

# Midwest Energy Solutions Conference

Re-Energizing the Rust Belt: Decarbonizing the  
Midwest's Large Energy Users

February 2, 2022

## CHP in a Decarbonized World

Jane Epperson

US DOE Central & Midwest CHP Technical Assistance Partnerships  
Energy Resources Center, University of Illinois Chicago



**CHP Technical Assistance Partnerships**

# DOE CHP Technical Assistance Partnerships (CHP TAPs)

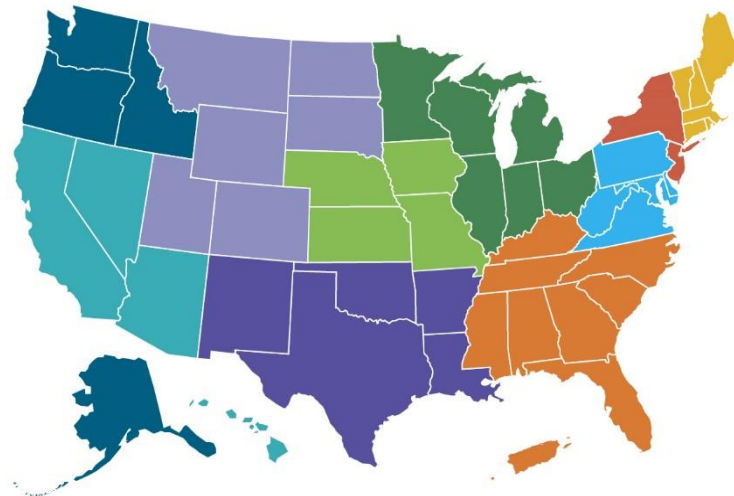
**Upper-West**  
CO, MT, ND, SD, UT, WY  
[www.uwchptap.org](http://www.uwchptap.org)  
Gavin Dillingham, Ph.D.  
HARC  
281-216-7147  
gdillingham@harcresearch.org

**Midwest**  
IL, IN, MI, MN, OH, WI  
[www.mwchptap.org](http://www.mwchptap.org)  
Cliff Haefke  
University of Illinois at Chicago  
312-355-3476  
chaefke1@uic.edu

**New England**  
CT, MA, ME, NH, RI, VT  
[www.nechptap.org](http://www.nechptap.org)  
David Dvorak, Ph.D., P.E.  
University of Maine  
207-581-2338  
dvorak@maine.edu

**Northwest**  
AK, ID, OR, WA  
[www.nwchptap.org](http://www.nwchptap.org)  
David Van Holde, P.E.  
Washington State University  
360-956-2071  
VanHoldeD@energy.wsu.edu

**Western**  
AZ, CA, HI, NV  
[www.wchptap.org](http://www.wchptap.org)  
Carol Denning  
Center for Sustainable Energy  
530-513-2799  
carol.denning@energycenter.org



**New York-New Jersey**  
NJ, NY  
[www.nynjchptap.org](http://www.nynjchptap.org)  
Tom Bourgeois  
Pace University  
914-422-4013  
tbourgeois@law.pace.edu

**Mid-Atlantic**  
DC, DE, MD, PA, VA, WV  
[www.machptap.org](http://www.machptap.org)  
Jim Freihaut, Ph.D.  
The Pennsylvania State University  
814-863-0083  
jdf11@psu.edu

**Southcentral**  
AR, LA, NM, OK, TX  
[www.schptap.org](http://www.schptap.org)  
Gavin Dillingham, Ph.D.  
HARC  
281-216-7147  
gdillingham@harcresearch.org

**Central**  
IA, KS, MO, NE  
[www.cchptap.org](http://www.cchptap.org)  
Cliff Haefke  
University of Illinois at Chicago  
312-355-3476  
chaefke1@uic.edu

**Southeast**  
AL, FL, GA, KY, MS, NC, PR, SC, TN, VI  
[www.sechptap.org](http://www.sechptap.org)  
Isaac Panzarella, P.E.  
North Carolina State University  
919-515-0354  
ipanarella@ncsu.edu

