**EE4: Building Decarbonization Start-Up Programs**

## Contents



## Introduction

The main goal of building decarbonization ("BD") is to reduce $CO_2$ emissions in the built environment, including emissions from activities within buildings as well as embodied emissions. In its role as the regulator of electric and natural gas utilities, BPU may more directly influence operational $CO_2$ emissions reductions through energy efficiency ("EE"), demand response ("DR"), and electrification programs. BPU Staff ("Staff) proposes Building Decarbonization Start-up programs ("BD Programs") that achieve emissions reductions primarily by fuel-switching of space heating and water heating from fossil fuels to electric heat pumps. The BD Programs would initially prioritize switching from delivered fuels to electric heat pumps through programs offered by electric distribution companies ("EDCs") and would not include fuel-switching from delivered fuels to natural gas systems. Gas distribution companies ("GDCs") could offer BD programs specifically to gas customers who are eligible for hybrid heating systems (as described further below), as well as district geothermal heating.

Future manifestations of BD Programs could include policy and programs to promote carbon-free on-site energy generation.

The BD Programs are proposed as a part of the portfolio of energy efficiency programs ("EE Programs") implemented pursuant to New Jersey's Clean Energy Act of 2018 ("CEA") to explore policy on program design, evaluation, measurement, and verification ("EM&V"), equity, workforce development, cost-effectiveness, and performance incentives for an electrification program. While EE seeks to reduce energy consumption, BD seeks to reduce and ultimately eliminate $CO_2$ emissions from the building sector. As such, the key performance metric is reduction in $CO_2$ emissions, in addition to therms, kWh, or

Btus. Through the following proposed BD Programs framework, investor-owned utility companies ("Utilities") may propose a portfolio of measures and/or sub-programs to target single and multifamily residential buildings and commercial buildings, with prioritization of low- and moderate-income customers.

## Background

The *2019 New Jersey Energy Master Plan: Pathway to 2050* ("EMP") defines two of the seven key strategies to achieve clean energy by 2050 as "Maximize Energy Efficiency and Conservation and Reduce Peak Demand" (Strategy 3) and "Reduce Energy Consumption and Emissions from the Building Sector" (Strategy 4).[1] With regard to Strategy 4, the EMP states that the building sector should be decarbonized and largely electrified by 2050 with an early focus on new construction and the conversion of electric baseboard heating and oil- and propane-fueled buildings. Section 4.1 of the EMP specifically highlights the urgency to act on electrification:

> Much of the infrastructure, technology, and assets used to power the building sector have decades-long lifespans. Therefore, continuing to expand the gas distribution system and rely on fossil fuel heating for new construction and replacement of aging heating systems will lock in decades of continued emissions and risk financing what will become stranded assets. Delaying the transition might pose a missed opportunity to replace existing equipment with more efficient electric options.

New Jersey's Global Warming Response Act 80x50 Report, "Evaluating Our Progress and Identifying Pathways to Reduce Emissions 80% by 2050" ("80x50 Report"), identifies building space heating and water heating-based electrification as a key strategy to reduce emissions.[2] Specifically, the 80x50 Report cites the modeling results of the Integrated Energy Plan in projecting the need and expectation to quadruple building electrification from about 5% to over 20% from 2020 to 2030 and to increase it to 90% by 2050.

Governor Murphy's Executive Order 315 (February 2023) calls for the development of a new Energy Master Plan pursuant to the State's new policy to advance clean energy market mechanisms and other programs in order to provide for 100% of the electricity sold in the state to be derived from clean sources of electricity by January 1, 2035.

In addition, Governor Murphy's Executive Order 316 (February 2023) directs that, by 2030:

> 400,000 additional dwelling units and 20,000 additional commercial spaces and/or public facilities statewide will be electrified, and an additional 10 percent of residential units serving households earning less than 80 percent of area median income will be made

[1] *2019 New Jersey Energy Master Plan: Pathway to 2050*, *available at* https://www.nj.gov/emp/

[2] GWRA 80X50 Report https://www.nj.gov/dep/climatechange/docs/nj-gwra-80x50-report-2020.pdf

ready for electrification through the completion of necessary electrical system repairs and upgrades. For purposes of this Order, 'electrification' shall be defined as the retrofitting or construction of a building with electric space heating and cooling and electric water heating systems.

The federal Inflation Reduction Act ("IRA") will further augment New Jersey's BD efforts.[3] The federal home electrification program will provide rebates of up to $8,000 and 100% of the cost of heat pumps for lower-income households. For higher-income households, a 30% tax credit is available for purchase and installation costs for energy audits, insulation, efficient HVAC and water heating, as well as battery storage and solar.

Two aspects of the CEA influence the design of the BD Programs. First, the CEA requires that Utility EE portfolio benefit-cost ratios equal or exceed 1.0, with exceptions allowed "if implementation of the program is in the public interest," noting emerging technology and low-income programs as exceptions.[4] The 2020 Order in which the Board adopted the first New Jersey Cost Test ("NJCT") expands on the reasons for "reasonable policy interests" for individual programs or measures to not have a 1.0 ratio, "such as to promote health and safety, to ensure equitable access, or to spur innovation, the adoption of other measures, or longer-term market transformation."[5] Electrification from delivered fuels is often cost-effective for customers; and switching from natural gas may be cost-effective under certain scenarios (e.g., when gas customers need to replace both a furnace and air conditioner, or when there are additional, integrated interventions such as weatherization, energy storage, renewable energy, rate changes, or bill credits) and depending on their utility territory and rate plan.[7] The *New Jersey Energy Master Plan: Ratepayer Impact Study* found that, due to natural gas rates rising faster than electricity rates, most utility territories by 2030 will find operating costs for heat pumps to be less than those for natural gas furnaces.[6]

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[3] The High Efficiency Electric Home Rebate Act ("HEEHRA") in the IRA will provide heat pump incentives of up to $8000 and 100% of the cost for heat pumps for lower- income households. The Energy Efficient Home Improvement Credit provides a 30% tax credit for energy efficiency upgrades. The act "allows an annual $1,200 limitation of the credit amount in lieu of a lifetime limitation. The act also allows an annual $2,000 credit for geothermal heat pumps and biomass stoves and increases the credit for windows and doors". It allows 30% tax credit, up to $150, for home energy audit.

[4] N.J.S.A. 48:3-87.9(d)(2), *available at* https://pub.njleg.gov/bills/2018/PL18/17_.PDF.

