Treatment of District or Campus Thermal Energy in LEED V2 and LEED 2009 – Design & Construction

Pertains to all Building Design & Construction and Interior Design & Construction LEED v2.0 through v2009 Rating Systems

(i.e., New Construction, Schools, Core & Shell, Commercial Interiors, Retail for New Construction, Retail for Commercial Interiors, and Healthcare)

(August 13, 2010)

This document is USGBC's second (v2.0) major release of guidance for district or campus thermal energy in LEED, and is a unified set of guidance comprising the following:

- An update to the original Version 1.0 guidance released May 2008 for LEED v2.x
- The initial release of formal guidance for LEED v2009

Contents

1. INTRODUCTION

This document describes the treatment of district and campus thermal energy in the LEED v2.x and LEED-2009 Design & Construction and Interior Design & Construction rating systems. This is the second (v2.0) major release of this document; version 1.0 was released on May 28, 2008. The document applies to buildings using thermal energy produced from or delivered to a source outside the LEED project building. The main document focuses on LEED for New Construction prerequisites and credits; please see Appendix A for additional guidance for LEED for Retail, LEED for Core & Shell, LEED for Commercial Interiors, and LEED for Healthcare.

1.1 Executive Summary

The following briefly summarizes the requirements of this document for the relevant prerequisite and credits:

Commissioning:

- EA Prerequisite 1 (Fundamental Commissioning): No commissioning is required for district energy systems.
- EA Credit 3 (Enhanced Commissioning): Commissioning of the district energy systems serving the building are required for larger buildings where the thermal energy supplied to the building exceeds a given percentage, or when the percentage of energy provided by the district plant to the building exceeds a given threshold, or when Option 2 is pursued under EAc1. Guidance is provided to identify whether a New Commissioning or Retro-commissioning approach should be used.

Energy Efficiency:

- EA Prerequisite 2 (Minimum Energy Performance) and EA Credit 1 (Optimize Energy Performance): All projects may choose either the prescriptive method or the performance method. For the prescriptive method compliance is demonstrated by meeting all prescriptive requirements for the building and any relevant off-site equipment, as required by the applicable reference standard.
- For the performance method compliance with both EAp2 and EAc1 is demonstrated via energy modeling using one of the following two options:
    - Performance Option 1 (streamlined path) – model district or campus thermal energy as purchased energy for both the baseline and proposed case energy models, with no direct accounting of the district or campus network's efficiency. This path is simpler but restricts the maximum number of points that can be earned. In some situations the guidance requires a change to the ASHRAE 90.1 baseline system type to accommodate the use of purchased energy in the baseline case.
    - Performance Option 2 (full accounting) – directly account for the efficiency of the district or campus energy source in the proposed case energy model and compare it to a standard ASHRAE 90.1 baseline system in the baseline case. This path is more complex but has no points cap. However, it does have a *points floor*: projects must achieve a certain minimum number of points in order to use this option.
    - *<u>IMPORTANT NOTE</u>: each project team using energy models chooses only one of the above performance options to show compliance with both EAp2 and EAc1; no team is required to do both. This is an important change compared to the*

original guidance from 2008, and is intended to offer LEED customers more flexibility and simplicity.

Renewable Energy / Green Power

Renewable energy generated at the district or campus plant and green power purchased for the district or campus plant may be applied towards individual LEED buildings served by the plant if the performance method option 2 is used for documenting EAp2 and EAc1.

- EAc2 (Renewable Energy): The renewable energy contribution to the building is determined based on the renewable energy contribution to the district or campus plant and the percentage of building energy cost associated with the plant.
- EAc6 (Green Power): The green power contribution to the building is determined based on the Green Power contribution to the district or campus plant and the percentage of building electricity consumption associated with the district or campus plant.

Refrigerants (EAp3 and EAc4)

- EAp3 (Fundamental Refrigerant Management): All applicable downstream equipment (see definition below) must meet the prerequisite requirements. All applicable upstream equipment (see definition below) must either be CFC-free, have a phase-out plan, or a phase-out must be determined to be economically infeasible.
- EAc4 (Enhanced Refrigerant Management): All applicable downstream & upstream equipment must meet the credit requirements.

Monitoring and Verification (EAc5)

- To achieve this credit, monitoring and verification must be provided for the district or campus energy systems for buildings exceeding a certain square footage where credit is being pursued under EAc1 for energy efficiency, or where the building consumes a large percentage of the energy provided by the district energy system.

1.2 Administrative

This document is an updated and improved version of the original guidance published in May 2008. As such, it may be used in lieu of the original document. Thus, because of the district energy CIR published in May 2008, all LEED v2.x registered after May 28, 2008 under the New Construction, Schools, Core & Shell and Commercial Interiors Rating Systems are required to follow either Version 1.0 or Version 2.0 of this guidance if the project building will use district or campus thermal energy. The submitted LEED review documentation must indicate which version of the guidance is being followed.

For EAc1, LEED v2.x projects registered prior to 05/28/2008 have the option of using the ASHRAE 90.1-2004 Appendix G method for modeling district thermal energy, or using Version 1 or Version 2 of this document. The method used for modeling must be consistent within the technical circumstances of the LEED project.

LEED v2009 projects are not formally required to use this guidance at this time, but using it is highly recommended to help ensure a smooth LEED certification review. USGBC is working to incorporate this guidance into LEED v2009 more formally, but that process is not yet complete.

USGBC expects to refine and improve this document over time. In particular, note some placeholder headings in Appendix E that indicate topics for future development. To submit a suggestion for improving this document, send an e-mail to leedinfo@usgbc.org. Please reference this document in the subject line of your e-mail.

1.3 Summary of Major Differences from Version 1.0 (May 2008) of the DES Document

General

1. The guidance now applies to both LEED 2009 and LEED v2.x. The vast majority of the guidance is the same for both versions; any differences are defined when necessary.
2. Clarified definitions, terminology, and document structure
3. Inclusion of guidance for additional types of project circumstances
4. Better document organization – information used less commonly now appears in appendices

Enhanced Commissioning (EAc3)

1. Clarification has been provided regarding system commissioning for district plants that include additions plus existing equipment.
2. Requirements have been changed slightly to align more closely with EBOM commissioning requirements.

Energy Efficiency (EAp2 / EAc1) – Performance Path

1. The modeling protocols that were called "Step 1 and Step 2" in the Version 1.0 guidance have been recast as "Option 1 and Option 2" in the new guidance. *Now each project team chooses one of the two performance options to show compliance with both EAp2 and EAc1; no team is required to do both.* This is an important change, and is intended to offer LEED customers more flexibility and simplicity.
2. The Combined Heat and Power (CHP) guidance for district energy systems is incorporated into this document. The CHP guidance has also been modified to provide defaults when efficiency values are not available, and to clarify how the energy generated from the CHP plant is distributed between projects.
3. Option 1 district thermal energy utility rates are now calculated based on the virtual electric and fuel rates from the energy model paired with default weightings multipliers.
4. Clarification is provided regarding the utility rates to be used for Option 2.
5. Clarification is provided for the determination of average efficiency. Additional options have also been provided for using an average seasonal, monthly, or hourly efficiency rather than an annual average efficiency.
6. Tables have been added to enhance clarity regarding the appropriate Option 1 and Option 2 Baseline System types.

