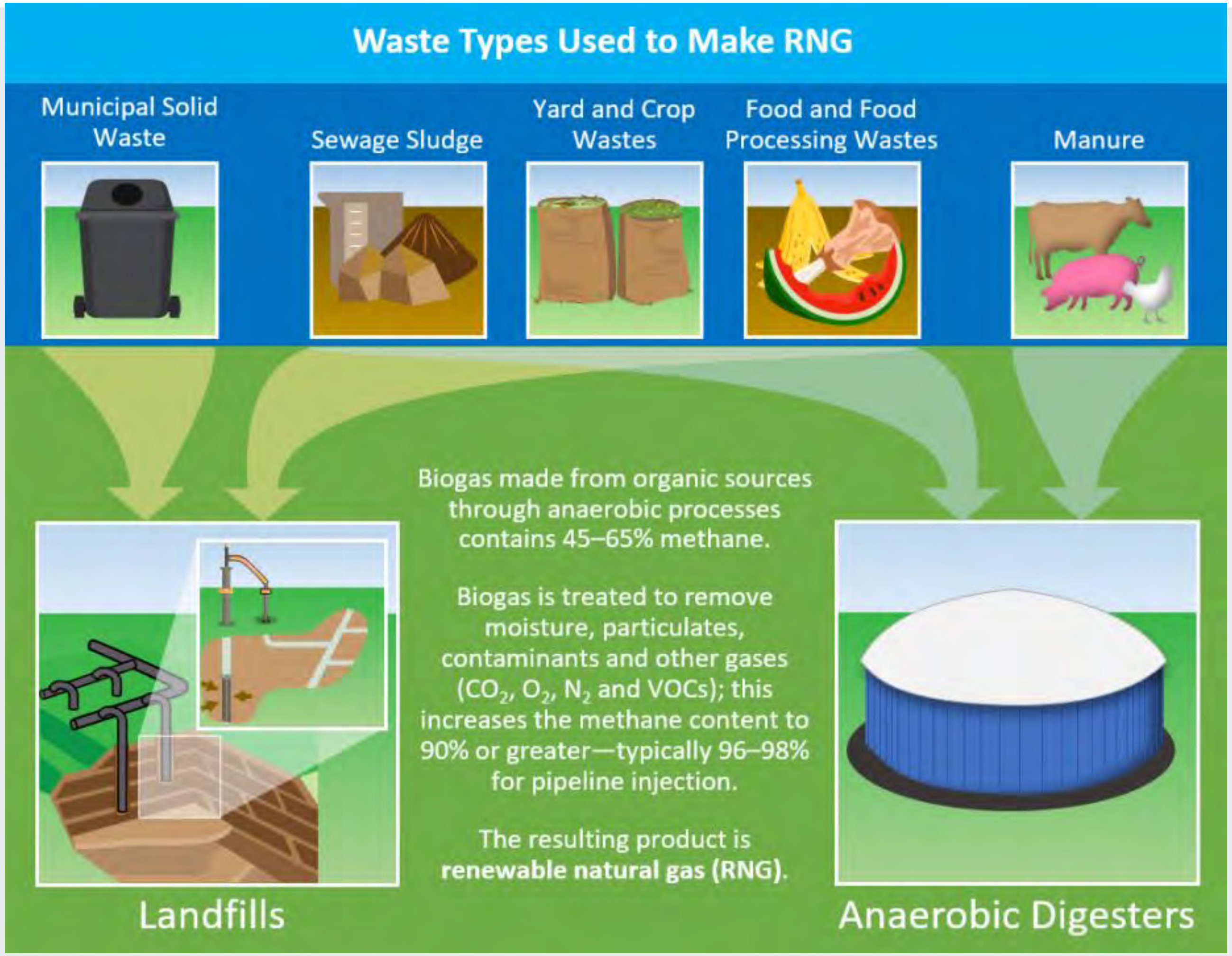
35% Reduction of CO_2 Emissions

CO_2 Emissions – 5 MW CHP Versus 5 MW of Separate Heat and Power Production



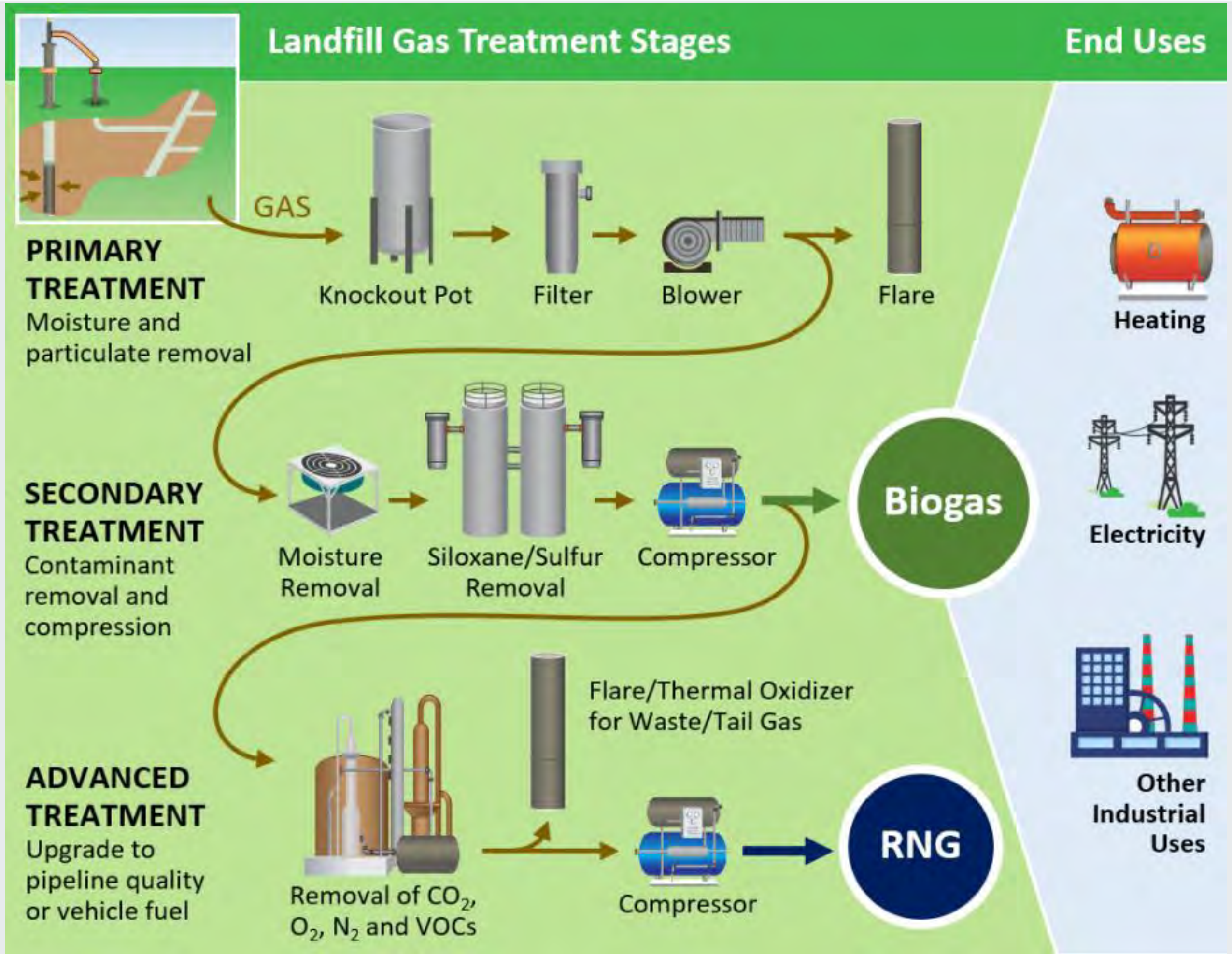
Source: U.S. EPA, 2015, https://bit.ly/2E2IByK.

Lower-Carbon Fuels: Biogas and RNG



Source: U.S. EPA, https://www.epa.gov/lmop/renewable-natural-gas.

Lower-Carbon Fuels: Biogas and RNG



Source: U.S. EPA, https://www.epa.gov/lmop/renewable-natural-gas.

