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Memorandum

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RE: ALLOCATION OF EMISSIONS FROM DISTRICT ENERGY SYSTEMS WITH MULTIPLE OUTPUTS—BUILDING PERFORMANCE STANDARDS

Introduction

This memo recommends a methodology for allocating emissions from district energy system emissions to multiple energy outputs. It seeks to inform the Building Performance Standard (BPS) Implementation Guide promulgated by the Institute for Market Transformation (IMT).

Many jurisdictions that will implement BPS policies contain district energy systems that provide steam, hot water, chilled water, electricity, or more than one such output to local buildings. The calculation for the emission factor for a district energy system that produces a single output is to divide the total emissions from all fuels consumed by the total energy supplied. However, for district energy systems that supply multiple outputs simultaneously, it is necessary to assign emission factors to each output stream separately. In such cases, emission factors cannot be derived by simply dividing the total emissions by the outputs because such systems may recover waste heat, co-mingle fuel inputs within the system, and produce output streams with different physical properties.

Research and Recommendations

In our work for jurisdictions implementing BPS policies and in support of the IMT Implementation Guide, Synapse Energy Economics (Synapse) prepared a literature review and survey of best practices for allocation of emissions from district energy systems with multiple outputs. Synapse also conducted extensive stakeholder engagement with building owners, operators of district energy plants, and public agencies with regulatory oversight of emissions from energy use. Numerous methods exist, which have been summarized and compared in prior studies. Relevant studies include:

1. Gillenwater, M., Woodfield, M., Simmons, T., McCormick, M., Camobreco, V., Hockstad, L. and Upton, B. 2006. *Calculation tool for direct emissions from stationary combustion: Allocation of GHG Emissions from a Combined Heat and Power (CHP) Plant*. World Resources Institute. Available at: https://ghgprotocol.org/sites/default/files/CHP_guidance_v1.0.pdf.

2. Noussan, M. 2018. “Allocation factors in Combined Heat and Power systems–Comparison of different methods in real applications.” *Energy Conversion and Management*, 173, pp.516-526.

3. Aldrich, R., Llauró, F.X., Puig, J., Mutjé, P. and Pèlach, M.À. 2011. “Allocation of GHG emissions in combined heat and power systems: a new proposal for considering inefficiencies of the system.” *Journal of Cleaner Production*, 19(9-10), pp.1072-1079.

4. Rosen, M.A. 2008. “Allocating carbon dioxide emissions from cogeneration systems: descriptions of selected output-based methods.” *Journal of Cleaner Production*, 16(2), pp.171-177.

Item #1 above, the allocation guidelines issued under the GHG Protocol (GHGP), is the result of a joint initiative of the World Resources Institute (WRI) and World Business Council for Sustainable Development (WBCSD). These guidelines are relevant to jurisdictions considering BPS policies, as many jurisdictions use GHGP standards for inventorying and reporting greenhouse gas emissions.[1] According to WRI, the GHGP is the world's most widely used greenhouse gas accounting standard.[2]

Allocation Methods

The guidelines issued under the GHG Protocol (GHGP)—*Allocation of GHG Emissions from a Combined Heat and Power (CHP) Plant*—summarize the various approaches to allocating emissions to district energy system outputs as follows:

- allocating emissions according to the energetic properties of each output stream (e.g., the efficiency method, the work potential method, or the energy content method);
- allocating all emissions to one of the outputs;
- assigning the efficiency “savings” from capturing waste heat to one of the outputs;
- allocating emissions in proportion to the economic value of each output; or
- allocating emissions according to a contractual agreement.

The GHGP publication recommends using the efficiency method when possible. Discussed in the section that follows, the efficiency method assigns emissions according to the fuel that was used to produce each output. In alignment with GHGP’s robust, widely adopted, third-party accounting standards, we recommend that jurisdictions adopting building performance standards use the efficiency method and ensure a consistent application of this method by all parties within the jurisdiction. Depending on the availability of data at a consistent time scale, the efficiency method can be used to calculate time-of-use emission factors (as well as average annual emission factors) for each output.

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[1] Gillenwater et al. 2006. *Allocation of GHG Emissions from a Combined Heat and Power (CHP) Plant*. WRI.

[2] World Resources Institute. “About Us." Accessed May 6, 2022. Available at: https://ghgprotocol.org/about-us.

