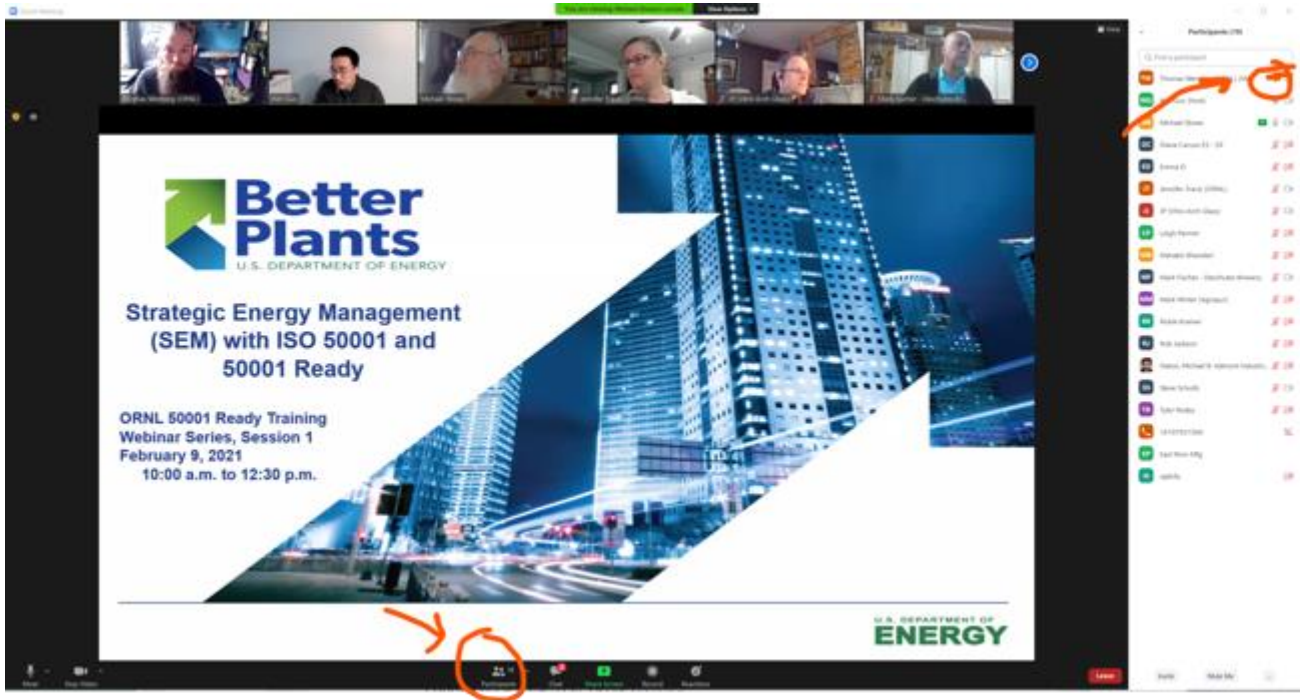
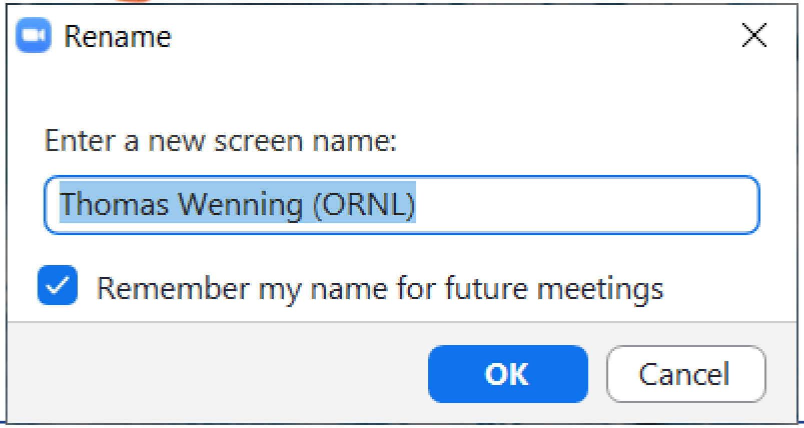
Rename Yourself to be your Real Name (Company Name)

1. Click on Participant list
2. Go to the right and hover over your name
3. Select “More” & “Rename”
4. Enter your company name in brackets
5. Turn on your camera ☺





Virtual Training: Combined Heat & Power Systems

Overview of GHG "Project Accounting" Methodology and Communicating CHP's Decarbonization Impact

Session #3
December 12, 2024
10:00am – 12:30pm EST

Agenda

1. Review Session #2 Homework
2. GHG Emissions Accounting
   - Paulomi Nandy, Oak Ridge National Laboratory
3. GHG Protocol's Project Accounting – Why it is Used in Conjunction with Inventory Accounting to Reflect CHP's Global CO2 Impact
   - Bruce Hedman, *Entropy Research, LLC*
4. How to Apply Project Accounting to CHP Projects & Forecasting CHP's U.S. GHG Impact Over the Next 25 Years Using a Marginal Emissions Model
   - Levi Hoiriis, *Sterling Energy Group, LLC*
5. CHP's Impact as a Decarbonization Option for Industry into the 2040s and 2050
   - Bruce Hedman, *Entropy Research, LLC*
6. Q&A

Today's Speakers

Paulomi Nandy

R&D Assistant Staff,
Oak Ridge National Lab.

Bruce Hedman

Managing Director,
Entropy Research, LLC

Levi Hoiriis

Energy Engineer,
Sterling Energy Group, LLC

U.S. DEPARTMENT OF ENERGY

Review of Session #2 Homework

1. What resources can be used to produce Renewable Natural Gas (RNG)?
2. Name two of the four primary classifications and production methods for clean Hydrogen.
3. Will RNG or hydrogen be less expensive than natural gas? If not, what could incentivize companies to use these fuels for CHP?
4. How can RNG and Hydrogen be used to help facilities with CHP decarbonize?
5. Which of the following is true?
    a. CHP is fuel flexible
    b. CHP is the most efficient way to generate power and thermal energy, and can reduce CO_2 emissions now and in the future
    c. Net-zero CHP can decarbonize industrial, commercial, and critical facilities.
    d. CHP's high efficiency can extend the supply of renewable, low carbon and hydrogen fuels
    e. All of the above

Review of Session #2 Homework

1. What resources can be used to produce Renewable Natural Gas (RNG)?
   - Biogas (landfill gas or anaerobic digester gas from farms and wastewater treatment facilities), or solid biomass resources.
2. Name two of the four primary classifications and production methods for clean Hydrogen.
   - **Green** hydrogen: Electricity is used to split water into hydrogen and oxygen, creating a zero-emission process if the electricity stems from renewable sources.
   - **Grey** hydrogen: Methane is reformed to produce hydrogen though either Steam Methane Reforming (SMR) or Autothermal Reforming (ATR). SMR's production process has two CO2 emission streams; whereas ATR has one single CO2 emission stream.
   - **Blue** hydrogen: Hydrogen is produced through SMR or ATR, but all carbon emissions are captured and stored (and potentially used). Carbon capture is simplified through ATR's single CO2 emission stream.
   - **Pink** hydrogen (with nuclear power) is another potential zero-carbon source.

Review of Session #2 Homework

3. Will RNG or hydrogen be less expensive than natural gas? If not, what could incentivize companies to use these fuels for CHP?
   - RNG and hydrogen are expected to cost more than natural gas, but incentives to reduce production costs, encourage utilization, or discourage the use of fossil fuels with disincentives (i.e., carbon tax) can help to level the playing field
   - Companies will choose RNG and Hydrogen for CHP because they have decarbonization goals and mandates, and CHP and high-temperature heating loads will be difficult and costly to electrify.
4. How can RNG and Hydrogen be used to help facilities with CHP decarbonize?
   - CHP systems already produce fewer emissions than separate heat and grid power in most locations. As the grid decarbonizes, CHP operators can incorporate blends of RNG and hydrogen to maintain the emissions advantage, and eventually convert to 100%.

Review of Session #2 Homework

5. Which of the following is true?
   a. CHP is fuel flexible
   b. CHP is the most efficient way to generate power and thermal energy, and can reduce CO_2 emissions now and in the future
   c. Net-zero CHP can decarbonize industrial, commercial, and critical facilities.
   d. CHP's high efficiency can extend the supply of renewable, low carbon and hydrogen fuels
   e. **All of the above**

GHG Emissions Accounting

Paulomi Nandy
Oak Ridge National Laboratory

Agenda

- Scope of Emissions
- Setting Corporate Boundary
- Calculate Scope 1 Emissions
  - Fuel Consumption Method
  - Estimation Method
- Calculate Scope 2 Emissions (Electricity)
  - Location Based
  - Market based
- Calculate Scope 2 Emissions (Other Utility)
- Reporting Best Practices
- Project Accounting

What is a GHG Inventory?

GHG Inventory is a list of all the emissions sources and associated emissions within an organization boundary.

Reasons for GHG inventory:

- Identifying emissions reduction opportunity
- Managing risk related to high GHG emissions
- Setting and tracking towards a goal

Steps to Develop a GHG Inventory

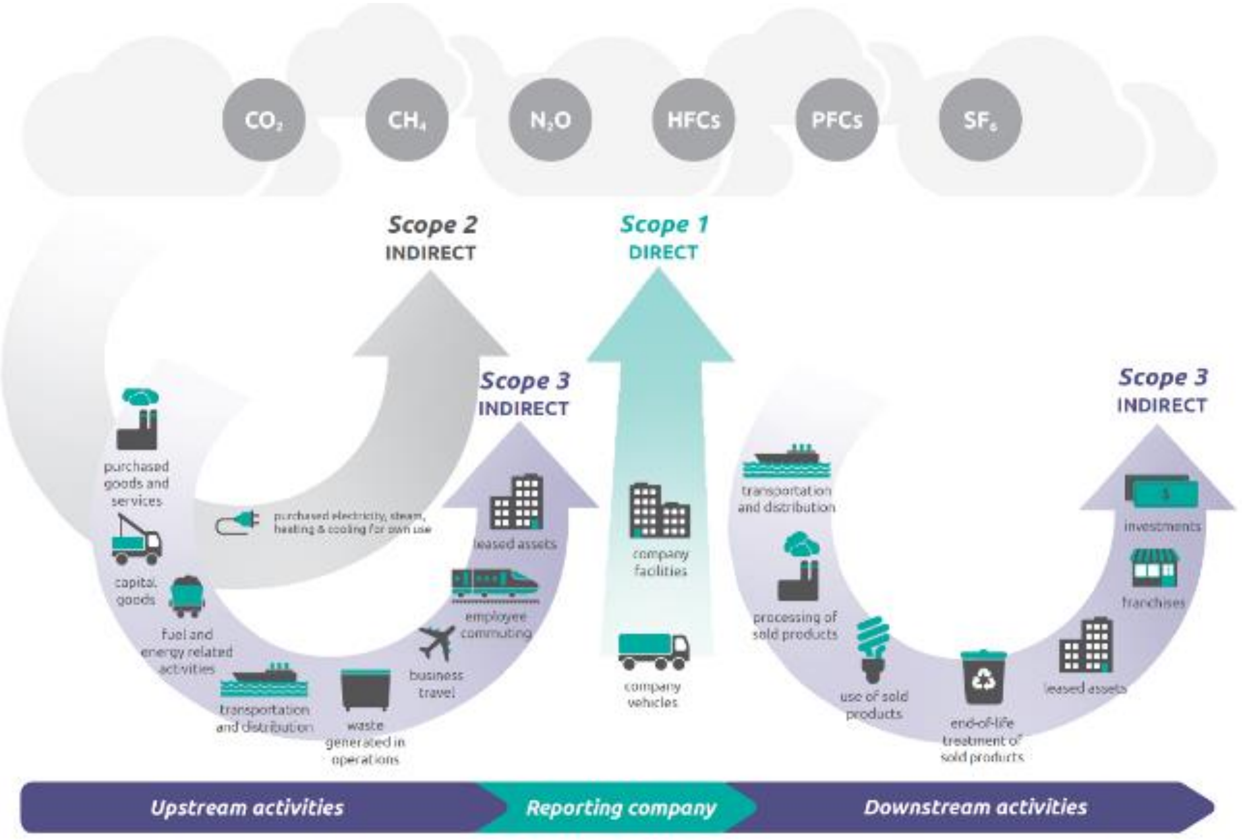
Evaluate Corporate Boundary	Identify Scope of Emissions	Collect Data & Quantify Emissions	Aggregate Data	Inventory Management Plan
Setting Corporate Boundary to include all Scope of Emissions List all facility/buildings that are owned or leased	Identify fuel and process source of emissions Categorize the source of emissions by Scope	Collect purchased fuel or utility quantity data Collect leak data Quantify emissions	Roll emissions data to corporate level	Develop data quality check Keep track of change in corporate boundary Keep track of fuel or energy purchase contracts

Scope of Emissions

Scope 1 emissions: Emissions directly generated by a company’s operations, like fossil fuel combustion for on-site machinery.

Scope 2 emissions: Emissions from the electricity, heat, or cooling a company purchases and uses, essentially the indirect emissions produced by the power plant generating that energy.

Scope 3 emissions: All other indirect emissions occurring throughout a company's value chain, including emissions from raw material production, transportation, waste disposal, employee commuting, and product usage by customers



Global Warming Potential

Global Warming Potential (GWP) helps compare the global warming impact of different gases.

Measure of how much energy the emissions of 1 ton of a gas will absorb over a given period of time, relative to the emissions of 1 ton of carbon dioxide (CO2)

GWP Values

Gas	AR4	AR5
CH4	25	28
N2O	298	265

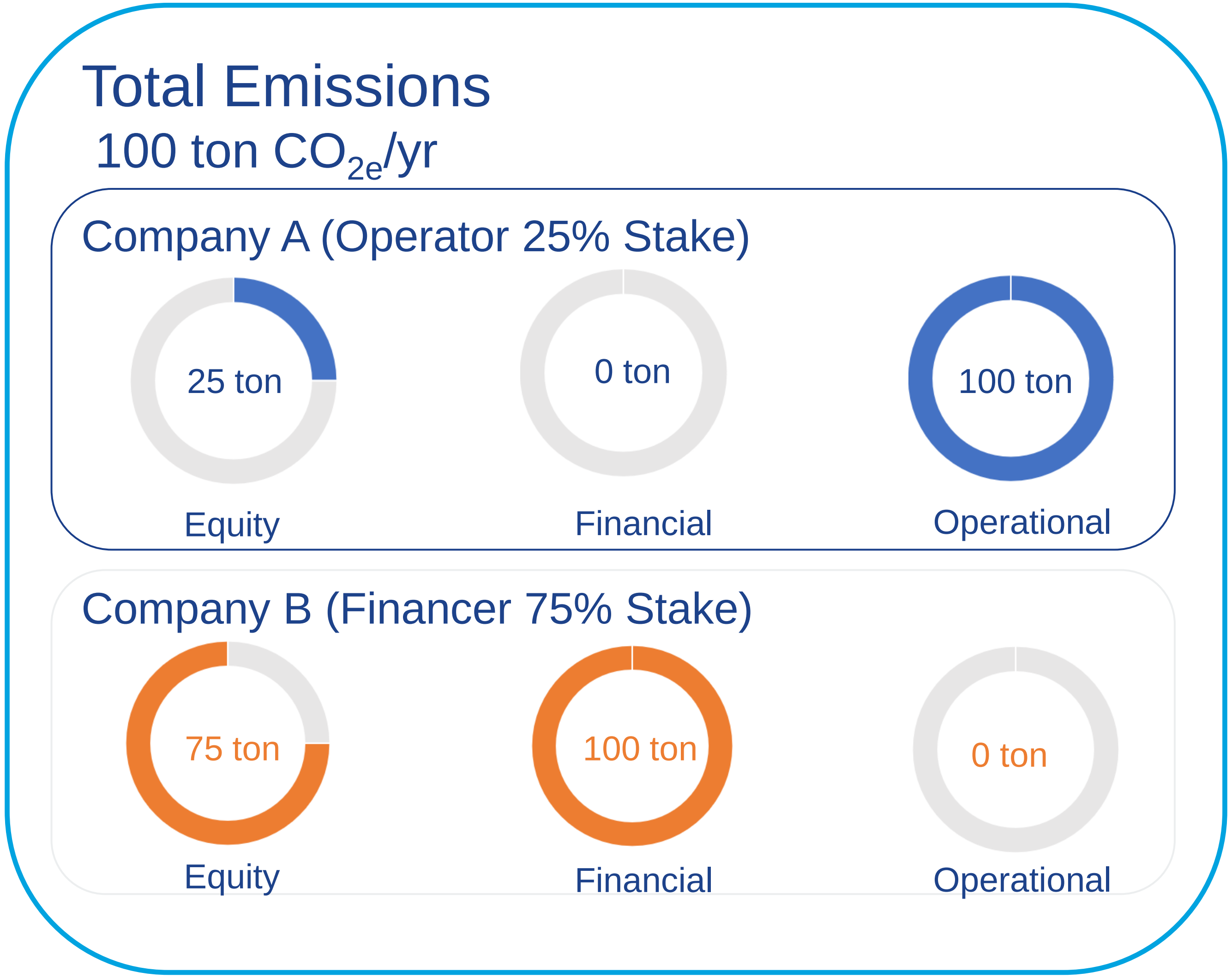
$$CO_2e(ton) = \frac{(CO_2\ emissions + (25 * CH_4\ emissions) + \ (298 * N_2O\ emissions))}{1000}$$

Setting a Corporate Boundary

Equity Share Approach
Reflects activities that are wholly or partially owned based on equity share

Financial Control
Reflects activities that organization can direct financial policies and gain economic benefits from activities.

Operational Control
Reflects activities that organization can implement operational policies.



Methods of Calculation

Calculation Based
Calculate CO_2e emissions for each unit of fuel consumption

Measurement Based
- Emissions measured directly through system that monitors the concentration of the GHGs and output flow rate using Continuous Emissions Monitoring System (CEMS)

Estimation Method
- Estimate emissions based on industry average such as sqft, occupancy, load profiles.

Scope 1 Stationary Emissions

- Stationary Emissions include emissions from boiler, turbine, process heating and generator.

- Emission from **biofuel** also needs to be reported as biogenic emissions (CO_2)

Common Fuel	Natural Gas, Propane, Fuel oil, Coal
Data	Utility usage data, sub-metered data

Calculating Emissions from Fuel Use

Quantifying emissions based on fuel consumption

Calculate CO_2 , CH_4 and N_2O using equation below

$$\text{Emissions} = Quantity\ of\ fuel \times Emissions\ factor$$

Reported Emissions for Fossil Fuel

$$CO_2e(ton) = \frac{(CO_2\ emissions + (25 * CH_4\ emissions) + (298 * N_2O\ emissions))}{1000}$$

Reported Emissions for Biofuel

$$\text{Biofuel}\ CO_2e(ton) = \frac{(Quantity\ of\ biofuel \times (25 \times CH_4\ emissions) + (298 \times N_2O\ emissions))}{1000}$$

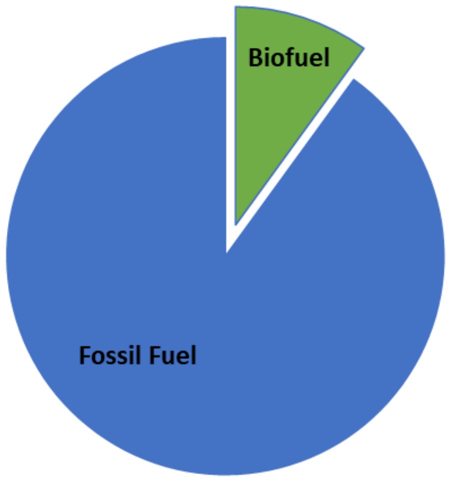
$$Biogenic\ CO_2(ton) = \frac{(Quantity\ of\ biofuel) \times Emission\ factor}{1000}$$

Emissions from Blended Fuel

Blended fuel is composition of fossil fuel with biofuel or other fuel sources.