**DOE CHP Deployment Program Contacts**  
[www.energy.gov/CHPTAP](http://www.energy.gov/CHPTAP)

**Robert "Bob" Schmitt**  
Technology Manager  
Office of Energy Efficiency and Renewable Energy  
U.S. Department of Energy  
Robert.Schmitt@ee.doe.gov

**Patti Garland**  
DOE CHP TAP Coordinator [contractor]  
Office of Energy Efficiency and Renewable Energy  
U.S. Department of Energy  
Patricia.Garland@ee.doe.gov

# CHP: A Key Part of Our Energy Future

- Form of Distributed Generation (DG)
- An integrated system
- Located at or near a building / facility
- Provides at least a portion of the electrical load and
- Uses thermal energy for:
  - Space Heating / Cooling
  - Process Heating / Cooling
  - Dehumidification



CHP applications can operate at about 75% efficiency, a significant improvement over the national average of about 50% for these services when provided separately.



# What Are the Benefits of CHP?

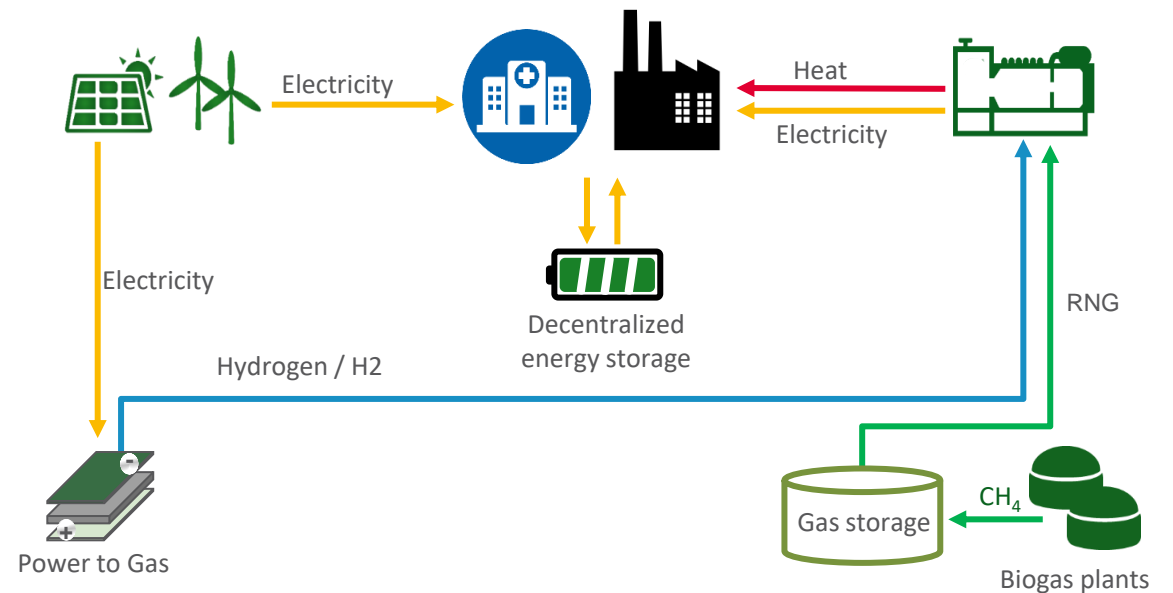
- CHP is **more efficient** than separate generation of electricity and heating/cooling
- Higher efficiency translates to **lower operating costs** (but requires capital investment)
- CHP can also increase **energy reliability** and enhance power quality
- Higher efficiency **reduces emissions** of pollutants



# CHP and Decarbonization

- CHP is fuel flexible - CHP currently uses renewable fuels, low carbon waste fuels, and hydrogen where available, and **will be ready to use higher levels of biogas, renewable natural gas (RNG) and hydrogen as they become available**
- CHP is the **most efficient way to generate power and thermal energy**, and can reduce CO<sub>2</sub> emissions now and in the future
- Renewable/hydrogen fueled CHP can **decarbonize thermal end-uses in industrial and commercial facilities that are difficult to electrify**
- Renewable/hydrogen fueled CHP can **decarbonize critical facilities that need dispatchable on-site power for long duration resilience and operational reliability**
- CHP's high efficiency can **extend the supply of renewable, low carbon and hydrogen fuels**