[5] In re the Implementation of P.L. 2018, c. 17 Regarding the Establishment of Energy Efficiency and Peak Demand Reduction Programs; In re the Clean Energy Act of 2018 – New Jersey Cost Test; BPU Docket Nos. QO19010040 and QO20060389, Order dated August 24, 2020, *available at* https://www.state.nj.us/bpu/pdf/boardorders/2020/20200824/8A%20-%20ORDER%20New%20Jersey%20Cost%20Test.pdf.

[6] New Jersey Energy Master Plan: Ratepayer Impact Study (August 2022), *available at* https://www.nj.gov/bpu/pdf/reports/2022-08-13%20-%20BPU,%20EMP%20Ratepayer%20Impact%20Study%20Report_PUBLIC_Brattle.pdf

Second, the CEA requires "each electric [or gas] public utility to implement energy efficiency measures that reduce electricity [or natural gas] usage in the State." Since the BD Programs are proposed as part of the portfolio of EE programs, measures implemented within the BD Programs must result in net energy savings on an MMBtu basis. All BD measures should therefore be tracked and analyzed for both net energy and $CO_2e$ savings.

## Program Goals and Scale

Given New Jersey's mid- and long-term goals for building electrification, clean energy, and emissions reductions by 2030, 2035, and 2050, BPU staff ("Staff") proposes that BPU's high-level goals for BD during Triennium 2 (2024–2027) include the following:

- Design, launch, and test a set of BD programs offered by utilities and targeted at space and water heating in the residential and multifamily sectors, while prioritizing switching from delivered fuels to electric heat pumps and making buildings electrification-ready[7]; these programs should prioritize low- and moderate-income customers who are not eligible for the low-income Comfort Partners program;
- Invite proposals for BD programs offered by utilities that target the commercial sector; these may include smaller scale programs that focus on switching from delivered fuels to electric heat pumps in smaller commercial buildings, and/or they may include district geothermal systems for commercial customers;
- Design, launch, and test a BD pilot program targeted at institutions of higher learning through the Large Energy Users Program offered by New Jersey's Clean Energy Program;
- Develop programmatic infrastructure to effectively market, deliver, and track BD program impacts and costs;
- Increase market knowledge, infrastructure, and capacity to accelerate the delivery of, and reduce the costs of, BD technologies, systems, and practices to end users;
- Develop New Jersey-specific analyses of BD impacts, costs, opportunities, barriers, and cost-effectiveness (both near term and longer term);
- Collect comprehensive performance and market transformation-related metrics and prepare evaluation studies informed by timely, sub-annual informal reporting using embedded, quasi-real time evaluation;
- Collaborate to consistently implement BD programs in coordination with core EE programs;
- Set the foundation for New Jersey in Triennium 2 to make significant progress in Triennium 3 (2027–2030) – with a specific focus on achieving EO 316 goals – and thereafter towards cost-effectively achieving its BD goals.

As noted previously, New Jersey's ambitious greenhouse gas ("GHG") reduction goals require significant reductions in emissions from buildings on a rapid trajectory. At the same time, there are a number of new policy, program, analytical, and market issues that need to be developed and assessed in the near term to enable prudent and effective BD over the longer term. Several states have adopted progressive decarbonization strategies such as large-scale building electrification targets, buildings performance

[7] Electrification readiness measures include panel upgrades; electric wiring; and installation of sufficiently-rated electrical receptacles near household ranges, cooking appliances, clothes dryers, water heaters.

standards, and/or clean heat programs with decreasing emissions targets.  While New Jersey can build and is building on the lessons learned from other jurisdictions already engaged in BD, this BD program is being launched as a first step towards large scale transformation in New Jersey's buildings sector, while recognizing the likely market transformation that will result from federal EE and heat pump rebates.

Staff's intention is to initiate programs of large enough scale in Triennium 2 to achieve some material economies, market adoption, and lessons learned, while managing the total cost to a target level that is well below that of EE programs.

Staff aims for a total utility BD programmatic effort of roughly $50 million per year for Triennium 2.  Spending may be scaled up year-to-year across the three years of the triennium subject to a total cost of $150 million for the triennium.  The allocation of the budget across the utilities should reflect the intended program participants in each Utility territory.  BD programs for the commercial sector are not required but may be proposed up to 30% of a Utility's BD program budget; these programs could serve smaller commercial buildings or propose district geothermal heating for commercial customers.

Based on Triennium 2 BD Programs results, as well as related analyses of market potential and cost-effectiveness, Staff anticipates that BPU will further scale and modify the BD programs and requirements for Triennium 3.

## Program Criteria and Considerations

The BD Programs must demonstrate net reductions in GHG emissions based on source energy, within the constraints of policy objectives such as cost-effective delivery to the customer and public health impacts. The BD Programs will be assessed based on the following criteria:

1. Net decrease in source emissions across affected fuels;
2. Net decrease in source energy across affected fuels;
3. Net end user bill savings across affected fuels; and
4. Cost-effectiveness as defined by the NJCT and Participant Cost Test ("PCT").

Net bill savings are an important goal for the longer term; however, for Triennium 2, the BD Programs would not be required to result in net bill savings.  Some early adopters may be willing to adopt BD measures without a reduction in their bills.

Note that reporting requirements for these metrics are included in the Minimum Filing Requirements section for BD programs later in this section.

With respect to cost-effectiveness, a goal of this initial BD effort is to demonstrate and, as necessary, improve the cost-effectiveness of BD Programs and measures.  The primary basis for assessing BD Programs' cost-effectiveness will be the NJCT.  Results for additional Standard Practice Manual tests are also required and should follow the reporting requirements for the CEA EE programs.  For Triennium 2, Staff proposes not requiring that the BD Programs achieve a cost-effectiveness ratio greater than or equal to 1.0; however, the level of cost-effectiveness will be an important metric in consideration of which programs should be approved.  The rationale for aiming for but not requiring an NJCT result of 1.0 or greater is that the goals for the BD Programs in Triennium 2 are to build the necessary capacity and skills for delivering meaningful GHG emission reductions while also producing the empirical data needed to fully assess impacts and cost-effectiveness.  Based on the results of the Triennium 2 effort, BPU will have the information needed to assess the BD Programs' cost-effectiveness and performance for the purposes of informing Triennium 3 requirements and funding levels. For example, there may be a greater expectation for the BD Programs to pass the NJCT in Triennium 3.

In this start-up phase, Staff encourages the utilities to develop plans for prioritizing customers who currently utilize delivered fuels for their space and water heating needs. As noted above, national data show that switching from delivered fuels to efficient electric heat pumps is cost-effective. A New Jersey-specific market characterization study to determine how to identify these customers is noted below as an additional research need prior to Triennium 2 and is expected to further inform these programs. In addition, the utilities are encouraged to collaborate to develop a targeted marketing plan to focus on supporting customers to switch from delivered fuels. Prioritizing projects that are likely to be highly cost-effective can help drive scale and learnings in this initial phase and eliminate the most emissions-intensive sources of space and heating.