Quantify quantity of biofuel= $Fuel\ consumption\ (unit) \times \%\ biofuel$

Quantify quantity of fossil fuel = $Fuel\ consumption\ (unit) \times \%\ fossil\ fuel$



$$\text{Fossil fuel } CO_2e(ton) = \frac{(Quantity\ of fossil\ fuel)\times(CO_2\ emissions+(25\times CH_4\ emissions)+)+(298\times N_2O\ emissions))}{1000}$$

$$\text{Biofuel } CO_2e(ton) = \frac{(Quantity\ of\ biofuel\times(25\times CH_4\ emissions)+(298\times N_2O\ emissions))}{1000}$$

$$Total\ emissions\ (CO_2e\ ton) = \text{Fossil fuel } CO_2e(ton) + \text{Biofuel } CO_2e(ton)$$

$$Biogenic\ CO_2(ton) = \frac{(Quantity\ of\ biofuel)\ \times Emission\ factor}{1000}$$

Scope 1 Mobile Emissions

- Emissions resulting from operation of owned or leased mobile sources that are within the organization boundary
- Emissions from **biofuel** also needs to be reported as biogenic emission (CO_2)

Common Fuel	Gasoline, Diesel
Data	Fuel used, vehicle type, miles travelled
Emission Factor	kg CO_2/unit, g CH_4 per distance travelled, g N_2O per distance travelled

Emissions for Mobile Emissions (On-Road Vehicles)

Emissions from On-Road Vehicles such as trucks, bus, ships, etc.

$$CO_2 \text{ Emissions} = Quantity\ of\ fuel \times Emission\ factor$$

$$CH_4, N_2O \text{ Emissions} = Miles\ travelled\ \times Emission\ factor$$

Reported Emissions for Fossil Fuel

$$\boxed{CO_2e(ton) = \frac{(CO_2\ emissions + (25 * CH_4\ emissions) + (298 * N_2O\ emissions))}{1000}}$$

CH_4 and N_2O emissions depend more on the emission control technologies employed in the vehicle and the distance traveled.

Emissions for Mobile Emissions (Off-Road Vehicles)

Emissions from Off-Road Vehicles such as tractors, forklifts, lawn care equipment etc.

Reported Emissions for Fossil Fuel

$$Emissions = Quantity\ of\ fuel \times Emissions\ factor$$

$$\boxed{CO_2e(ton) = \frac{(CO_2\ emissions + (25 * CH_4\ emissions) + (298 * N_2O\ emissions))}{1000}}$$

Scope 1 Fugitive Emissions

- Emissions due to refrigerant or gas leaks during installation, operation or disposal.

Common Refrigerants	HFCs, R-410A, R-404A
Data	Type of refrigerant, quantity of refrigerant leaks
Emission Data	GWP of Refrigerant

Quantifying Fugitive Emissions from Leaks

Mass Balance Method

Method relies total amount of refrigerants/gases purchased

Reported Emissions from Refrigerant Leaks

$$Emissions = (I_B - IE) + (CB - CE)$$

Screening Method

Method relies on emission factors which are equipment specific.

Reported Emissions for Installed or Operated Equipment

$$Emissions = Volume\ of\ refrigerant\ leak\ \times \left(\frac{\%\ loss}{100}\right)$$

Scope 2: Purchased Electricity, Steam etc.

- Emissions from purchased electricity, steam over the boundary
- Electricity can be considered emissions free only if you retain the Renewable Energy Credits(RECs)
- Emissions Estimation: Location Based, Market Based

Data	Energy usage from utility bill, sub-meter, Certificates, Contracts
Common Contracts	Electricity from grid, onsite, green tariff, RECs, PPPA
Emission Factor	kg CO_2/unit, g CH_4/unit, g N_2O/unit

Location Based vs. Market Based Emissions

Location Based Approach

This method allows you to quantify average emissions from electricity consumption in organization's geographic regions of operation

Calculation Method: Based on regional grid averages
Emission Factors: eGRID emissions factor

Market Based Approach

This method allows you to quantify emissions from electricity generated or consumed that the organization has purposefully purchased

Calculation Method: Based on purchase contracts
Emission Factors: Contractual instruments

Scope 2: Location Based vs. Market Based Emissions

Electricity from Grid= 20,000 MWh
Onsite Direct Connected Solar = 100 MWH
RECs = 20,000
Location Based Emissions = 0.372846274 e-GRID (RFC Michigan)
Market Based Emissions = Residual mix (RFC Michigan)

Electricity Consumed (MWh)	Location Based (mtCO2e)	Market Based (mtCO2e)
From Grid	20,000 X 0.3728= 7,456	(20,000-20,000) X Residual Mix factor
Onsite Solar	100 MWH X 0	100 MWH X 0
Total	7,456	0

Market Based Emissions Hierarchy

Market based emissions follows a hierarchy of emissions factor

Energy Attribute Certificates

Energy Contracts

Supplier Specific Factors

Residual Mix Factors

Regional Emissions Factor

National Average

Decreasing Precision

Renewable Energy Certificate Quality

Primary Requirement

✓Organizations can claim renewable electricity only when RECs have been retired on their behalf

✓REC owners of the RECs should have exclusive ownership and claims on the certificates

✓Source renewable energy from within the boundary of the market in which they are consuming electricity

Certification Requirement

✓Verify and reliable generation sources

✓Verified by third party (Green-e)

✓Clear renewable energy benefits documentation

✓Generation should occur relatively close to the year a credit is retired

Renewable Thermal Credits (RTCs)

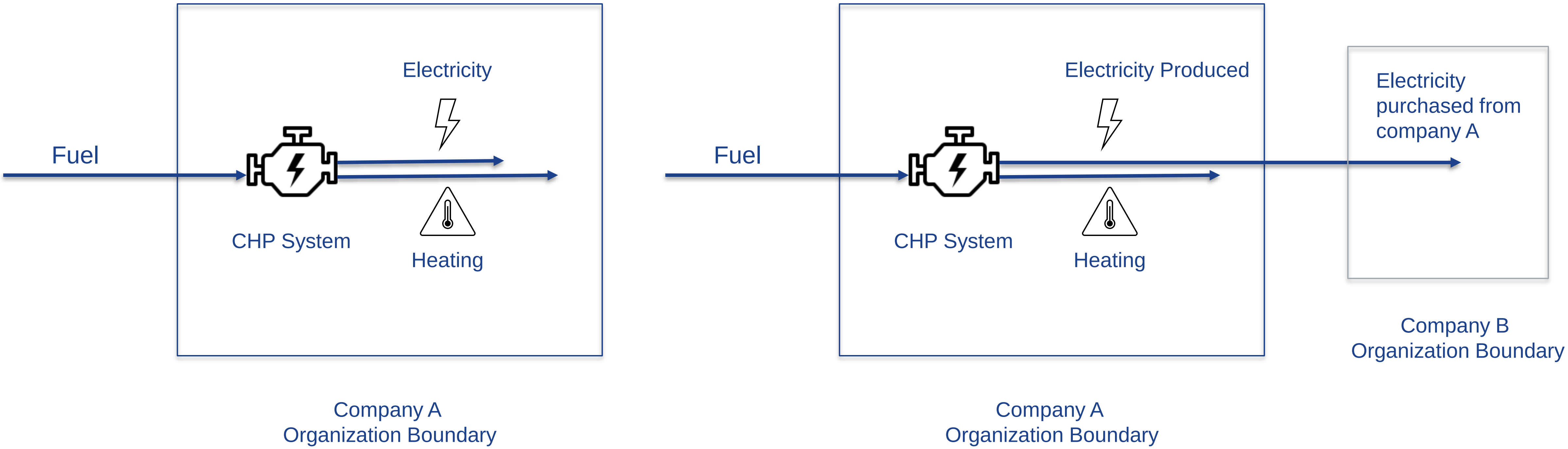
A Renewable Thermal Certificate (“RTC”) is a unique representation of the Environmental Attributes associated with the production and use of one dekatherm (“Dth”) of renewable thermal energy.

Renewable thermal power for various fuel sources, including clean hydrogen, renewable natural gas (RNG/ Biomethane), Biogas, and Combined Heat and Power (CHP)

https://www.mrets.org/wp-content/uploads/2021/06/M-RETS-Thermal-Tracking-System-6-2021.pdf
https://www.cesa.org/wp-content/uploads/Renewable-Thermal-RPS.pdf

Emissions for a CHP system

The fuel used for onsite CHP operation would fall under Scope 1 stationary emissions.



Reporting Best Practices

- Include all emissions sources in your inventory
- Report all scope of emissions
- Track and report Scope 2 location and market-based emissions
- Use correct and most current emissions factor
- If you don’t have actual data start with estimation
- Avoid double counting for emissions

Project Based Accounting

- Project Accounting Protocol provides specific principles, concepts, and methods for quantifying GHG reductions from climate change mitigation.

- Provide a credible and transparent approach for quantifying and reporting GHG reductions from GHG projects;
- Enhance the credibility of GHG reduction from a project through the application of common accounting *concepts, procedures, and principles*;

GHG Effects

There are 2 types of GHG effects of a project:

- **Primary Effect** : A primary effect is the intended change caused by a project activity in GHG emissions. Each project activity will generally have only one primary effect.
- **Secondary Effect** : A secondary effect is an unintended change caused by a project activity in GHG emissions. Secondary effects are typically small relative to a project activity's primary effect.

One Time Effects : Changes in GHG emissions associated with the construction, installation, and establishment or the decommissioning and termination of the project activity.

Upstream and downstream effects: Recurring changes in GHG emissions associated with inputs to the project activity (upstream) or products from the project activity (downstream), relative to baseline emissions.

Examples of Primary and Secondary Effects

Project Description	Primary Effect	Secondary Effect
Transportation Fuel Switch Project	Reduction in combustion emissions from generating energy or off-grid electricity, or from flaring	Increase in emission from land use change
Installing wind power project	Reduction in combustion emissions from generating grid-connected electricity	Emissions associated with building the wind blades
Energy Efficiency Project	Reduction in combustion emissions from generating grid-connected electricity	Emissions associated with the production of efficient product

Additionality

Additionality is a criterion that says GHG reductions should only be recognized for project activities that would not have "happened anyway."

Examples
Additional: New renewable energy project that wouldn't be financially viable without credits
Non- Additional: Already planed efficiency upgrades required by regulations

While there is general agreement on the importance of additionality, its meaning and application remain open to interpretation.

Comparison of GHG Inventory and Project Accounting

Characteristics	Corporate Based Accounting	Project Based Accounting
Scope	Encompasses entire organization's GHG emissions inventory	Focuses on specific emission reduction activities or initiatives
Timeline	Continuous monitoring across fiscal years	Limited to project duration and specific milestone
Key Features	• Organizational boundaries • Scope 1, 2, and 3 emissions • Annual reporting cycles • Corporate-wide targets	• Baseline determination • Additionality assessment • Direct emission reductions • Project specific boundaries
Purpose	Complete emissions inventory	Specific reduction initiatives

Questions?

Paulomi Nandy, ORNL

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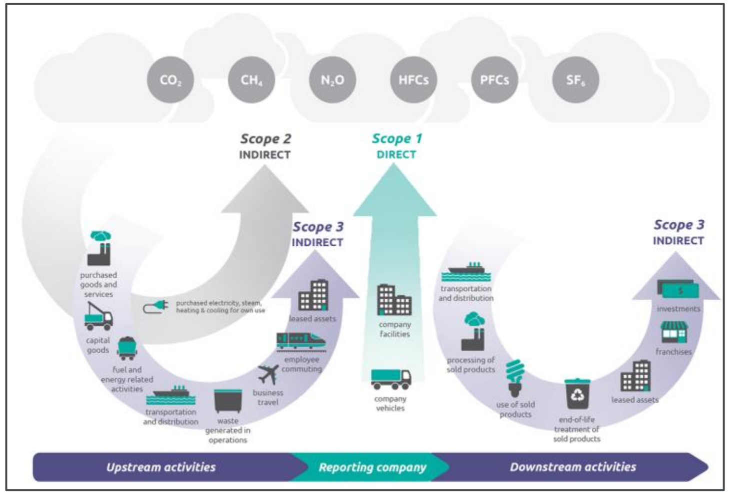
GHG Protocol's Project Accounting:

Why it is Used in Conjunction with Inventory Accounting to Reflect CHP's Global CO2 Impact

Bruce Hedman
Entropy Research, LLC

Emissions Accounting Issues for CHP

- Annual GHG reporting using WRI's GHG Protocol Guidelines have become widely established –essentially the *defacto global standard*
  - Used by over 85,000 Organizations in 180 countries, including over 90% of Fortune 500
  - Annual reporting of Scopes 1, 2 and 3 emissions at the facility level
- GHG Accounting Issues Impacting CHP
  - Prevailing GHG reduction wisdom is that electrification provides a means to convert Scope 1 emissions to Scope 2
  - Once emissions are shifted to Scope 2, purchase of renewables (RECs or PPAs) is a viable near-term GHG reduction option as the grid decarbonizes
  - Implementation of CHP usually increases Scope 1 emissions
  - Scope 2 inventory accounting for a facility is based on average grid emissions factors and does not capture the global emissions impacts of CHP (*average vs marginal generation debate*)
  - Feedback from CHP developers and prospective users confirm that corporate focus on inventory reporting has negatively impacted CHP development

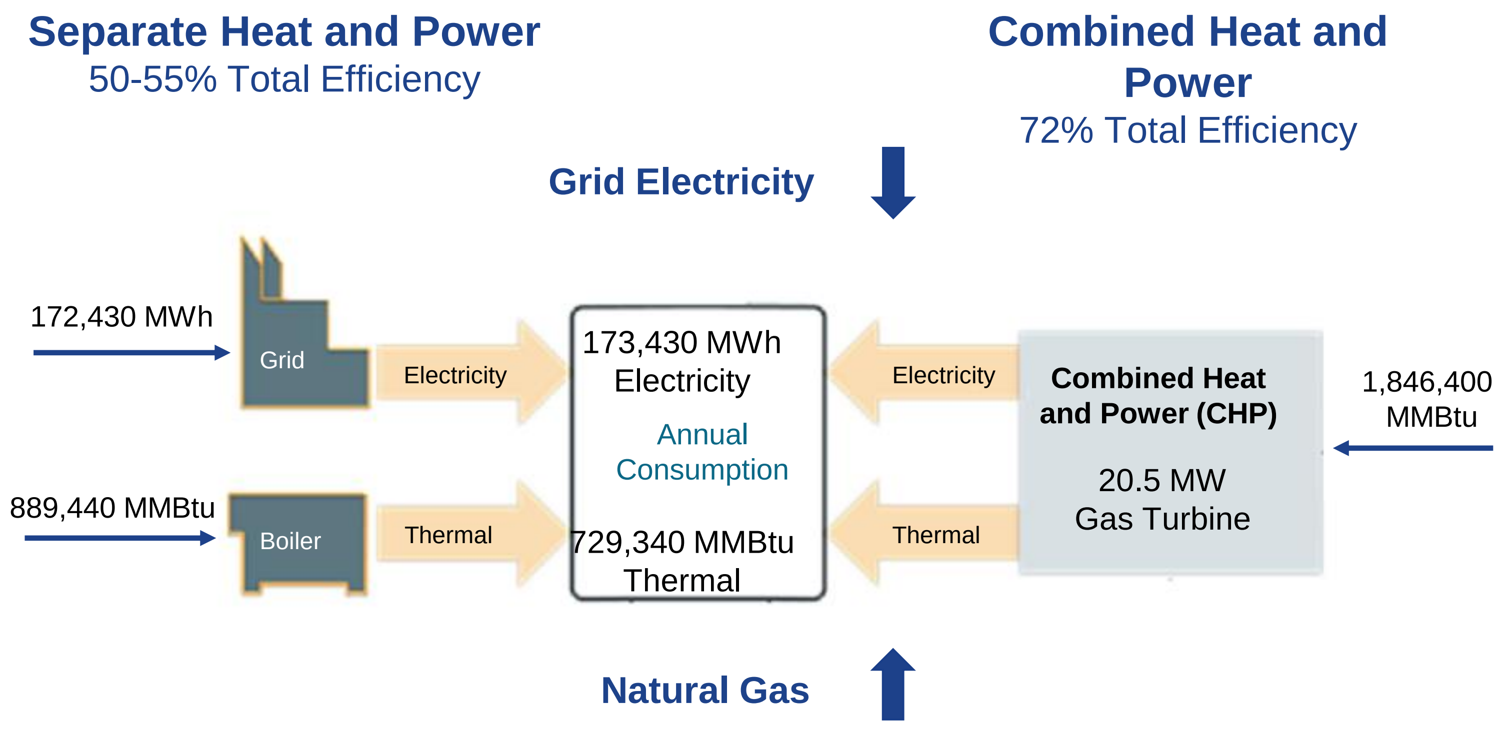


US EPA -- Scope 1 emissions based on direct fuel use at the facility; Scope 2 emissions based on grid power, and/or third-party steam and cooling purchases

CHP – Saves Energy and Emissions……….

Natural gas CHP system replacing natural gas boiler and purchased electricity

- 20.5 MW Gas Turbine CHP with unfired HRSG
  - 96% capacity factor
  - 32% electric efficiency
  - 40% thermal efficiency
  - CHP steam displaces 82% efficient natural gas boiler
  - All CHP power and steam used onsite



Grid Electricity Decrease = 172,430 MWh

Fuel Increase at Site = 956,960 MMBtu

……. But How Do You Measure Emissions Impacts?