## CHP in a Decarbonized Economy



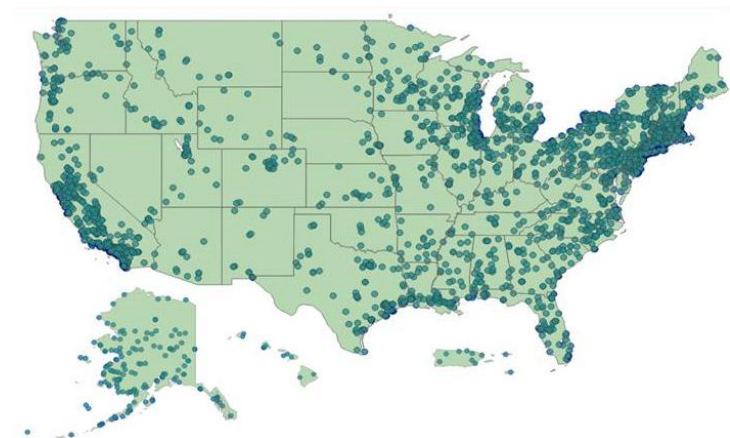
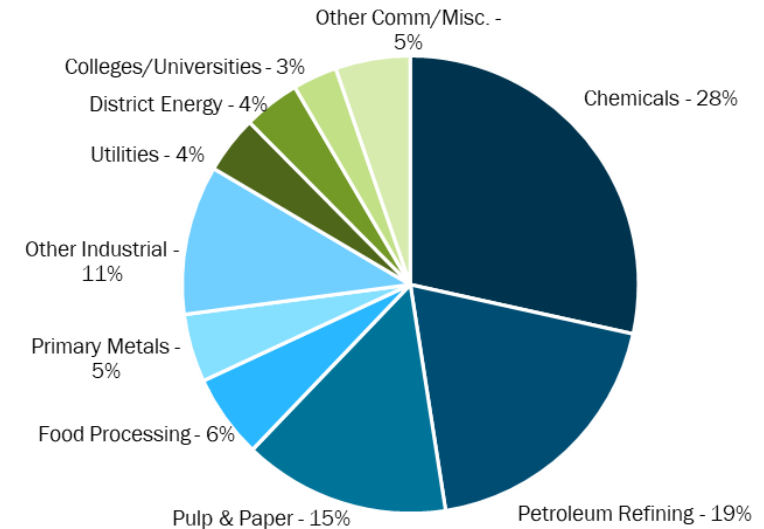
Source: Based on 2G Energy



# CHP Today in the United States

- CHP increases energy efficiency in industrial, institutional and commercial applications
  - ✓ 81.6 GW of existing CHP at more than 4,700 facilities saves 1.3 Quads of fuel and 215 MT CO<sub>2</sub> annually
- CHP improves energy reliability & resilience for both the user and the grid
  - ✓ Growing interest in CHP for **resilience and sustainability**, especially in critical infrastructure facilities
  - ✓ CHP serves as a **resilient anchor for clean microgrids**
- CHP uses a variety of fuels – fossil and renewable
  - ✓ 72% natural gas fueled
  - ✓ 15% biomass, biogas, and municipal and process waste fueled – **and growing**