The proposed scope of the BD Programs includes all customers not eligible for Comfort Partners, which is currently developing its own decarbonization pilot for customers eligible for the program. The BD Programs, therefore, should serve non-low-income residential customers and multifamily customers, and they may also serve commercial customers. While serving all eligible customers, the BD Programs must be designed to enable participation by LMI and multifamily customers and thereby encourage equitable conversion. In particular, EO 316 calls for 10% of residences in low- and moderate-income ("LMI") communities to be made "electric ready." Moreover, the *NJ Energy Master Plan – Ratepayer Impact Study* noted the importance of encouraging electrification for LMI households. If LMI households comprise an increasing share of the natural gas customer base, they would be disproportionately saddled with rising natural gas rates and therefore unsustainable energy burdens.

All BD Programs should seek to leverage IRA tax credits and electrification rebates based on customer eligibility.

The BD Programs should be designed in alignment with the EE Programs (and the IRA EE rebates that those programs will leverage) and should be designed to promote targeted complementary measures that support and enhance BD, such as weatherization, replacement of electric resistance heating with heat pumps, electrification-readiness when combined with other EE upgrades, and behind-the-meter demand response measures, through integration with EE Programs. For example, three existing utility residential programs offer incentives for measures that overlap with potential BD Programs' measures, and these should be integrated with the new BD Programs:

- *Home Performance with Energy Star* (HPwES) offers incentives and financing for whole building solutions which may be a combination of weatherization and HVAC equipment upgrades.
- *Prescriptive incentives* are offered for Energy Star heat pumps, including cold-climate heat pumps, as well as heat pump water heaters.
- *Moderate-Income Weatherization* provides cost-free weatherization for moderate-income households (less than 400% of the federal poverty level).

Additionally, BD Programs serving the multifamily sector should similarly be designed in alignment with the EE Programs and also in consultation with the New Jersey Housing and Mortgage Finance Agency and New Jersey Economic Development Authority to ensure alignment with other existing and complementary State programs or incentives for affordable and multifamily housing.

Guidance for Integrating the BD programs into EE programs:

In developing program proposals, the utilities should collaborate to ensure a consistent set of BD Program requirements and features statewide, utilizing the below guidance as a starting point. Utilities should also seek stakeholder input to refine the design of these programs through at least 2 virtual public stakeholder outreach sessions during and after business hours that are advertised on their websites.

- **Customer choice** – BD Programs should at a minimum offer a pathway for simple equipment swap outs and a more comprehensive pathway that offers packaged measures that include weatherization plus efficient electric equipment. The more comprehensive pathway can be met by serving customers with both BD and EE Programs.
- **Coordinating incentives for BD measures** – Utilities should continue to offer incentives to reduce energy consumption by fuel (including, for example, weatherization measures and appliance incentives for converting from electric resistance to electric heat pumps) through the EE Programs, and this should be made clear and simple for contractors and customers to navigate. The BD Programs will offer fuel switching and electrification-readiness incentives.
  - For projects that include BD measures + weatherization or other complementary measures to support electrification, the BD Program should be layered with existing EE offerings (e.g., for residential customers, HPwES or Moderate-Income Weatherization) to avoid duplicative or competing program offerings.
  - In overlapping utility service territories, utilities should coordinate delivery of BD Programs to preclude duplicative or competing program offerings.
- **Single intake with simplified application requirements** – Customers choosing to do energy efficiency and electrification should not have to apply separately to the BD Programs and other EE Programs. There should be a single intake where the coordination and incentive stacking is done behind the scenes.
- **Positioning the EE programs to support BD** – To further support the BD Programs, there should be a mechanism within the Utilities' existing EE programs to identify whether the customer would be a good candidate for electrification and to inform them of the potential BD incentive opportunities. The utilities should develop criteria to determine whether customers are good candidates for electrification (e.g., age of equipment, decision event, health and safety, envelope efficiency) and have a process for marketing and coordinating BD incentives if a customer is found to be a good candidate. Further, the utilities' EE Programs – for example, Quick Home Energy Check-up – should be configured such that the customers' existing heating equipment type and age is recorded and that customer data should go into a database for future marketing efforts for electrification.
- **Incentive levels and structure** – In developing proposals for core programs and for BD Programs, utilities should assess current incentive amounts for all heating and cooling equipment and realign incentive levels such there is a clear and strong incentive for customers to pursue the BD pathway. Utilities should collaborate with BPU Staff and other stakeholders to identify appropriate incentive levels and ensure balance across programs, with consideration of market dynamics, program budgets, etc. Utilities should also include mid-stream incentives in both EE and BD programs for contractors to encourage adoption. Further, incentive structures should be designed to be as simple as practicable to support program accessibility and uptake.

- **Contractor training** – Utilities should develop required trainings for contractors to ensure that contractors have the tools and training that they need to effectively promote the BD Programs, as well as to effectively size and install BD measures.

## Building Decarbonization Program Measures

For the BD Programs, fossil fuel to electric fuel switching, subject to the requirements above, is the proposed initial priority for Triennium 2. Examples of program measures include:

- Fuel switching of a space heating system, such as a fuel oil or natural gas furnace, to a heat pump;
- Fuel switching of a domestic water heater, such as a propane or natural gas heater, to a heat pump;
- Replacement of both a furnace and air conditioner with a heat pump;
- Hybrid heating system, such as the replacement of an air conditioner with a heat pump in a central air system that retains the natural gas furnace that is operating well and not at end of life, and could include integrated controls to switch between the furnace and the heat pump during the heating season; and
- Conversion of other gas to electric end-uses, such as induction cooking and dryers.

Henceforth, these measures will be referred to as BD measures.

<u>Minimum Equipment Performance Specifications</u>

The utilities should adopt a consistent set of minimum performance specifications for the BD measures statewide and should take into account existing standards to maximize alignment with other state and federal incentives.

## Fuel Switching Events

The BD measures depend upon various baseline scenarios, which determine the performance of the particular measure. The baseline condition may be either an existing fossil-based system, a new fossil-based system under consideration, or an early replacement fossil-based system with dual baseline considerations.[8] For space heating, the most common substitutions involve heat pumps displacing boilers or furnaces. For water heating, heat pump water heaters displace fossil fuel-fired water heaters. Substitution also covers other end-uses such as cooking equipment and clothes dryers. In all cases, the primary intent is to reduce net GHG emissions impacts, and wherever applicable consider indoor air quality impacts.