Source: Entropy Research, 2024

GHG Accounting Methods – GHG Protocol

- GHG Protocol has two separate standards for reporting emissions
  - **Inventory (or Attributional) Accounting** – Physical emissions an organization is responsible for – attributed inside an organization / plant's boundary (based on Average Grid emissions)
  - **Project (or Consequential) Accounting** – Reports on the impact a specific project has on emissions without regard to boundary – measured against a counterfactual baseline (based on Marginal Grid emissions)
- Project Accounting captures global emissions impact of CHP
  - Scope 1 emissions go up INSIDE plant's boundary with CHP as Scope 2 emissions are reduced as purchased power is displaced; Inventory Accounting cannot take credit for emissions reduced on the grid by CHP displacing high emissions marginal generation
  - Project Accounting has no physical boundary and captures emissions reduced (avoided) on the grid by CHP
- Both methods are important for management to use in evaluating GHG mitigation efforts
  - Project Accounting has not played a visible role in the past, but GHG Protocol has committed to raise awareness of Project Accounting's important role in it's current updating process

CHP – CO_2 Emissions Savings Based on Inventory Accounting

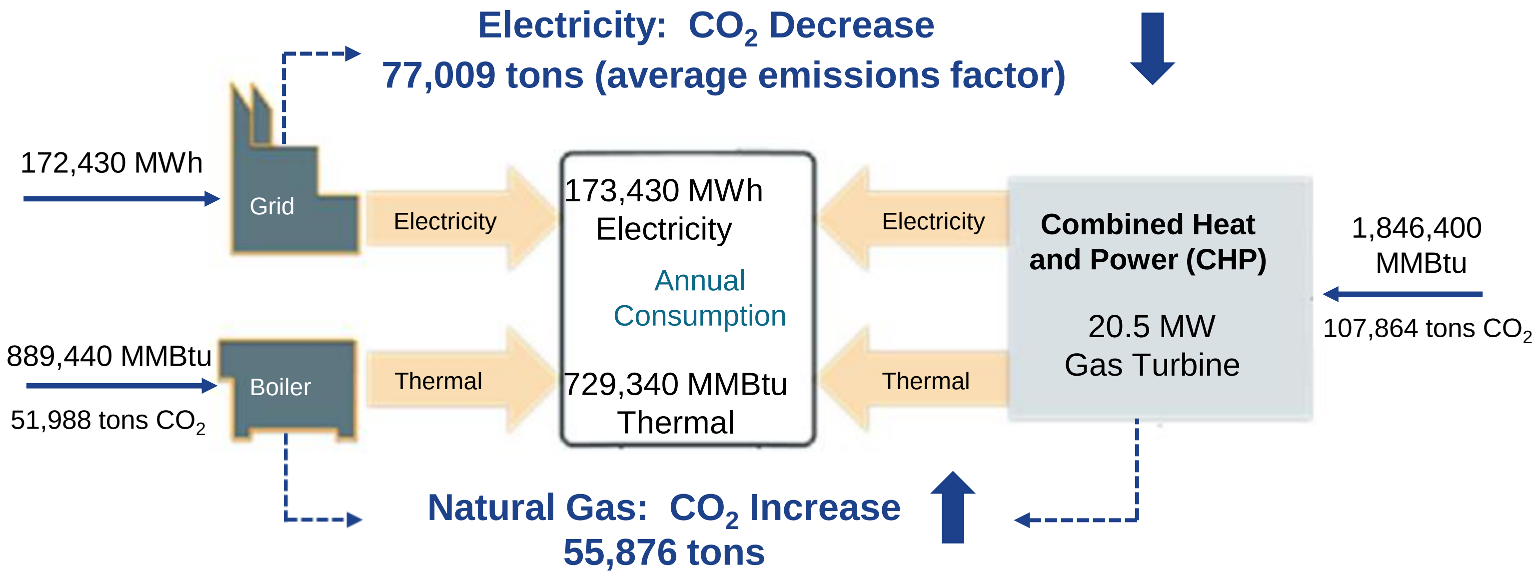
Natural gas CHP system replacing natural gas boiler and purchased electricity

- 20.5 MW Gas Turbine CHP with unfired HRSG
- Baseline CO_2 emissions at facility:
  - Scope 1: 51,988 tons
  - Scope 2: 77,009 tons*
  - **Total: 128,997 tons**
- CHP CO_2 emissions at facility:
  - Scope 1: 107,864 tons
  - Scope 2: 0 tons
  - **Total: 107,922 tons**

**EPA 2022 eGRID SERC average emissions factor with 4.5% T&D loss = 893 lbs CO_2/MWh*

Separate Heat and Power
50-55% Total Efficiency

Combined Heat and Power
72% Total Efficiency



Grid Electricity Savings = 172,430 MWh

Fuel Increase = 956,960 MMBtu

Net CO_2 reduction = 21,075 tons

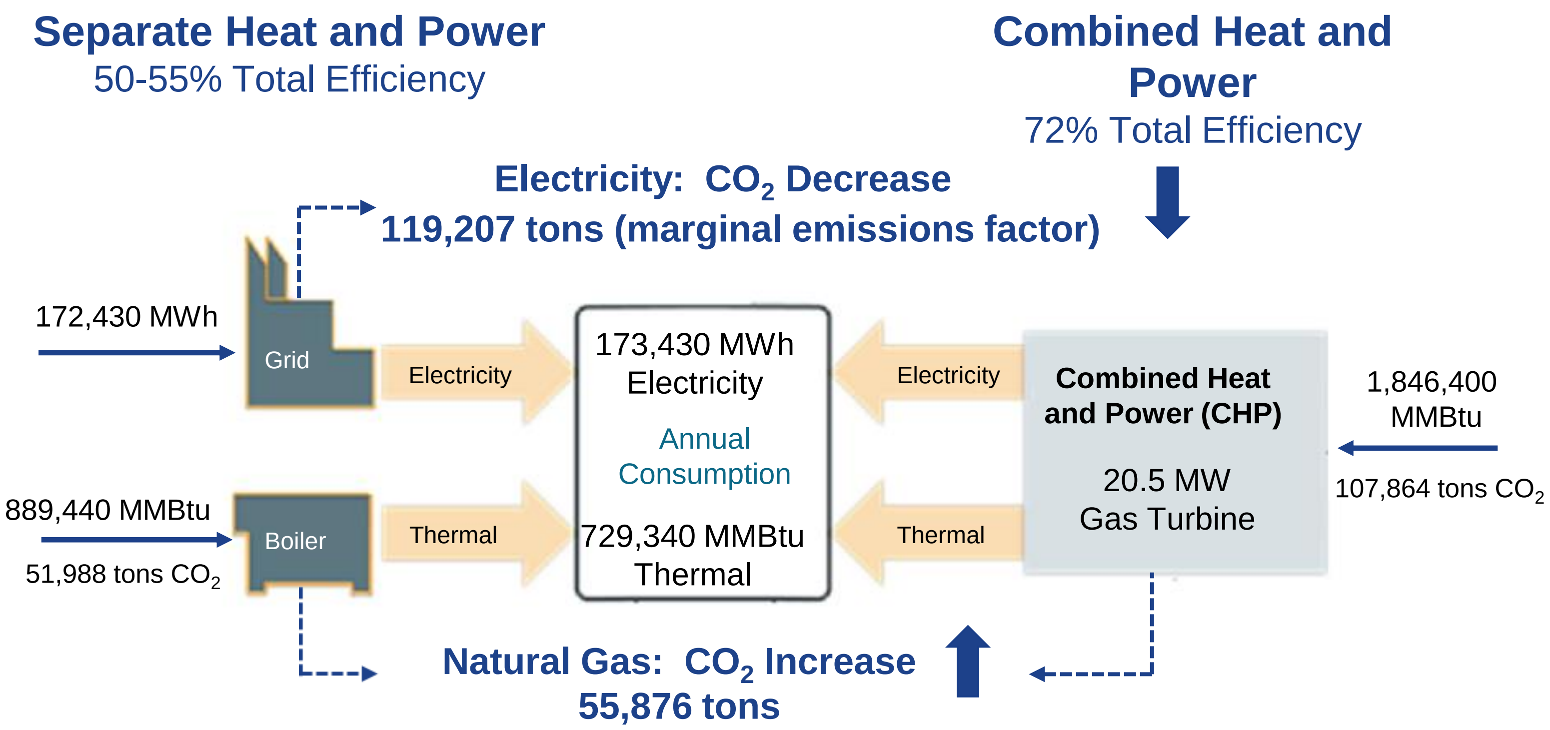
Source: Entropy Research, 2024

CHP – CO_2 Emissions Savings Based on Project Accounting

Natural gas CHP system replacing natural gas boiler and purchased electricity

- 20.5 MW Gas Turbine CHP with unfired HRSG
- Baseline CO_2 emissions at facility:
  - Fuel: 51,988 tons
  - Electricity: 119,207 tons*
  - **Total: 171,195 tons**
- CHP CO_2 emissions at facility:
  - Fuel: 107,922 tons
  - Electricity: 0 tons
  - **Total: 107,922 tons**

**EPA 2022 eGRID SERC non-baseload emissions factor with 4.5% T&D loss = 1,383 lbs CO_2/MWh*



Grid Electricity Savings = 172,430 MWh

Fuel Increase = 956,960 MMBtu

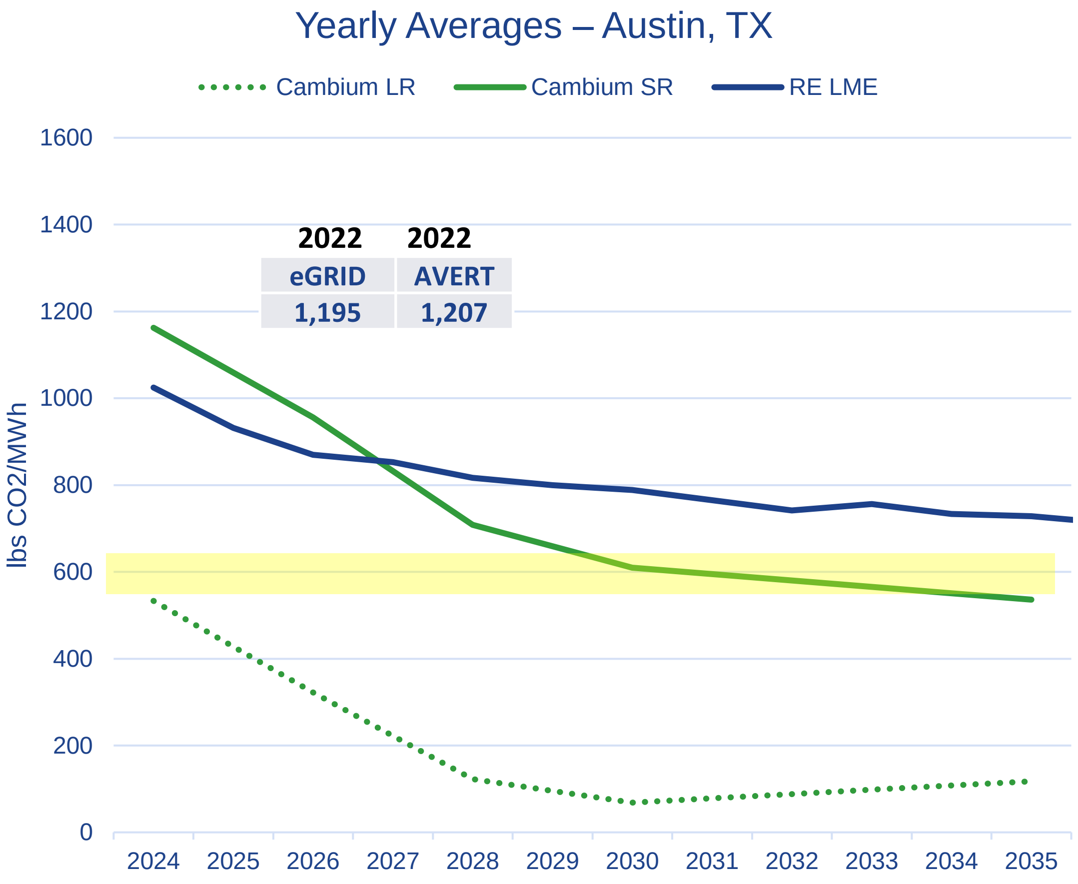
Net CO_2 reduction = 63,273 tons

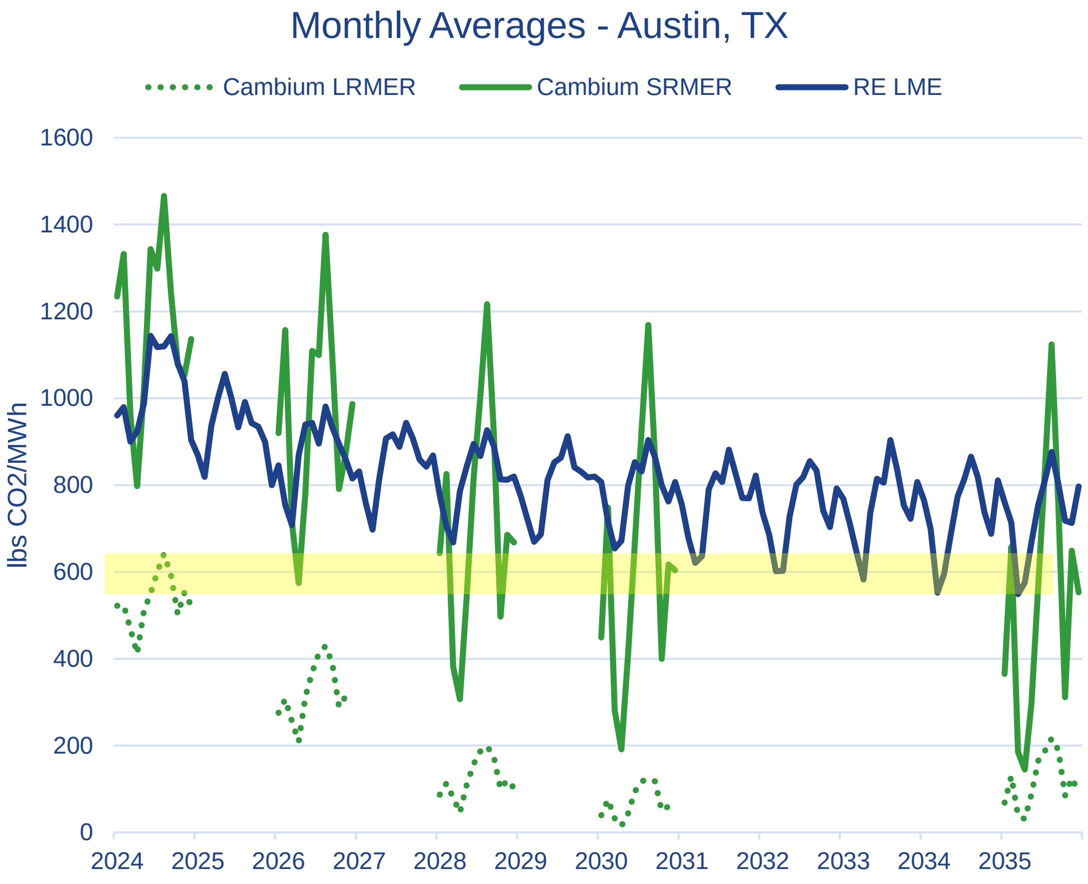
Source: Entropy Research, 2024

Sources of Marginal Emissions Data

- The U.S. EPA has two tools to estimate regional marginal emission factors:
  - Emissions & Generation Resource Integrated Database (eGRID) Annual regional and national *Non-Baseload* emissions factors - 2 year old data
  - Avoided Emissions and Generation Tool (AVERT) Annual and hourly regional and national marginal emissions rates - 1 year old data, ability to forecast over 3 to 5 year period
- NREL CAMBIUM model provides regional short run and long run marginal emissions factor projections (annual and hourly) for various scenarios
- Private forecasts of locational marginal emissions factors and projections (e,g,. REsurety, WattTime, Singularity, etc)
- Regional ISOs beginning to provide marginal emissions data (NE-ISO, PJM, MISO)

Marginal Emissions Factors – ERCOT (Austin TX area)





LR = Cambium Long Run Marginal Emissions Rate – Mid Case
SR = Cambium Short Run Marginal Emissions Rate – Mid Case
LMR = REsurety Locational Marginal Emissions Rate

CHP Net Emission Range

Source: Sterling Energy, 2024

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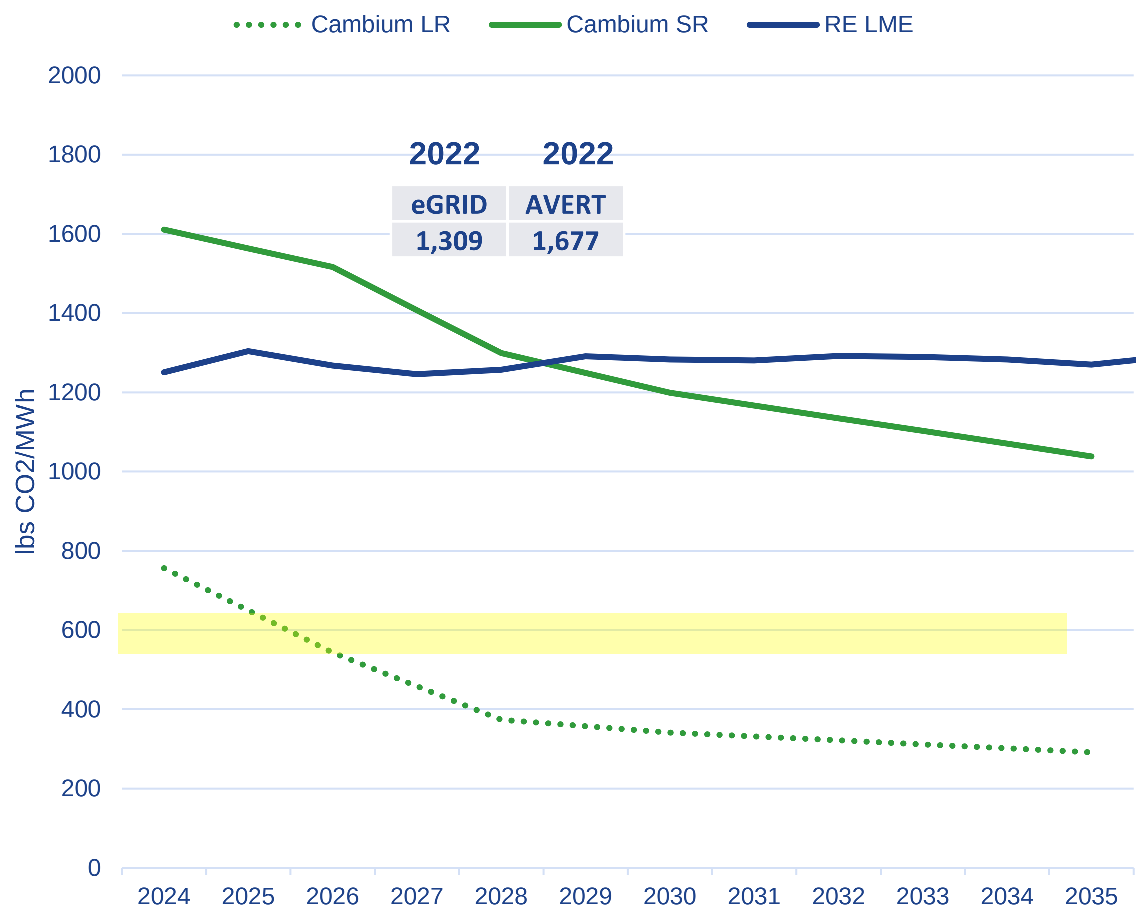
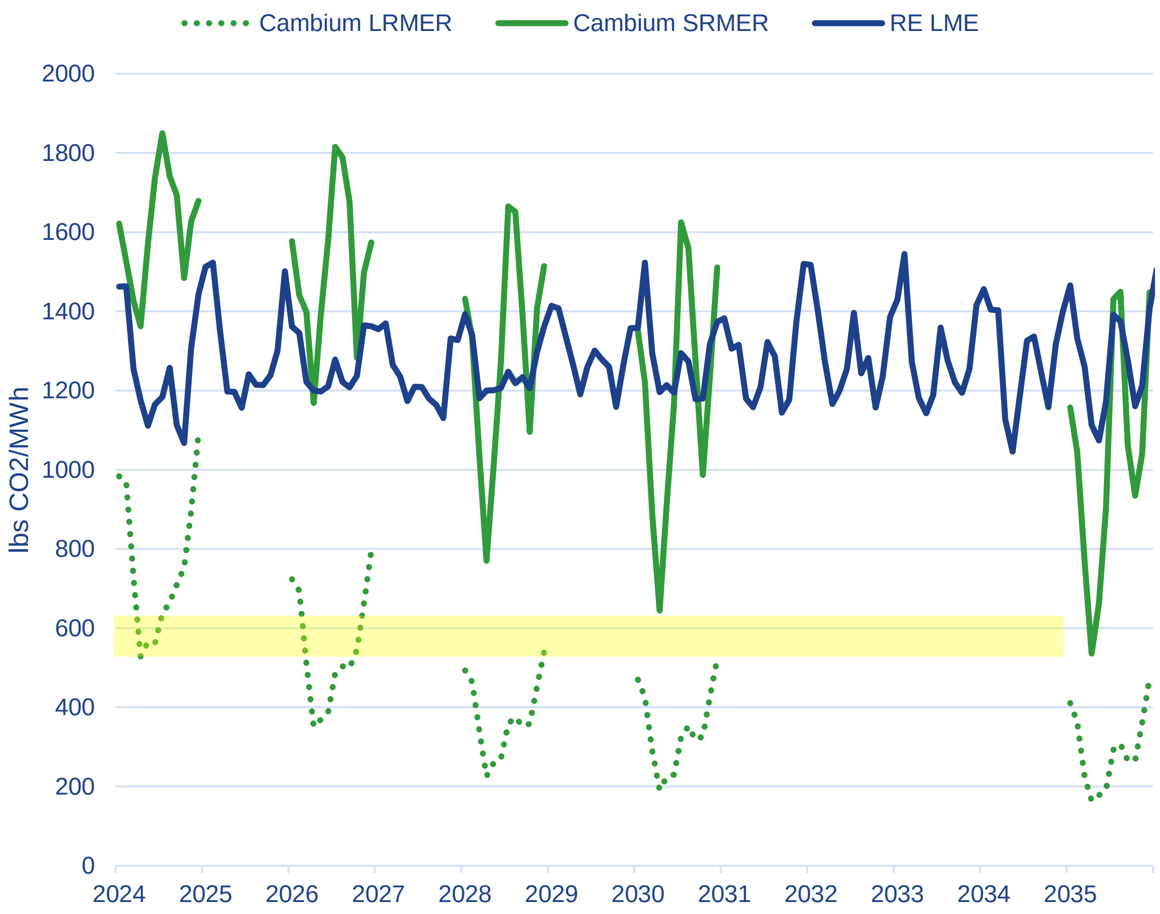
Marginal Emissions Data – PJM (Northeastern NC)