Existing CHP Capacity

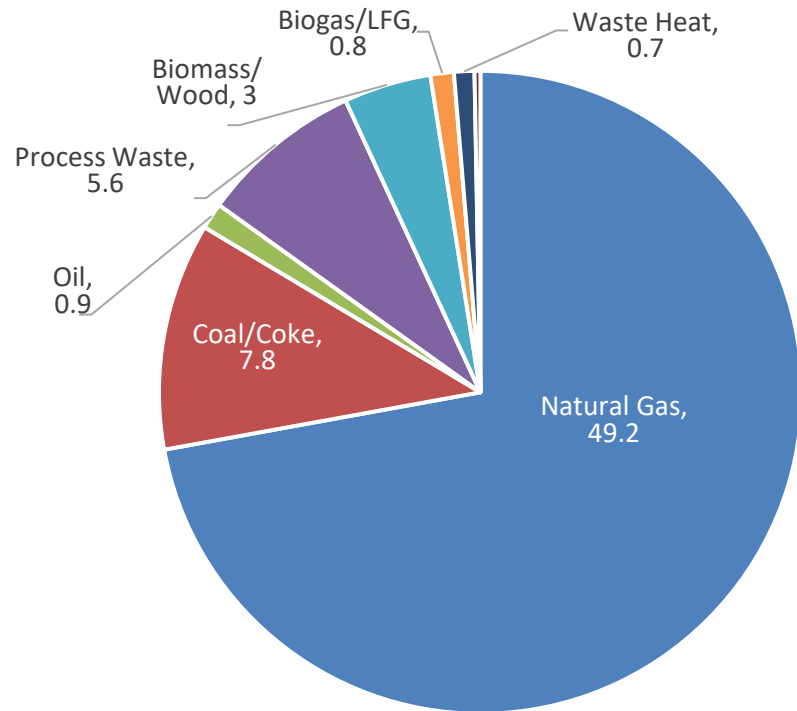


Source: DOE CHP Installation Database (U.S. installations as of August 31, 2021)