[8] The NJ TRM defines these terms in greater detail.

It is important that the BD Programs track key parameters that describe the baseline:

- **Baseline heating fuel.** Displacing an oil-fired boiler will have a different emissions impact than displacing a propane or natural gas furnace or a wood-fired boiler.[9]
- **Baseline equipment type, heating.** A central furnace will have a different baseline energy use than a water boiler or a steam boiler. This variable is less critical than others on the list.
- **Baseline equipment type, cooling.** Is the heat pump displacing another existing or anticipated cooling system, or is it being installed and used in a space that otherwise would not be cooled? Or is cooling use not planned at all?
- **Baseline condition (event type), heating.** The 2023 Technical Reference Manual ("TRM") presents six baseline conditions or event types. Five of the six could apply to a heat pump. Table 1 repeats the conditions and provides an illustrative but not exhaustive list of baseline and replacement scenarios. BD Programs should assess each participant's baseline condition, as this affects first-year and lifetime energy savings and cost.
- **Baseline condition (event type), cooling.** Cooling baselines typically follow the logic of the heating baseline. One significant difference that evaluators may investigate is the possibility of program-induced load growth and related emissions impact.

Table 1: Event Type Examples

| Event Type | Baseline | Efficient Case |
|---|---|---|
| Replace on Failure (ROF) | Replacement of a failed central air conditioner and old but working propane-fired furnace integrally built with the central air conditioner ("CAC"). The baseline is a new industry standard practice ("ISP") CAC and propane furnace. | New ducted air source heat pump ("ASHP") |
| Retrofit ("RF") | Existing functional oil-fired central system | Ductless minisplit heat pump added to one room |
| Early Replacement ("EREP") (including Direct Install) | Replacement of a working propane water heater. The initial baseline is the existing water heater; then, after the remaining useful life expires, nominally 1/3 of the 11-year effective useful life, the baseline is a new ISP propane water heater for the remaining years of life. | New heat pump water heater |
| Early Retirement ("ERET") | | Not applicable for heat pumps or heat pump water heaters. There is no material resale market for them. |

Hybrid dual-fuel systems are the combination of a fuel-fired furnace with a heat pump in a central air system. The replacement heat pump operates for cooling and heating and must be sized to meet the full heating demand load. The fuel-fired furnace turns on at a balance point when either the operating cost or emissions are lower for the furnace than for the heat pump. Event types for the replacement of a traditional central air system of a fuel-fired furnace and air conditioner with a hybrid system include two cases: i) replace on failure for air conditioner or furnace and ii) early replacement of the air conditioner or

[9] New Jersey GHG Inventory, https://dep.nj.gov/ghg/nj-ghg-inventory/

furnace. The financial analysis of the two cases must take into account the age of the still-working system and whether the replacement heat pump meets full

## Program Impacts for Program Administrators

For BD measures, the primary policy objectives are cost-effective net reductions in GHG emissions and source energy (source Btu). For reporting and compliance purposes, the source energy savings and emissions impacts shall be claimed by the utility that implements the measure. As discussed earlier, the treatment of energy and emissions savings for fuel switching measures are more complicated than for EE measures in that estimation of the primary impacts requires an assessment of source energy and emissions impacts that considers all of the end uses and fuels affected by the fuel switching measure, rather than only site energy impacts.

For example, a project that replaces a gas furnace and electric air conditioning system with a heat pump system that provides heating and air conditioning would have a reduction in site therms for heating, an increase in site electric kWh for heating, and a change in site air conditioning usage. The change in air conditioning usage is likely to be a reduction or neutral change in cases where a heat pump replaces an existing central air conditioner (if the HP's cooling efficiency is equal to or greater than that of the AC unit it replaces, and the size of the systems are the same in terms of cooling tons of capacity). The impact on site air-conditioning usage also could be an increase in site electricity use, if there was no air conditioning system previously and there is low likelihood that air conditioning would have been installed absent the influence of the program.

In addition, some measures that may be targeted at one end use, such as a heat pump water heater replacing a delivered fuel or gas water heater, may have impacts on other end uses. For example, a heat pump water heater pulls heat from the surrounding air, which may impact building heating and cooling loads depending on where the water heater is located (e.g., fully-conditioned, semi-conditioned, or unconditioned space) and other factors. These impacts also must be accounted for.

Once all of the site energy impacts have been estimated across all of the impacted end uses and fuels, they can be converted to the common unit of source energy (source Btu) and the total source energy impacts can be estimated and claimed by the implementing utility, as discussed below. For Triennium 2 BD programs, the utility that implements and whose ratepayers fund the BD program, may apply source Btu impacts to their EE savings goals and QPIs. Table X addresses conversion of electricity from site energy to source energy.

For reporting and compliance purposes, the BD measures are evaluated as typical EE measures, where the energy savings may be claimed by the Utility that implements the measure. Unlike for typical EE measures (for which energy savings are reported by each program administrator and $CO_2$ emissions savings are reported at a statewide level), the $CO_2$ emission savings from BD measures will also be calculated and reported. When fuel switching results in changes in therms or kWh, there will be no adjustment of retail sales baselines if it is determined that the three-year average of retail sales will apply for goal setting for the duration of the triennium.[10]

## Source Energy and Emissions Impacts

As discussed in the preceding section, estimation of fuel switching impacts requires estimation of both site and source energy, as well as emissions, impacts. The TRM provides values for many of the parameters needed to calculate site-level consumption and impacts for the measures related to fuel switching. The TRM will be updated prior to Triennium 2 to directly address the site energy impacts of fuel switching measures for all targeted and affected fuels. The remainder of this section addresses conversion of site-to-source energy and emissions.

1. *Source Energy Impact*

For BD measures, source energy impacts are the primary objective rather than site energy impacts. This is because source energy impacts are directly related to the total emissions impacts and costs associated with fuel switching, while site energy impacts are not.[11] For electricity impacts, site kWh must be converted to a common energy unit, Btu, and then further adjusted to account for the energy required to generate each kWh. This is known as the heat rate and is typically expressed in Btu per MWh of electric generation. The conversion from site to source Btu must also account for losses associated with delivery of the electricity from generation to site (T&D losses). Losses shall be calculated consistent with the requirements of the NJCT. Conceptually, source Btu is calculated by taking the site kWh impact, converting kWh to Btu, and then adjusting for losses associated with power plant generation and line losses from transmission and distribution.

A key question in developing the source Btu per MWh intensity factors is how to account for different types and mixes of electricity generation. For fossil generation, the source Btu is obtained by accounting for the efficiency and associated losses in the fossil fuel's conversion to electricity based on the heat rate. Heat rates vary widely within[12] and across different types of fossil-based electricity generation plants such as combined cycle gas, combustion turbine gas, coal, and oil. Table 2 shows EIA estimates of heat rates for different types of non-renewable generation resources.