Renewable Energy / Green Power (EAc2, EAc6)

1. Calculations of the percentage of renewable energy or green power applied to the building have been clarified.

2. DISTRICT OR CAMPUS THERMAL ENERGY GUIDANCE

2.1 Overview

In the U.S. a typical commercial building has its own energy conversion plants (chillers, boilers, furnaces) that serve only the heating and cooling energy needs of the building itself. Some buildings, however, are connected to a district or campus thermal energy system where the thermal energy is produced for or distributed to multiple buildings. These district or campus systems can vary widely in size, scope, and complexity, ranging from two small buildings sharing a common chiller to entire city-wide central distribution networks serving hundreds of buildings. Generally such systems are designed for high levels of energy efficiency or to use less environmentally damaging energy sources, but they may be old and have poor part-load performance, high parasitic energy consumption, or thermal losses in energy conversion or transport. From the global environmental perspective it doesn't matter whether the building heating or cooling is generated within the building itself or in an energy plant and delivered by a thermal distribution system – a green building should properly account for the performance of a district or campus system if it's connected to one.

The intent of this document is to clarify whether and to what degree project teams must account for a district or campus energy system in the scope of the prerequisites and credits in LEED programs oriented toward design and construction of buildings. This document defines requirements that apply to all such district or campus energy systems, whether new or pre-existing, and whether owned by the project building's owner or another entity. This document does not change the usage of prerequisites or credits – all prerequisites are still required, and all credits are still optional.

The only portions of a LEED application affected by the presence of a district or campus energy system are the Energy and Atmosphere prerequisites and credits. Other LEED credit categories are unaffected.

2.2 Terminology

District or Campus Energy System (DES) – a central thermal energy conversion plant and transmission and/or distribution system that provides thermal energy (heating via hot water or steam, and/or cooling via chilled water) to more than one building, and where some part of the system (whether the energy conversion, or the transmission and distribution) extends beyond the boundaries of the LEED project site. Examples include a 20,000-ton central cooling plant and network on a university campus serving dozens of buildings or a single 500-ton chiller located within one building that also serves a second, separate building. This definition includes only thermal energy systems; central energy supply systems that provide only electricity are excluded from this definition. Combined heat and power (cogeneration) plants that provide thermal energy are included.

Exception: When several buildings are grouped as part of a single LEED project, including a central plant building, the central plant is defined as a DES only if it currently serves or is expected to serve other buildings not within the LEED project boundaries for the project.

Hereafter in this document, for simplicity the abbreviation "DES" is used to refer to all scenarios in which thermal energy is transported across the LEED project boundary, whether as part of a city-wide system, a campus network, or just two neighboring buildings.

Upstream equipment – all heating or cooling systems, equipment, and controls associated with the DES, but not part of the LEED project building's thermal connection or interface with the DES.

This includes the thermal energy conversion plant and all the transmission and distribution equipment associated with transporting the thermal energy to the project building and/or site.

Downstream equipment – all heating or cooling systems, equipment, and controls located within the LEED project building and/or on the project site associated with transporting the thermal energy of the DES into heated or cooled spaces. This includes the thermal connection or interface with the DES, secondary distribution systems in the building, and terminal units.

Exception: When the building housing the thermal energy plant is itself seeking LEED certification, then the project shall treat the DES equipment as "downstream equipment" for the following prerequisites and credits:

- EA prerequisite 1
- EA prerequisite 2
    - Mandatory Measures: The district energy equipment shall comply with all mandatory measures from ASHRAE 90.1-2004.
    - Prescriptive Method: The district energy equipment shall comply with any applicable prescriptive requirements
    - Performance Method: The district energy equipment shall be modeled as upstream equipment, NOT downstream equipment. USGBC recommends that such projects use modeling Option 2 (described below).
- EA prerequisite 3
- EA credit 3
- EA credit 4
- EA credit 5

Building Stand-Alone Scenario – the building is treated separately from the DES; all upstream equipment is ignored. Generally this approach is simpler to execute but fails to fully account for upstream equipment efficiency.

Aggregate Building / DES Scenario – the building and relevant upstream DES equipment are treated together as a single, integrated energy system. Generally this approach is more complicated to execute but more accurately accounts for upstream equipment efficiency.

Virtual energy rate – the virtual energy rate of a given fuel is determined by dividing the annual energy cost for that fuel by the annual energy consumption for the fuel.

Virtual DES rate – the price per unit of energy supplied by a DES used for LEED modeling purposes in Option 1 (described below). This rate is calculated using a procedure prescribed in this document and may differ from the "purchased energy rate" actually paid to the DES supplier.

2.3 Commissioning (EAp1 and EAc3)

2.3.1 EA Prerequisite 1: Fundamental Commissioning of Building Energy Systems

All downstream equipment is included in the scope of EAp1. Such equipment includes heat exchangers, steam pressure reduction stations, pumps, valves, pipes, building electrical services, and controls.

All upstream equipment is *excluded* from the scope of EAp1.

2.3.2 EA Credit 3: Enhanced Commissioning

All downstream equipment is included in the scope of EAc3. Such equipment includes heat exchangers, steam pressure reduction stations, pumps, valves, pipes, building electrical services, and controls.

All upstream equipment associated with serving the project building is *included* in the scope of EAc3 if all the following conditions are true for the project building; otherwise upstream equipment is *excluded* from the scope of EAc3:

- the project building's gross floor area is greater than 50,000 square feet

AND

- the DES supplies energy constituting more than 20% of the project building's annual energy cost, as determined from the Proposed Case energy modeling run of either the EAc1 Option 1 or Option 2 scenario (whichever option the team uses). Projects that use no energy model shall assume the DES supplies at least 20%.

AND EITHER

  - the project building is pursuing points under EAc1 using the performance path (energy model)

  OR

  - The project building's connected load is 50% or more of the DES total connected load or expected connected load at the date of the project building's substantial completion.

All upstream DES equipment associated with serving the project building subject to EAc3 requirements may show compliance with EAc3 using either of the following approaches:

1. <u>If the DES is new, being substantially upgraded, has new additions, or conditions are otherwise suitable</u> – show that commissioning or recommissioning of all relevant DES equipment has taken place within the past three years of the date of the project building's substantial completion (see specific requirements under "interpretations" below), or
2. <u>If the DES is pre-existing and in ongoing operation</u> – show that preventive maintenance, corrective maintenance, and efficiency monitoring programs have been in place for all relevant DES equipment that ensure ongoing DES energy efficiency performance meets or exceeds the DES design intent. Show that DES energy efficiency performance has been tested, recorded, and improved as needed under those programs within the past three years of the project building's substantial completion. Any reasonable efficiency metric may be used for this purpose, such as overall system COP, kW/ton, etc.

Interpretations:

Commissioning of upstream equipment applies to the entire DES serving the building, including both the central plant and the transmission and distribution systems.

Commissioning applies only to the DES services the project building is using. For example, if the building is using only the heating services of a district heating and cooling plant, then only the heating systems of the DES must be included in the scope of EAc3.

If approach 1 (commissioning) is chosen above, use the following guidance to define the specific commissioning requirements. A DES that is three years old or less at the date of the project building's substantial completion is considered "new" construction and is to be commissioned in accordance with the requirements of EAc3 for the relevant LEED rating system for the project. Similarly, any new equipment additions to an existing plant along with any controls or plant distribution equipment that have changed as a result of the additions shall be commissioned in accordance with the requirements of EAc3 for the relevant LEED rating system for the project.

A DES greater than three years old and with no substantial new equipment additions is considered to be "existing" and is to be commissioned in accordance with the requirements of LEED for Existing Buildings: Operations & Maintenance v2008 EA Credit 2.2 or 2.3.

2.4 Energy Performance (EAp2 & EAc1)

All downstream equipment is always included in the scope of EAp2 and EAc1. Such equipment includes heat exchangers, steam pressure reduction stations, pumps, valves, pipes, building electrical services, and controls. Upstream equipment may be included or excluded depending on the compliance path the project team uses.