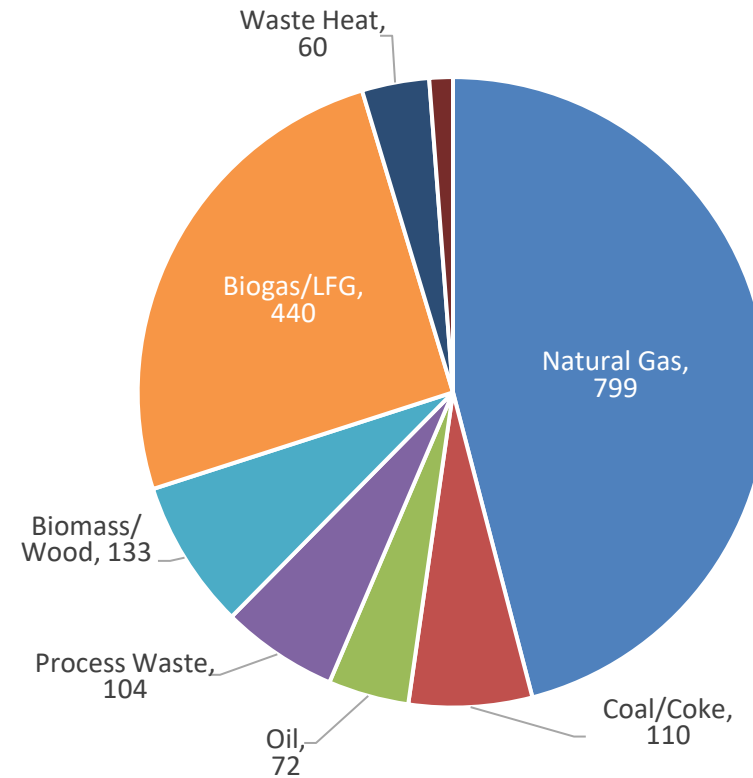


# Industrial CHP is Fuel Flexible

Industrial CHP in U.S.,  
GW Capacity



Industrial CHP in U.S.,  
Number of Installations



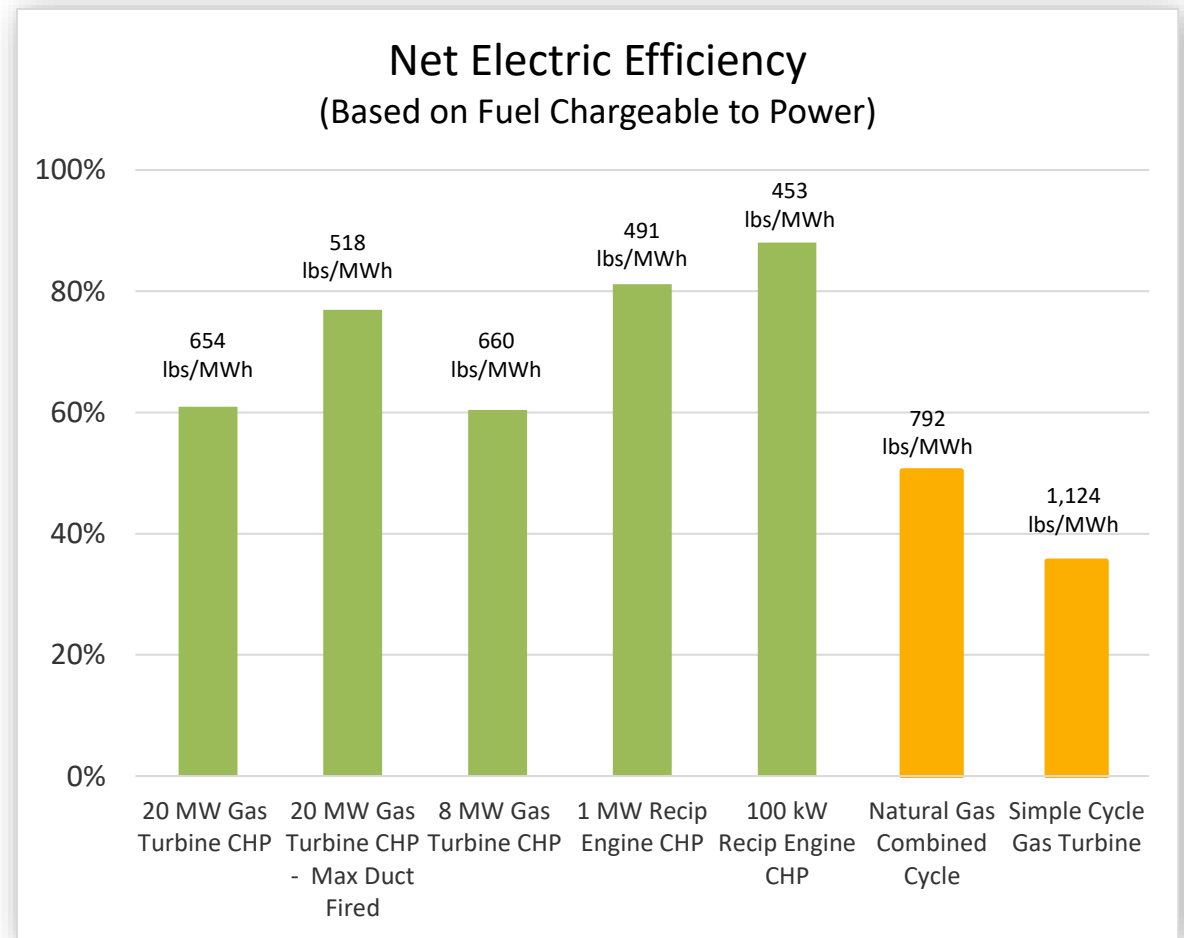
Source: DOE CHP Installation Database (U.S. installations as of December 31, 2020)





# CHP is the Most Efficient Marginal Generation

- CHP has higher net electric efficiency than state-of-the-art marginal natural gas generation (combined cycle)
- CHP systems have lower net GHG emissions than marginal natural gas generation (lbs CO<sub>2</sub>/MWh)
- CHP can meet marginal grid loads more efficiently and with less CO<sub>2</sub> emissions
- CHP's efficiency and emissions advantages will remain as the natural gas infrastructure decarbonizes