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[10] Any aggregate impact of fuel switching during the triennium likely would be *de minimus* with respect to energy efficiency goal targets for the triennium.

[11] See, for example, Trupe, Luke, et al., 2020. *Spatio-Temporal Change Among Site-to-Source Conversion Factors for Building Energy Modeling, Energy and Buildings*, Volume 213, April 15.

[12] Heat rates within generation types can vary significantly based on factors such as age of the unit and capacity factors. For example, the most efficient new combined cycle gas plants may have average heat rates as low as 6,600.

Table 2. EIA Average Tested Heat Rates by Prime Mover and Energy Source, 2021, in Btu per kWh[13]

| Prime Mover | Coal | Petroleum | Natural Gas | Nuclear |
|---|---|---|---|---|
| **2021** | | | | |
| Steam Generator | 10,002 | 10,347 | 10,365 | 10,429 |
| Gas Turbine | -- | 13,227 | 11,068 | -- |
| Internal Combustion | -- | 10,461 | 8,821 | -- |
| Combined Cycle | W | 9,208 | 7,580 | -- |

For renewable resources, such as solar, wind, and hydropower, the marginal source energy can be considered to be equivalent to the energy delivered to the grid, implying a heat rate of 3,412. There are multiple approaches in the literature used for imputed heat rates for renewable electricity generation. As this is an emerging area of analyses, we welcome stakeholder comments on the proposed approach. As noted in the footnote, the forecast used for de-escalating emissions is not affected by this choice of heat rates [14]

For the purposes of assessing the impacts of increased electricity generation associated with fuel switching from fossil fuels to electricity, source Btu per MWh of generation should be calculated based on the marginal generation of electricity for PJM, consistent with reported emissions values to be used in the NJCT.[15] The starting value for the 2022 heat rate is based on the mix of marginal generation units for PJM using heat rates by plant type from EIA (Table 2) and calculating a weighted average based on PJM's reported share of each plant type associated with marginal generation. The weighted average heat value is calculated for 2022 using the heat rates from EIA weighted by the percent of each generator type for PJM as shown in Table 3.

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[13] EIA's Electric Power Annual, *Table 8.2 Average Tested Heat Rates by Prime Mover and Energy Source, 2017-2021* https://www.eia.gov/electricity/annual/.

[14] In reviewing the literature on use of heat rates for decarbonization analyses, we found that some analyses choose to use a heat rate of zero Btu per kWh of generation for renewable sources, because they have zero emissions as compared to fossil-based resources. Other analyses have chosen to use the average heat rate of the entire generation mix and apply that average to renewables. Yet others have chosen to use 3,412 Btu per kWh for renewables, essentially a 100 percent efficiency. Since our purpose in using heat rates is to normalize site to source energy across fuels using a site-to-source conversion factor, we use a heat rate of 3,412 per kWh. Thus, the minimum site-to-source conversion factor possible would be 1.0, rather than a value below one if zero was used as the heat rate for renewable generation. Note we are trying to align heat rates with an emissions trajectory (50 percent reduction in $CO_2$ by 2050) we are not using heat rates to estimate emissions.

[15] Within an hour, throughout a year, and across years, different generation resources may be on the margin. Differences in the source Btu of marginal electricity generation that may occur throughout a year, for example, by time of day, day of week, month, or season, can be addressed through use of time differentiated source Btu values. PJM shows little difference in its marginal emission rates for on-peak and off-peak for 2022, however, differences across the hours of a year are expected to increase as the mix of renewable resources increases over time.

Table 3. PJM Marginal Units by Fuel Type and Technology, 2022[16]

| Unit Type | PJM % of Marginal Generation | Heat Rate in Btu per kWh |
|---|---|---|
| Gas CC | 61% | 7,580 |
| Coal St | 10% | 10,002 |
| Wind | 11% | 3,412 |
| Gas CT | 11% | 11,068 |
| Gas St | 1% | 10,365 |
| Oil CT | 2% | 10,461 |
| Ur | 0% | 10,429 |
| All Other | 2% | 8,821 |
| Weighted Average | | **7,899** |

Source Btu for electricity by year are based on an estimate of the heat rate per kWh for PJM, de-escalated to a value equivalent to a 50 percent reduction in $CO_2$ emissions by 2050,[17] as compared to the initial PJM-based value, consistent with the rate of de-escalation of $CO_2$ emissions as specified in the NJCT. The site-to-source conversion factor is calculated as the Heat Rate divided by (3,412*(1-T&D losses)). The resulting heat rates and Site-to-Source MMBtu Conversion Factors by year are shown in Table 4. For electricity, conversion of Site kWh to Site Btu is first calculated based on 3,412 Btu per kWh and then converted to Source Btu using the Site-to-Source Conversion Factors shown in Table 4. The Site-to-Source Conversion values in the table include line losses, which are calculated using a statewide average of 5.8% multiplied by a marginal loss factor of 1.5, as per the NJCT.

Source Btu for fossil fuels shall be based on the latest EPA Btu conversion values, adjusted to account for losses (Source Btu = Site Btu/(1-T&D losses)).

[16] The weighted average heat value is calculated for 2022 using the heat rates from EIA weighted by the percent of each generator type from *PJM's 2018–2022 CO2, SO2 and NOX Emission Rates*, April 27, 2023, Table 1 for the year 2022. https://www.pjm.com/-/media/library/reports-notices/special-reports/2023/2022-emissions-report.ashx

[17] To benchmark the marginal heat rate in 2050, we equate the 50% reduction in C02 per MWh in 2050 to a 50% decrease in the shares of fossil-based electricity generation for PJM in 2050 (as compared with 2022) with the reduced fossil generation sources replaced in the generation mix by renewable resources (and renewable-supplied storage).