All LEED v2.x projects registered after 06/27/2007 are required to earn a minimum of two points under EA Credit 1 for LEED certification. Note that for LEED v2009 USGBC folded this level of performance into EAp2, so the 2-point minimum in EAc1 does not apply.

Both EAp2 and EAc1 offer prescriptive and performance compliance paths, and for DES projects compliance is shown for both EAp2 and EAc1 using similar techniques.

Prescriptive paths – project teams using any prescriptive path either to document compliance with EAp2 or to document points under EAc1 shall include or exclude effects of upstream DES equipment as specified in the applicable reference standard listed in the LEED Rating System. If the reference standard does not specify either approach, the upstream effects shall be excluded.

Performance path – each project team chooses *either* Option 1 *or* Option 2 to show compliance for both EAp2 and EAc1 in a single unified step:

Option 1 (streamlined) – the building stand-alone scenario

Option 2 (full accounting) – the aggregate building / DES scenario

CRITICAL NOTE: under this updated (version 2) DES guidance document, no project team is required to assess both options, nor to model separately for EAp2 and EAc1. This is a substantial difference from version 1 of this guidance intended to simplify the guidance and improve its flexibility.

For DES projects the points available under the energy modeling/performance path have restrictions in each Option as shown in Table 1:

Table 1: EAc1 points restrictions for DES projects using energy models

	Points available in Rating System	DES Option 1 points cap*	DES Option 2 points floor**
LEED v2.x			
LEED-NC	10	5	3
LEED Schools	10	5	3
LEED CS	8	4	2
LEED CI	N/A (see Appx. A)		
LEED v2009			
LEED-NC	19	10	6
LEED-NC Retail	19	10	6
LEED Schools	19	10	6
LEED CS***	21	12	8
LEED Healthcare****	24	12	7
LEED CI	N/A (see Appx. A)		
LEED CI Retail	N/A (see Appx. A)		

* *points cap* means this is the *maximum* number of points that can be earned in this scenario; projects seeking more points must use Option 2

** *points floor* means this is the *minimum* number of points that can be earned in this scenario; projects seeking fewer points must use Option 1. (Exception: this points floor does not apply when the building housing the thermal energy plant is itself the LEED project building.)

*** EAc1 has a 3-point minimum for all projects in the v2009 LEED-CS rating system. The points caps and floors in this table reflect that 3-point minimum.

**** these are the *expected* points values for LEED for Healthcare. As of the publishing date of this document this rating system was not yet final, so these values are subject to change.

Using either performance Option 1 or Option 2, follow the modeling guidelines and requirements in ASHRAE standard 90.1 Appendix G, except as noted below under Sections 2.4.3 to 2.4.5 of this document, “Energy Model Implementation.”

2.4.1 Energy Model Implementation: Treatment of Heating/Cooling Equipment

2.4.1.1 Model for Option 1 (Building stand-alone scenario):

In Option 1, the energy model’s scope accounts for only downstream equipment. This scenario is modeled in accordance with ASHRAE 90.1 Appendix G requirements with the following exceptions:

1. The energy source is modeled as purchased energy in both the Proposed and Baseline buildings for all air handlers, fan-coil units, and other downstream equipment serviced by district or campus energy systems in order to hold the DES cost-neutral in the model (Table 2 below).
2. Where necessary, building Baseline HVAC system types from Tables G3.1.A and G3.1.B are modified to be consistent with the purchased energy source (Table 3 below). Any system parameters not specifically referenced in Table 3 are modeled as specified in Appendix G. These changes only apply for building equipment serviced by the DES.

All other portions of the building shall be modeled in accordance with Appendix G requirements.

Table 2: Energy Source for Option 1

	Baseline	Proposed
District heating	Purchased heat	Purchased heat
District cooling	Purchased chilled water	Purchased chilled water

Table 3: Option 1 Baseline System Type Revisions From ASHRAE Appendix G Instructions

	ASHRAE App G Baseline System Type		District Energy System Used in Proposed Design:		
			District Cooling Only	**District Heating Only**	**District Heating & Cooling**
Changes from App G Baseline	System 1	→	4-pipe Fan Coil w/ HW Boiler Heat	No Change[1]	4-pipe Fan Coil
	System 2	→	4-pipe Fan Coil w/ HW Boiler Heat		
	System 3	→	2-pipe CV AHU w/ Fossil Fuel Furnace	PSZ-AC w/district heating	4-pipe CV AHU
	System 4	→	2-pipe CV AHU w/ Fossil Fuel Furnace		
	System 5	→	Change to System 7	No Change	Change to System 7
	System 6	→	Change to System 8		
	System 7	→	No Change	No Change	No Change
	System 8	→	No Change		

2.4.1.2 Model for Option 2 (Aggregate Building / DES Scenario):

In Option 2, the energy model's scope accounts for both downstream equipment and upstream equipment. The DES energy source is no longer modeled as cost-neutral purchased energy; rather, a virtual DES-equivalent plant for the Proposed case is constructed and compared to code-compliant on-site equipment for the Baseline case (Table 4). The Proposed case modeling

[1] For spaces that are served by district chilled water, and meet exceptions (b) or (c) to G3.1.1, the changes to System types 3 and 4 shall be as shown in Table 3 above.

requirements differ from those in ASHRAE standard 90.1 Appendix G as described below. However, the Baseline case system type is modeled as instructed in Appendix G.

Table 4: Energy Source for Option 2

District heating	Baseline	On-site heating plant or fossil fuel furnaces as defined in ASHRAE 90.1 Appx. G, tables G3.1.1A and G3.1.1B, representing code minimum efficiency[2]
	Proposed	Virtual on-site hot water or steam boiler representing upstream DH system
District cooling	Baseline	On-site cooling plant or packaged cooling as defined in ASHRAE 90.1 Appx. G, tables G3.1.1A and G3.1.1B, representing code minimum efficiency[3]
	Proposed	Virtual on-site chiller representing upstream DC system

2.4.1.2.1 Efficiency calculation

The energy model for Option 2 shall specify the efficiencies of the equipment as follows:

Baseline building, heating or cooling: use the nominal rated efficiencies for the appropriate system as instructed in Appendix G and as defined in Paragraph 6.8, Minimum Equipment Efficiency Tables. Model the actual operating inefficiencies and part-load performance for all equipment and systems using the rules and procedures defined in Appendix G.

Proposed building, transmission and distribution system: secondary pumping energy, leaks, and thermal losses between the DES central plant and the connected building in both directions must be accounted for in the Proposed Case model for all cases where they apply. Projects shall use actual DES operational data if the DES is pre-existing, or for new DES's design estimates based on expected operation may be substituted.

Proposed building, heating, cooling, and CHP generation:

Use a virtual plant with the same average efficiencies of the entire upstream DES heating, cooling and/or CHP system based on actual loading. Average efficiencies can be determined using either the ***Monitoring*** or ***Modeling*** methods described in Appendix C, and may be determined annually, seasonally, monthly, hourly, or for each utility time block.

See Appendix C for further guidance on calculating virtual plant efficiencies.

2.4.1.2.2 Proposed Building, Calculating Combined Heat & Power Efficiency

Combined heat and power (CHP) captures the heat that would otherwise be rejected in traditional fossil fuel generation of electrical power so that the total efficiency of these integrated systems is much greater than from central station power plants and separate thermal systems. CHP systems also produce lower emissions compared to traditional fossil fuel generation. Other benefits include reduction in peak demand, releasing of electrical system capacity, and reduction in overall electrical system transmission and distribution losses.

---

[2] Note: For the Option 2 baseline energy model, the Section G3.1.1.1 requirement to model purchased hot water or steam shall be ignored, and baseline boilers or fossil fuel furnaces shall be modeled in the Baseline Case.