Case Study: Bell's Brewery

- Location: Galesburg, MI
- Size:
  - 150 kW CHP
- Facility Type: Brewery
- Facility Size: 130,000 square feet
- Microbes in anaerobic digesters feed on sugar and malt leftover from the brewing process, converting these biological wastes into biogas, which is used in the CHP system.

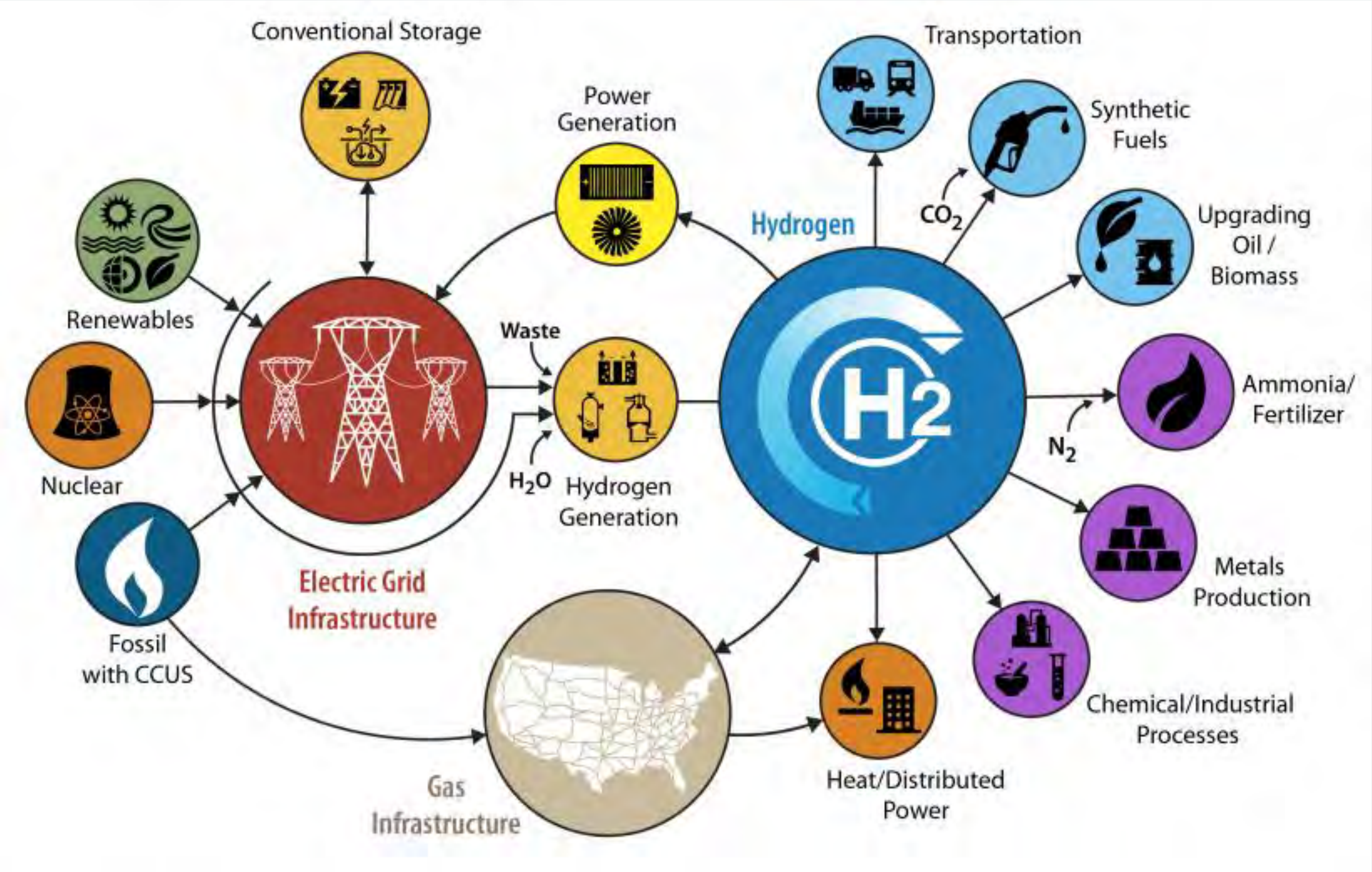
For additional information, see: https://chptap.lbl.gov/profile/299/BellsBrewery-Project_Profile.pdf

Lower-Carbon Fuels: Hydrogen

Types of Hydrogen		
green	**blue**	**grey**
produced using renewable electricity	produced using natural gas, carbon emissions captured and stored	produced using natural gas

Lower-Carbon Fuels: Hydrogen

H2@Scale

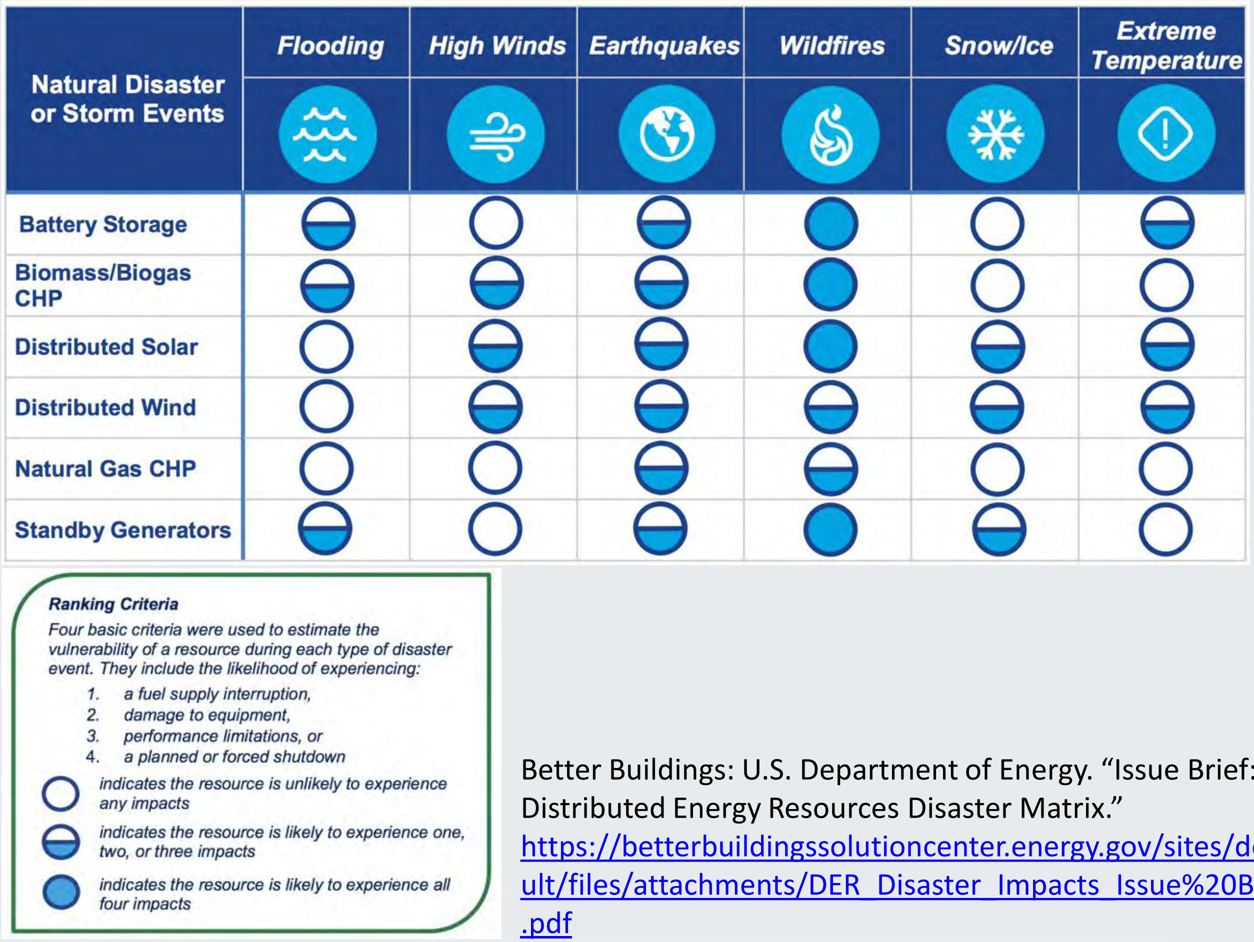


Source: U.S. DOE Hydrogen and Fuel Cell Technologies Office, https://www.energy.gov/eere/fuelcells/h2scale.