Recommended Approach: Efficiency Method

The efficiency method allocates emissions according to the amount of fuel input used to produce each final energy output stream. The efficiency method uses plant-specific values for heat and power production efficiency, if available, or generic values when plant-specific information is missing.

Methodology

1. **Calculate the total direct greenhouse gas emissions for all fuels consumed.** Include all relevant greenhouse gases: carbon dioxide, methane, and nitrous oxide. Use greenhouse gas emission factors appropriate to each fuel consumed by the district energy plant. Apply global warming potentials for each greenhouse gas type emitted. Sum the total for all greenhouse gases.
2. **Calculate the energy content of each output stream for the district energy system.** Include each output stream of thermal energy (e.g., water/steam at various temperatures and pressures) and electricity. Convert all outputs to consistent units, such as MMBtu. Use enthalpy tables to determine the energy content (enthalpy) of water/steam at different temperatures and pressures.
3. **Identify the efficiencies of production of each output stream from the district energy system.** The efficiencies determine the amount of fuel, and therefore the associated emissions, required to generate a unit of energy stream output. The calculations should use plant-specific efficiency factors if available. In absence of plant-specific data, default values can be used.[3]
4. **Allocate the total emissions to each output stream.** Use the following formula:[4]

$$E_i = \frac{\frac{Q_i}{e_i}}{\sum_{i=1}^{n} \frac{Q_i}{e_i}} \times E_T$$

   where:

E_i	=	emissions allocated to output stream i
Q_i	=	energy content of output stream i
e_i	=	efficiency of the production of output stream i
E_T	=	total emissions of the district energy system
n	=	number of output streams

5. **Calculate emission factors for each output stream.** Divide the total emissions from each output stream by the total quantity of that output stream. We recommend dividing by the total energy sales or total energy delivered to consumers (as opposed to total output at the central plant). This approach is appropriate for building-level emission factors, and effectively assigns a pro-rata share of system-level transport and thermal losses to the buildings.

[3] The GHGP tool recommends default efficiency values of 0.80 for steam production and 0.35 for electricity production, based on U.S. EPA Climate Leaders reporting guidelines.

[4] The original GHGP formula is specific to co-gen plants that produce steam and electricity. Some plants in the Greater Boston area produce more than two output streams, such as the Medical Area Total Energy Plant (MATEP), which generates steam, electricity, and chilled water (also known as "tri-generation"). Synapse adjusted the formula to include the potential for more than two output streams, while preserving the methodology.