[3] Note: For Option 2, per ASHRAE 90.1-2004, Section G3.1.3.7, the energy source for chillers shall always be electric regardless of the cooling energy source used at the central plant.

The treatment of CHP under the ASHRAE 90.1 Performance Rating Method (PRM, Appendix G) comes under the purview of G2.4 Energy Rates. G2.4 adequately addresses on-site CHP systems but does not provide a methodology for recognizing the potential benefits of district or campus CHP. This document provides additional guidance for district or campus CHP systems.

See Appendix D for further guidance on calculating CHP in Option 2.

2.4.1.2.3 Default Efficiencies

Actual efficiency performance data on the DES serving the project building is preferred, based on either ongoing operations (existing DES) or design specifications (new DES or DES with added capacity). If the project team cannot obtain the actual performance data, it is permissible to use the following default average performance values. These values are conservative, intended to represent a DES with relatively low efficiency. A well-designed, maintained, and operating DES will generally offer better performance than the defaults listed here. Default values are as follows:

- DES heating plant – 70% (Higher Heating Value) for the total boiler plant average efficiency.
- DES cooling plant – COP of 4.4 for the total cooling plant average efficiency (including cooling towers and primary pumps).
- Thermal distribution losses – the following values may be used to account for seasonal thermal distribution losses including minor leaks and/or condensate losses (but not pumping energy, which must be accounted for separately where it applies):
    - chilled water district cooling 5%
    - hot water district heating 10%
    - closed loop steam systems 15%; open loop steam systems 25%
    - steam systems that are partially open/closed must prorate between the above 15% and 25% losses in accordance with the fraction of expected or actual condensate loss

NOTE: all the guidance in Section 2.4.3 assumes that DES-generated heat is used for heat in the connected building, and DES-generated cooling is used for cooling in the connected building. If the DES produces heating that is then converted to cooling for the connected building using absorption chillers or other similar technology then this guidance must be modified. See Appendix E for details.

2.4.2 Energy Model Implementation: Energy rates

Energy tariffs (rate structures) for both the Proposed and Baseline Buildings must be identical to each other for the corresponding energy types, and are defined in the models as follows:

2.4.2.1 Option 1 (Building stand-alone scenario)

Energy rates for all non-DES-supplied energy are assigned using the normal ASHRAE and LEED modeling rules, using the local utility rate schedules as they would normally be applied.

DES-supplied energy is not modeled using the actual purchased energy rates paid to the DES supplier. Instead, separate *virtual DES rates* are calculated for each type of energy supplied by the DES (e.g., chilled water, hot water, or steam) based on the virtual energy rates for each type of fuel. If a flat rate structure is being used for all energy sources (meaning the cost per unit energy is the same throughout the year, and there are no demand charges), then these flat rates simply become the virtual energy rates for the project.

Otherwise, if all energy rate structures are not flat, then a preliminary run of the Option 1 Baseline Case energy model must first be completed to identify the virtual electric and fossil fuel rates for the project. For this preliminary run only, the rate for the DES-supplied energy may be left blank, or may be entered as any value.

Once all the virtual energy rates are known for electricity and fossil fuel, the virtual DES rates for both the Baseline and Proposed Case are then derived as follows:

District Chilled Water Rate:

- Units of $/MBTU = Virtual Electric Rate (in $/kWh) x 71
- Units of $/ton-hour = Virtual Electric Rate (in $/kWh) x 0.85

District Hot Water Rate:

- Units of $/MBTU = Virtual Fuel Rate (in $/MBTU) x 1.59 + Virtual Electric Rate (in $/kWh) x 3

District Steam Rate:

- Units of $/MBTU = Virtual Fuel Rate (in $/MBTU) x 1.81 + Virtual Electric Rate (in $/kWh) x 3

Exception: to obtain the virtual fuel rate when the connected building does not use fossil fuel but the DES central plant does, use a flat rate consistent with the central plant rates or the historic average local market rates (no preliminary model run is needed). The virtual fuel rates must match in the Baseline and Proposed Case.

The virtual DES rates are then input into the modeling software for each DES source and used for the remainder of the process. Alternatively, the virtual DES rates may be used to calculate the DES energy costs directly by multiplying the DES energy consumption for each DES source by its virtual DES rate. All virtual DES energy rates must be identical in the Baseline and Proposed Case.

2.4.2.2 Option 2 (Aggregate Building / DES scenario)

In this modeling scenario fuel and electricity rates are assigned using the same local utility rates as normally applied to the building and using the normal ASHRAE and LEED modeling rules. For the Baseline Building the rates are applied to the code-compliant heating or cooling plant as instructed in Appendix G, and for the Proposed Building the rates are applied to the virtual plant according to the actual energy sources used in the upstream DES (electricity, gas, oil, etc.).

Exception:

(a) For fuels used at the central plant that are not available at the building (e.g. diesel fuel), use the central plant rates for that fuel type in the Baseline and Proposed Case.

(b) For district energy plants utilizing methods to reduce cost by shifting electric Peak or Mid-Peak demand (such as thermal energy storage or hybrid absorption / electric cooling), the average cooling efficiencies may be determined for each utility time block (e.g. Summer Peak, Summer Mid-Peak, Summer Off-Peak, Winter Mid-Peak, Winter Off-Peak). If this method is employed, the cooling and plant pumping energy and demand shall be separately metered in both the baseline and proposed energy models, and the district plant utility tariffs may be used for these meters in both the baseline and proposed case.

2.4.3 Energy Model Implementation - Run and Compare the Proper Scenarios

Assess the number of potential points earnable using the performance tiers listed in the Rating System. Compliance with the modeling requirements in ASHRAE 90.1Informative Appendix G is required, except where modified in this document. In the LEED Online certification documentation, provide a narrative that derives the claimed DES performance and explains how it is used in the energy model.

2.4.3.1 Option 1 (Building Stand-Alone Scenario)

Perform a model run on the project building modeling only downstream equipment and using purchased DES energy in the models with the energy rates described above.

2.4.3.2 Option 2 (Aggregate Building / DES Scenario)

Perform a model run that incorporates the effects of the DES on the heating and/or cooling systems as described above (i.e., modeling both downstream and upstream equipment). Both the DES central plant and the transmission and distribution network shall be accounted for using the above guidance. This may be procedurally implemented in any technically reasonable manner, e.g., a chiller or boiler efficiency correction coefficient within the model to account for upstream energy losses, post-processing of the energy model results, etc. The procedural method chosen must be fully explained in the LEED certification application.

2.5 On-Site Renewable Energy (EAc2)

Renewable energy sources as defined in EAc2 (e.g., electricity, heat, or chilled water energy produced from photovoltaics, solar thermal systems, wind turbines, geothermal, low-impact hydro, wave/tidal, untreated wood waste, agricultural crops or waste, animal and other organic waste, and landfill gas) are the only renewable sources allowed for credit under EAc2. The use of air; ocean, lake, or river water; or ambient earth for a thermal heating or cooling sink is categorized as an efficiency strategy in LEED and falls under EAc1. The proper treatment of renewable energy in LEED certification application calculations is covered in the Reference Guide.

For projects documenting EAp2/c1 using energy model Option 2 (aggregate building/DES scenario), qualifying renewable energy sources according to the definition above used in a DES may earn points in EAc2 for a connected building, i.e., they count as “on-site” renewable energy for the connected building. For any projects using energy model Option 1 for EAp2/c1, renewable DES sources *do not* earn points in EAc2 for a connected building.

Performance for EAc2 is based on the fraction of the project building’s annual energy cost that is renewable energy. The project building’s total annual energy cost shall be derived from the Proposed Case modeling run of the Option 2 scenario described in the EAc1 section of this document.