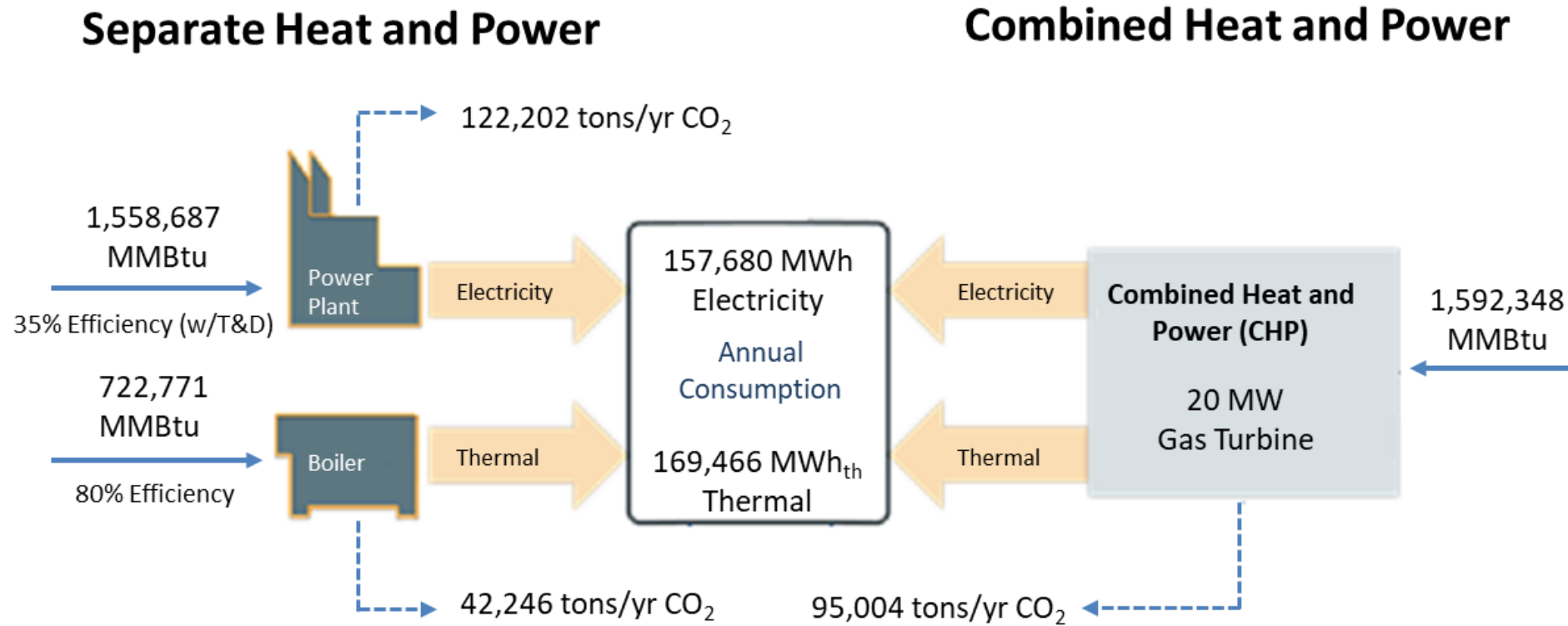


Prepared by: Entropy Research,  
LLC, 3/29/21





# CHP Provides both Energy and CO2 Emissions Savings



**49% Total Efficiency**

**70% Total Efficiency**

Energy savings: 689,110 MMBtu/year      CO2 Savings: 71,375 tons/year

# CHP's High Efficiency Saves CO2 Emissions Today

- CHP and renewables displace marginal grid generation (including T&D losses)
- Marginal generation is currently a mix of coal and natural gas in most regions of the US
- CHP's high efficiency and high annual capacity factor currently results in significant annual energy and emissions savings
- CHP's efficiency advantages will continue as the gas infrastructure decarbonizes
- *"Because emissions are cumulative and because we have a limited amount of time to reduce them, carbon reductions now have more value than carbon reductions in the future"*

Category	Natural Gas CHP	Utility Solar PV	Utility Wind	Biogas CHP
Capacity, MW	20.0	43.3	30.7	20.0
Annual Capacity Factor	90%	24.3%	34.3%	90%
Annual Electricity, MWh	157,680	92,096	92,096	157,680
Annual Thermal Provided, MWh <sub>th</sub>	169,466	None	None	169,466
Annual Energy Savings, MMBtu	689,110	863,954	863,954	689,110
Annual CO <sub>2</sub> Savings, Tons	71,375	71,375	71,375	164,448
Annual NOx Savings, Tons	59.8	39.1	39.1	59.8

