

# **Early Designs and Deep Retrofits: Meeting Affordable Multifamily Organizations with Useful Technical Services**

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## **ABSTRACT**

Many older existing multifamily structures owned and operated by affordable housing organizations have deferred maintenance needs that impact resident health and comfort. Even with new project funding sources on the horizon, decision makers at these affordable multifamily properties have noted a lack of technical information on building retrofits as a barrier to scoping potential projects and developing funding proposals. Energy Trust of Oregon (Energy Trust) is piloting innovative approaches to provide early design assistance and portfolio planning support to identify and prioritize deep retrofits to help scale energy and health benefits. These approaches are being developed with affordable housing organizations using “Voice of Customer” feedback to understand how the pilot objectives are meeting customer needs.

Energy Trust and its Existing Buildings program implementer, TRC Companies, have partnered with Pacific Northwest National Laboratory to develop prototypes for comprehensive multifamily retrofits and explore how the United States Department of Energy’s tools like Total System Performance Ratio (TSPR) can be used to design program incentives and provide customers with tools to explore deep retrofit opportunities across a portfolio of sites. TSPR – a ratio that compares the annual space heating and cooling load of a building to the annual consumption of the building’s entire heating, ventilation, and cooling systems – has not been evaluated for existing buildings until this study.

We present initial feedback from affordable multifamily housing organizations on how enhanced program services and tools can add value to their capital planning efforts and mission to provide healthy housing options for Oregonians experiencing low and moderate incomes.

## **Introduction and Background**

Energy Trust of Oregon’s (Energy Trust’s) 2020-2024 Strategic Plan describes five focus areas to guide future program and outreach efforts, including:

- Engaging customers with programs, information and services, with attention to customers historically underserved by Energy Trust.
- Delivering multiple benefits, including leveraging additional funding to advance clean energy investments that deliver multiple benefits.
- Supporting energy policies by providing objective information and analysis.

With a successful track record of delivering energy savings and system benefits, Energy Trust has been working to identify gaps in program services by engaging customers on their terms wherever possible. We’ve learned that customers are seeking benefits beyond energy efficiency and are exploring ways to scope and fund projects that aren’t solely focused on energy

efficiency. Yet, the potential for efficiency remains largely untapped in many market segments, including existing multifamily buildings. For this analysis we define multifamily buildings as five or more units in a stacked structure.

Even savvy customers who monitor their energy use and actively seek program resources have noted barriers to participation in Energy Trust's programs and a need for technical services to help scope projects, particularly in older structures with deferred maintenance needs. This isn't just a single site problem, however, but a problem of scale that requires Energy Trust to consider how to better support customers across their portfolio of existing buildings that can, in turn, help leverage additional funding sources and realize energy savings and health benefits for residents and businesses. More information on efficiency strategies and tailored technical services could better support customers with needs and objectives beyond energy efficiency while also increasing the program's pipeline of projects to drive deeper savings. This paper describes one approach and pilot to explore how United States Department of Energy (DOE) tools and customer perspectives might address these gaps and lead to enhanced program technical services for affordable housing organizations owning and operating existing multifamily buildings.

## **Research Overview**

The overarching tasks and primary research questions of this study addressed Energy Trust's program planning efforts to broaden early design services for existing multifamily customers and assess the viability of using DOE tools in program services. The goals for the pilot were as follows:

- Improve Energy Trust's understanding of customers' capital planning processes and data collected on portfolios of existing building conditions, including frequency and granularity of data.
- Develop building efficiency retrofit prototypes using DOE tools to assist help customers with early design and portfolio planning for energy efficiency retrofits in multifamily buildings. Key considerations included the following:
  - Can building prototypes help inform program and/or customer planning efforts?
  - What information is most useful to customers – energy savings, energy performance, carbon reduction, other?
- Field test the efficiency retrofit prototypes and DOE tool interface with Energy Trust program engineers, outreach and field staff, and customers. Key considerations included the following:
  - How does building modeling analysis in DOE tools compare to existing Energy Trust's offers for deemed/prescriptive savings and Custom savings?
  - Can Energy Trust provide deeper savings opportunities for customers by integrating HVAC systems and controls in the savings analysis?