Overview of CHP: Resilience

- Increased reliance on the electric grid increases the impact grid disruptions have on businesses, industry, and communities.
- CHP can reliably deliver power and thermal energy locally for critical infrastructure.
- CHP systems can support industrial and manufacturing facilities that are essential to the reliable supply of food and health and safety products.

Matrix of DER Vulnerability to Weather Events



Better Buildings: U.S. Department of Energy. “Issue Brief: Distributed Energy Resources Disaster Matrix.” https://betterbuildingssolutioncenter.energy.gov/sites/default/files/attachments/DER_Disaster_Impacts_Issue%20Brief.pdf

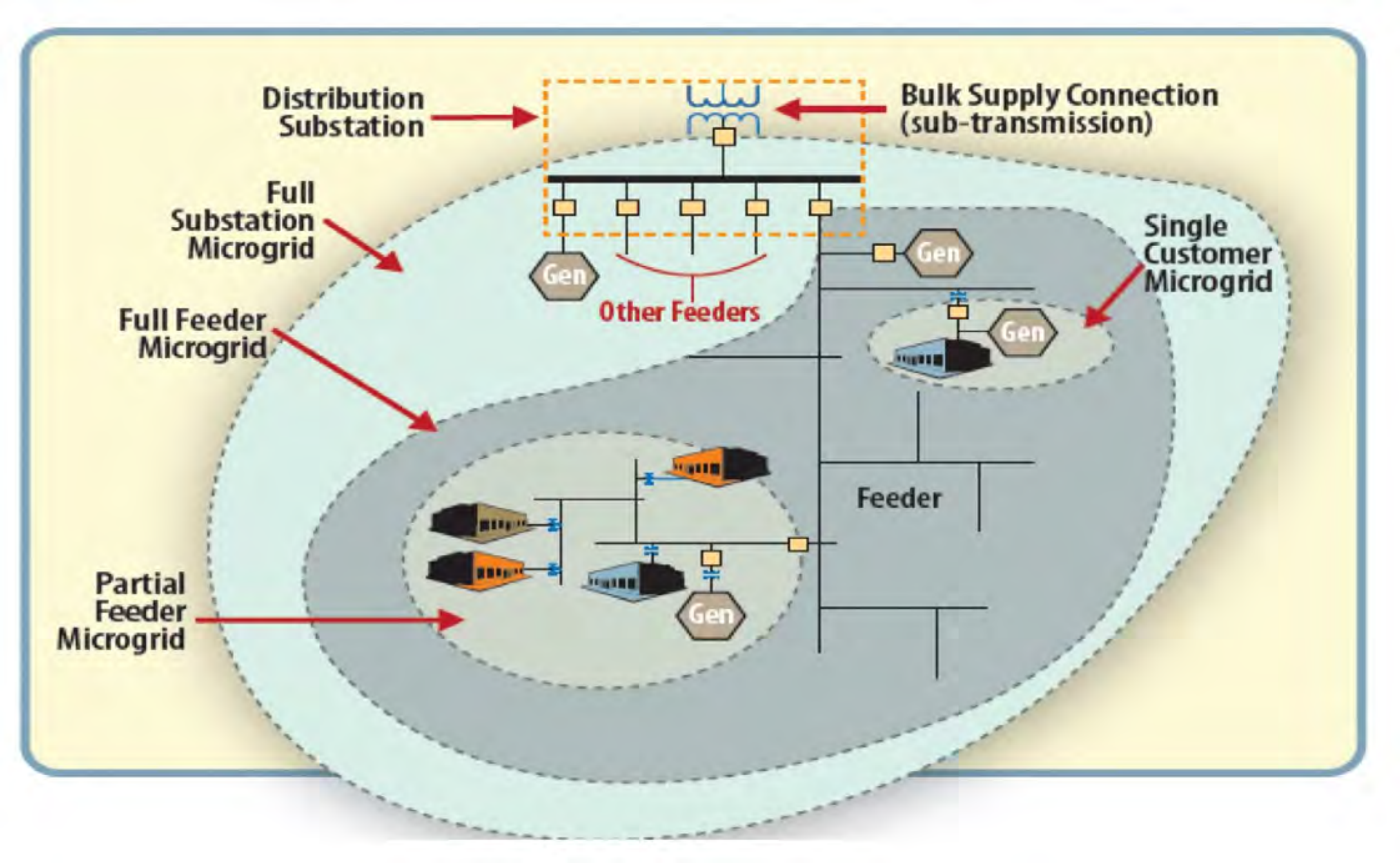
Case Study: Ann Arbor VA Healthcare System

- Location: Ann Arbor, MI
- Size:
  - 1,000 kW CHP
- Facility Type: Healthcare
- Facility Size: 1.1 million square feet
- Emissions Benefits: Reduces GHG emissions by more than 2,628 metric tons annually
- Yearly savings of more than $373,000

For additional information, see: https://chptap.lbl.gov/profile/13/AnnArborVA-Project_Profile.pdf

CHP and Microgrids

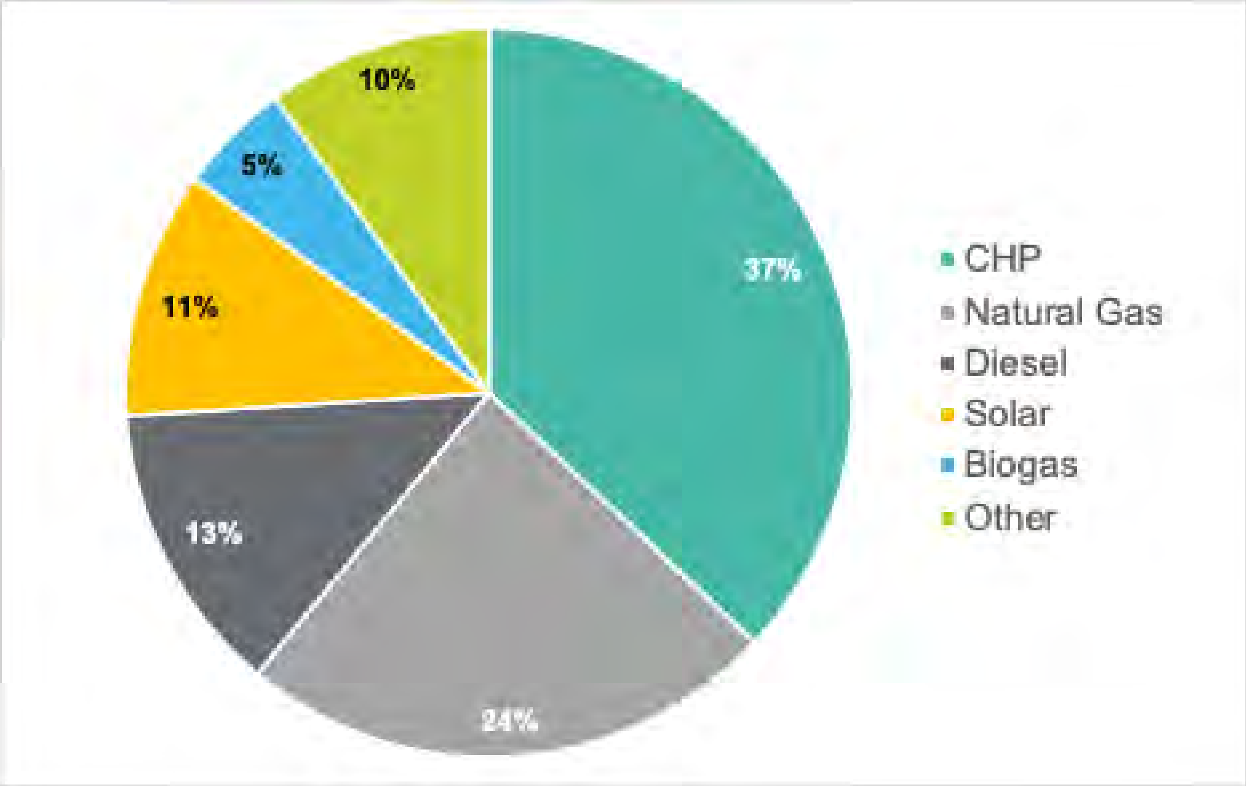
The Role of Microgrids in Helping to Advance the Nation's Energy System



Source: U.S. Department of Energy Office of Electricity, https://www.energy.gov/oe/activities/technology-development/grid-modernization-and-smart-grid/role-microgrids-helping.