The fraction of project costs offset by renewable energy contributed by the DES depends on how much of the building’s load the DES supplies, and how much of the DES energy source is renewable. The total cost offset is based on the product of these two factors. For each thermal energy source provided to the building by the District Plant, calculate the renewable contribution as follows:

1. Find the fraction of the annual DES thermal energy source provided by qualifying renewable sources. If two fuel sources are required to generate the thermal energy source (e.g., electric pumps and natural gas burners for boilers), the fraction of DES provided by the qualifying renewable source should be based on amount (e.g., kBtus), and should account for all end-uses used to generate the thermal energy source.

2. Find the fraction of the project building's annual energy consumption that is supplied by the DES thermal energy source.
3. Multiply number 1 (above) by number 2 (above) for each energy source provided by qualifying renewables.
4. Add together the renewable energy contribution from each district thermal energy source serving the building (3 above), in order to identify the total renewable energy contribution from the district plant.

If renewable energy contributions from the DES are applied to a connected building, a letter must be provided from the DES owner or operator verifying all of the following:

- the quantity of renewable energy reported in #1 above is allocated to the DES itself (i.e., the upstream generation and/or distribution equipment) and not directly to any building, and
- within the overall DES renewable energy allocation, no renewable energy assigned specifically to the DES central plant building, if any (in a separate LEED application), is also being counted towards the renewable energy contribution of the connected project building, and
- no renewable energy is being double-counted among any connected project buildings (in separate LEED applications), and
- either the DES owner or operator maintains rights to the environmental benefits of the site-generated renewable energy, OR the requirements under "Retention of Renewable Energy Environmental Attributes" in the LEED 2009 Green Building Design & Construction Reference Guide (page 293, 1st edition) are met

For projects without an energy model, EAc2 credit may not be taken for renewable energy sources used for the DES upstream of the project. However, credit may be taken for on-site renewable energy associated with the project building itself. In this situation, project teams follow the standard guidance provided in the applicable LEED Reference Guide for documenting renewable energy percentage using the DOE Commercial Building Energy Consumption Survey (CBECS) data.

2.6 Refrigerant Management (EAp3 and EAc4)

2.6.1 EA Prerequisite 3, Fundamental Refrigerant Managements

All applicable downstream equipment must meet the prerequisite requirements.

All applicable upstream systems must either be CFC-free or a commitment to phasing out CFC-based refrigerants must be in place, with a firm timeline of five years from substantial completion of the LEED project. Prior to phase out, reduce annual leakage of CFC-based refrigerants to 5% or less using EPA Clean Air Act, Title VI, Rule 608 procedures governing refrigerant management and reporting.

An alternative compliance path for buildings connected to a central chilled water system requires a third party audit showing that system replacement or conversion is not economically feasible. The replacement of a chiller(s) will be considered to be not economically feasible if the simple payback of the replacement is greater than 10 years. To determine the simple payback, divide the cost of implementing the replacement by the annual total cost avoidance for energy (consumption and demand charges) that results from the replacement and any difference in maintenance costs including make-up refrigerants. If CFC-based refrigerants are maintained in the central system, reduce annual leakage to 5% or less using EPA Clean Air Act, Title VI, Rule 608 procedures governing refrigerant management and reporting and reduce the total leakage over the remaining life of the unit to less than 30% of its refrigerant charge.

2.6.2 EA Credit 4, Enhanced Refrigerant Management

All applicable downstream AND upstream equipment must meet the credit requirements to earn this credit.

2.7 Measurement & Verification (EAc5)

All downstream equipment is included in the scope of EAc5. Such equipment includes heat exchangers, steam pressure reduction stations, pumps, valves, pipes, building electrical services, and controls.

All upstream equipment is *included* in the scope of EAc5 if the following conditions are true for the project building; otherwise upstream equipment is *excluded* from the scope of EAc5:

- the project building's gross floor area is greater than 50,000 square feet

AND

- the DES supplies energy constituting more than 20% of the project building's annual energy cost, as determined from the Proposed Case energy modeling run from EAp2/EAc1 Option 1 or 2 Projects that use no energy model shall assume the DES supplies at least 20%.

AND EITHER

- the project building is pursuing any points under EAc1 using the performance path (energy modeling),

OR

- The project building's connected load is 50% or more of the DES total connected load or expected connected load at the date of the building's substantial completion.

Interpretations

If required according to the criteria above, M&V of upstream DES equipment shall be implemented to the extent necessary to verify the DES performance claimed under EAc1, and accordingly applies only to the DES systems that the building is utilizing. For example, if the building is utilizing only the heating services of a district heating and cooling plant, then only the heating systems of the DES are to be included in the M&V scope.

This guidance does not necessarily require that any metering be installed on upstream DES equipment itself according the IPMVP protocol. Rather, the M&V Plan for the project building must include metering of the site energy delivered to the project building by the DES (generally using a BTU meter), as well as full accounting of upstream DES whole-system energy performance so that overall (DES+building) energy efficiency can be derived. Generally this requires some knowledge of input energy consumption of the DES central plant. Any reasonable efficiency metric may be used to account for overall upstream system energy performance, such as overall system COP, kW/ton, etc.

2.8 Green Power (EAc6)

For projects documenting EAp2/c1 using energy model Option 2 (aggregate building/DES scenario), green power used in a DES may contribute towards EAc6 for a connected building. For any projects using energy model Option 1 for EAp2/c1, green power used in a DES *does not* contribute to EAc6 for a connected building.

Performance for EAc6 is based on the fraction of the project building's annual electric energy consumption that is supplied by green power. In the DES setting, this fraction depends in turn on the fraction of district plant electricity that is supplied by green power, and the fraction of the Option 2 model's annual electric consumption associated with the DES. For each thermal energy source provided to the building by the District Plant, calculate the renewable contribution as follows:

1. Find the fraction of the annual DES energy use supplied by qualifying green power sources.
2. Find the fraction of the project building's annual energy consumption that is supplied by the DES thermal energy source.
3. Multiply number 1 (above) by number 2 (above).

The project building's total annual electric energy consumption reported for EAc6 credit compliance path 1 (Energy Model) shall be derived from the Proposed Case modeling run of the EAc1 Option 2 scenario.

If green energy contributions from the DES are applied to the project, a letter must be provided from the DES owner or operator verifying that the renewable energy reported (in 1 above) is allocated specifically to the DES generation and/or distribution equipment, and confirming that no renewable energy allocated specifically to the DES central plant building, if any (in a separate LEED application), is being counted towards the renewable energy contribution of the satellite project building. The letter must also confirm that no renewable energy is being double-counted among any satellite project buildings (in separate LEED applications).

For projects without an Option 2 energy model, EAc6 credit may not be taken for renewable energy sources used for the DES upstream of the project. However, credit may be taken for green power associated with the project itself. In this situation project teams follow the standard guidance provided in the applicable LEED Reference Guide for documenting green power percentage using the DOE Commercial Building Energy Consumption Survey (CBECS) data.

APPENDIX A: Application to LEED-Retail, LEED-CI, LEED-CS, and LEED for Healthcare

LEED-NC Retail

Projects under the LEED-NC Retail rating system shall follow the same guidance for District Energy Systems as provided for LEED-NC.

LEED for Commercial Interiors (including Retail)

For projects under the LEED-CI rating system, District Energy Systems have no effect on any EA section prerequisites or credits. Any effects of District Energy Systems shall be picked up by SS Credit 1, Site Selection, under one of the following paths:

- Option K / Path 11, On-Site Renewable Energy – renewable energy supplied through a DES is treated as "on-site" for the purposes of this credit, subject to the restrictions listed under the guidance for EA credit 2 above
- Option L / Path 12, Other Quantifiable Environmental Performance

LEED for Core & Shell

Projects under the LEED-CS rating system shall follow the same guidance for District Energy Systems as provided for LEED-NC. Note that the LEED-CS Reference Guide contains detailed guidance for energy modeling a core and shell project.