Yearly Averages – PJM North Carolina



Monthly Averages – PJM North Carolina



LR = Cambium Long Run Marginal Emissions Rate – Mid Case
SR = Cambium Short Run Marginal Emissions Rate – Mid Case
LMR = Resurety Locational Marginal Emissions Rate

CHP Net Emission Range

Source: Sterling Energy, 2024

Reporting Project Accounting Results

- Project Accounting impacts outside the site boundary are not Scopes 1 & 2 – <u>should be reported in the organization’s Additional or Supplemental Information reporting sections </u>of their overall GHG report

- Specific reporting guidance available in Project Accounting Protocol documents:
  - https://ghgprotocol.org/project-protocol
  - https://ghgprotocol.org/sites/default/files/2022-12/Guidelines%20for%20Grid-Connected%20Electricity%20Projects.pdf

- GHG Protocol is working on updated guidance to integrate Inventory and Project Accounting Reporting more effectively

inventory (see chapter 9). Appropriate information addressing the credibility of purchased or sold offsets or credits should be included.

When companies implement internal projects that reduce GHGs from their operations, the resulting reductions are usually captured in their inventory’s boundaries. These reductions need not be reported separately unless they are sold, traded externally, or otherwise used as an offset or credit. However, some companies may be able to make changes to their own operations that result in GHG emissions changes at sources not included in their own inventory boundary, or not captured by comparing emissions changes over time. For example:

- Substituting fossil fuel with waste-derived fuel that might otherwise be used as landfill or incinerated without energy recovery. Such substitution may have no direct effect on (or may even increase) a company’s own GHG emissions. However, it could result in emissions reductions elsewhere by another organization, e.g., through avoiding landfill gas and fossil fuel use.

  Installing an on-site power generation plant (e.g., a combined heat and power, or CHP, plant) that provides surplus electricity to other companies may increase a company’s direct emissions, while displacing the consumption of grid electricity by the companies supplied. Any resulting emissions reductions at the plants where this electricity would have otherwise been produced will not be captured in the inventory of the company installing the on-site plant.

  Substituting purchased grid electricity with an on-site power generation plant (e.g., CHP) may increase a company’s direct GHG emissions, while reducing the GHG emissions associated with the generation of grid electricity. Depending on the GHG intensity and the supply structure of the electricity grid, this reduction may be over- or underestimated when merely comparing scope 2 emissions over time, if the latter are quantified using an average grid emission factor.

Alcoa: Taking advantage of renewable energy certificates

Alcoa, a global manufacturer of aluminum, is implementing a variety of strategies to reduce its GHG emissions. One approach has been to purchase renewable energy certificates, or RECs, to offset some of the company’s GHG emissions. RECs, which represent the environmental benefits of renewable energy unbundled from the actual flow of electrons, are an innovative method of providing renewable energy to individual customers. RECs represent the unbundled environmental benefits, such as avoided CO_2 emissions, generated by producing electricity from renewable rather than fossil sources. RECs can be sold bundled with the electricity (as green power) or separately to customers interested in supporting renewable energy.

Alcoa found that RECs offer a variety of advantages, including direct access to the benefits of renewable energy for facilities that may have limited renewable energy procurement options. In October 2003, Alcoa began purchasing RECs equivalent to 100% of the electricity used annually at four corporate offices in Tennessee, Pennsylvania, and New York. The RECs Alcoa is purchasing effectively mean that the four corporate centers are now operating on electricity generated by projects that produce electricity from landfill gas, avoiding the emission of more than 6.3 million kilograms (13.9 million pounds) of carbon dioxide annually. Alcoa chose RECs in part because the supplier was able to provide RECs to all four facilities through one contract. This flexibility lowered the administrative cost of purchasing renewable energy for multiple facilities that are served by different utilities.

For more information on RECs, see the Green Power Market Development Group’s Corporate Guide to Green Power Markets: Installment #5 (WRI, 2003).

These reductions may be separately quantified, for example using the GHG Protocol Project Quantification Standard, and reported in a company’s public GHG report under optional information in the same way as GHG trades described above.

GUIDANCE

NOTES

[1] Primary effects are the specific GHG reducing elements or activities (reducing GHG emissions, carbon storage, or enhancing GHG removals) that the project is intended to achieve.

[2] This problem with the temporary nature of GHG reductions is sometimes referred to as the “permanence” issue.

[3] The term “GHG trades” refers to all purchases or sales of allowances, offsets, and credits.

Statements by GHG Protocol Regarding Importance of both Inventory and Project Accounting*

- *“**With Project Accounting, the GHG assessment boundary encompasses GHG effects, regardless of where they occur** and who has control over the GHG sources or sinks associated with them”*

- *“**Project accounting enables sustainability professionals to consider system-wide impacts of interventions or projects** and pursue those that go beyond reducing their own GHG emissions inventories to reduce emissions across an entire system”*

- *“**A company can use both GHG Protocol modules in combination to meet different purposes and objectives.** Where a company is developing an inventory of its corporate-wide GHG emissions, the Corporate Accounting Standard can be used. If the same company develops a GHG project, then the Project Protocol can be used to quantify its project-based GHG reductions.” (page 8 GHG Project Accounting Standard)*

- *“**Throughout both the GHG Protocol Corporate Standard and Project Protocol, there is a clear recognition of the value these two fundamental accounting methods provide to organizations in evaluating their decarbonization strategies**. <u>Companies should generate and use both types of information to inform decision-making”</u>*

* December 20, 2023

5 Minute Break

How to Apply Project Accounting to CHP Projects

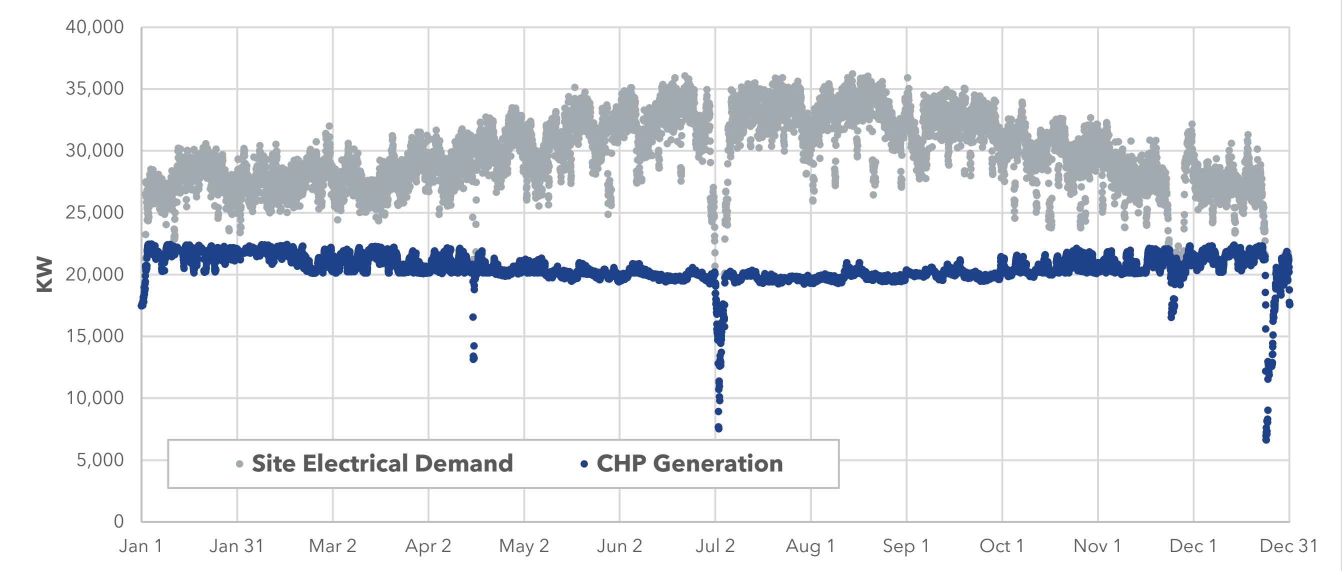
Levi Hoiriis
Sterling Energy Group, LLC

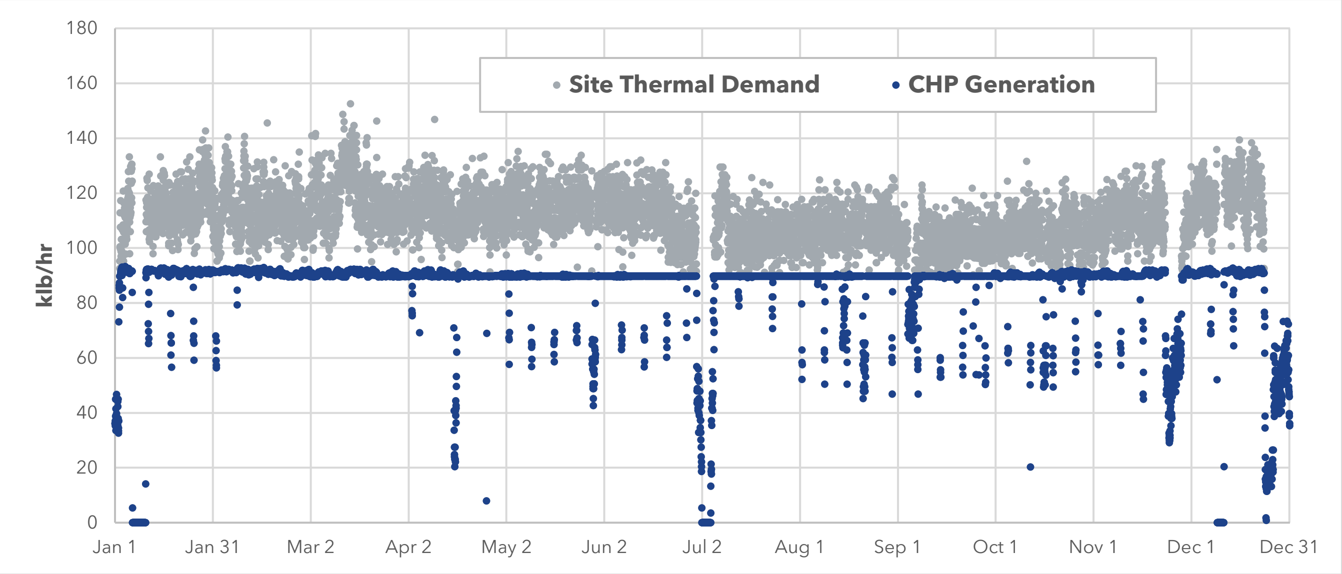
High-Level Steps for Project Accounting

- Define the GHG assessment boundary
  - For grid-connected CHP plants, this will typically be those resources that would serve the facility’s electric and thermal loads under a separate heat and power scenario, i.e., the regional electric grid and alternative thermal energy resource
- Estimate Baseline Emissions
  - This will typically be based on historical fuel and electricity consumption, taking into account any anticipated changes to facility operating profile and equipment
- Estimate Project Emissions
  - These numbers will generally be derived by modeling of the proposed project
- Monitor and Quantify GHG Reductions
  - After start-up, actual operating data from the CHP and actual grid emissions rates should be used to validate the estimated emissions savings

Emissions Accounting for Example CHP Project

- The upper chart shows the hourly electric demand of an industrial facility along with the electrical output of a 20 MW CHP plant
  - Gray markers represent the demand for the facility
  - Blue markers represent CHP electrical output
- The lower chart shows the hourly thermal demand of an the facility along with the unfired thermal output from the CHP plant
  - Gray markers represent the demand for the facility
  - Blue markers represent CHP thermal output





Baseline and Project Fuel Emissions

- Fuel related emissions
  - Calculating the emissions associated with the fuel consumptions is relatively straight forward using fuel-specific emissions factors and the equation below.
  - In this case, all fuel consumption is natural gas, so a factor of 116.9 lb CO_2/MMBtu was used
    - This is the rate for combustion of natural gas. In some cases, upstream emissions related to the production of the fuel are included. These upstream emissions impacts can be used for the analysis so long as the calculated grid-emissions rates use the same underlying assumptions.

$$Thermal\ Emissions\ = \frac{F \cdot ER_F}{2000}$$

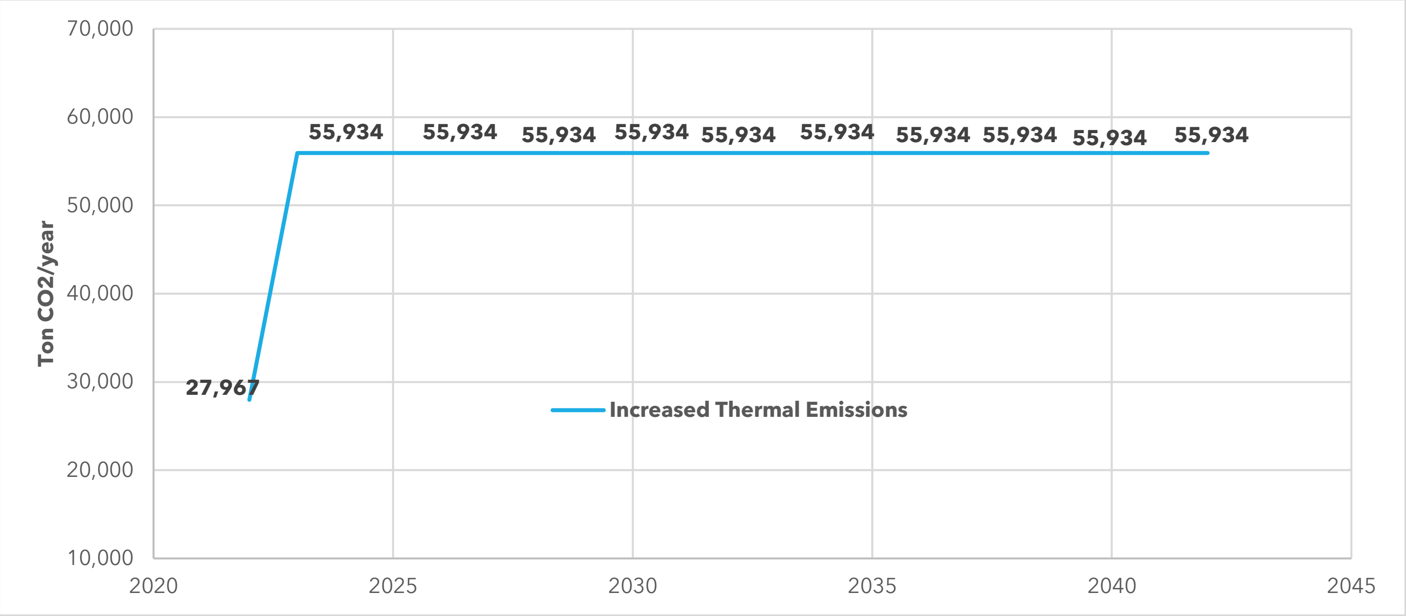
Where,

F	=	Annual fuel use, MMBtu/yr
ER_F	=	Fuel-specific emissions rate, lb/MMBtu
2000	=	Conversion from lb to Ton

Baseline and Project Fuel Emissions

- Fuel related emissions
  - In this example, the baseline fuel consumption is ≈1,100,000 MMBtu/yr or approximately 64,350 Ton CO_2/year.
  - For the CHP scenario, the fuel consumption rises to approximately 2,058,000 MMBtu/yr, or ≈120,300 Ton CO_2/year.
  - Thus, the fuel related emissions increase by ≈55,930 Ton/yr.

In this example, the expected start-up of the CHP plant was mid-2022, so the project is expected to operate for only half of that year.



Baseline and Project Electric Emissions

- Electric energy emissions
  - Guidelines from GHG Protocol's Project Accounting standard outline the steps for estimating what electrical generating units would serve the project and how to estimate the impact of the project on the build and operating margins through the life of the project.
  - In today's rapidly evolving grid, this would be a complicated and time-consuming effort. However, the marginal emissions forecasting models essentially supersede the steps required by Project Accounting. The data available from these models can be leveraged to use the latest and most sophisticated industry model data, and establish a project baseline derived for project-specific inputs. This provides the best available forecast of a CHP or other GHG mitigation project (RE, efficiency, etc.) against its baseline.
  - This example will use data from Cambium, which calculates both a short-run and long-run marginal emissions rate. Short-run (SRMER) is an operational rate similar to that calculated by EPA's AVERT. Long-run (LRMER) estimates what the marginal emissions rate would be factoring in how an intervention might influence the structure of the grid.
  - Because smaller, behind-the-meter CHP impacts the grid essentially as a reduction in load, is frequently still backed up by the grid, and can be dispatched against price or carbon signals, a short-run marginal rate is an appropriate metric for use in calculating CHP's emissions impacts for Project Accounting.