## **Overview of Energy Trust's Technical Services**

Energy Trust currently delivers a range of technical services to existing commercial multifamily customers through the Existing Buildings program. These technical services range in

complexity and time required by both program staff and customer project teams and are designed to support customers from initial project idea generation to more detailed analyses of energy savings and cost-effectiveness. We highlight two primary technical services as follows:

- *Walkthrough Survey (WTS)*: identifies prescriptive (or standard) energy-efficient measures that the participant can apply for in the Program. The level of detail is generally equivalent to a Level 1 ASHRAE audit and does not incorporate utility billing (usage) data or submeter data.
- *Technical Analysis Study (TAS)*: is a more extensive analysis of measure savings, measure costs, simple payback, and other metrics for a specific site and uses billing data, where available. The TAS is intended to test the cost-effectiveness of measures applying through Energy Trust's custom pathway on a site-by-site basis. A TAS generally requires a customer to understand potential efficiency upgrades and have project funding to justify the study cost.

Energy Trust's technical services have been an established pathway to help multifamily customers move forward with energy efficiency projects.<sup>1</sup> While these services have been successful in influencing interested customers by providing them direct account management and ad-hoc reports, customers have indicated a need for more early design support to identify potential energy efficiency improvements throughout their portfolio of existing buildings before considering a site-specific custom study.

Tools developed by DOE may help Energy Trust work with customers to consider potential efficiency projects in early phases of their planning cycles that go beyond limited prescriptive offers without having to expend customer or program resources on complex, site-specific studies. Before this study, Energy Trust had not used prototype energy models to look at multiple components within an HVAC system for retrofits in existing stacked multifamily buildings.<sup>2</sup>

## **Past Explorations of DOE Tools for Customer and Program Portfolio Planning**

In 2017, Energy Trust and PNNL advised the City of Portland (City) on a project to use the City's Commercial Benchmarking Data along with DOE's Building Asset Score (Asset Score tool) to explore opportunities for capital equipment and operations and maintenance (O&M) upgrades to existing commercial buildings.<sup>3</sup> This preliminary study on commercial buildings in Portland, Oregon evaluated potential applications of the Asset Score tool for informing energy saving opportunities for commercial buildings (Mason et al 2018). Asset Scores were generated for a small group of buildings, along with their EnergyStar Portfolio Manager (ESPM 2017)

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<sup>1</sup> For the Existing Multifamily Program, a 2017 Process Evaluation noted that the Walkthrough Survey has been successful in helping customers pursue energy efficiency projects (RIA 2017). <https://www.energytrust.org/wp-content/uploads/2017/07/ETO-MF-Process-Evaluation-3-7-17Final-w-SR.pdf>

<sup>2</sup> Energy Trust uses energy modeling to develop measure packages for New Commercial Buildings through the "Market Solutions" offer (Energy Trust 2022). This study is focusing on existing commercial and multifamily buildings.

<sup>3</sup> The series of reports under the CitiesLEAP project can be found here: <https://www.energy.gov/eere/analysis/policy-permit-perform-using-city-benchmarking-data-and-building-construction-permit>.

scores and a comparison of both was used to identify the potential for energy savings in a building through both retrofits and retro-commissioning. The results helped prove a model for screening for energy efficiency opportunities for capital and/or O&M; challenges with actual data collection for building information were noted in this study.

For building owners and property managers who talk “scores” (e.g., ENERGY STAR score or Asset Score rating) rather than energy use intensity (EUI), Figure 1 is an example of the program- or portfolio-wide view from the 2018 CitiesLEAP project with large commercial buildings in Portland, OR.<sup>4</sup>