LEED for Healthcare

(Further guidance for LEED for Healthcare, if needed, will be added here at a future date.)

APPENDIX B: Title 24 & Oregon Energy Code Guidance

The performance compliance methodology for District Energy Systems referenced in the main body of this document for EAp2, EAc1, EAc2, and EAc6 relates to LEED modifications to the ASHRAE 90.1Appendix G methodology (v2004 and v2007). The following additional mandatory guidance shows how to apply this guidance to alternate performance compliance methods such as California Title-24 (for California projects) or Oregon Energy Code (for Oregon Projects) when District Energy Systems are included in the project.

Oregon Energy Code

All guidance provided in the main body of this document regarding the performance compliance method using ASHRAE 90.1applies to the Oregon Energy Code. The Option 1 Baseline system types shall be determined as defined above. Similarly, the Option 2 default and average efficiencies for the Proposed Case shall be determined as defined in the main body of this document. The Option 2 Baseline Case shall be modeled using the Oregon Energy Code requirements for the Baseline Case with the same exceptions as are listed for ASHRAE 90.1above.

California Title-24

The Option 1 and Option 2 performance models shall apply as indicated in the original guidance except as modified below. This guidance applies to both the 2005 and 2008 versions of Title-24:

Model for Option 1 (Building stand-alone scenario):
In Option 1, the energy model's scope accounts for only downstream equipment. This scenario is modeled in accordance with Title-24 LEED modeling requirements without exceptions. As required by Title-24, any district plant equipment servicing the building is modeled using default minimum Title-24 efficiencies in the Proposed Case model. In EnergyPro, this means the plant equipment is not explicitly modeled. In eQUEST, plant equipment following the Title-24 ACM Manual Section 2.5.3.15 requirements for quantity and type of equipment must be defined for the Proposed Case, and the minimum efficiencies must be defined based on California Title-24 minimum efficiency requirements from the Building Energy Efficiency Standards Tables 112-A to 112-M for the given system selection (e.g. 4.45 COP for a water-cooled screw chiller < 150 tons from Table 112-D). Both eQUEST and EnergyPro will automatically define the Baseline Case based on standard Title-24 rules, and no special modeling requirements are required.

Model for Option 2 (Aggregate Building / DES scenario):
In Option 2 the energy model's scope accounts for both downstream equipment and upstream equipment. In such situations the secondary equipment within the building is modeled in accordance with Title-24 requirements. The Option 2 Baseline case remains the same as that modeled for Option 1. However, a virtual DES-equivalent plant for the Proposed case is constructed and compared to this Title-24 Baseline Case. The virtual DES-equivalent plant shall follow all of the Option 2 modeling guidelines provided for in the main body of this document. The Baseline case is modeled in accordance with the Title-24 ACM Manual.

Credits EAc2 and EAc6 apply as indicated in the main body of this document, except that the models used for identifying the building performance are the Title-24 Option 1 and Option 2 models described in this Appendix rather than the ASHRAE 90.1 models described in the main body of this document.

APPENDIX C: Virtual Plant Modeling Guidance for EAp2/EAc1 Option 2

Use a virtual plant with the same efficiencies of the entire upstream DES heating, cooling and/or CHP system. Average efficiencies can be determined using either the ***Monitoring*** or ***Modeling*** methods described herein, and may be determined annually, seasonally, monthly, hourly, or for each utility time block. The time scales used to derive the average efficiency must be the same time scales used in the virtual plant model.

Additionally, the methodology for determining average efficiency (whether Monitoring or Modeling) and the time period used for determining the average efficiency (whether annually, seasonally, monthly, or hourly) must be consistent for all related district thermal or CHP systems that are part of the LEED project. For example, if hourly efficiency values are used for a district absorption chiller that is served by district steam generated by a district cogeneration plant, the hourly efficiency values must be used not only for the district chilled water but also for the district steam and the cogeneration.

Monitoring: Proposed building heating/cooling efficiency: Project teams may define the virtual plant and calculating heating/cooling efficiency via monitoring:

Heating:

- Monitor the total annual MBTU of fuel input at the plant (using a natural gas meter, oil delivery records, etc.), and the total MBTU of steam or hot water delivered to each of the buildings serviced by the district plant (using BTU meters at each delivery point). Average heating efficiency including losses is equal to the sum of the annual heating energy delivered to the buildings divided by the total annual fuel input. Also monitor annual pump kWh for the hot water primary loop and distribution loop, and use this value to calculate plant distribution pump energy as a fraction of district hot water energy used at the building.
- Monitor the fuel input at the plant and pump kWh as described above. Also monitor the heating energy generated at the plant using a BTU meter. Average heating efficiency excluding losses is equal to the heating energy generated at the plant divided by the total annual fuel input. Use default values for heating distribution losses as shown below, or use monitored data to measure these losses, or provide a calculation for the losses.

Cooling:

- For an electric chiller plant, monitor the total annual electric energy consumed by the plant (this would be best accomplished by monitoring only energy used by district energy equipment such as chillers, cooling towers, and pumps; however, it is acceptable to use the more conservative value from a plant electric meter as well). Also monitor the total MBTU of chilled water delivered to each of the buildings serviced by the district plant (using BTU meters at each delivery point). Use these values to calculate the average cooling plant COP including losses.
- For an electric chiller plant, monitor the total annual electric energy consumed by the plant as described above. Also monitor the cooling energy generated at the plant using a BTU meter. Use these values to calculate the average cooling plant COP excluding losses. Use default values for cooling distribution losses as shown below, or use monitored data to measure these losses, or provide a calculation for the losses.
- For a chiller plant requiring fuel inputs, use a similar process to that listed in the previous two bullets, but measure fuel inputs to the cooling equipment as well.

Modeling: Proposed building, heating/cooling efficiency:

Create a model of the district plant that reflects actual installed district energy equipment. Apply measured or estimated load profiles as "process loads" to reflect the estimated total loads on the district energy plant. Use the total energy consumption and total district energy generated from this analysis to calculate the average heating or cooling efficiency.

Heating:

- Model heating equipment efficiencies, equipment staging, and part-load conditions based on the rules and procedures defined in Appendix G. Apply measured or estimated load profiles for all buildings served by the DES as "process loads" to reflect the estimated total loads on the plant. Use the total energy consumption and total district energy generated from this analysis to calculate the average DES heating efficiency. Use monitored data to calculate heating distribution losses, or provide a calculation for the losses, or use the default values in section *2.4.3.2.3 Default Efficiencies*, and include these losses in the energy model calculations.

Cooling:

- Model cooling equipment efficiencies, equipment staging, and part-load conditions based on the rules and procedures defined in Appendix G. Apply measured or estimated load profiles for all buildings served by the DES as "process loads" to reflect the estimated total loads on the plant. Use the total energy consumption and total district energy generated from this analysis to calculate the average cooling efficiency. Use monitored data to calculate cooling distribution losses or use the default values in section *2.4.3.2.3 Default Efficiencies*, or provide a calculation for the losses, and include these losses in the energy model calculations.

For hybrid absorption/electric cooling, the ratio of absorption cooling to electric cooling shall be reflected identically in the building energy model as metered or modeled for the district energy plant.