Baseline and Project Electric Emissions

- Electric energy emissions
  - In this example, the baseline electric purchases from the grid are 257,500 MWh/yr and the CHP scenario electric purchases from the grid are 85,000 MWh/yr (CHP system reduces grid purchases by 172,500 MWh/yr).
  - Note that when the additional 55,930 Ton CO_2 associated with the fuel increase is spread over the 172,500 MWh avoided, the average carbon intensity of the avoided purchases is ≈650 lb CO_2/MWh.
  - If the hourly operation of the CHP plant is available, this can be used along with the hourly Cambium data to calculate project-specific marginal emissions rate based on the expected dispatch of the plant using the equation below.

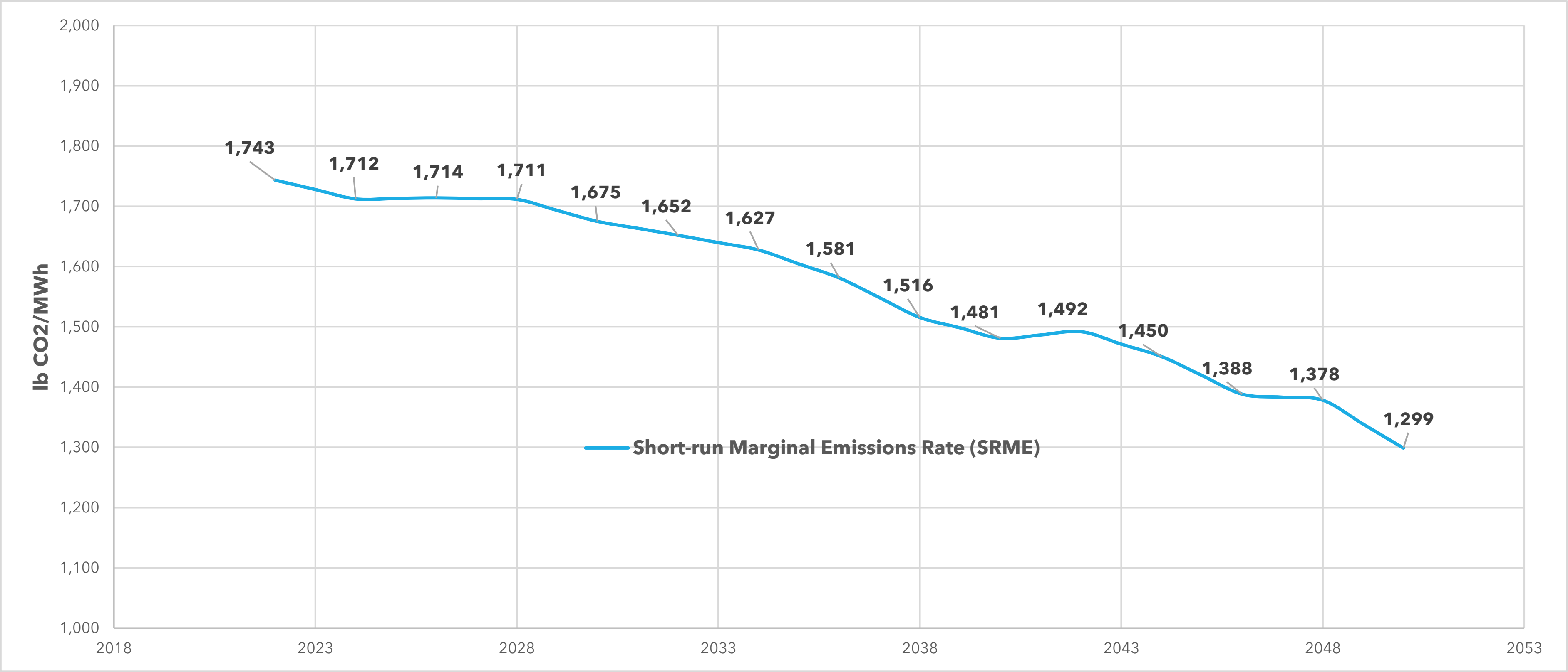
$$ER_W = \frac{\sum_{i=1}^{8760} P_i \cdot ER_i}{\sum_{i=1}^{8760} P_i}$$

Where,

ER_W	=	Weighted emissions rate
P_i	=	Hourly CHP electrical output
ER_i	=	Hourly emissions rate

Marginal Emissions Forecasts

- The chart below shows the weighted average marginal emissions rate for the Southeast region compared to the net CHP emissions rate for this example.



Baseline and Project Electric Emissions

- Electric energy emissions
  - Avoided grid emissions associated with the project can be calculated using the annual CHP electrical generation and the weighted average emissions rates using the equation below
  - Because the project is only expected to operate during half of 2022, the emissions reductions for that year are based on only those months of operation

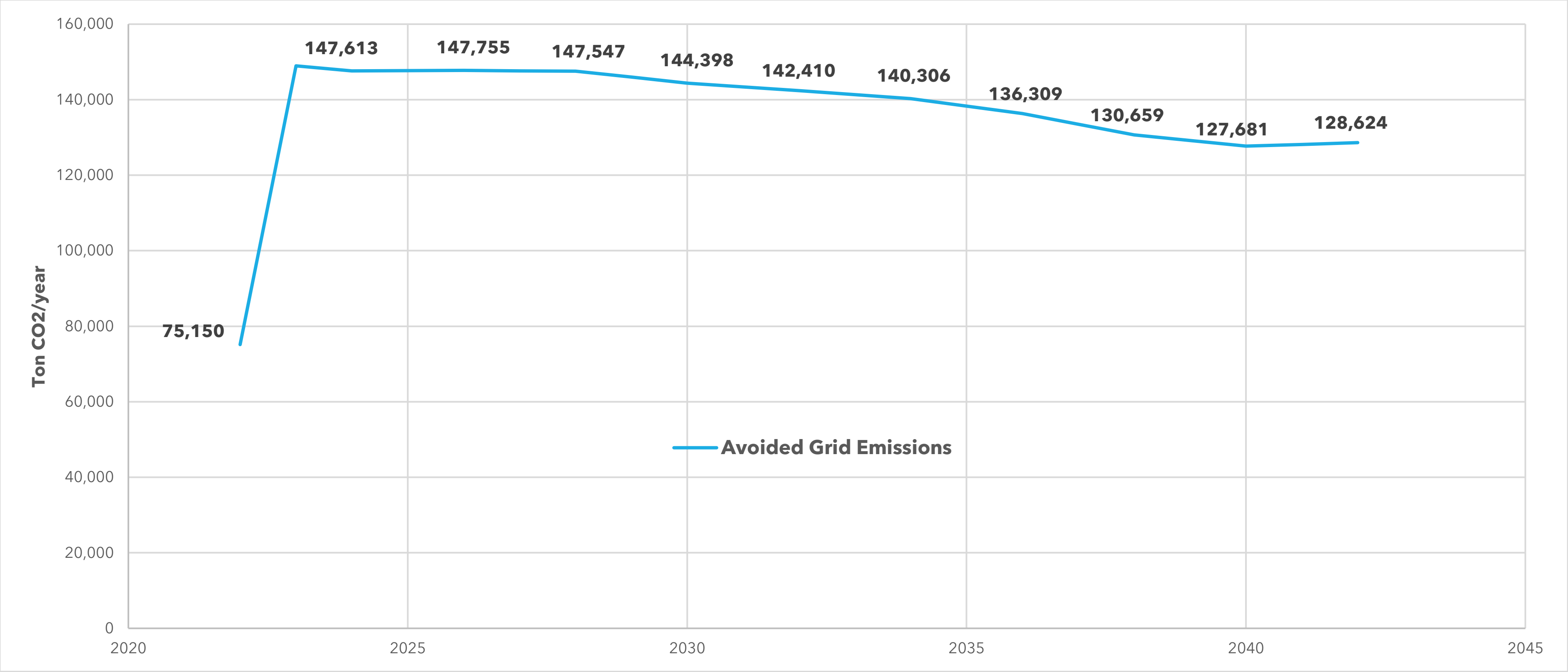
$$Marginal\ Grid\ Emissions\ Savings\ = \frac{(P_{BL} - P_{CHP}) \cdot SRMER_W}{2000}$$

Where,

P_{BL}	=	Baseline purchased power, MWh/yr
P_{CHP}	=	CHP purchased power, MWh/yr
$SRMER_W$	=	Weighted average short-run marginal emissions rate, lb/MMBtu
2000	=	Conversion from lb to Ton

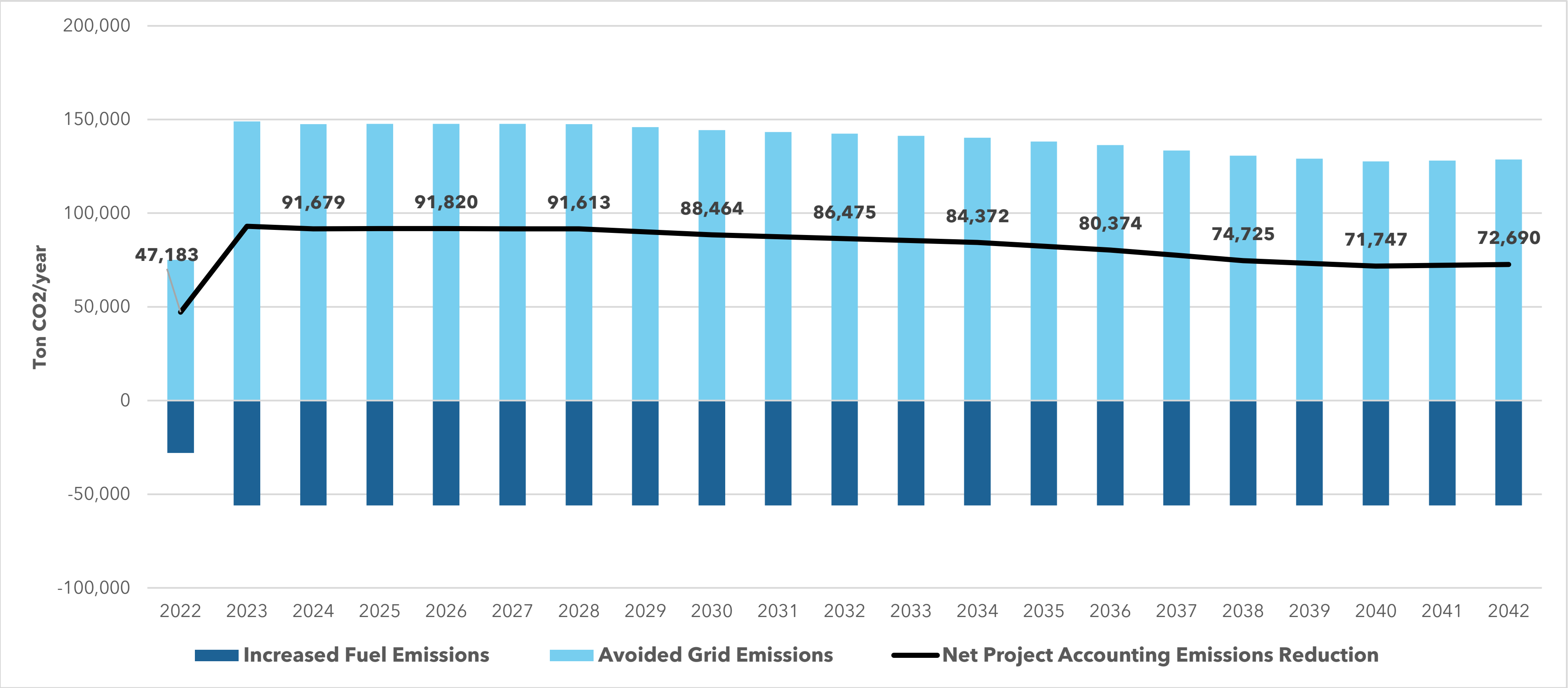
Hourly Marginal Emissions Rates

- The chart below shows the estimated annual grid emissions reductions
- Because the project was expected to operate during half of 2022, the emissions reductions for that year are based on only those months of operation.



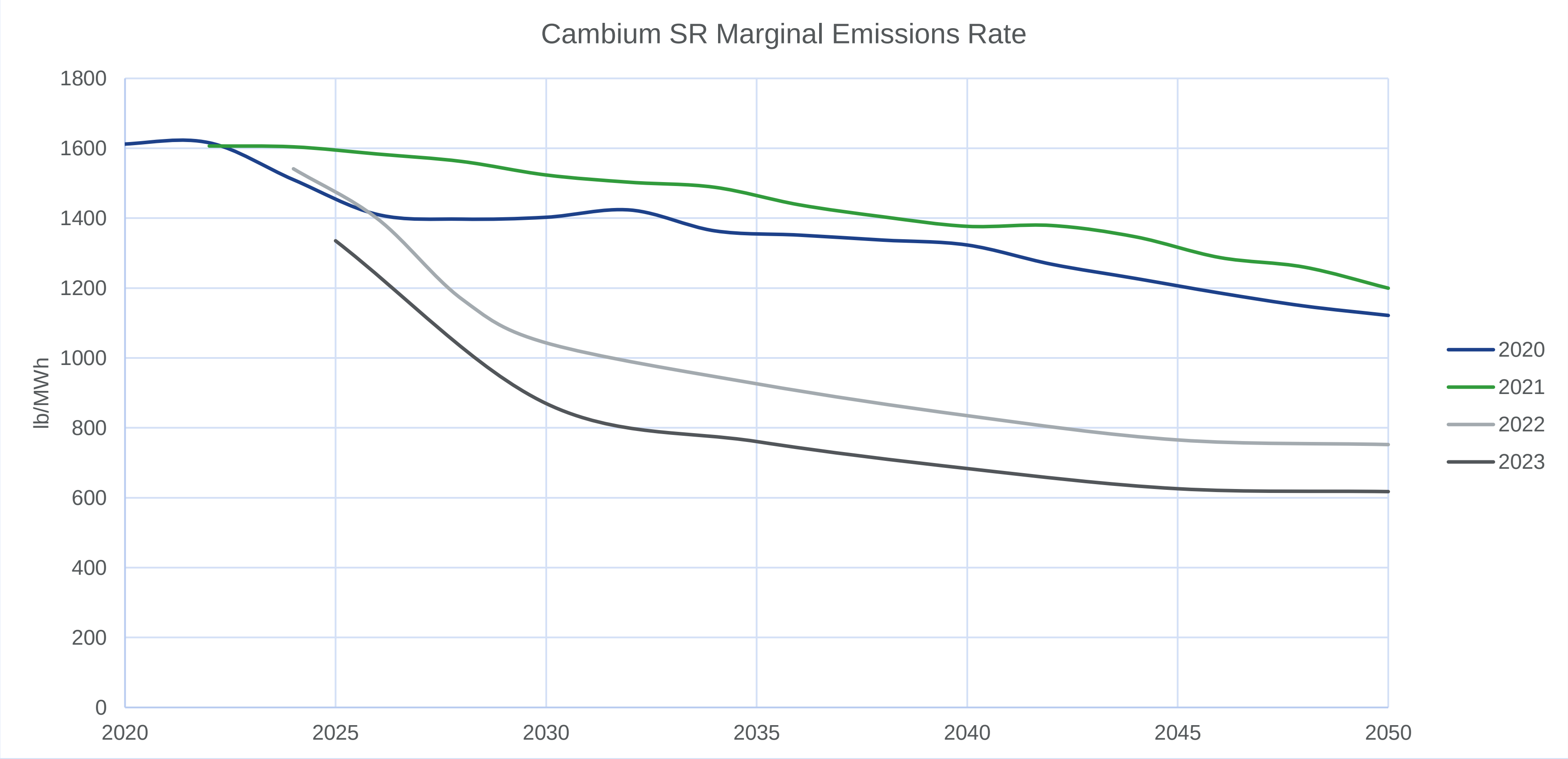
Project Accounting Emissions

- The chart below shows the net emissions from the project with the increased fuel emissions deducted from the avoided grid emissions. Lifetime savings is projected to be 1,725,000 Tons.
- However, this is the **projection**. Actual data should be used to calculate the final numbers as they become available.



Projections Are Just That – And do Change

- The final step of monitoring and quantifying actual emissions savings is critical. Projections can change quickly, as shown in the chart below showing Cambium's SRMER projections.
  - The next release has a high chance of coming back up closer to 2021 due to tremendous electrical load growth and the 75GW of natural gas generating capacity currently planned to be built – this is not reflected in the 2023 numbers below.



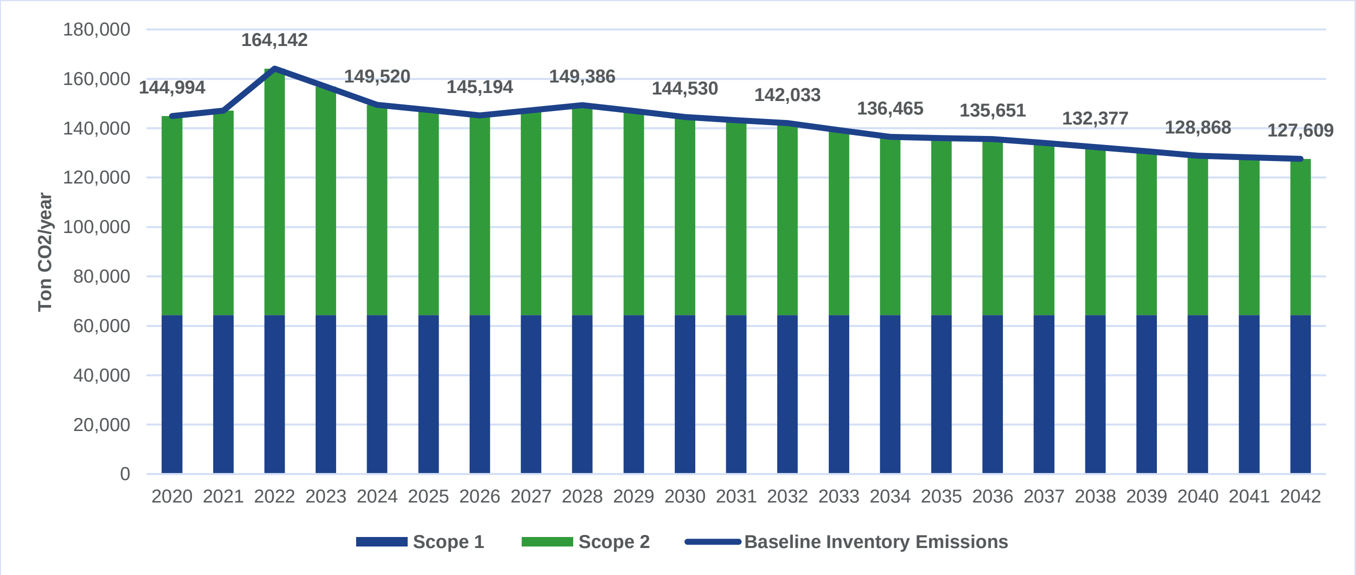
Monitoring Actual Emissions Reductions

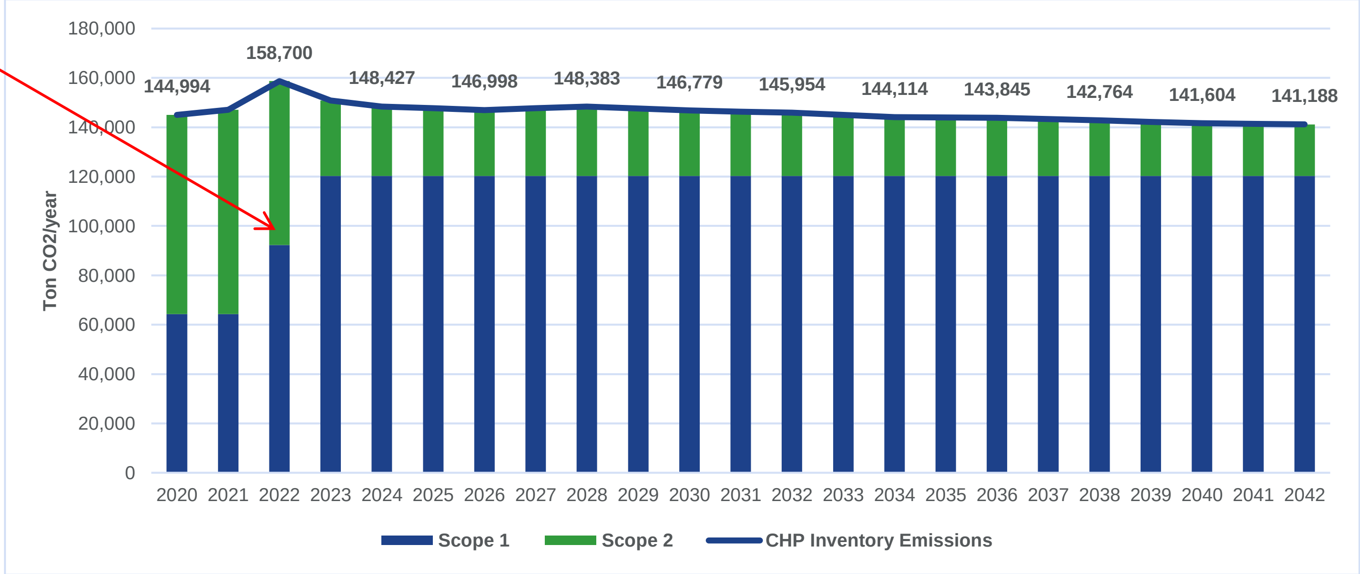
- Once the project is operating, actual CHP project operations should be monitored and recorded so that previously established forecasts of baseline and project emissions can be replaced with actual project operation and actual grid marginal emissions rates.
- For this example, the forecasted SRME rates calculated from the Cambium 2021 dataset were 1,743 lb CO_2/MWh for 2022 and 1,728 lb CO_2/MWh for 2023. However, actual marginal emissions rates for 2022 and 2023, as calculated by AVERT, ended up being 1,434 and 1,511 lb CO_2/MWh.
- Thus, actual savings would have been less than projected, as shown in the table below.