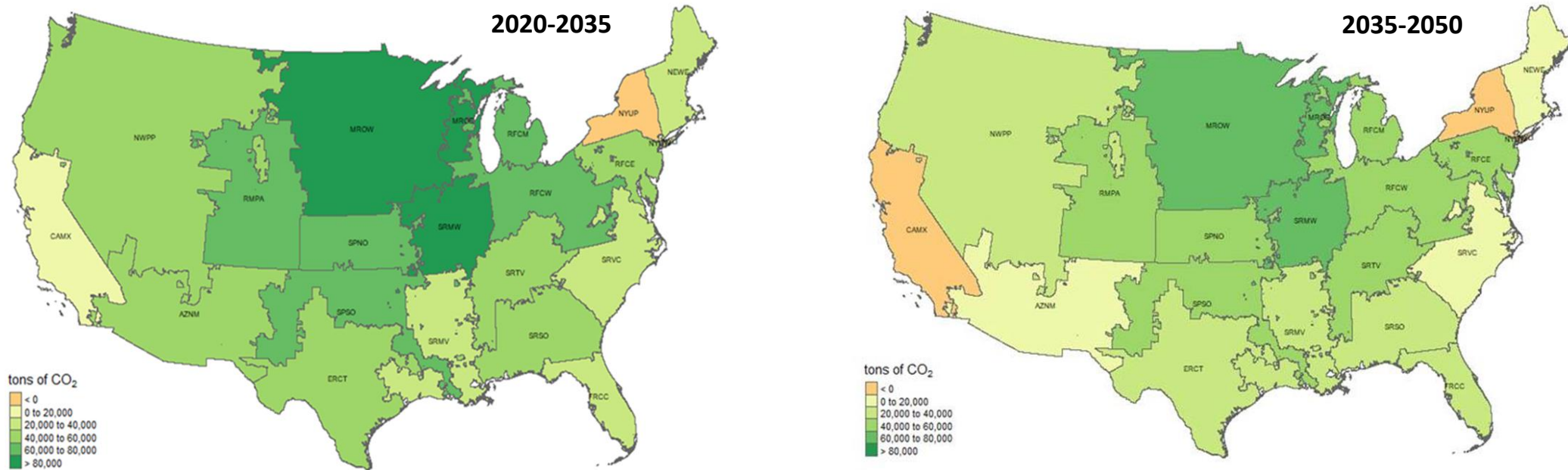
Savings based on EPA AVERT Uniform EE Emissions Factors as a first level estimate of displaced marginal generation (<https://www.epa.gov/avert>)

Prepared by: Entropy Research, LLC, 9/26/21

Source: "Time Value of Money", Larry Stein, Carbon Leadership Forum, April 2020



# CHP Will Continue to Reduce Emissions in Most Regions of the Country



- CHP will continue to reduce emissions in most U.S. locations through 2050
- Emission reduction potential depends on location and timing
- For states with 100% clean/renewable energy mandates, natural gas CHP eventually becomes a net emitter as the grid goes green, but *timing is uncertain*

Caveat: 2021 legislation passed in some states has altered some of the data and mapping results

Source: "Combined Heat and Power Potential for Carbon Emission Reductions", ICF for Energy Solution Center, July 2020



# Summary: CHP and Decarbonization

- Reducing carbon today is important
  - 81.6 GW of existing CHP nationally saves 215 MT CO<sub>2</sub> annually NOW
  - 15% of national CHP fuel source NOW is biomass, biogas, and municipal and process waste
- RNG/Hydrogen increasingly looked at as a critical part of decarbonization
- Fully electrifying the economy will not be easy or quick
- CHP can play an important role now and in the future

# Thank You

**Cliff Haefke**  
Director  
(312)-355-3476  
chaefk1@uic.edu

**Jane Epperson**  
Assistant Director  
(573) 645-7674  
ercjane@uic.edu

**Graeme Miller**  
Assistant Director  
(312) 996-3711  
gmille7@uic.edu

U.S. DOE Central and Midwest CHP Technical Assistance Partnerships

[www.energy.gov/chp](http://www.energy.gov/chp)



**CHP Technical Assistance Partnerships**

Energy Resources Center  
University of Illinois at Chicago