Table 4. Electricity Heat Rates and Site-to-Source Conversion Factors

| | Heat Rate (MMBtu per MWh) | Site-to-Source Conversion Factor (StS-CF) |
|---|---|---|
| 2022 | 7,899 | 2.54 |
| 2023 | 7,822 | 2.51 |
| 2024 | 7,744 | 2.49 |
| 2025 | 7,667 | 2.46 |
| 2026 | 7,589 | 2.44 |
| 2027 | 7,512 | 2.41 |
| 2028 | 7,435 | 2.39 |
| 2029 | 7,357 | 2.36 |
| 2030 | 7,280 | 2.34 |
| 2031 | 7,203 | 2.31 |
| 2032 | 7,125 | 2.29 |
| 2033 | 7,048 | 2.26 |
| 2034 | 6,971 | 2.24 |
| 2035 | 6,893 | 2.21 |
| 2036 | 6,816 | 2.19 |
| 2037 | 6,738 | 2.16 |
| 2038 | 6,661 | 2.14 |
| 2039 | 6,584 | 2.11 |
| 2040 | 6,506 | 2.09 |
| 2041 | 6,429 | 2.06 |
| 2042 | 6,352 | 2.04 |
| 2043 | 6,274 | 2.01 |
| 2044 | 6,197 | 1.99 |
| 2045 | 6,120 | 1.96 |
| 2046 | 6,042 | 1.94 |
| 2047 | 5,965 | 1.91 |
| 2048 | 5,888 | 1.89 |
| 2049 | 5,810 | 1.87 |
| 2050 | 5,733 | 1.84 |
| 2051 | 5,655 | 1.82 |
| 2052 | 5,578 | 1.79 |
| 2053 | 5,501 | 1.77 |
| 2054 | 5,423 | 1.74 |
| 2055 | 5,346 | 1.72 |
| 2056 | 5,269 | 1.69 |
| 2057 | 5,191 | 1.67 |
| 2058 | 5,114 | 1.64 |
| 2059 | 5,037 | 1.62 |
| 2060 | 4,959 | 1.59 |

*2. Emissions Impact*

The net emissions due to fuel switching is the difference between emissions from burning natural gas or delivered fuels on-site, and grid emissions associated with the generation of electricity used by the replacement technology. In order to assess the net impact of fuel switching, the generation profile of the grid must be considered in addition to the on-site emissions. As with EE measures, many fuel-switching measures are expected to be relatively long-lived (e.g., 15–20 years for space heating equipment, 50 or more years for new construction infrastructure). Thus, emissions and benefit-cost analyses require a forecast of the electricity generation mix.

There are a number of sources available related to forecasting emissions over time including EIA AEO,[18] NREL Cambium,[19] and the *2019 New Jersey Energy Master Plan: Pathway to 2050* study. In the case of EIA, the EIA AEO emissions reductions reviewed by staff were not normalized per MWh and were available at too aggregated a geographic area (Middle Atlantic). NREL's Cambium tool includes forecasts of marginal emissions under several clean energy electricity generation scenarios. Cambium also provides significant time-differentiation of emissions, which can be important to address seasonal and time of day variation.[20]

Considering the above and New Jersey's long-term GHG reduction policy, consistent with the approach for the updated NJCT, the starting year (2022) quantity of avoided electric $CO_2$ emissions should be calculated in tons per MWh based upon the average of on-peak and off-peak marginal emissions in the most recent PJM Emissions rate report,[21] de-escalated to a value equivalent to a 50 percent reduction in $CO_2$ emissions by 2050, as compared to the initial 2022 PJM-based value. This 2050 value represents a significant decarbonization of electricity generation and is similar to the rate of emissions reductions estimated in the 2023 EIA AEO for the Middle Atlantic region (reference case). The same approach should be used for $SO_2$ and $NO_x$ emissions, consistent with the updated NJCT. The PJM 2022 values are shown in Table 5. The resulting emissions values by year, converted from pounds to tons per MWh are shown in Table 6.

Table 5. PJM 2022 Marginal Emissions Values, *Pounds per MWh*

| Period | CO2 | SO2 | NOx |
|---|---|---|---|
| Peak | 1041 | 0.27 | 0.79 |
| Off-Peak | 976 | 0.29 | 0.54 |
| Weighted Ave | 1006 | 0.28 | 0.65 |

[18] For example: https://www.eia.gov/outlooks/aeo/data/browser/#/?id=17-AEO2023&region=1-2&cases=ref2023&start=2021&end=2050&f=A&linechart=ref2023-d020623a.3-17-AEO2023.1-2&map=ref2023-d020623a.4-17-AEO2023.1-2&sourcekey=0

[19] https://www.nrel.gov/analysis/cambium.html

[20] The NREL Cambium dataset is a promising new source; however, Staff believes additional time is needed to review the study's methods and outputs, as well as which, if any, scenario fits best with New Jersey's policies. The NJ EMP study was also reviewed; however, Staff was unable to obtain marginal emissions per MWh from the reported results.

[21] Table 2 of the report, *PJM 2017–2021 CO2, SO2 and NOX Emission Rates*, April 18, 2022

https://pjm.com/-/media/library/reports-notices/special-reports/2021/2021-emissions-report.ashx

Table 6. Emissions Rate by Year for 50% Reduction by 2050, $CO_2$, $SO_2$, $NO_x$, *Tons per MWh*

| Year | De-escalation Rate | CO2 | SO2 | NOx |
|---|---|---|---|---|
| 2022 | 1.00 | 0.50 | 0.00014 | 0.00033 |
| 2022 | 0.98 | 0.49 | 0.00014 | 0.00032 |
| 2023 | 0.97 | 0.49 | 0.00014 | 0.00032 |
| 2024 | 0.95 | 0.48 | 0.00013 | 0.00031 |
| 2025 | 0.93 | 0.47 | 0.00013 | 0.00030 |
| 2026 | 0.91 | 0.46 | 0.00013 | 0.00030 |
| 2027 | 0.90 | 0.45 | 0.00013 | 0.00029 |
| 2028 | 0.88 | 0.44 | 0.00012 | 0.00029 |
| 2029 | 0.86 | 0.43 | 0.00012 | 0.00028 |
| 2030 | 0.84 | 0.42 | 0.00012 | 0.00028 |
| 2031 | 0.83 | 0.42 | 0.00012 | 0.00027 |
| 2032 | 0.81 | 0.41 | 0.00011 | 0.00027 |
| 2033 | 0.79 | 0.40 | 0.00011 | 0.00026 |
| 2034 | 0.78 | 0.39 | 0.00011 | 0.00025 |
| 2035 | 0.76 | 0.38 | 0.00011 | 0.00025 |
| 2036 | 0.74 | 0.37 | 0.00010 | 0.00024 |
| 2037 | 0.72 | 0.36 | 0.00010 | 0.00024 |
| 2038 | 0.71 | 0.36 | 0.00010 | 0.00023 |
| 2039 | 0.69 | 0.35 | 0.00010 | 0.00023 |
| 2040 | 0.67 | 0.34 | 0.00009 | 0.00022 |
| 2041 | 0.66 | 0.33 | 0.00009 | 0.00021 |
| 2042 | 0.64 | 0.32 | 0.00009 | 0.00021 |
| 2043 | 0.62 | 0.31 | 0.00009 | 0.00020 |
| 2044 | 0.60 | 0.30 | 0.00008 | 0.00020 |
| 2045 | 0.59 | 0.29 | 0.00008 | 0.00019 |
| 2046 | 0.57 | 0.29 | 0.00008 | 0.00019 |
| 2047 | 0.55 | 0.28 | 0.00008 | 0.00018 |
| 2048 | 0.53 | 0.27 | 0.00008 | 0.00017 |
| 2049 | 0.52 | 0.26 | 0.00007 | 0.00017 |
| 2050 | 0.50 | 0.25 | 0.00007 | 0.00016 |
| 2051 | 0.48 | 0.24 | 0.00007 | 0.00016 |
| 2052 | 0.47 | 0.23 | 0.00007 | 0.00015 |
| 2053 | 0.45 | 0.23 | 0.00006 | 0.00015 |
| 2054 | 0.43 | 0.22 | 0.00006 | 0.00014 |
| 2055 | 0.41 | 0.21 | 0.00006 | 0.00014 |
| 2056 | 0.40 | 0.20 | 0.00006 | 0.00013 |
| 2057 | 0.38 | 0.19 | 0.00005 | 0.00012 |
| 2058 | 0.36 | 0.18 | 0.00005 | 0.00012 |
| 2059 | 0.34 | 0.17 | 0.00005 | 0.00011 |
| 2060 | 0.33 | 0.16 | 0.00005 | 0.00011 |