	Projected Savings			Actual Savings		
Year	**Thermal**	**Electric**	**Total**	**Thermal**	**Electric**	**Total**
2022	-27,967	75,150	47,183	-27,967	61,810	33,843
2023	-55,934	148,957	93,023	-55,934	130,307	74,372

How Does Project Fare with Inventory Accounting

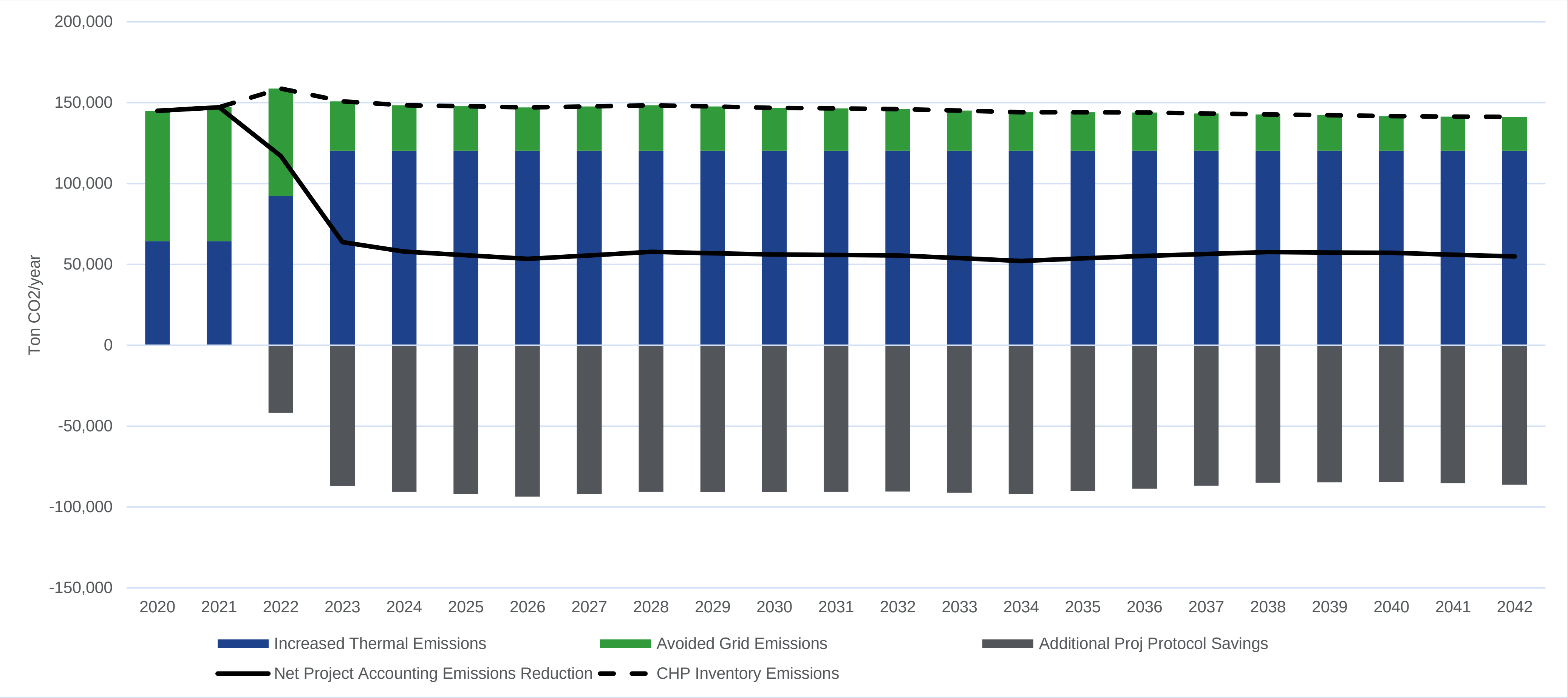
- The upper chart shows the separate heat and power inventory accounting for the facility (BAU)
- The lower chart shows the inventory accounting for the CHP case, assuming the project went online in mid-2022.
- Because inventory accounting uses average grid emissions rate, the electric savings shown here is much lower than for project accounting.





Showing Combined Inventory and Project Accounting

- Results from Project Accounting are separate from Inventory Accounting, but we can show a combined impact.



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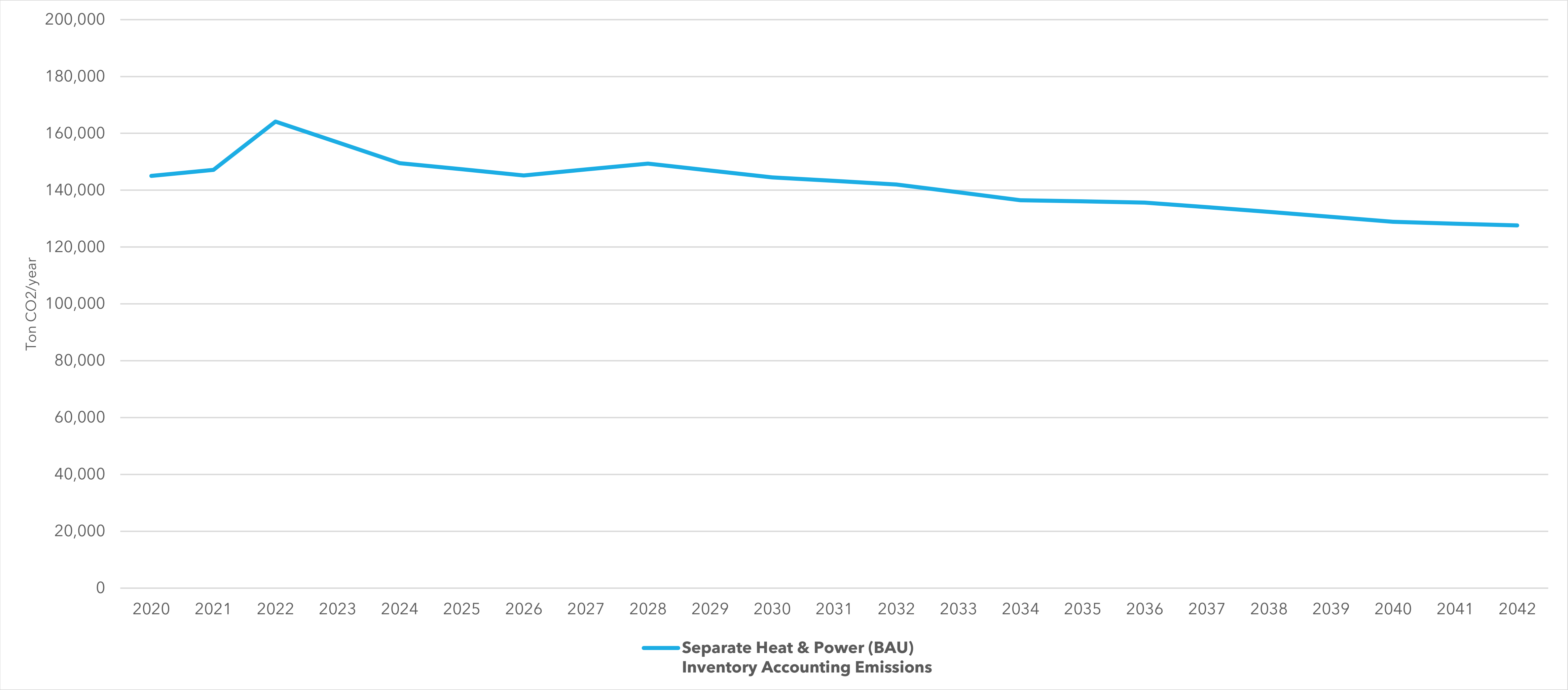
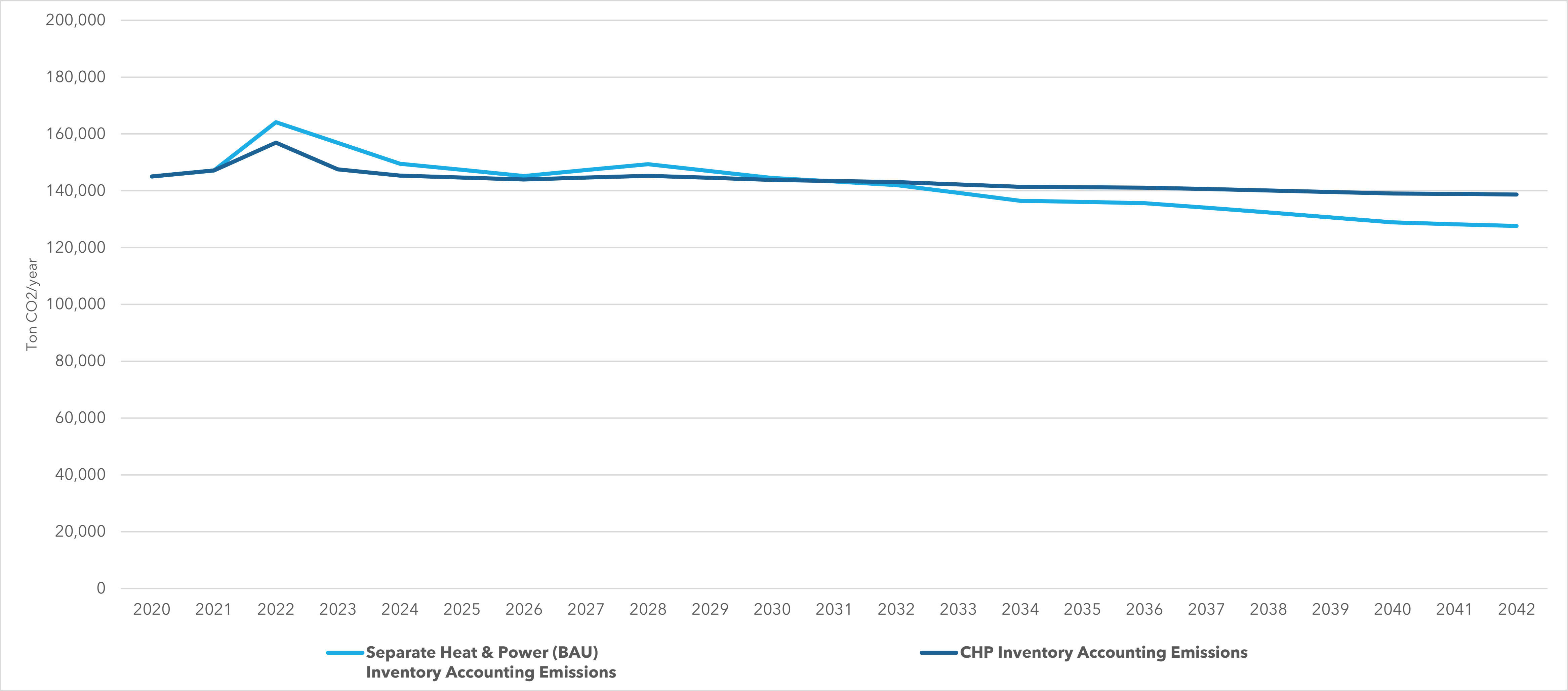
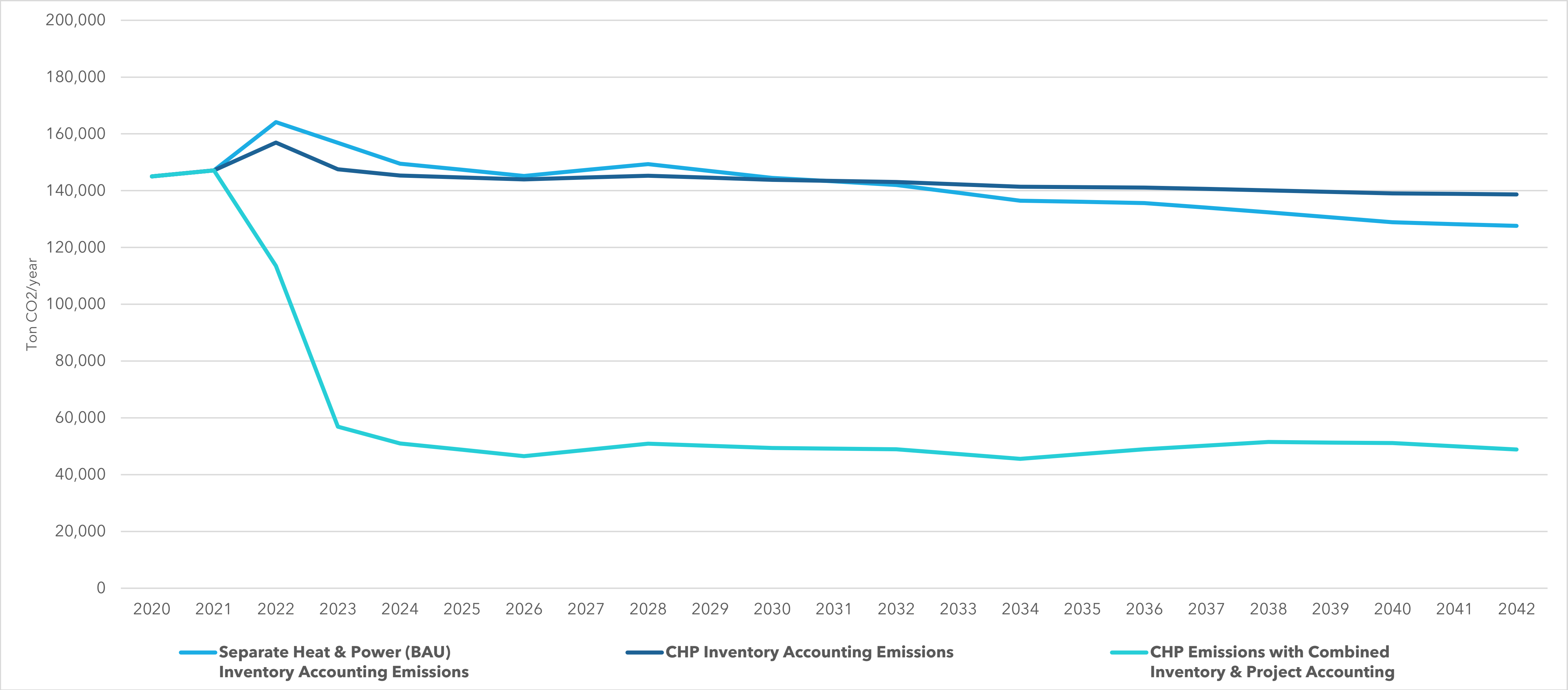
Emissions Comparison



Emissions Comparison



Emissions Comparison



Key Considerations in Evaluating Project Emissions Impacts

- **Energy projects such as CHP that impact grid electricity consumption result in GHG emissions impacts beyond the facility boundary – these impacts can be captured by use of *marginal grid emissions* factors as prescribed in the GHG Protocol's Project Accounting methodology**
  - Grid-connected energy projects impact the use of marginal generation resources across the grid
- **GHG Protocol's Corporate Standard's reporting of Scope 2 emissions for inventory accounting is based on *average grid emissions* factors – this does not capture the full emissions impacts**
  - Used for annual tracking and reporting of <u>physical</u> GHG emissions <u>at the facility</u>
- **The GHG Protocol Corporate Standard allows for separate reporting of the impacts of grid connected projects based on *marginal emissions* factors (Project Accounting)**
  - Marginal emissions factors account for emissions impacts outside the boundaries of the facility that are not captured in current inventory reporting, but can be documented and reported separately
- **The operating and build margin calculations required by GHG Protocol's Project Accounting are superseded with the availability of sophisticated marginal emissions models, but continued validation of actual operation is key**
  - Marginal emissions information is becoming increasingly available from utilities, ISOs, and others.

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Forecasting CHP’s U.S. GHG Impact Over the Next 25 Years Using a Marginal Emissions Model

Levi Hoiriis
Sterling Energy Group, LLC

U.S. DEPARTMENT OF ENERGY

Cambium 2023 GEA Regions

- Cambium 2023 models the contiguous US as 134 balancing areas which are combined into 18 generation and assessment (GEA) regions.
- The chart at right shows a map of the regions. Note that these regions are somewhat different than eGRID or AVERT regions.