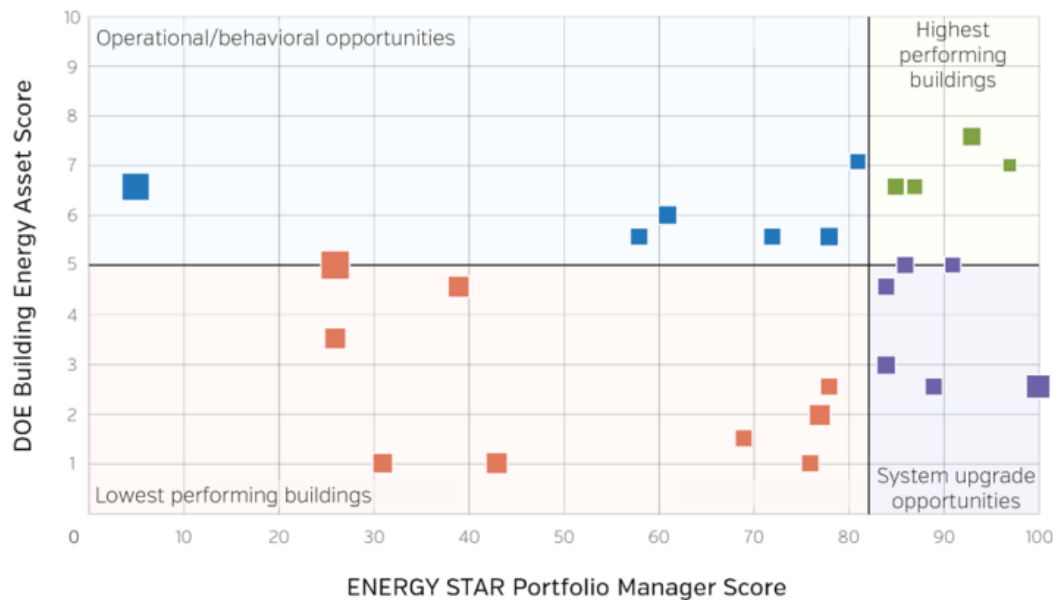


Figure 1: Quadrant view of building Energy Asset Scores and Portfolio Manager Scores from commercial buildings in Portland, OR. *Source:* City of Portland (2018).

This quadrant analysis was a useful starting point to understand how Energy Trust might leverage DOE tools to help customers develop a portfolio-wide view of building performance. The Asset Score rating and report, however, did not provide customers with enough detail or scenarios between existing baseline conditions and efficiency retrofit cases to understand the opportunities and savings impacts of upgrades to systems.

### What’s the Gap and How to Bridge It?

Energy Trust and PNNL began exploring ways to bridge the gap between whole building scores and metrics and bid-ready project scopes to help customers uncover more opportunities to improve building performance. For this paper, we discuss the stacked multifamily segment (e.g., mid-rise and high-rise buildings) with a focus on a limited field test with affordable housing organizations. These customers have been very engaged in Energy Trust’s free or low-cost offers

<sup>4</sup> Cadmus (2018) performed a statistical analysis of the Cities Leap data that plotted “modeled site EUI” (from Asset Score) vs. “actual site EUI” (from ENERGY STAR(c) Portfolio Manager) that flipped both axes seen in Figure 1. By looking at site EUI, the “highest performing buildings” are in the lower righthand quadrant. Displaying information in terms of site EUI may be more directly applicable to energy engineers and facility managers, but the idea of screening for opportunity by quadrant remains the same.

(e.g., direct install and appliance offers) for existing buildings and early design for new construction and are seeking additional early design and planning support to assess the potential for efficiency upgrades across their portfolio of existing buildings.

Simply put, the current prescriptive heating, ventilation, and cooling (HVAC) measures (e.g., based upon equipment efficiency rating alone) are too rigid, and the custom program pathway is too onerous (e.g., requiring a project scope to conduct a site-specific study for energy) for customers to explore deep retrofits in a systematic or holistic fashion. Thus, the project team explored how looking at measure packages – including HVAC system and controls – using the DOE’s Total System Performance Ratio (TSPR) tool might help address this gap in program technical services as the early design and planning phases. These early design and planning phases are often crucial for customers to procure additional project funding sources (e.g., grants, municipal and federal funds, financing) that often ask for some degree of energy savings analysis or potential. Should TSPR prove valuable to customers in their early design, Energy Trust may expand the TSPR suite to include other priority customer segments such as existing small commercial businesses.

## **System Performance Approach**

Building energy performance has typically been analyzed at a whole-building level (energy use intensity, peak demand) or at an equipment level (e.g., chiller efficiency coefficient of performance (COP)) (Li et al. 2020). A whole building metric can be affected by the performance of any building system, including building envelope, lighting, HVAC, and service water heating, among others. Isolating the performance of individual building systems (for instance, reduced infiltration rate) using whole building metrics can be challenging.