CHP and Microgrids

Microgrids in the U.S. by Technology Type
(Percent of Total Generating Capacity)



Source: Consulted ICF Microgrid Database, determined CHP's capacity in operational microgrids.

- CHP is a key component for microgrids
  - Option to disconnect during disasters, outages
  - CHP provides 37% of power for existing microgrids
  - CHP, WHP are a less expensive backbone resource than storage
  - CHP and WHP in microgrids enables deployment of zero emission resources

Microgrid Case Study: Montgomery County (MD) Public Safety Headquarters

- Location: Gaithersburg, MD
- Size:
  - 865 kW CHP
  - 2 MW Solar
- Facility Type: Administrative facility for crucial public services
- Facility Size: 400,000 square feet
- Emissions Benefits: Reduces GHG emissions by 5,900 metric tons annually, equivalent of taking more than 1,200 cars off the road
- The project includes multiple clean energy technologies integrated seamlessly as part of a microgrid.

For additional information, see: https://chptap.lbl.gov/profile/135/MoCoPublicSafetyHQ-Project_Profile.pdf

COMBINED
HEAT AND POWER
ALLIANCE

Questions?

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ALLIANCE

Thank you.

Lynn A. Kirshbaum

Deputy Director

lynn@dgardiner.com

Aisin mCHP Development

Tom Miller

General Manager

Emerging Regulations & New Technology Research

Aisin Technical Center of America

AISIN

We Touch the Future

Aisin mCHP Development

Southeast Michigan Project

Tom Miller – General Manager, Regulations & Research

Aisin Technical Center of America

AISIN Corporation

AISIN = "EYE+SHIN"

Aisin was formed through a merger in 1965 between auto parts manufacturers Aichi Kogyo and Shinkawa Kogyo.

Global Network

- **214 consolidated and affiliated group companies, operating over 20 countries**
- **110,000 employees worldwide**

AISIN Corporation

Parent Company: Aisin Corporation
Based in: Kariya City, Aichi, Japan
Established: August 31, 1965

	Global	North America
Net Sales	$35 billion	$5.2 billion
Employees	110,000	15,000
Subsidiaries	214 consolidated	39 domestic companies
Standing	6th largest	13th largest

www.AISIN.com

2020 Coremo mCHP Installation

Location:

Oakland County, MI 48025 (Southeast, MI)

Info:

- Single Family Home - 2 Adults, 2 Children (22), (17)
  - 2718 Square feet (252.5 Square Meters)
  - 4 Bedrooms
  - 2.5 bathrooms
- Forced air natural gas furnace
  - Furnace replaced by home owner March 2020
- Natural gas domestic hot water tank
- Electric central Air Conditioner
- Natural gas clothes dryer
- Natural gas cook stove
- Natural gas BBQ grille
- Electric double oven
- Electric heat hot tub (360 gallon)
- LED and CFL light bulbs throughout house

AISIN
We Touch the Future

Regulation & Research

Purpose

- To test the system which provides onsite power generation to cover electric base load
- To identify ideal energy storage for residential application, and blackout solution.
- To effective utilize the generated heat while reducing CO2 produced from typical fossil fueled power generation plants
- To identify the balance of system while reducing overall system cost and provide design flexibility for the home builders.

AISIN
We Touch the Future

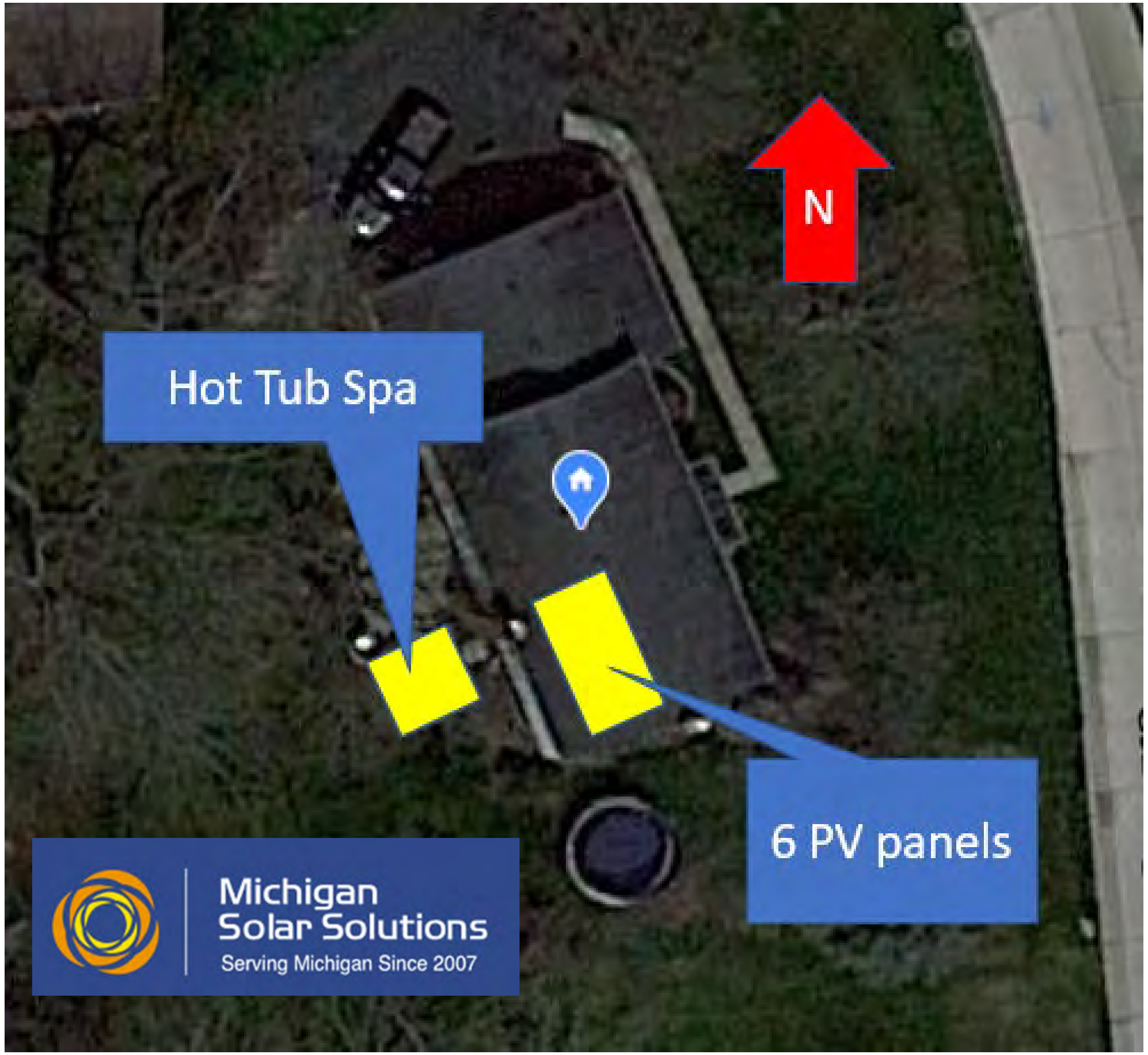
COREMO = "This or That"