For thermal energy storage, the percentage of peak or mid-peak thermal energy shifted to off-peak periods in the building model shall be identical to the value metered or modeled in the district energy plant (using the same granularity as the efficiency calculations – e.g. seasonally, monthly, etc.). For example, if 50% of the on-peak period cooling load in the district plant is shifted to off-peak during the month of July, then the building model shall show 50% of the peak building cooling load shifted to off-peak during the month of July.

All equipment from the DES central plant shall be reflected in the average efficiency calculations. When new chillers or boilers are added to an existing plant, their performance shall be combined with that of the pre-existing chillers or boilers, reflecting the anticipated sequence of operations and plant loads, to derive the overall plant-average performance.

Applying Average Efficiencies to the Option 2 Proposed Case Model

The average efficiencies may be factored into the Option 2 proposed case using either of the following methods:

Method 1 (DES average efficiency accounted for in energy model) – model heating or cooling equipment with a flat equipment part-load performance curve where the full load efficiency modeled for each DES system reflects the average efficiency calculated above:

- In general, the cooling will be modeled as air-cooled chillers with the district heat rejection and pumping energy reflected in the average cooling efficiency for the chiller.
- In general, heating equipment will be modeled as forced draft boilers with the natural gas inputs reflecting the average heating efficiency, and the electric inputs reflecting the pumping and auxiliary energy per unit heating.
- In general, pumps will be modeled to reflect only the downstream pump equipment.
- Losses can be reflected either in the calculation of average efficiency or in the losses inputs for the energy model.
- If average efficiency calculations are determined using anything other than annual averages, a different piece of equipment would likely need to be specified for each level of time granularity modeled (i.e. – seasonally, monthly, etc.), and the energy model would need to link the operation of the equipment to the time period when the equipment efficiency applied. Alternatively, it may be possible to generate a custom equipment efficiency curve that reflects the efficiency of the equipment at each level of time granularity modeled. If custom efficiency curves are developed, backup documentation must be provided to verify that the efficiency curve appropriately reflects the efficiency at each level of granularity modeled.
- Equipment capacities must be auto-sized using capacity ratios that are equal to those modeled in the Baseline Case (e.g. 1.15 for cooling and 1.25 for heating). As a quality control check, changes to the DES equipment capacity modeled should not impact the results for the model since a flat-load performance curve is used for the DES equipment.

Method 2 (DES average efficiency accounted for in post-processing) – in the proposed case energy model, meter the energy consumption for each DES energy source. Perform a post-processing analysis to derive total annual energy costs using the modeled site energy consumption for each DES energy source, the DES average upstream efficiencies, and the virtual electric and fossil fuel rates from the proposed case energy model.

If anything other than annual average efficiencies are used, then the modeled site energy consumption for each DES source exported to the post-processing analysis must reflect the total DES energy consumption at each level of time granularity modeled (e.g. each season, each month, etc.). Likewise, the virtual electric or natural gas rates must use the same level of time granularity. For each level of granularity modeled (e.g. seasons, months, etc.), the DES average upstream efficiencies are used in combination with the simulated DES consumption and virtual electric or natural gas rates to calculate the total annual DES energy cost. If this method is applied, the post-processing analysis (generally in spreadsheet format) must be uploaded to LEED Online as backup documentation.

APPENDIX D: CHP Modeling Guidance for EAp2/EAc1 Option 2

Generally, LEED projects using the energy modeling path for EAp2 or EAc1 may use either the Option 1 approach (Building Stand-Alone Scenario) or the Option 2 approach (Aggregate Building / DES Scenario). Under Option 2 some projects will have a CHP plant (cogeneration plant) within the DES. In such scenarios the fuel inputs, electric generation outputs, and heat recovery shall be modeled as described in this appendix.

The baseline case is modeled as described in ASHRAE 90.1 Appendix G and as summarized in section 2.4 above. Although the baseline case is not modeled as CHP (i.e., the model assumes separate production of electricity and thermal energy), in some situations, for CHP energy accounting purposes, the baseline case is charged with extra energy use. The situations when this applies and the method for making this adjustment are defined below.

The proposed case may be modeled in various ways, each of which is described below.

Calculation Methods

The average electric generation, fuel input, and heat recovery of the CHP shall be determined OR the defaults for electric and thermal efficiency below shall be used in conjunction with capacity ratings of the equipment to calculate the average electric generation and fuel input.

The following are acceptable methods of calculating annual electric generation:

- Monitor the total annual gross electric generation. Also monitor the total annual parasitic loads (such as the annual electricity used for cooling the intake air for a turbine). The net annual electric generation would be calculated as the annual gross electricity generated with all parasitic loads subtracted out.
- Model the generators in energy simulation software based on the rules and procedures defined in Appendix G: Use peak electric efficiencies, and generator curves that match the installed generator(s). Apply measured or estimated load profiles as “process loads” to reflect the estimated total electric and thermal loads on the district energy CHP system. Use the total energy generated and total fuel input from this analysis. Any parasitic loads (such as the annual electricity used for cooling the intake air for a turbine) must be included in the analysis and subtracted from the annual electric generation to calculate the total annual electric generation.

The following are acceptable methods of calculating annual fuel input:

- Monitor the total annual fuel input to the generator(s).
- Model the generators in energy simulation software based on the rules and procedures defined in Appendix G. Use peak electric efficiencies, and generator curves that match the installed generator(s).

The following are acceptable methods of calculating waste heat recovery:

- Monitor the total waste heat recovered.
- Model the generators in energy simulation software based on the rules and procedures defined in Appendix G. Use peak electric efficiencies, and generator curves that match the installed generator(s). Model the thermal equipment served by the CHP waste heat (e.g. boilers, absorption chillers, etc.) using the installed equipment capacities, efficiencies and efficiency curves, and reflecting the total heating and cooling loads on

the plant as a process load. Use the energy modeling outputs to identify the total heat recovered.

CHP Electric Output

Proposed case: allocate the electricity generation to the building based on the fraction of thermal loads to the building for the DES sources that use recovered waste heat. For each DES source supplied to the building, determine the fraction of the recovered waste heat applied to that source as well as the amount serving the project building. The same calculation approach is taken for all DES systems, but relatively simple DES systems can use a simplified formula as shown below:

Simple DES/CHP arrangement: for CHP plants in which the recovered waste heat is used directly in the DES and that heat serves only heating loads in the connected buildings, the electricity generation assigned to each building is calculated as:

$$CHP\_ELEC_{BLDG} = (X_{HEAT} * BLDG_{HEAT}) * CHP\_ELEC_{TOTAL}$$

Where:

CHP_ELEC_{BLDG} = The CHP electricity generation allocated to the building

X_{HEAT} = The fraction of the CHP plant's total production of waste heat applied to the DES directly

$BLDG_{HEAT}$ = The fraction of total district heat provided to the building

CHP_ELEC_{TOTAL} = The total CHP electricity generated at the DES plant

General, more complex arrangement: this is for CHP plants in which a portion of the recovered heat is used to drive absorption chillers that provide cooling through a DES chilled water loop, and/or a portion of the recovered heat is used for a third, separate district energy source (e.g., if the building connects to both a steam loop and a hot water loop, or to two separate chilled water loops). In this case the electricity generation assigned to each building is calculated as:

$$CHP\_ELEC_{BLDG} = [\ (X_{HEAT} * BLDG_{HEAT}) + (Y_{CHW} * BLDG_{CHW}) + (Z_{SOURCE} * BLDG_{SOURCE})\ ] * CHP\_ELEC_{TOTAL}$$

Where:

CHP_ELEC_{BLDG} = (same as above for simple case)

X_{HEAT} = (same as above for simple case)

$BLDG_{HEAT}$ = (same as above for simple case)

Y_{CHW} = The fraction of the CHP plant's total production of waste heat applied to producing chilled water in the DES

$BLDG_{CHW}$ = The fraction of total district chilled water provided to the building

Z_{SOURCE} = The fraction of the CHP plant's total production of waste heat applied to the 3rd district energy source

$BLDG_{SOURCE}$ = The fraction of the 3rd district energy source that is provided to the building

CHP_ELEC_{TOTAL} = (same as above for simple case)

Baseline case: follow the general procedures described in section 2.4 of this document, and adjust the results as follows depending on the results of the DES electricity allocation and the total modeled electricity use of the building in the Option 2 Proposed Design (including the electricity consumption of district plant equipment serving the building):

- **Scenario A – the building's allocation of CHP-generated electricity is less than or equal to its modeled electricity consumption:** No adjustment. The Baseline building is charged with the energy used by its (non-CHP) systems at market rates using standard procedures.
- **Scenario B – the building's allocation of CHP-generated electricity exceeds its modeled electricity consumption:** the amount of excess CHP electricity allocated to the building is considered "process energy" in the energy model. Adjust the input fuel associated with this excess CHP electricity in the Baseline case as described below.