Prescriptive analysis of HVAC systems includes the equipment’s rated efficiency to determine equipment performance as well as compliance with the energy code. Commonly used HVAC system efficiency metrics include COP, energy efficiency ratio (EER), seasonal energy efficiency ratio (SEER), integrated part load value (IPLV), heating seasonal performance factor (HSPF) and annual fuel utilization efficiency (AFUE). Though excellent metrics for evaluating efficiency of system components at standard conditions, these ratings are not effective in quantifying actual system performance, which is affected by part load conditions. These metrics do not account for other controls and requirements for associated HVAC system components such as energy recovery ventilation (ERV), economizers, and variable frequency drives on fans and pumps, as well as control requirements for things like temperature resets, fan speed control, and reheat limitations. While a whole building performance-based approach (such as ASHRAE Standard 90.1 Performance Rating Method) looks at the overall building performance, it is resource intensive, and distilling HVAC system performance from that analysis can be quite challenging. Additionally, whole building performance approaches allow trade-offs between long-lived components such as the building envelope and short-lived components such as HVAC equipment and controls (Jonlin et al. 2018)

Figure 2 below illustrates the gap between complex whole building performance approaches on the left side of figure and simplified prescriptive analysis approaches on the right side of the figure, with the various building systems (e.g., HVAC system) and system components (e.g., heating, cooling, fans) as gaps (middle of figure). A sample of HVAC system components and associated prescriptive offers are listed here to illustrate the concept and are not an exhaustive list.

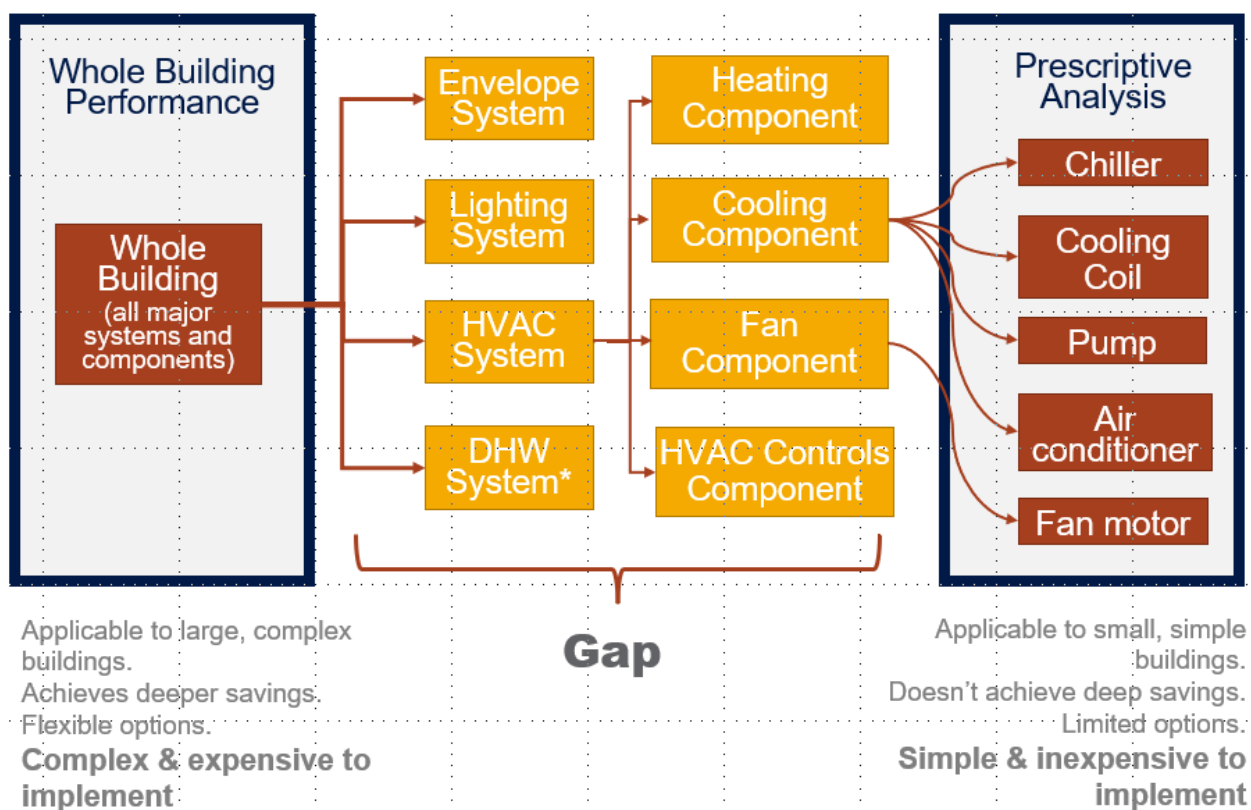


Figure 2: Current Performance Analysis Approaches in Codes and Energy Efficiency Programs

\*DHW stands for domestic hot water. This figure illustrates the gap between whole building and common standalone prescriptive offers and provides examples specific to HVAC systems and HVAC system components. The list of system components and prescriptive offers are not exhaustive. *Source:* Pacific Northwest National Labs 2022.