Dimensions =
48"H x 28"L x 15"W

Benefits of Aisin mCHP

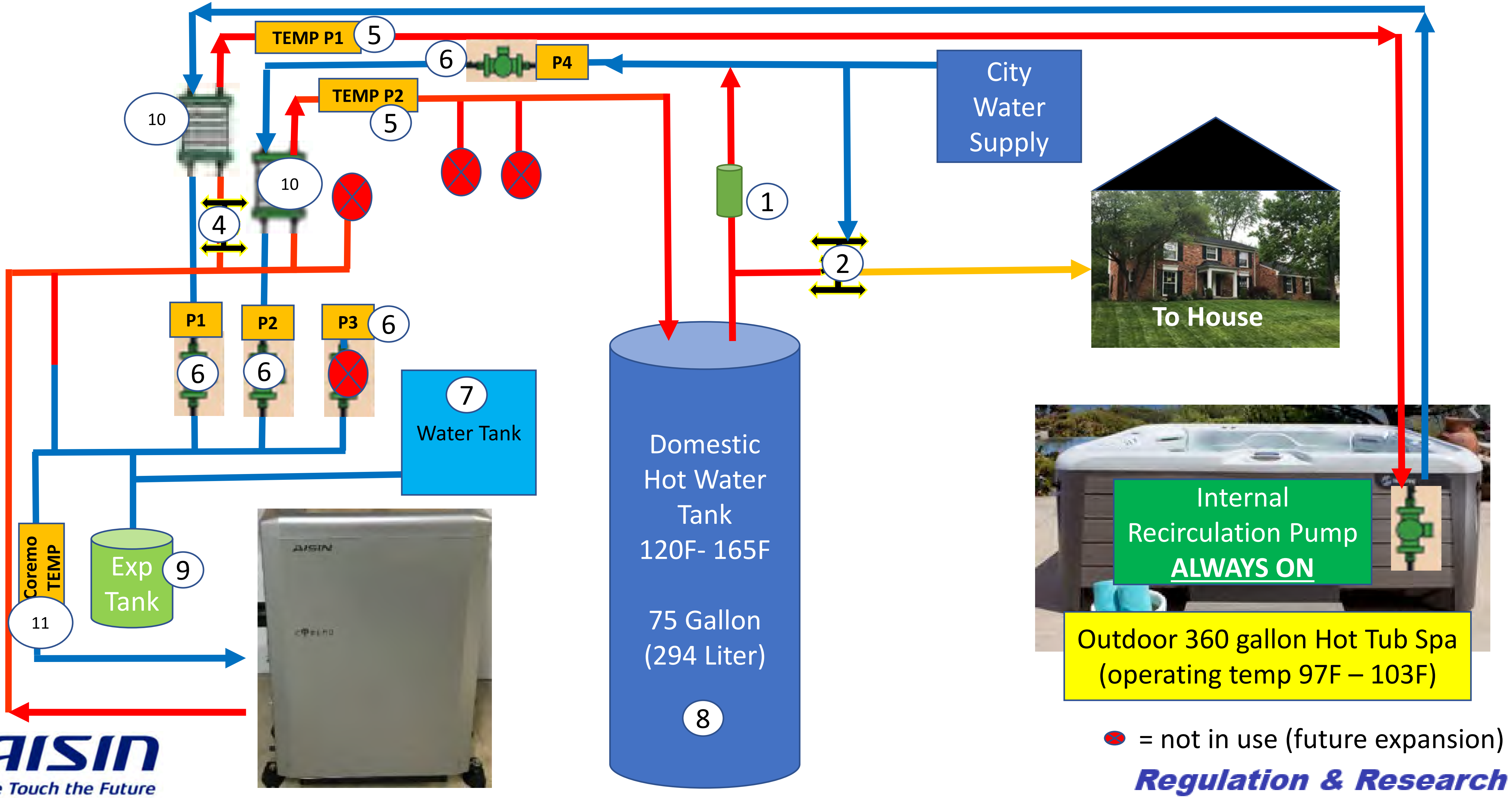
- Reduce the need and dependency on electricity from the grid
- Lower total energy costs
- Clean power generation (Low NOx and CO2)
- Black out power protection / generation
- Off grid applications
- Provide power to remote areas (LP)
- Support areas where grid is over stressed
  - Growth of electric vehicles power demand
  - Highly populated regions with old grid infrastructure (NY)
  - California (wildfires, grid concerns, lack of capacity)
- Potential use of recycled EV/hybrid batteries

2020 Coremo Installation Plan



- Install Coremo mCHP unit (1.5 kW)
- Route the Coremo liquid heat (13,000 BTU) from engine through 2 heat exchangers
  1. Heat 360 gallon hot tub (spa) water to reduce the need for electric heat
  2. Heat 75 gallon domestic hot water tank
- Install 6 PV solar panels on the Southwest corner of the roof. (320 watts each)
- Add 4 – 230Ah lead acid deep cycle carbon batteries
  - Back up power
  - Blackout restart
- Request permission for interconnection to grid from DTE

Hydronics Diagram



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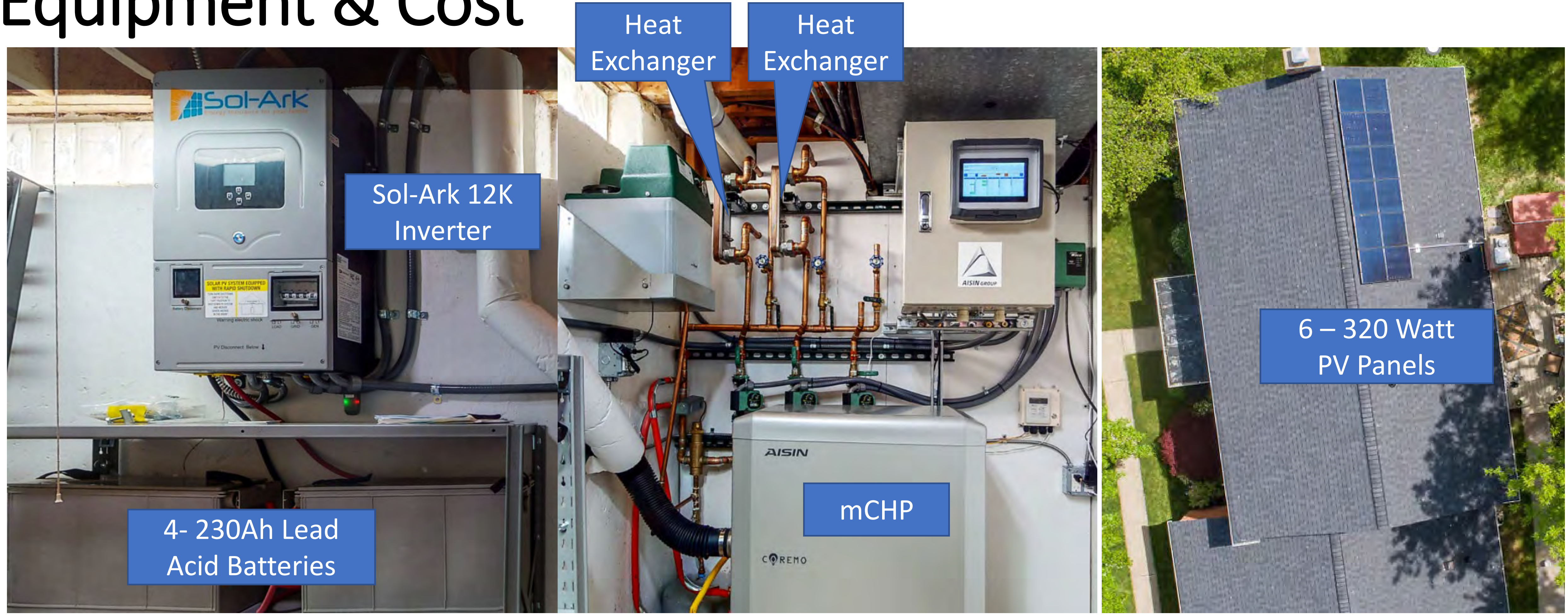
Regulation & Research