Staff is interested in stakeholder comments on these or other sources for emissions and source energy per MWh that should be considered. The quantity of avoided natural gas emissions should be calculated based upon the Natural Gas Emissions Values published by EIA (11.7 pounds per therm saved of $CO_2$[22]) un-escalated into the future.

*3. Avoided Costs*

BPU is considering conducting a New Jersey-specific, policy-compliant, avoided cost study to assess future average and marginal energy costs and emissions. This study would model energy supply and demand, on an hourly basis, for PJM and New Jersey in accordance with state policy goals for GHG reductions by 2035 and 2050. Policy-compliant, modeling-based approaches are being used in other leading states with aggressive GHG reduction policies because the expected change in policy-compliant energy resources is significant and is unlikely to be fully reflected in shorter-term, market-based forward price curves or other secondary analyses, particularly over the longer term. This avoided cost and emissions forecast study would not be conducted in time to support Triennium 2 planning but would be targeted at supporting Triennium 3 planning and analysis.

In the interim, BD programs should use the same avoided costs as are required for EE Programs, based on the Board's approval of the NJCT requirements for Triennium 2.

*4. Avoided Social Cost of Carbon*

After determining the total emissions impacts, avoided $CO_2$ damage values can be calculated for electric and natural gas using the most current federal assessment of emissions damages per ton, such as from the Interagency Working Group on Social Cost of Greenhouse Gases or the EPA's Regulatory Impact Analysis. This should follow the approach described for the NJCT. The emissions scenario should be that which is mostly closely in line with the discount rate used in the NJCT.

*5. Transmission and Distribution Losses from Methane Leakage*

Losses associated with the production and delivery of natural gas need to be considered. "Fugitive" energy loss factors between the end use and production have been estimated on one basis to be 2.8%.[23]

The greenhouse gas effects of methane leakage are much greater than the greenhouse gas effects of carbon dioxide released when burning the same amount of methane. Thus, from the perspective of emissions, a 1% natural gas line loss could mean the GHG-equivalent of burning up to 10%

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[22] https://www.eia.gov/environment/emissions/co2_vol_mass.php

[23] Losses of 2.3% are from production and delivery to buildings per Alvarez, et al., *Assessment of Methane Emissions from the U.S. Oil and Gas Supply Chain (2018)*, *Science*, Vol. 361, Issue 6398, *available at* https://www.science.org/doi/10.1126/science.aar7204?url_ver=Z39.88-2003&rfr_id=ori:rid:crossref.org&rfr_dat=cr_pub%20%200pubmed. Losses of 0.5% occur within buildings, per Fischer et al, *An Estimate of Natural Gas Methane Emissions from California Homes* (2018), *available at* https://pubs.acs.org/doi/pdf/10.1021/acs.est.8b03217.

additional natural gas.[24] When determining if a fuel-substitution offering is carbon-positive, leakage must be considered.

## Program Evaluation & Reporting

The EM&V governance for the BD Programs should follow the same governance structure as the EE Programs as described in the EE Program Board Order.[25] Because the BD Programs are the first such effort in New Jersey, EM&V efforts will be especially important and are central to the purpose of fielding the programs. The Statewide Evaluator ("SWE") shall oversee these evaluations and be involved in early design and oversight of the evaluation studies. Research in other states shows that many different baselines can come into play in fuel switching programs.[26] Market research and evaluation will be needed to determine the true baselines for the BD measures.

The BD Programs' evaluations and performance tracking will also be designed to support the estimation of emissions and energy savings. Utilities proposing BD Programs will propose performance targets for the following metrics, which will be established by the Board prior to program launch. These performance targets should align with EO 316 goals for residential dwelling units, commercial spaces, and LMI units.

- Number of program participants, overall, and for all key segments
- Number of LMI program participants
- Number of measures installed by type, overall, and for all key segments; this should include all measures included in a project scope (i.e., measures through EE program + BD program weatherization or other EE measures)
- Number of fossil-based units decommissioned and number of avoided new installations by type and fuel source, overall, and for all key segments
- Number of participants with any new end uses added, if any (e.g., participants adding air conditioning that did not previously have any air conditioning)
- Net to Gross, overall and by end use (e.g., separately for heating and cooling, when applicable)
- Site and source energy impacts (MMBtu)
- Emissions impacts ($CO_2e$ MT)
- Levelized cost per metric ton of $CO_2e$ (costs levelized over the EUL or AUL, as appropriate, of the measure or project divided by lifetime net $CO_2e$ impacts)
- Participant bill impacts by fuel
- Net lifetime participant bill impacts

Additionally, the EM&V Working Group should address research questions, not limited to the following:

- What are participants' actual baseline conditions?

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[24] The 100-yr GWP of methane is about 28 pounds of $CO_2e$ per pound of methane leaked (https://www.epa.gov/ghgemissions/understanding-global-warming-potentials).

[25] In re the Implementation of P.L. 2018, c. 17 Regarding the Establishment of Energy Efficiency and Peak Demand Reduction Programs, BPU Docket Nos. QO19010040, QO19060748, QO17091004 (Order dated June, 10, 2020).