A more appropriate metric for analyzing an HVAC system would therefore be one that analyzes all components of the HVAC system, accounts for part load performance and system controls, normalizes for building loads and does not allow for trade-offs between different building systems (such as envelope and HVAC system). The current analysis approaches utilized by incentive programs as well as code compliance include either a component level analysis through prescriptive measures or custom whole building analysis pathways. There is a significant gap between these two approaches, as depicted in Figure 2. While the prescriptive approach provides an easy-to-use approach for incentives, it fails to account for interactive effects between various building systems and components. On the other hand, a whole building performance approach accounts for these interactive effects but is a costly and tedious approach, usually not a viable option for small or simple buildings and customers that may not have dedicated energy engineering and design resources. There is a need for a flexible pathway which is easier to implement while ensuring an acceptable level of accuracy. The system performance approach addresses these limitations by providing a performance-based approach that is simpler than the whole building performance approach while addressing the challenges associated with the prescriptive approach by considering the overall HVAC system. The TSPR metric calculates the amount of energy required to deliver each unit of heating and cooling to the building over the course of a typical year (Goel et al. 2014; Jonlin et al. 2018). Systems using less overall energy each year to meet the building's annual thermal and ventilation loads would be rated as more efficient. It does not allow trade-offs between different building systems and performance needs to be demonstrated through improvements within the HVAC systems in the building. We discuss the system performance approach and the TSPR metric in greater detail in subsequent sections.

### **Total System Performance Ratio Metric**

TSPR is calculated as the ratio of the sum of a building's annual heating and cooling load to some metric that represents the annual energy consumed by the building HVAC systems. That input metric could be annual site energy, source energy, energy cost, or (for stretch codes and programs) carbon emissions. The appropriate TSPR metric can be chosen based on the policy goals and priorities of the jurisdiction or program adopting the HVAC System Performance approach. For the analysis in this pilot effort, Energy Trust and PNNL focused on the site energy consumption and savings outputs from the TSPR models as potential savings inputs in Energy Trust's cost-effectiveness screening for measures and projects. This approach produces a consistent result that does not change based on region or utility (e.g., source energy use). Additional TSPR metrics like CO<sub>2</sub> reduction may be of interest to customers and other project stakeholders.

A larger TSPR indicates lower HVAC energy use to meet the loads, and therefore can be considered a more efficient system. The annual heating and cooling loads include envelope loads, solar gains through fenestration, internal loads due to lights, equipment, and occupants, as well as ventilation and infiltration loads. This metric provides a single analysis criterion that addresses all components of the HVAC systems used to move heat and air into, out of, and within a building. It includes distribution system effectiveness, considers both full and part load performance, and accounts for system controls. This differs from standard system efficiency ratings (such as SEER, COP, or kilowatt-hours per ton) that usually address part of a system and fail to account for all the system inefficiencies that may be present within a building as well as their interaction with building loads and ventilation requirements. In addition, such component

efficiency ratings are based on standard rating conditions that may not reflect actual building conditions and the ambient conditions at the building site. The HVAC System Performance approach accounts for all of these parameters to provide a comprehensive analysis of a building's HVAC system as described in equation 1.

$$\begin{aligned}
 \text{HVAC Energy Consumption}_{Total} &= (E_{\text{Heating-Elec}} + E_{\text{Heating-gas}} + E_{\text{Heating-propane}} + E_{\text{Heating-oil}} + E_{\text{Cooling}} + E_{\text{Fan}} + E_{\text{Pump}} \\
 &+ E_{\text{Heat-Rejection}} + E_{\text{Heat-Recovery}}) [\text{kBtu}]
 \end{aligned} \tag{1}$$

where:

- $E_{\text{Heating-Elec}}$  = heating electric energy consumption (kBtu)
- $E_{\text{Cooling}}$  = cooling electric energy consumption (kBtu)
- $E_{\text{Fan}}$  = fan electric energy consumption (kBtu)
- $E_{\text{Pump}}$  = pump electric energy consumption (kBtu)
- $E_{\text{Heat-Rejection}}$  = heat rejection energy consumption (kBtu)
- $E_{\text{Heat-Recovery}}$  = heat recovery energy consumption (kBtu)
- $E_{\text{Heating-gas}}$  = heating gas energy consumption (kBtu)
- $E_{\text{Heating-propane}}$  = heating propane energy consumption (kBtu)
- $E_{\text{Heating-oil}}$  = heating oil energy consumption (kBtu)