Equipment & Cost

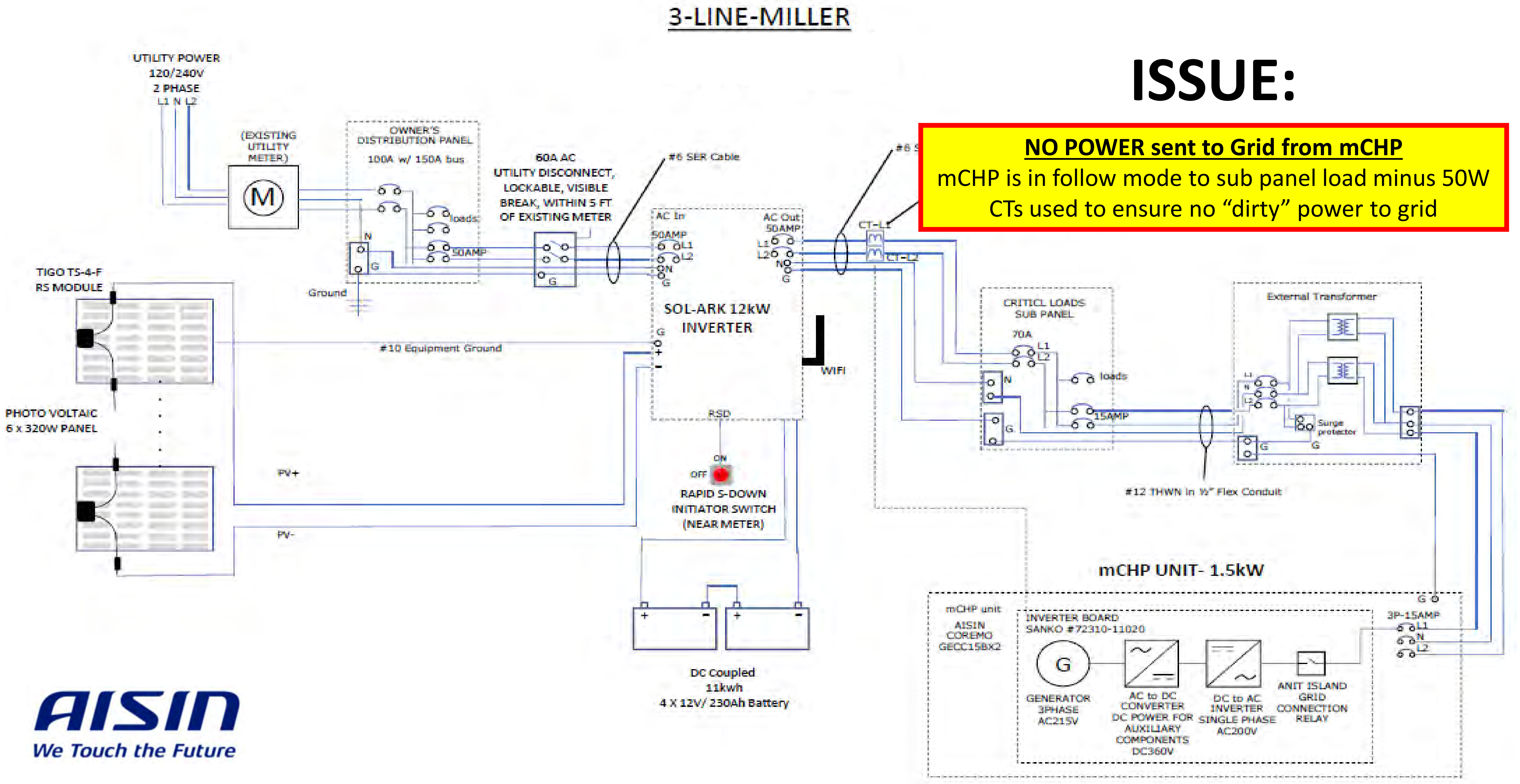


- Overall Approximately ~ $40,000
  - Standard system - CHP main unit and DHW storage with install ($15,000)
  - PV, main inverter, battery with install ($17,500)
  - Hydronic system with pumps and controls ($7,500)

Wiring Line Diagram

ISSUE:

NO POWER sent to Grid from mCHP
mCHP is in follow mode to sub panel load minus 50W
CTs used to ensure no "dirty" power to grid



AISIN
We Touch the Future

DTE Interconnection Application - Approval

Distributed Generation (DG) Tariff Approval and Interconnection

Hello Tom Miller,

Project Number:	DE-05892
Applicant Name:	Tom Miller
Company:	Tom Miller
Site Address:	Oakland County, MI
Category:	Category 1 (< 20 kW)
System Rating:	12 kW AC
Generator Type:	Combination/Multiple Small Solar Array with PV Inverter and 1.5KW micro combined heat and power unit
System Type:	Inverter

This letter is to acknowledge that your **1.92 DC/12 AC** kW Solar System Interconnection (**# DE-05892** 025 has been approved for **DG Tariff. The Interconnection Application Review is complete.**

- Project took over **9 months** to get approval from DTE.
  - Originally submitted under Rider 18DG due to PV Installation but was changed to Rider 14DG
- Approved under Rider 14 Distributed Generation (DG)
  - Not limited to renewable energy projects but has a lower buy back rate.
    - Rider 18 = $0.075
    - Rider 14 = $0.023
  - However, we are not pushing any mCHP power to batteries or grid so this rate still seems unfair

Results

$0.15609/KWh (delivered)

$0.022608/KWh Rider 14 DG

Detail of Current Charges

For Service at 31119 Old Stage Rd, Beverly Hills, MI

DTE Electric Company Residential Electric Service

Current Charges		
Power Supply Charges		
Power Supply Capacity Charge	95 KWH @ 0.045000	4.28
Power Supply Non Capacity Charge	95 KWH @ 0.041760	3.97
Power Supply Cost Recovery	95 KWH @ 0.003220	0.31
Delivery Charges		
Service Charge		7.50
Distribution	95 KWH @ 0.066110	6.28
LIEAF Factor		0.91
Other Delivery Surcharges		0.56
Residential Michigan Sales Tax		0.92
Total DTE Electric Company Current Charges		**24.73**

Current Billing Information

Service Period	Mar 2, 2021 - Mar 30, 2021
Days Billed	29
Meter Number	**7851909 19**
Meter Reading	751 Actual - 846 Actual
KWH Used	95

Your next scheduled meter read date is on or around APR 29, 2021

Usage History - Average per day

	Current Month	Last Month	Year Ago
KWH Usage	3.3	7.1	0.0
Change		-54%	0%

DTE Electric Company Distributed Generation

Delivery Charges		
Generated KWH	53 KWH @ -0.022608	-1.20
Commercial Michigan Sales Tax		-0.07
Total DTE Electric Company Current Charges		**-1.27**

Current Billing Information

Service Period	Mar 2, 2021 - Mar 30, 2021
Days Billed	29
Meter Number	**7851909 19**
Meter Reading	10 Actual - 63 Actual
KWH Used	53

Your next scheduled meter read date is on or around APR 29, 2021

Usage History - Average per day

	Current Month	Last Month	Year Ago
KWH Usage	1.8	0.3	0.0
Change		632%	0%

- **What is the incentive for consumer to sell back?**
- **Why bother selling back to the grid for PENNIES?**

Results

Oakland County, MI Site Utility Usage – Gas/Electric

	Before Coremo				After Coremo					Totals		
	Gas		Electric		Gas		Electric			2019	2020	Coremo Savings
	$	Usage (Mcf)	$	Usage (KWh)	$	Usage (Mcf)	$	Usage (KWh)	PV Sell (KWh)			
November	$118.54	15.4	$171.86	962	98.65	12.1	142.23	768	NA	$290.40	$240.88	$49.52
December	$135.62	18.2	$193.85	1101	188.94	25.5	85.54	460	0	$329.47	$274.48	$54.99
January	$116.12	15.7	$202.19	1163	187.41	25.4	74.76	392	2	$318.31	$262.17	$56.14
February	$159.45	22.2	$181.60	1015	201.43	27.9	46.6	227	8	$341.05	$248.03	$93.02
March	$94.55	12.9	$173.32	985						$267.87	$0.00	$267.87
April	$78.54	10.3	$231.35	1303						$309.89	$0.00	$309.89
May	$57.53	6.8	$199.50	1077						$257.03	$0.00	$257.03
June	$53.49	6.4	$193.03	1069						$246.52	$0.00	$246.52
July	$57.56	7.1	$271.73	1500						$329.29	$0.00	$329.29
August	$30.41	2.8	$233.91	1289						$264.32	$0.00	$264.32
September	$37.20	3.7	$132.90	722						$170.10	$0.00	$170.10
October	$70.27	8.1	$157.17	828						$227.44	$0.00	$227.44