CHP Fuel Input

Allocate the CHP input fuel to the project building based on a proration and assignment of the total input fuel according to the results of the CHP electricity allocation described above. Use the prevailing energy rates as they apply to the design building. Any additional energy used by the proposed design building is also charged at market rates. Use the following formulas:

Proposed Case (all scenarios): the CHP input fuel allocated to the building is calculated as:

$$ProposedBLDG_{FUEL} = (CHP\_ELEC_{BLDG} / CHP\_ELEC_{TOTAL}) * CHP_{FUEL}$$

Where:

$ProposedBLDG_{FUEL}$ = The proposed case CHP input fuel allocated to the building

CHP_ELEC_{BLDG} = The CHP electricity generation allocated to the building (i.e., the result of the previous calculations)

CHP_ELEC_{TOTAL} = The total CHP electricity generated at the DES plant

CHP_{FUEL} = The total CHP fuel input for electricity generation at the DES plant

Baseline Case (scenario B only): If the CHP-generated electricity allocated to the building exceeds the modeled electricity consumption of the proposed building, then the baseline case is charged with the CHP input fuel associated with that "process" electricity in order to hold this portion of the CHP energy use cost-neutral in the model:

$$BaselineBLDG_{FUEL} = (PROCESS\_ELEC_{BLDG} / CHP\_ELEC_{TOTAL}) * CHP_{FUEL}$$

with

$$PROCESS\_ELEC_{BLDG} = CHP\_ELEC_{BLDG} - PROPOSED\_ELEC_{BLDG}$$

Where:

$BaselineBLDG_{FUEL}$ = The baseline case CHP input fuel charged to the building

$PROCESS\_ELEC_{BLDG}$ = the amount of allocated CHP electricity in excess of the building's modeled

annual electricity consumption (treated as process energy in the model) *CHP_ELEC*$_{TOTAL}$ = (same as above for proposed case) CHP_{FUEL} = (same as above for proposed case) *CHP_ELEC*$_{BLDG}$ = (same as above for proposed case) *PROPOSED_ELEC*$_{BLDG}$ = The modeled electricity consumption for the building from the Option 2 proposed case

CHP Generator Default Efficiencies

Actual efficiency performance data on the CHP serving the project building is preferred, based on either ongoing operations (existing CHP) or design specifications (new CHP). If the project team cannot obtain the actual performance data, it is permissible to use the following default seasonal performance values. These values are conservative, intended to represent a CHP system with relatively low efficiency. A well designed, maintained, and operating CHP system will generally offer better performance than the defaults listed here. Default average values are as follows:

- Generator Electrical Efficiency – 22%
- Generator Thermal Efficiency – 25%
- Single-effect absorption chillers – 0.60 COP
- Double-effect absorption chillers – 0.90 COP
- Absorption cooling plant electrical efficiency (including cooling towers and primary pumps) – 40 COP

APPENDIX E: Special Situations for DES energy models

Service water heating

Many commercial buildings heat their service water using a variety of different sources. If one of those sources is DES-supplied heat then that is implemented in the energy model according to which optional compliance path the project team is using:

> Option 1 (Building Stand-Alone Scenario) – no change from the standard guidance in section 2.4: model the energy source as "purchased energy" in order to hold the DES cost-neutral for service water heating.
>
> Option 2 (Aggregate Building / DES Scenario) – as a default streamlined method, USGBC recommends modeling the energy source as "purchased energy" in order to hold the DES cost-neutral for service water heating. Thus, for service water heating Option 2 is implemented in the same way as Option 1. If desired, the project team may use an exceptional calculation method to document DES-related savings from service water heating, but in this event the project team must fully justify and support the annual energy consumption and cost in both the Baseline Case and the Proposed Case models.

For either option use a reasonable, well-founded purchased energy rate in the models, such as the actual rate paid to the DES supplier or a virtual rate derived using a method similar to the one described in section 2.4 of this document.

Heating converted to cooling as part of the LEED project

Generally, district or campus systems that produce heating energy (steam or hot water, whether directly or as waste heat) serve heating end use applications in the connected buildings. Sometimes the heating energy supply is converted to chilled water using absorption chillers or other similar technologies in order to serve cooling loads instead. In this circumstance the equipment that converts heating to cooling may reside either within the DES itself (i.e., DES provides cooling to building) or within the connected buildings (i.e., DES provides heating to building; building converts heating to cooling).

When the equipment converting DES-supplied heat into cooling is part of the LEED project's scope of work, then the DES guidance in this document must be modified for the EAp2/c1 energy modeling path. The modifications for this situation are as follows; guidance for all other LEED credits remains unchanged:

1. Model the district heating source servicing the chilled water generation equipment as follows:
    - For Option 1 – Building Stand-Alone Scenario: use "Purchased Heating" in both the Baseline and Proposed Case as described above in Section 2.4.
    - For Option 2 – Aggregate Building/DES Scenario: use a virtual upstream DES plant for the Proposed Case and compare it to code-compliant on-site equipment for the Baseline Case as described above in Section 2.4.

2. Model absorption chiller(s) in the Baseline Case as follows:

- When the purchased heating is hot water with average supply temperatures below 300 °F, the chiller(s) shall be modeled as single-effect absorption chiller(s) (0.7 COP); when the purchased heating is steam or hot water with average temperatures greater than or equal to 300°F, the chiller(s) shall be modeled as double-effect absorption chiller(s) (1.0 COP).
- Building conditioned floor area ≤ 120,000 ft^2 : 1 water-cooled absorption chiller
- Building conditioned floor area > 120,000 ft^2 : 2 water-cooled absorption chillers minimum with chillers added so that no chiller is larger than 800 tons, all sized equally
- For a project including BOTH absorption chillers driven by purchased hot water AND electric chillers on site, the type and quantity of absorption chillers shall be as identified above, and the type and quantity of electric chillers shall be as in Table G3.1.3.7 (or DX equipment as specified), but the total capacity ratio of electric to absorption cooling shall be identical to that of the proposed design.
- For a project including BOTH district chilled water AND absorption chillers on site driven by purchased heating, the type and quantity of absorption chillers shall be as identified above, and purchased cooling shall also be modeled in accordance with the District Energy Requirements document. However, the total capacity ratio of the on-site cooling to purchased cooling shall be identical to that of the proposed design.

3. Model the Baseline Case cooling towers, pumps, chilled water loop configurations, and loop temperature controls as indicated in Appendix G.
4. Model the absorption chiller(s) in the Proposed Case based on the as-designed type and capacity of chillers

Chillers driven by steam turbines

(TBD)

Thermal plant energy inputs without local market prices

(TBD)

Very large, complex DES networks

(TBD)