To determine the annual heating, cooling, and total loads for each building, the simulation uses a special HVAC system type available in DOE's EnergyPlus software called the Ideal Loads system (DOE 2018). This system calculates the annual heating and cooling load (including ventilation load) for each zone in the building and supplies heating or cooling air to meet the set-points at a system efficiency of 100% based on the specifications of the system. This system includes setpoints for temperature and humidity control, and outdoor air quantity, so it truly represents the complete load on the HVAC system. Thus, the TSPR is calculated according to Equation (2).

$$\text{Total System Performance Ratio} = \frac{\text{Ideal annual heating load} + \text{Ideal annual cooling load (kBtu)}}{(\text{TotalElectricityCost} + \text{TotalGas Cost}) (\$)} \tag{2}$$

## TSPR Analysis Tool

The Asset Score tool, developed by PNNL for DOE, is a web-based tool to help building owners and managers assess the efficiency of a building's energy-related systems and to encourage investment in cost-effective improvements (DOE 2018b; Wang 2015). Asset Score tool uses EnergyPlus and OpenStudio to develop a whole building energy model of a building and provides an assessment of building systems based on the specified building characteristics (DOE 2018a; OpenStudio 2018). An additional module (TSPR) was added to the Asset Score tool for HVAC system performance analysis that allows a user to define their proposed building design in accordance with the program requirements and automatically generates the existing building case following the rules specified by the program. Building simulation runs generate a PDF report that includes the TSPR analysis results and additional details about the building for a program administrator or evaluator to verify against building information and drawings.

## Methodology for Technical Approach: Developing Existing Buildings Prototypes in EnergyPlus and TSPR Tool

For this study, the existing multifamily buildings were modeled based on the PNNL prototypes originally created to support the development and implementation of updated editions of energy codes and standards (EnergyCodes 2019). This work uses versions of the prototypes that are minimally compliant with ASHRAE Standard 90.1-2004 for envelope properties and lighting power density (ASHRAE 2004). Other characteristics of the buildings that are not regulated by code such as form and fabric of envelope components, plug load density, occupant density, and operational schedules are based on common practices for each building type (Thornton et.al. 2011). The baseline case represents the existing building prior to any energy efficiency intervention, while the efficiency retrofit case represents an improved building with the HVAC retrofit measures applied. The detailed configurations for the multifamily baseline and efficiency retrofit cases are listed in Table 1. The HVAC system types and efficiency levels for the existing condition (or baseline case) identified are based on the Northwest region Residential Building Stock Assessment (NEEA 2017) dataset for multifamily buildings and insights from local experts. For example, the predominant heating system type in multifamily buildings is electric baseboard with thermal efficiency of 95% (see Table 1). The efficiency retrofit measure scenario (Efficiency Retrofit Case) is informed by Energy Trust’s program implementation team to be consistent with existing one-off prescriptive measures, where possible. For multifamily buildings, other than high-efficiency mini-split HVAC systems, smart thermostats with an automatic setback feature (for unoccupied hours), efficient bathroom exhaust fans, and heat pump water heaters are also modeled as retrofit measures.

Table 1: Multifamily Building Descriptions for Existing (Baseline) and Proposed (Efficiency Retrofit) Scenarios

|                                      | Existing Building Case                                                               | Efficiency Retrofit Case                                                                   |
|--------------------------------------|--------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------|
| Heating system                       | Electric baseboard, thermal efficiency: 95%                                          | Mini-split heat pump, HSPF: 9.0                                                            |
| Cooling system                       | Packaged terminal air conditioner, EER: 12.5 – $(0.213 \times \text{Capacity}/1000)$ | Mini-split heat pump, EER: 12.5                                                            |
| Supply fan                           | Total efficiency: 52%, Pressure drop: 1.3 in.w.g                                     | Total efficiency: 51%, Pressure drop: 0.3 in. w.g                                          |
| Thermostat                           | Conventional thermostat: 75°F Cooling/70°F Heating, No setback                       | Smart thermostat: 75°F Cooling/70°F Heating, 82.5°F Cooling setback/62.5°F Heating setback |
| Bath fan efficacy                    | 2.8 cfm/W (minimum EnergyStar)                                                       | 10 cfm/W (most efficient EnergyStar)                                                       |
| Domestic hot water (DHW) system type | Individual residential electric resistance water heater with storage tank,           | Individual residential heat pump water heater with storage tank, UEF: 2.8                  |