2021 vs 2020 (4 mo)

- **NG usage +27%**
- **Electricity purchased -44%**

- **PV generation = 67 kWh (Dec 2020 – Feb 28, 2021)**
- **Beginning March 2021, began using stored battery power (25%) at night and PV to recharge batteries during day to reduce need from grid**
- **Goal = reduce grid dependency while still leaving enough battery power for backup and blackout restart**

Results

Operation Results in Feb/2021

COREMO

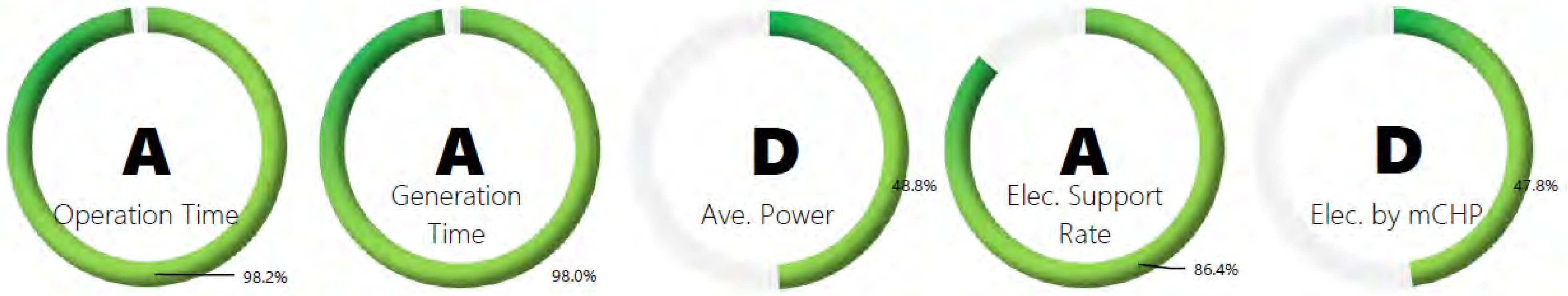
BH Location

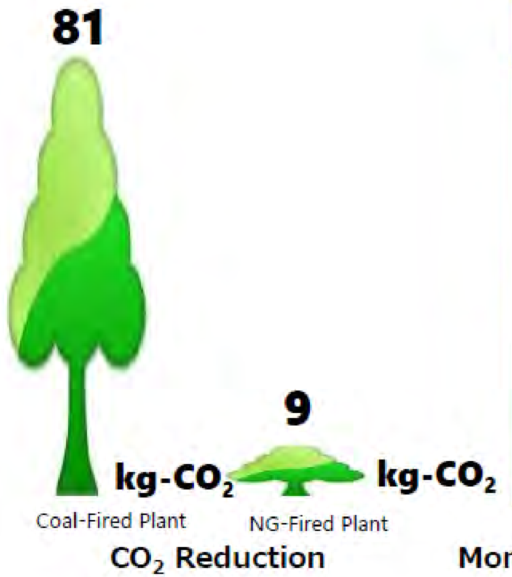
Data period (a)	2/2	~	2/28	26 days				
	Actual	Maximum	Rate	100-85%	84-70%	69-55%	54-40%	Below39%
Operation Time (hr) Cumulative engine run time during the period (a)	579.8	590.5	98.2%	X				
Generation Time (hr) Cumulative mCHP power generation time during the period (a)	578.6	590.5	98.0%	X				
Avg. Power Output (kW) "Power Output" average during the period (a)	0.73	1.5	48.8%				X	
Electricity Support Rate (%) mCHP generated power over total power cunsumption	---	---	86.4%	X				
Electricity Generated by mCHP (kWh) Cumulative mCHP power output during the period (a)	423.6	886	47.8%				X	
Purchased Electricity (kWh) Cumulative grid power amount during the period (a)	66.5	---	---	ECO Points		3.8		
Total Electricity Cunsumption (kWh) Sum of "Electricity Genrated by mCHP" and "Purchased Electricity"	490.2	---	---	ECO Level		C		
CO_2 Reduction (kg-CO_2) Amount of reduction compared with Coal-fired power plant	81	---	---					
CO_2 Reduction (kg-CO_2)	9	---	---					

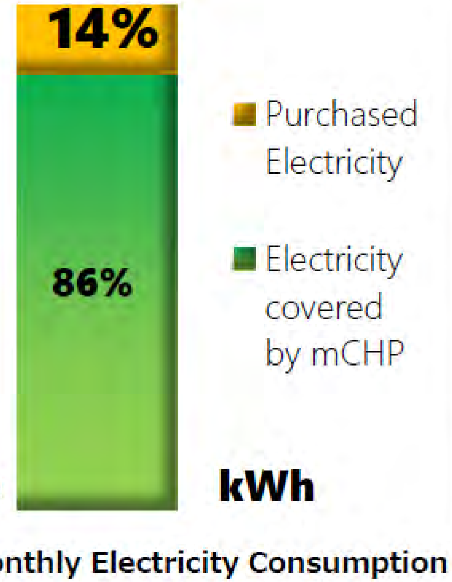
- "C" grade is due to the mCHP only allowed to provide power to the subpanel (critical load) NOT the entire house
- This is due to concerns from DTE of sending "dirty" NG power bad to the grid