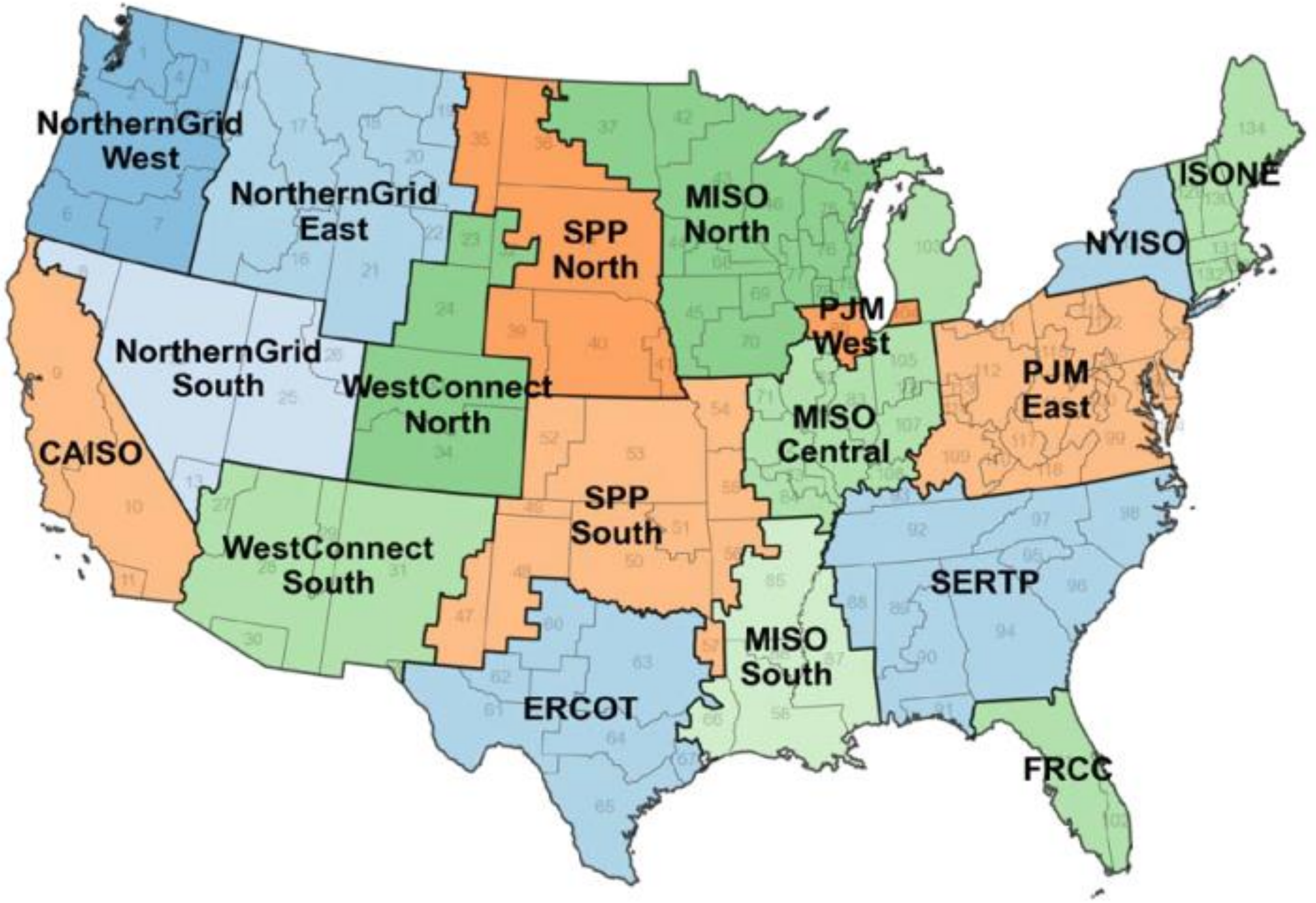
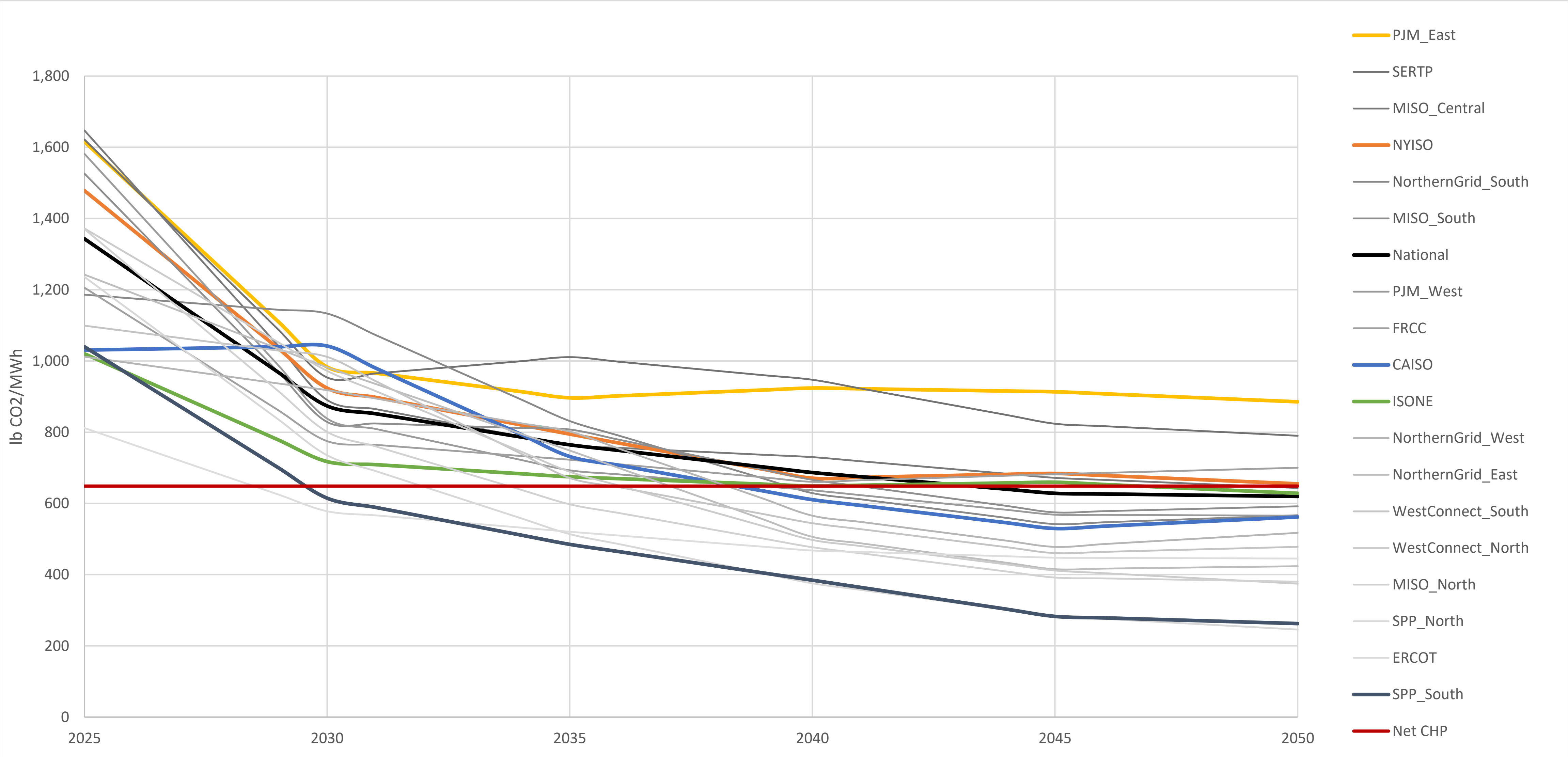


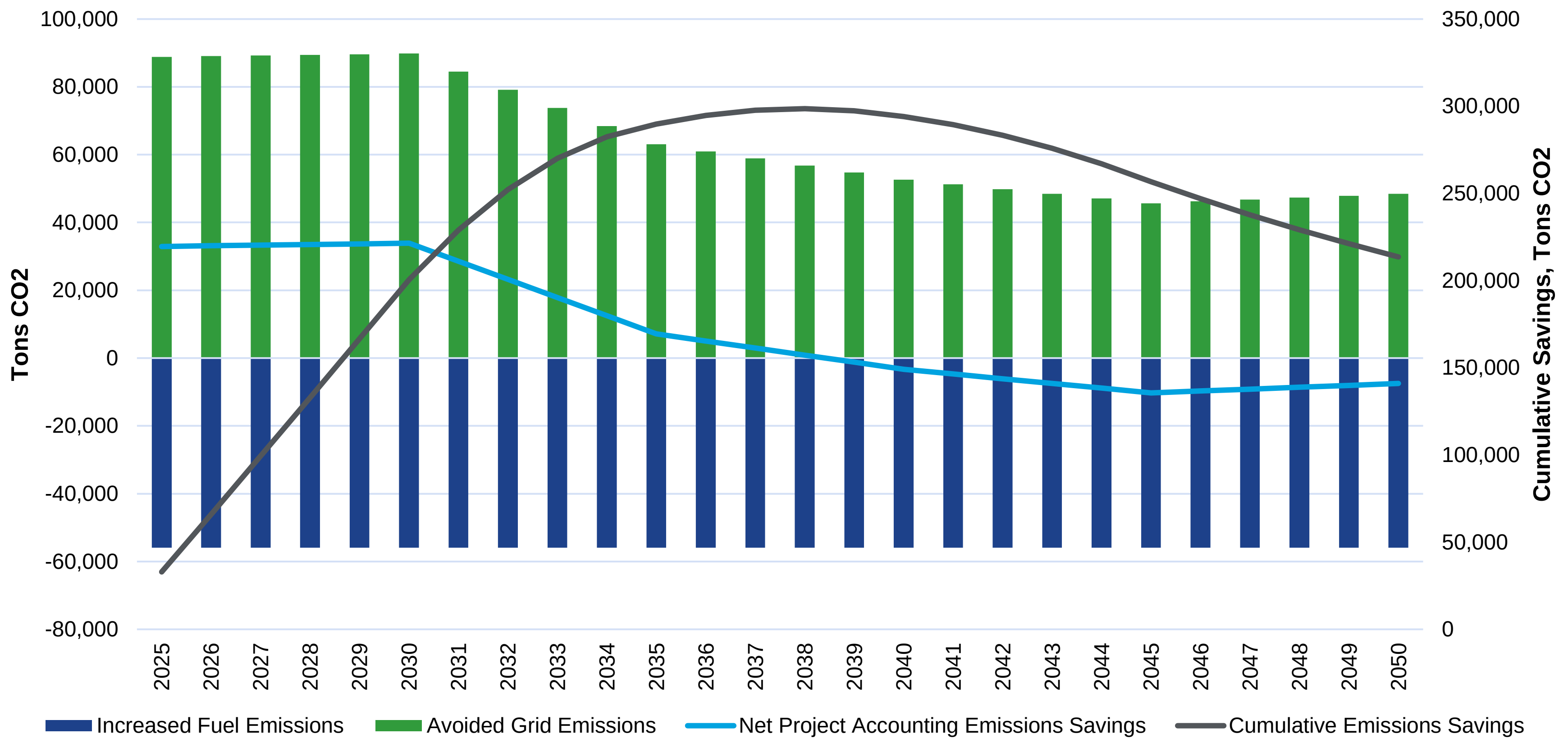
Figure 7: Cambium's generation and emission assessment (GEA) regions, 2023 version

Cambium 2023 Regional SRMERs vs 20MW Net CHP Emissions Rate

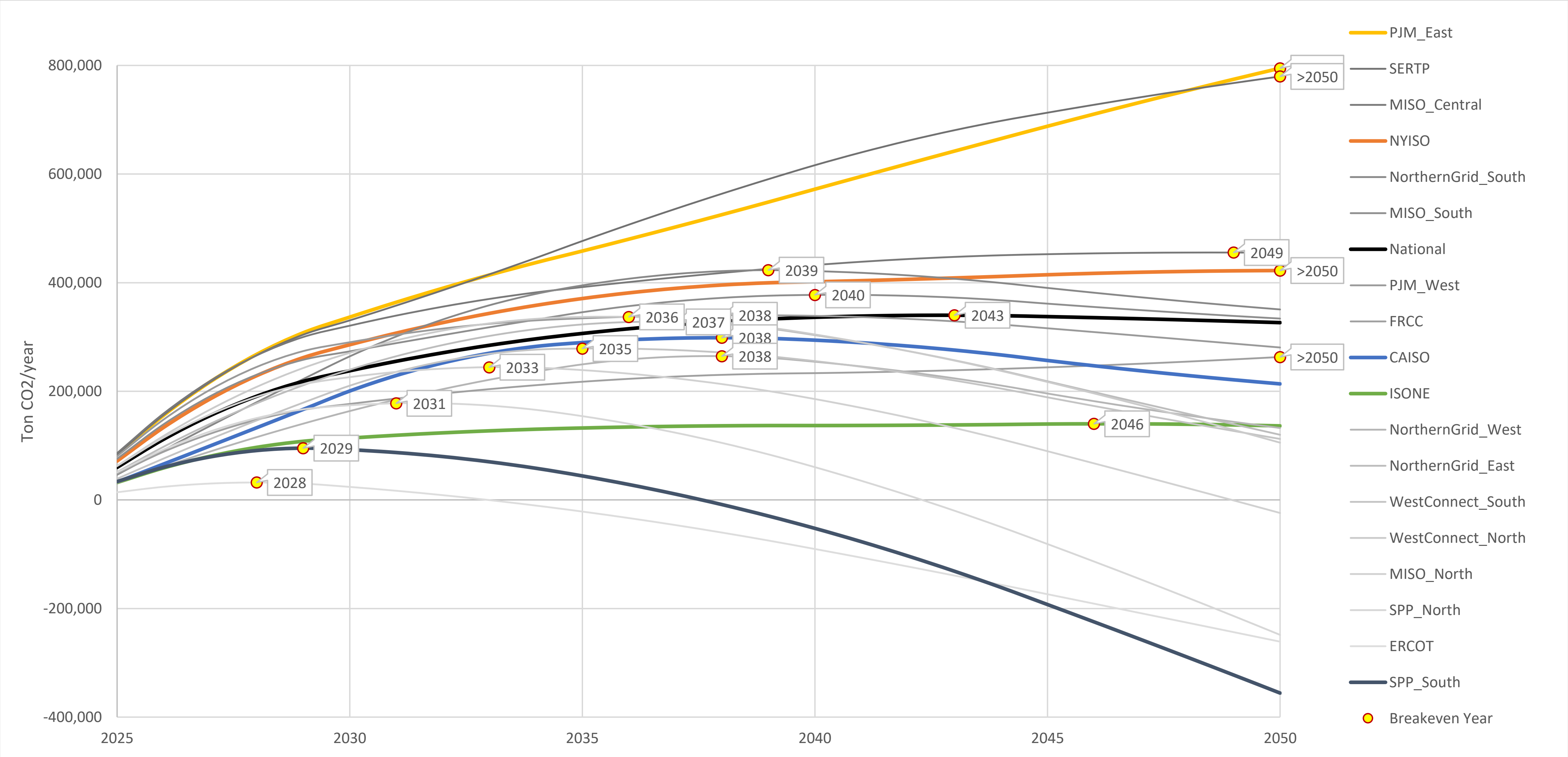


Project Accounting Emissions for 20MW CHP Plant

- The chart below shows the net emissions from the project with the increased fuel emissions deducted from the avoided grid emissions. Savings is based on Cambium 2023 data for the CAISO region.

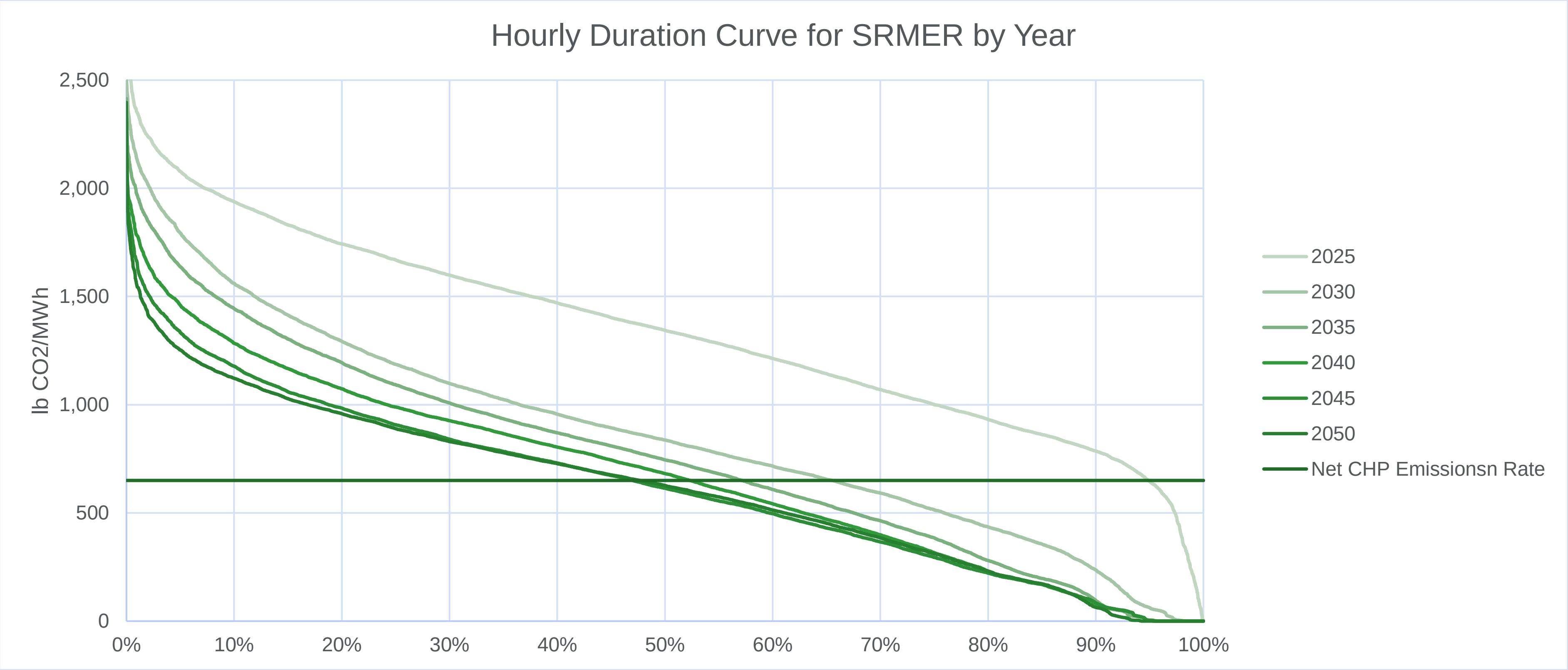


Cumulative Emissions Savings by Region for 20MW CHP Plant



Hourly Marginal Emissions Rates

- The chart below shows the hourly SRMER (national average) by year compared to the net CHP emissions rate. CHP plants can improve their net rate of emissions by dispatching according to grid carbon intensity.