|                |                                                                                                                                                                     |
|----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Envelope       | Exterior wall U-factor: 0.36 Btu/h*ft2*°F,<br>Roof U-factor: 0.36 Btu/h*ft2*°F,<br>Window U-factor: 0.59 Btu/h*ft2*°F residential,<br>Window SHGC: 0.39 residential |
| Internal loads | Lighting power density: 1.26 W/ft2,<br>Plug load density: 1.04 W/ft2                                                                                                |

The EnergyPlus models analyzed for both HVAC retrofit measures and water heating measures while holding envelope and internal loads constant in the baseline and efficiency retrofit cases. While this provides energy usage and savings estimates for HVAC and water heating packages, the EnergyPlus models are complex and require experience with building modeling. The TSPR tool allows the creation of prototypes for existing buildings (baseline) and efficiency retrofit buildings (proposed) with a front-end user interface and output templates that can be used by program staff and customers without extensive modeling experience. The tool also provides an estimate of energy usage and associated carbon emissions. The TSPR web tool outputs for multifamily are presented in Figure 3 below.

#### Whole Building Annual HVAC Site Energy Use by End-Use

| End Use                                  | Proposed Building |             | Baseline Building |             |
|------------------------------------------|-------------------|-------------|-------------------|-------------|
|                                          | Electricity (kWh) | Gas (Therm) | Electricity (kWh) | Gas (Therm) |
| Heating                                  | 26,285            | 0           | 63,357            | 0           |
| Cooling                                  | 8,941             |             | 17,198            |             |
| Fans                                     | 12,961            |             | 38,883            |             |
| Pumps                                    | 0                 |             | 0                 |             |
| Heat Rejection                           | 0                 |             | 0                 |             |
| Heat Recovery                            | 0                 |             | 0                 |             |
| <b>Total HVAC Energy Use</b>             | <b>48,188</b>     | <b>0</b>    | <b>119,439</b>    | <b>0</b>    |
| <b>Total HVAC Energy Use (kBtu)</b>      | <b>164,424</b>    |             | <b>407,543</b>    |             |
| <b>Total HVAC Carbon Emissions (lbs)</b> | <b>33,707</b>     |             | <b>83,546</b>     |             |

#### Whole Building Annual HVAC Heating and Cooling Loads

| Proposed and Baseline System |                |
|------------------------------|----------------|
| End Use                      | (kBtu)         |
| Heating                      | 278,527        |
| Cooling                      | 195,550        |
| <b>Total</b>                 | <b>474,078</b> |

Figure 3: HVAC Energy Use by End-Use Results for Multifamily Efficiency Retrofit Case (Proposed Building) and Baseline Building (Existing Building) for Climate Zone 4C

Applying the efficiency retrofit measures (proposed building) can result in significant energy use reductions in heating and cooling end use. The TSPR values are calculated based on the method in Goel et.al. 2021, with the only difference being considering site energy consumption instead of energy cost. The TSPR methodology also assumes standard operations based on building type, hence the smart thermostat measure was not analyzed through the TSPR tool in this example . The TSPR of the proposed case is 2.88 whereas that for the existing building case is 1.16, a 150% improvement in the overall HVAC system performance due to the measures listed in Table 1.

## **Voice of Customer Feedback**

For customer engagement in developing a new offer or service, Energy Trust’s goal was to engage a subset of efficiency-savvy and motivated “early adopters” in the design of a potential offer and conduct a limited field test on actual buildings. We used a “Voice of Customer” approach to better understand their needs for medium- and long-term capital planning and develop a minimum viable product before scaling an offer or service program-wide. We engaged past participants who had some prior knowledge and experience with energy efficiency projects and monitoring energy use (e.g., benchmarking) and other program services (e.g., early design assistance for new construction). Energy Trust’s program outreach team has ongoing relationships with these customers who provided critical insight to this pilot effort.