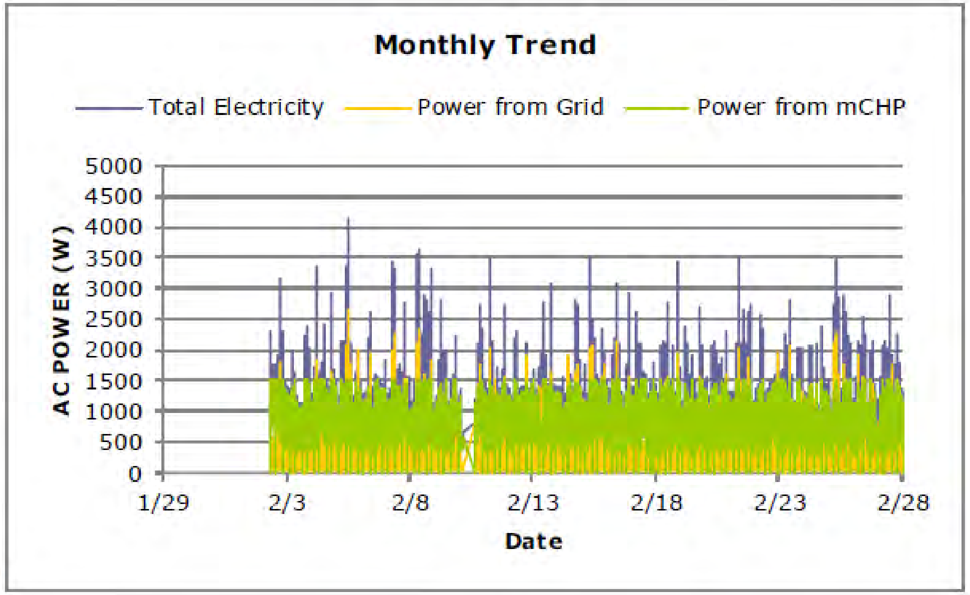
Results

Feb 2021



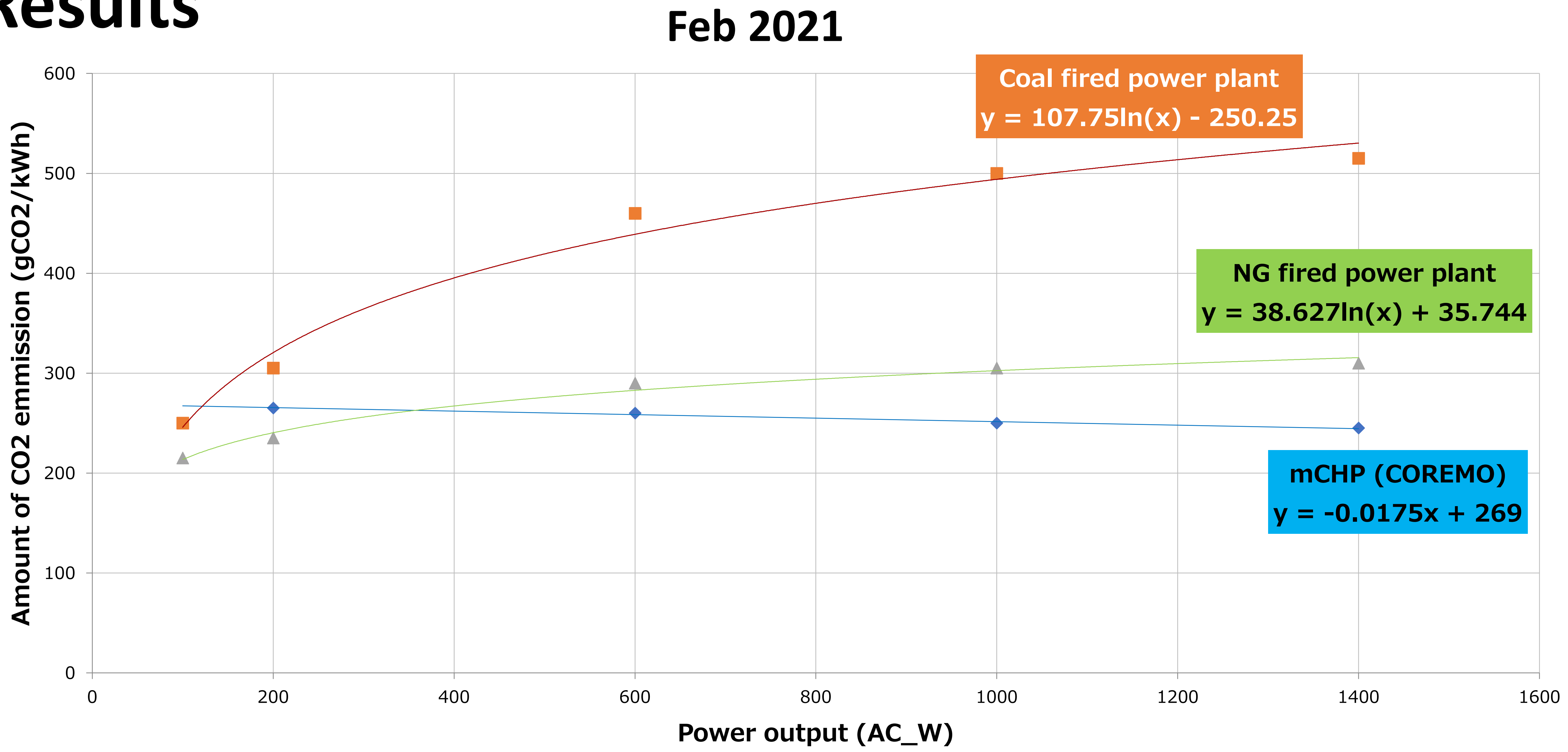






- 81 kg-CO2 reduction compared to coal fired plant
- 9 kg-CO2 reduction compared to NG fired plant

Results


Feb 2021
Coal fired power plant
y = 107.75ln(x) - 250.25
NG fired power plant
y = 38.627ln(x) + 35.744
mCHP (COREMO)
y = -0.0175x + 269
Amount of CO2 emmission (gCO2/kWh)
600
500
400
300
200
100
0
0
200
400
600
800
1000
1200
1400
1600
Power output (AC_W)

Results

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
2020 MODEL YEAR
CERTIFICATE OF CONFORMITY
WITH THE CLEAN AIR ACT

OFFICE OF TRANSPORTATION
AND AIR QUALITY
ANN ARBOR, MICHIGAN 48105

Certificate Issued To: Aisin World Corp. of America
(U.S. Manufacturer or Importer)

Certificate Number: LAWAS.2452N1-002

Effective Date: 08/07/2020

Expiration Date: 12/31/2020

Byron J. Bunker, Division Director
Compliance Division

Issue Date: 08/07/2020

Revision Date: N/A

Manufacturer: Aisin World Corp. of America
Engine Family: LAWAS.2452N1
Useful Life : 1000 Hours / 5 Years
Engine Class : Nonhandheld-Class II
Fuel : Natural Gas (CNG/LNG)
Emission Standards (g/kW-hr):
NMHC+NOx : 8.0
CO : 610

Emission:

NMHC+NOx = 8.0 g/kW-hr

CO = 610g/kW-hr

Clean Alternative Energy Source

AISIN
We Touch the Future

Regulation & Research

Opportunities in Michigan

- **Potential increase in EV demand**
- **Northern Michigan and Upper Peninsula of Michigan (LP - propane)**
  - **Higher energy rates**
  - **Potential Enbridge line 5 shut down**

Michigan Gov. Whitmer's declaration of energy emergency draws criticism over ongoing plans to shut down Line 5

By Scott McClallen | The Center Square   Feb 22, 2021

Canadian pressure mounts on Michigan governor to back off Enbridge pipeline

Updated Jan 26, 2021; Posted Jan 26, 2021

POLITICS

What a Line 5 shutdown would mean for Michigan's energy

Beth LeBlanc The Detroit News

Aisin mCHP plans – Japan Sales

- mCHP in Northern Region (Better use of thermal heat)
- SOFC in Southern region

COREMO（Japan）(micro Combined Heat and Power) (unit)

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019
Total	**85**	**143**	**408**	**447**	**587**	**705**	**929**	**1,157**	**1,323**

SOFC（Japan） (Solid Oxide Fuel Cell) (unit)

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019
Aisin	0	697	1,353	2,823	3,106	16,940	21,582	23,228	18,626
Others	13,460	23,820	32,178	35,195	37,341	30,130	27,248	23,362	22,362
Total	**13,460**	**24,517**	**33,531**	**38,018**	**40,447**	**47,070**	**48,830**	**46,590**	**40,988**

Aisin mCHP plans – North America

- Goal is to rollout mCHP in 2022 but we must satisfy ROI of 7 years or less for Standard System.
- Targeted volume for the 1st year is 500.
- Targeted location is still pending review of business cases and support from States interested in this technology (CA? NY? Michigan? Canada?)
- Trying to work with State governments, ESOC as well as utilities to increase education and find suitable demonstration locations
    - Preferred location is Michigan due to Aisin Technical center located in Michigan
- Aisin mCHP usage in other countries
    - Japan, Korea, Europe, India

Barriers and Solutions to Entry

BARRIERS:

- Misconception of NG and LP as "DIRTY"
- Not all electric companies are willing to allow net metering of NG/LP
- Standardizing site vs. source concept for GHG calculation
- Electric utilities not wanting to allow for interconnection
    - Cap on solar generation
    - Difficult hurdles with interconnection
- No regulation support to allow growth of NG/LP technologies

Solutions:

- Technology awareness is the 1st barrier
- Incentive programs to reduce the initial cost and reduce ROI period
- Special gas rates
- Allow net metering even for fossil fuel generated electricity (need to gain public support for "site vs. source"
- Contractor trainings
- Technology education for public
- Regulations to allow easier installation of NG/LP technologies

Final Coremo Installation

Drone Video and 3D virtual photos

http://tour.milookingglass.com/tour/MLS/AisinCoremo_MI_628_130648.html

Thank you for your attention

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Making the Most of Michigan's Energy Future

New Technologies and Business Models

Closing Comments

Stakeholder Meeting 6: Combined Heat & Power

April 7, 2021

Thank You and Please Stay Engaged!

- Thank you for your participation
  - Share your thoughts through:
    - Meeting survey
    - Meeting chat
      - Remains open for comments or discussions after meeting.
      - Easier to access with the Teams App
    - Stakeholder comment section of workgroup website
      - Send a document to be posted to the comment section via email to Joy Wang at WangJ3@Michigan.gov
- Please stay engaged
  - Sign up for the listserv if you have not already
    - Go to MI Power Grid New Technologies and Business Models workgroup page
    - Scroll to bottom to add email
  - Attend future meetings
    - Next meeting on April 21 from 1 – 5 PM
    - Topic: Microgrids

Thank you!