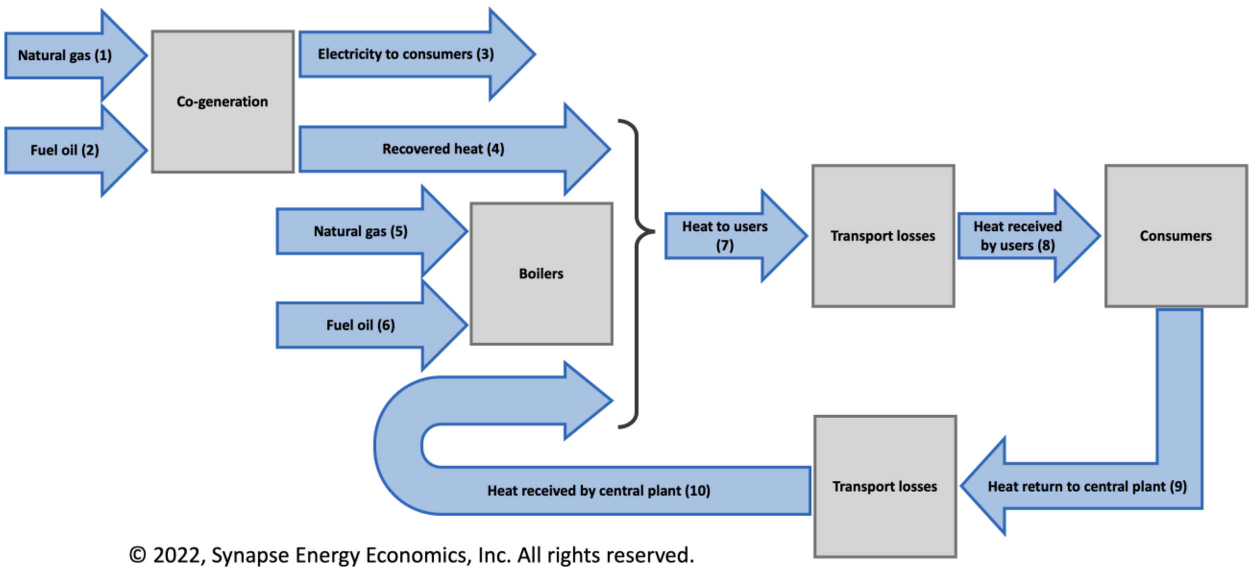
Data Needs

To facilitate the calculation of emission rates, we recommend that jurisdictions obtain from district energy system operators the following data annually and that jurisdictions verify the accuracy of the data:

1. A block diagram that represents current configuration of the district energy system configuration. See Figure 1 for an example.

2. An energy and mass/volumetric balance on the district energy system. See Figure 1 for an example. Data for the return loop may not be required in all circumstances.

Figure 1. Illustrative block diagram of co-gen system configuration indicating energy and mass flows



Fuel inputs may differ from those illustrated, such as including electricity, waste heat, or other combustion fuels.

Jurisdictions that seek to utilize time-of-use emission factors need to ensure that the relevant data is available at a consistent, granular time scale. This includes:

- District energy system fuel and electricity input;
- District energy system thermal and electrical resource outputs;
- Grid emission factor; and
- Building-level consumption of each resource: (1) co-generated electricity, (2) co-generated thermal resources, and (3) grid electricity. In the case of a campus that operates its own plant, campus-level energy use data may be sufficient for BPS compliance.

Additional Considerations

District energy system operators may have preexisting obligations or methods for allocating emissions under service contracts, regulations—local, state, or federal—or greenhouse gas reporting programs. Nonetheless, jurisdictions typically have regulatory authority to designate a different accounting protocol under the enabling authority used to adopt the BPS policy.[5] For example, home rule municipalities may have authority to adopt such regulations unless either expressly prohibited or inconsistent with state constitution, state laws, or the municipality's charter. This home rule authority may extend to matters already regulated by the state.[6]

Jurisdictions can use the above methodology and data to assign emission factors in alignment with the GHGP methodology from WRI.[7] The GHGP publication, however, is not a comprehensive guidebook. Jurisdictions may need to seek technical advice, legal advice, or stakeholder input to address considerations and circumstances that fall outside the GHGP framework, such as the following:

- Accounting for transport losses
- Allocation of emissions among more than two simultaneous output streams
- Regulatory preemption under existing local, state, or federal rules
- Qualifications, eligibility, and accounting methods for low-carbon electricity and fuel inputs
- Inclusion of central plants as covered buildings within a BPS framework
- Locally appropriate use of other emission allocation methods, including the work potential method and the energy content method[8]

Synapse has prepared additional research, methodological guidance, stakeholder outreach, and best-practice recommendations related to allocation of emissions from district energy systems. This work includes addressing considerations that fall outside the GHGP framework. We expect these findings to be published soon as an outcome of our work for jurisdictions implementing BPS policies. Synapse looks forward to reviewing these with IMT and Integral Group at that time, for possible reference or inclusion within the BPS Implementation Guide.

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[5] Regulatory authority will vary by location. Jurisdictions should seek legal and technical advice as needed.

[6] See, for example: Joroff, A. 2019. *Strategies for Massachusetts Municipalities to Implement Net Zero Building Mandates*. Emmett Environmental Law & Policy Clinic Harvard Law School. https://clinics.law.harvard.edu/environment/files/2020/05/Strategies-for-Massachusetts-Municipalities-to-Implement-Net-Zero-Building-Mandates-July-2019.pdf

[7] Gillenwater et al. 2006. *Allocation of GHG Emissions from a Combined Heat and Power (CHP) Plant*. WRI.

[8] For example, the work potential method may be appropriate in jurisdictions where heat from district energy systems is primarily used for mechanical work (such as in steam-powered manufacturing processes). The energy content method may be appropriate in unique circumstances that meet the all the following criteria: (1) data is unavailable to estimate plant efficiency for the efficiency method, (2) default plant efficiency assumptions provided by WRI are inappropriate due to system configuration, (3) systems thermal output can be characterized as useful energy, and (4) data are available to determine an appropriate reference enthalpy. These circumstances may be quite rare.