Key questions guiding the “Voice of Customer” (Osterwalder et al. 2014) process were as follows:

- How do customers develop plans for building upgrades? How formal are these capital planning efforts and what do they do with the collected data?
- How can the TSPR tool be leveraged by affordable housing organizations alongside other “non-energy” tasks, such as capital needs assessments (CNAs) and property condition assessments (PCAs)?
- Do customers find value in detailed, site-specific audits and models or more general prototypes specific to building segments and fuels (e.g., mid-rise multifamily buildings with primarily electric HVAC systems).

As an early step in the “Voice of Customer” process to potentially developing a more program-wide offer, Energy Trust program outreach staff engaged interested customers to better understand their capital needs processes, data collection and building documentation to validate some assumptions (e.g., what data customers are currently collecting and how often) and where we might provide insight from the tasks described in this study. Energy Trust program staff worked with customers to collect initial building info (e.g., building plans and architectural drawings) and any capital needs/planning information that existed.

For existing multifamily affordable housing, customers participating in the pilot did have a formal capital planning process. This varied in frequency (e.g., 1-year or 5-year cycles) and level of detail for equipment (e.g., system type only or detailed model numbers and equipment age). The Energy Trust team reviewed the customer capital planning documents (in addition to building plans) and compared the data collected and existing Energy Trust studies (e.g., walkthrough surveys and technical analysis studies) to map existing information to data points

needed to inform a TSPR prototype models for HVAC retrofits and what other information might inform savings opportunities for other end-uses.

Early insights from these customer engagements helped Energy Trust refine the initial value proposition for exploring TSPR models for early design support. We streamlined the TSPR prototype models for existing multifamily buildings so that no further calibration would be required by the customer to use the TSPR prototypes and outputs in portfolio planning and early design. This was possible by isolating specific existing conditions (e.g., heating system type and equipment age) for the initial prototype models and limiting these to a set of specific existing conditions. At the time of this paper, we are awaiting additional customer feedback on how the TSPR prototypes might help customers considering deep retrofit projects move from early design to scoping and implementation. Should customers find value in the initial set of TSPR prototype models as technical services early in their planning cycle, Energy Trust will seek to expand the range of existing conditions available in the TSPR prototypes to address additional configurations of existing multifamily buildings in customer portfolios. We will also monitor whether customers are seeking the HVAC system retrofits that TSPR can model or if additional end uses such as water heating might require a more complex modeling approach using more detailed EnergyPlus.

## **Future Considerations and Research Directions**

### **Scaling TSPR Prototypes Across Energy Trust Territory**

This paper focused on existing stacked multifamily structures and a small sample of affordable multifamily organizations to test the viability of DOE tools like TSPR on a subset of their portfolio of existing buildings. Future research efforts will continue to be informed by customer feedback on new potential technical services, with a focus on the impact of enhanced technical services in planning retrofit projects across a portfolio of buildings and seeking additional project funding beyond current program incentives. Local and federal funding for energy and health related upgrades is anticipated to be substantial and of great interest to affordable housing organizations and their stakeholders, which also presents an opportunity to prioritize efficiency in early stages of project planning.

Beyond multifamily housing, Energy Trust plans to explore how to deploy the TSPR prototypes for small commercial offices. Energy Trust's newly revamped Small Business Offering works with a trade ally network to expand service to customers historically underserved by Energy Trust's program, including small businesses in communities of color, customers experience low incomes, and rural communities. Package solutions may help provide similar early design support to understand the potential for deeper retrofits and leverage additional project funding sources.

If TSPR prototypes are developed for additional building types and climate zones in Energy Trust territory, the TSPR tool could include an interface for customers (or program staff) to answer a few brief questions about their building which would be used to fit their actual building to one of the existing prototypes and the corresponding measure package would be provided to them along with tailored energy savings results.

In addition, municipalities seeking to develop or expand building performance initiatives are likely to seek input from Energy Trust on the technical merit of these tools and any insight on their use in practice.

## Streamlining Data Collection & Modeling

Energy Trust may explore potential future use of the DOE Standard Energy Efficiency Data (SEED) platform for managing large datasets of commercial and multifamily building data. This could be increasingly important to Energy Trust’s state, local, and municipal partners pursuing energy benchmarking and other building performance standards. Providing information to local stakeholders is a key focus of Energy Trust’s 2020 – 2024 Strategic Plan and the DOE tools and platforms could be a valuable resource (Energy Trust 2019). These tools could pair well with existing program offers such as Commercial Strategic Energy Management (SEM) that focus on long-term energy conservation and resource planning for commercial customers and is expanding to affordable multifamily housing organizations.

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