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CHP's Impact as a Decarbonization Option for Industry into the 2040s and 2050

Bruce Hedman

Entropy Research, LLC

Recap - GHG Protocol's Project (Intervention) Accounting

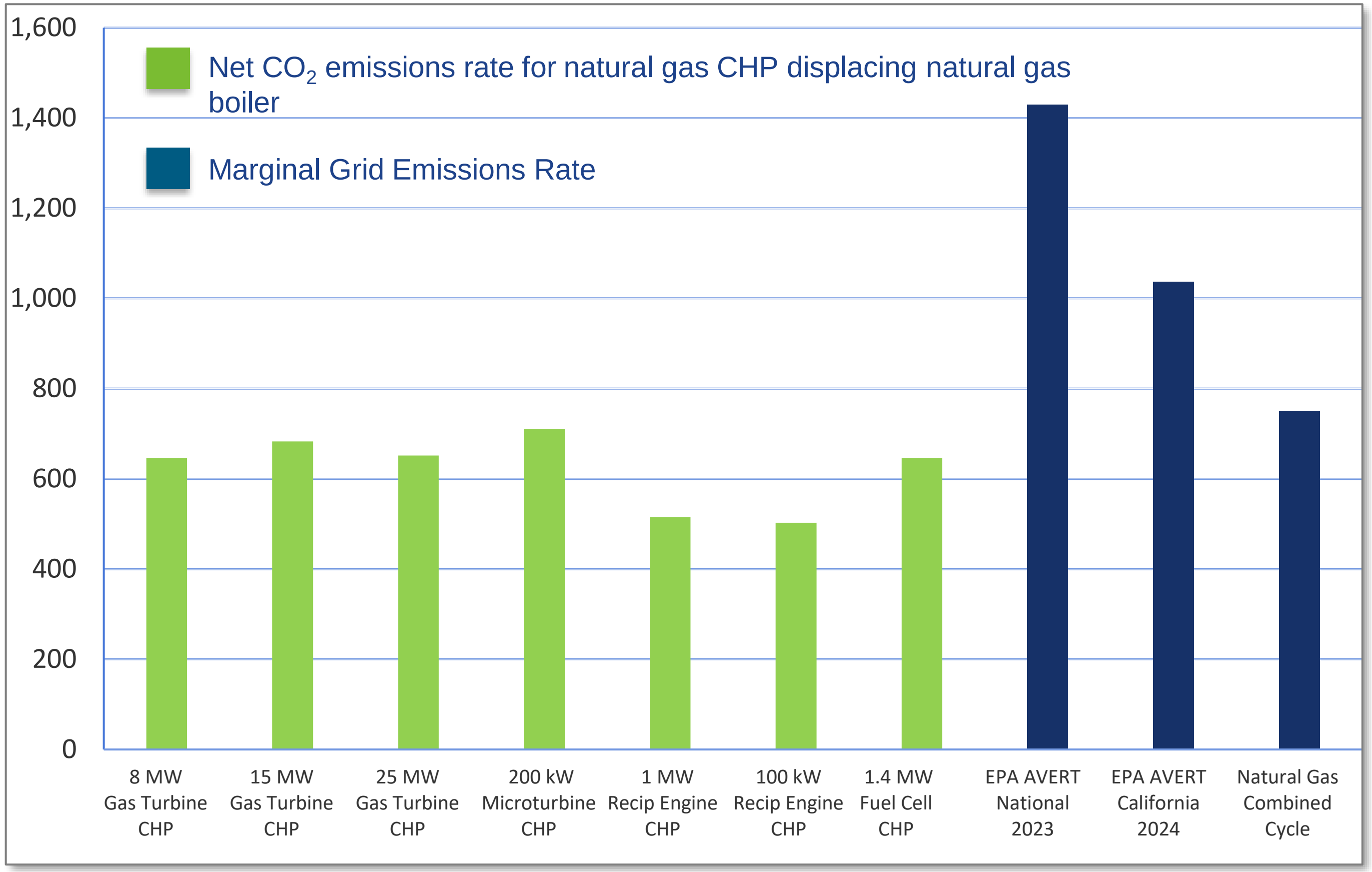
- **Project Accounting (Intervention) Methodology**
  - Used to quantify the impacts (consequences) on GHG emissions or removals caused by specific GHG project's actions or interventions - outside site boundaries
  - A Baseline must first be established by forecasting GHG impacts relative to a counterfactual scenario (baseline without project /intervention) to compare Project results against
- **Inventory Accounting (Attributional or Allocational) Methodology**
  - Continues to be used for tracking and reporting physical GHG emissions & removals annually
- **Organization continues to report actual Scope 1 & Scope 2 emissions in Inventory Accounting**
  - While also reporting project-based emissions against the established Baseline – which can report emission reductions resulting from the project which occur outside the site boundary

Natural Gas CHP Emissions vs Marginal Grid Emissions

- CHP displaces marginal grid generation
- Natural gas CHP provides emissions savings as long as the marginal grid emissions rate is greater than 450 to 675 lbs CO_2/MWh
- Natural Gas CHP reduces GHG emissions in all regions of the country today (*marginal grid emissions factors range from 1,037 lbs CO_2/MWh in California/New England to 1,890 lbs CO_2/MWh in the Rocky Mountain region*)*
- *"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"*

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

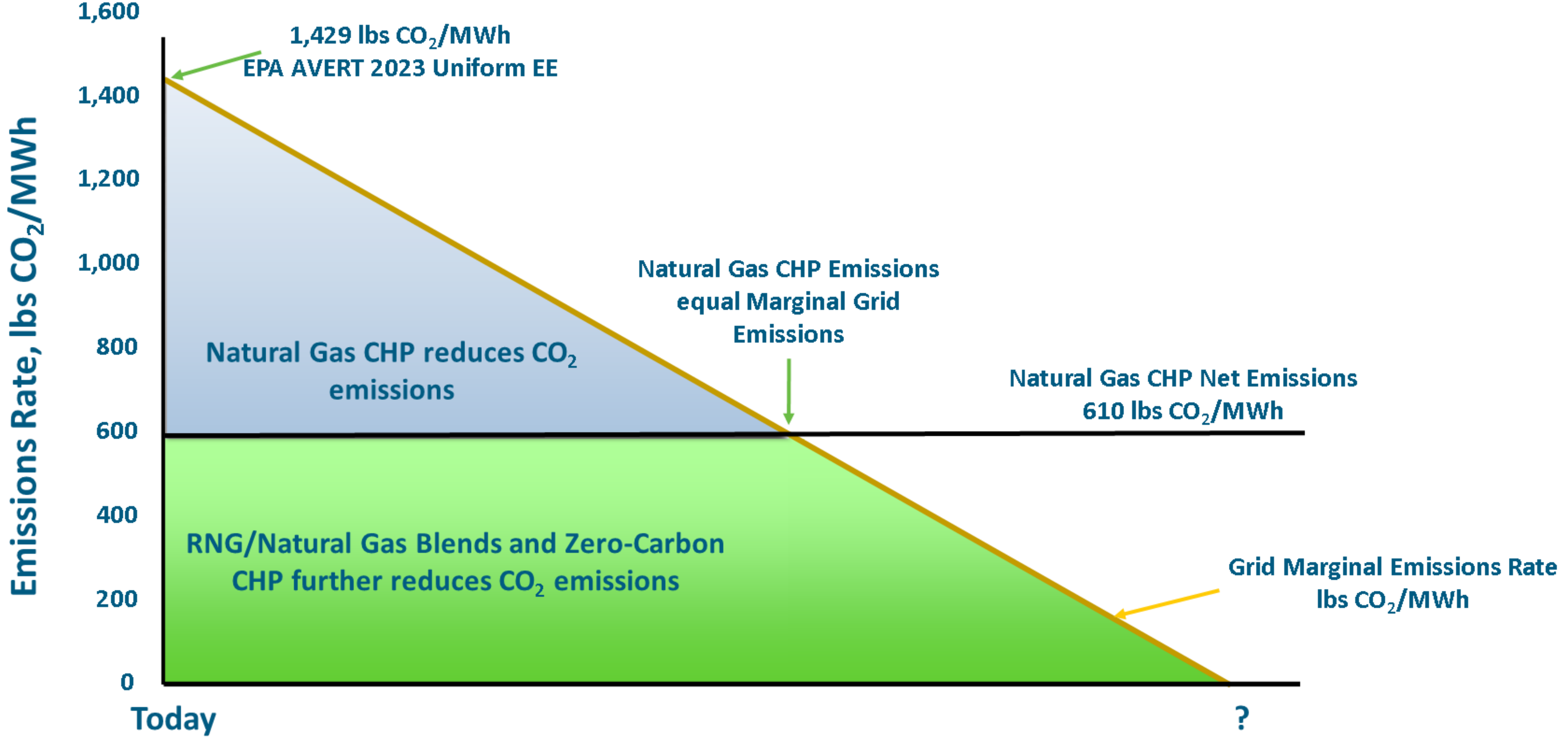
Net Electric CO_2 Emissions Rate, lbs /MWh



Based on 100% CHP Thermal Utilization

Prepared by: Entropy Research, LLC, 11/1/22

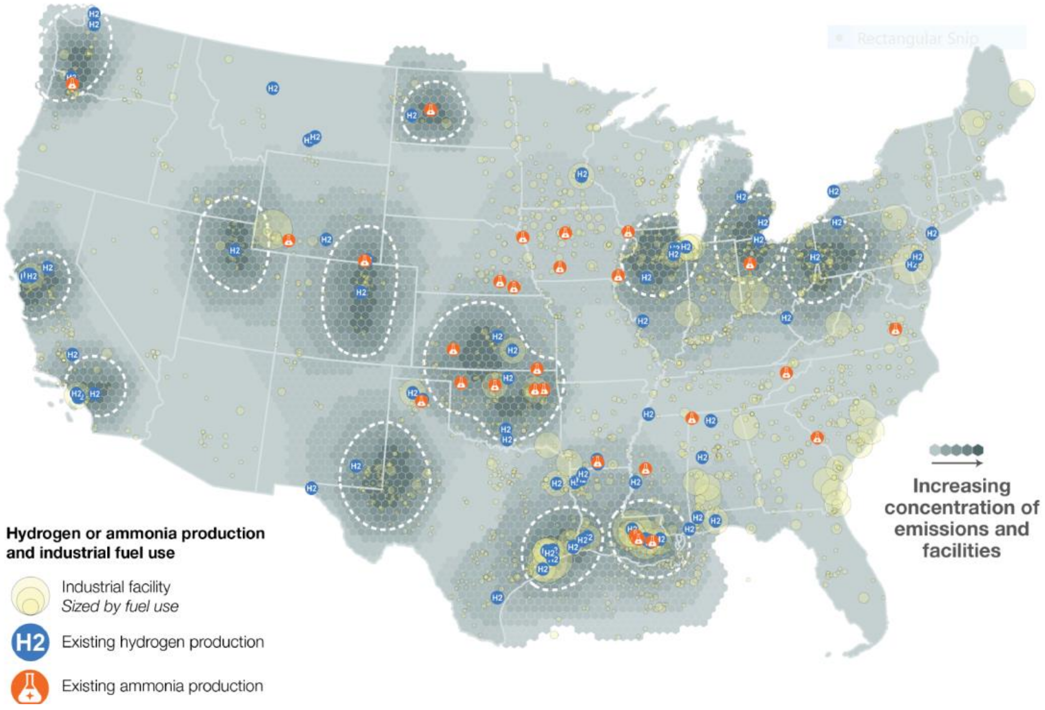
CHP's Evolving Role as the Grid Decarbonizes



Renewable and Hydrogen Fueled CHP

- Existing CHP systems can utilize biogas and biofuels.
- All natural gas-fueled CHP is compatible with renewable gas (RNG).
- Most existing turbines and engines can operate on hydrogen mixtures up to 10-40%.
- All major engine and gas turbine manufacturers are working on the capability to operate at high levels of hydrogen, targeting 2030 for 100% hydrogen prime movers.
- CHP systems can be changed out or modified in the field to 100% hydrogen-fuel blends

The ultimate scale of renewable and hydrogen-fueled CHP deployment will depend on resource availability.

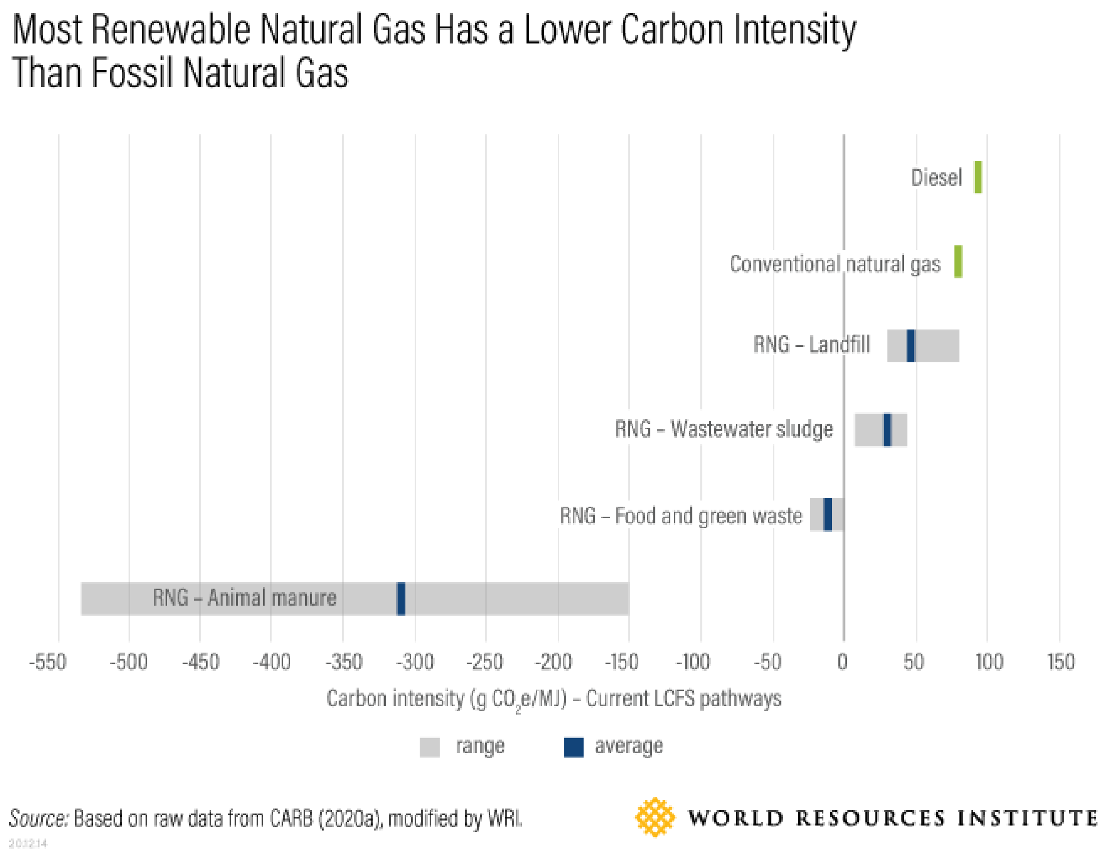


Source: Atlas of Carbon and Hydrogen Hubs, Great Plains Institute, February 2022

Emissions Accounting with RNG

RNG can have a range of carbon intensity values, depending on the source of biogas and the accounting methods used.

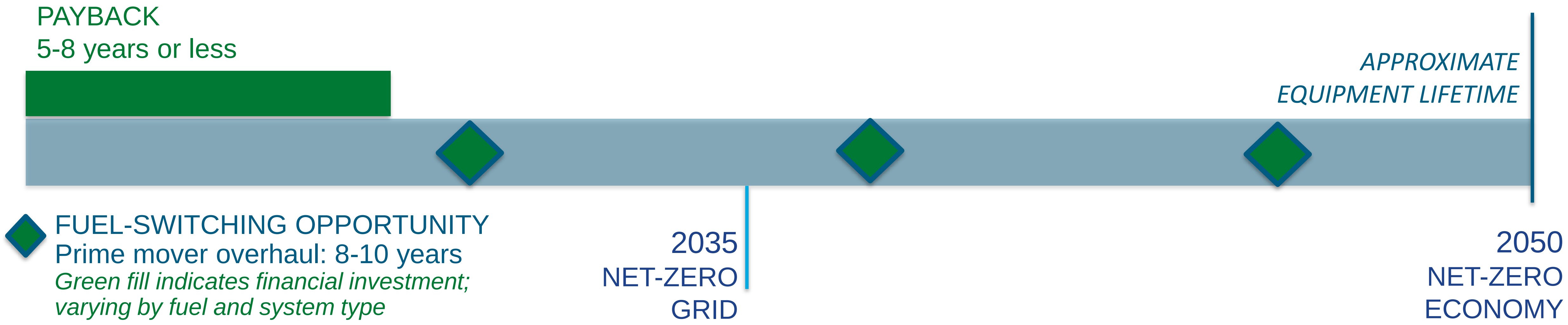
- RNG from animal manure and food waste – derived from biogenic resources – has negative carbon emissions values.
- RNG from WWTFs and landfills has positive carbon emissions values, but lower than conventional fossil fuels.
- When RNG is injected into a natural gas pipeline, it is documented with Renewable Identification Numbers (RINs) that can be transferred to end users (similar to Renewable Energy Certificates, or RECs).



[Is Renewable Natural Gas Environmentally Friendly? | MRR (odorizationbymrr.com)]

CHP Life Cycle Offers Multiple Opportunities for Fuel Switching

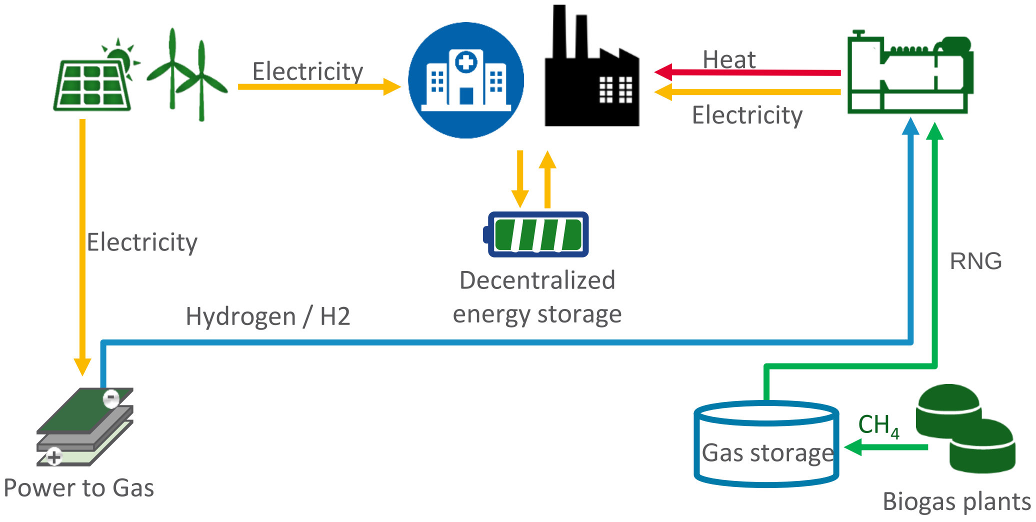
- Payback periods and regular maintenance schedules offer multiple decision points for re-optimization of emissions reduction measures as the grid evolves and other decarbonization options mature:
  - Payback: Typical payback for CHP installations is between 6–8 years. After the initial equipment and installation costs are recovered, future investment decisions can be based on operating costs only.
  - Fuel-switching opportunity: Industrial CHP prime movers require periodic overhauls on an 8 to 10-year cycle (at ~10 to 15% of the original installation cost), which offer at least three opportunities to switch fuel or select an alternate decarbonizing path.



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 in the future
- CHP is the most efficient way to generate power and thermal energy, and can reduce CO_2 emissions now and in the future
- Net-zero CHP can decarbonize industrial and commercial facilities that are difficult to electrify
- Net-zero 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 can provide dispatchable net-zero generation and regulation support to maintain the long-run resource adequacy of a highly renewable grid

CHP in a Decarbonized Economy



Source: Based on 2G Energy

Questions?

Kahoot and Q&A

Please use your phones to join our fun Kahoot game, testing your CHP Virtual Training Session #3 knowledge.

Thank you!

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