[26] Example of research on fuel switching baselines: https://ma-eeac.org/wp-content/uploads/MA20R24-B-EOEval_Fuel-Displacement-Report_2021-10-13_Final.pdf

- How many full load hours of heat do heat pumps provide?
- What are the principal factors motivating fuel switching and program participation? What are the key barriers to participation, and can they be mitigated?
- What degree of unintended cooling load building should be anticipated, and how should this be planned for?
- What is the actual heating performance of new HP systems in the coldest likely weather?
- How cost-effective are the programs? How can cost-effectiveness be improved?

Reporting requirements – In addition to the standard EM&V reporting requirements associated with EE EM&V, findings and recommendations will need to be developed for BD Programs throughout the program implementation process, on an ongoing basis, not solely ex post. Therefore, evaluations should include features of embedded evaluation and quasi-real time data collection and reporting. In consultation with the SWE, selected findings and study results should be developed and reported sub-annually.

## Planning Prior to Triennium 2

Several planning efforts and research studies are needed prior to Triennium 2 (July 1, 2024) to inform the calculation of energy savings of fuel switching measures, cost effectiveness, and emissions, as well as marketing and workforce development.

- TRM
  - Additional measures should be added to the TRM along with fuel-switching specific algorithms for a range of fuel-switching measures for the residential sector (e.g., space heating, water heating, cooking), or existing measures should be modified to more explicitly accommodate fuel switching and the more complex baselines.
  - Calculations and factors for site and source emissions, including near- and long-term impacts
- Market Characterization
  - Industry standard practice and baseline practices study to understand the delivered and fossil fuels markets
  - Study of contractor readiness and training needs for fuel switching and electrification
  - Study of customer awareness, opportunities, and barriers for fuel switching and electrification
- Cost Effectiveness
  - Incremental measure costs – Develop fuel switching costs for a range of measures, baseline combinations, event types, and market segments
  - NJCT
    - Avoided costs, average and marginal emissions forecasts for fuel switching
    - Demand reduction induced price effects (“DRIPE”) to address load increases and decreases and seasonality
- Evaluate equity, indoor air quality, and rate impacts, particularly on disadvantaged communities

The SWE shall lead and plan this effort, allocating responsibilities to the TRM and NJCT Committees as appropriate, and assigning studies to the Evaluation Study Team, Rutgers Center for Green Building, and other analytical vendors as appropriate.

## Minimum Filing Requirements ("MFRs")

The general filing requirements for the BD Programs should follow the MFRs applicable to the EE program petitions for Triennium 2. As a pilot program, the BD Programs are not required to be cost-effective, but Staff will require benefit-cost analysis to be conducted during pilot execution and prior to approval of any future full-scale BD Programs.[27] Staff recommends applying Sections V, VI, and VII with the following modifications:

Section V – The benefit-cost analysis requirements are the same as for the EE program petitions, except for sub-section V(b), which is replaced with the following: The utility must calculate and track the results of the tests in Section V(a) to analyze and improve program design and performance with the goal of having BD Programs for Triennium 3 that achieve a benefit-to-cost ratio greater than or equal to 1.0 when using the NJCT.

Section VI – The utility shall describe the methodology, processes, and strategies for monitoring and improving program and portfolio performance related to developing a full program for Triennium 2. The utility shall confirm that these methodologies, processes, and strategies conform with the current New Jersey EM&V guidance documents and standards or propose modifications and additions as needed for BD programs. The utility shall also provide an EM&V budget consistent with the current New Jersey EM&V guidance documents and standards.

Section VII - The utility shall file target values for each program year for the following metrics:

- Site and source energy savings by fuel (MMBtu)
- Site and source lifetime energy savings by fuel (MMBtu)
- Site and source annual emissions by fuel ($CO_2$e MT)
- Site and source lifetime emissions by fuel ($CO_2$e MT)
- Net annual peak demand savings by fuel (electricity and natural gas only) (peak MW or peak-day therm)
- $CO_2$ emissions impacts by fuel ($CO_2$e MT)
- Net $CO_2$ emissions impacts across fuels ($CO_2$e MT)
- Levelized cost per metric ton of $CO_2$e (costs levelized over the EUL or AUL, as appropriate, of the measure or project divided by lifetime net $CO_2$e impacts)
- Number of distributors and contractors engaged in the program
- Number of program participants and installations, overall and for LMI
- Number and geographic location of installations

The utility shall provide a description of how the proposed portfolio achieves the targets.

[27] Staff suggests that it will be important to assess and track the cost-effectiveness of the BD Programs but that these start-up BD Programs should be excluded from assessment of the cost-effectiveness of the Utilities' portfolio for purposes of compliance with the CEA.

# Glossary

*Site Energy*

Site energy is the amount of energy consumed at a site and reflects end-use consumption across all fuel types as reflected in the customer bill.

*Source Energy*

Source energy refers to the total energy associated with energy consumption at a site and represents the total amount of raw fuel required to operate the building, including site energy and all energy associated with production, transmission, and delivery.[28]

*Site Emissions*

Site emissions are related to the combustion of fossil fuels used for space and water heating and cooling, and for appliances such as cooking stovetops and clothes dryers. The primary emissions of interest are GHG emissions (i.e., $CO_2$, methane, NOx, fluorinated gases), which can be expressed in $CO_2$ equivalent ("$CO_2$e") based on their global warming potential.  In addition to GHG emissions, other site emissions (e.g., criteria air pollutants) may include carbon monoxide and particulate matter.

*Source Emissions*

Source emissions are associated with energy purchased from a utility, for example, emissions released from the generation of electricity in power plants.

*Embodied Emissions*

Embodied emissions refers to the total emissions associated with delivering an end-use or whole-building service inclusive of the emissions associated with producing and retiring the associated technologies and services (e.g., emissions from extracting, transporting, manufacturing, and installing materials on site, as well as the operational and end-of-life emissions associated with those materials), across affected fuels and materials.

*Fuel Switching*

Fuel switching refers to the replacement of one fuel with another within the context of serving a particular end-use service or entire facility.

*Beneficial Electrification*

Beneficial electrification in buildings refers to the replacement of fossil fuel-fired equipment with high-efficiency electric alternatives that results in net reductions in GHG and other emissions, as well as lower energy costs and better grid management.

*Building Decarbonization*

Building decarbonization refers to the process of reducing or eliminating greenhouse gas emissions associated with embodied energy, supplying energy, and end-use services in buildings. Currently, many states are addressing building decarbonization through policies aimed at replacing heating technologies that use delivered fuels (e.g., oil and propane) and natural gas with high-efficiency electric systems subject to the constraint that such conversions reduce source energy and GHG emissions.

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[28] "ENERGY STAR: The Difference Between Source and Site Energy," https://www.energystar.gov/buildings/benchmark/understand_metrics/source_site_difference