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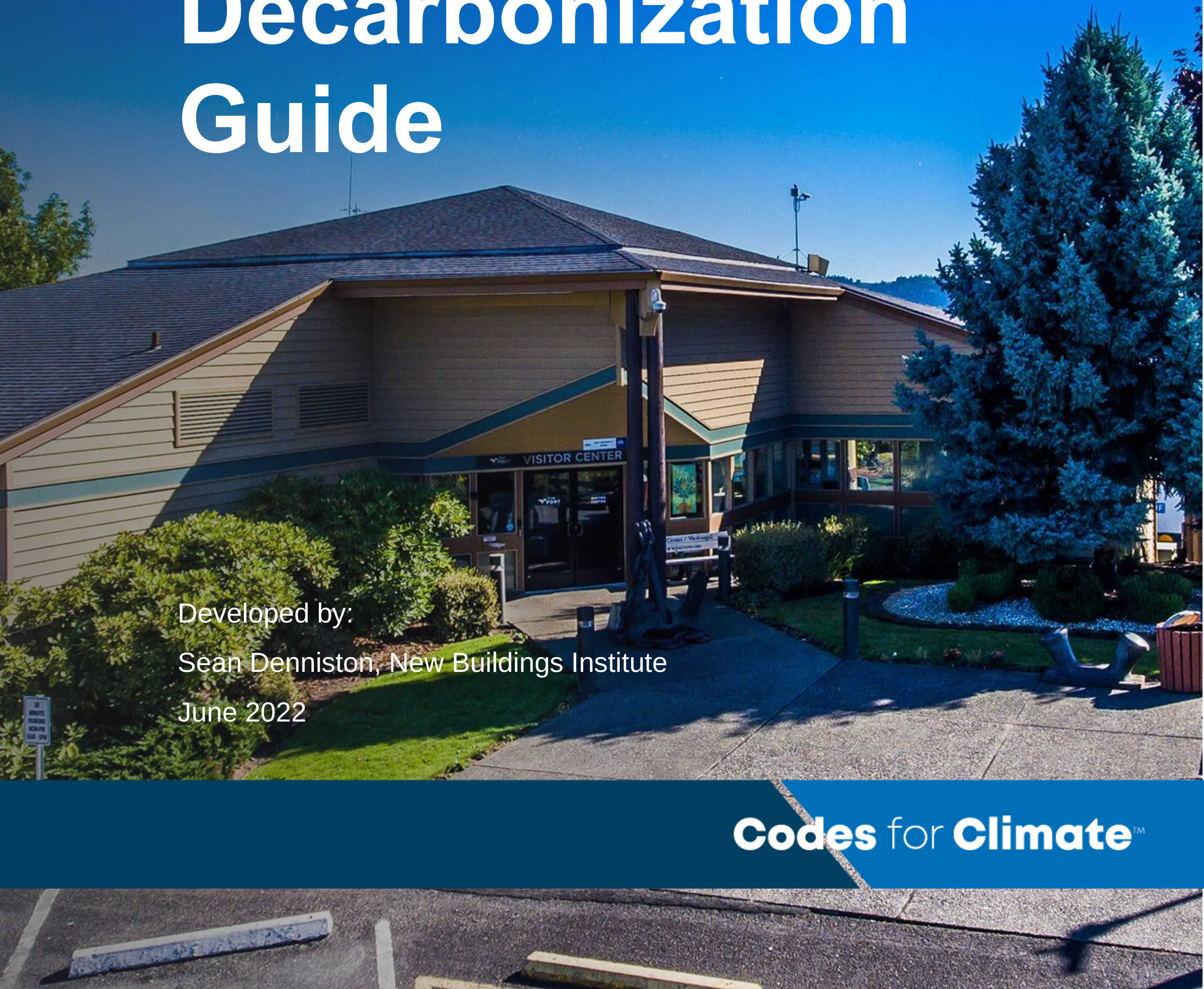
Port of Camas-Washougal Decarbonization Guide



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Introduction

Located along the Columbia River, the Port of Camas-Washougal provides recreational, industrial, business and transportation uses to Clark County and the greater Southwest Washington region. Established in 1935, today the Port has grown to encompass 300 acres of non-contiguous property in the Camas and Washougal communities.

Like many ports around the country, the Port of Camas-Washougal has evolved over time to include more than just industrial, and transportation uses. With two economic opportunity zones and a new Vision and Master Plan for the waterfront, the Port is poised to grow and evolve further with plans to add mixed-use developments that include multifamily residential components.

With buildings currently representing 39% of U.S. carbon emissions from operational and embodied sources, building decarbonization has emerged as a critical tool to address the challenges posed by climate change. Recognizing these challenges, particularly in light of the Port's plans to grow and add new kinds of buildings and uses, the Port of Camas-Washougal has created the Port Decarbonization Guide for Port staff, tenants and partners. The Guide is intended to provide basics about building decarbonization and strategies for pursuing building decarbonization in new and existing buildings at the Port.

Figure 1: Parker's Landing Marina was established in the early 1950s and includes over 350 moorage slips as well as a public boat launch, boat fueling, a boat repair shop, and a restaurant.

Figure 2: The Industrial Park was created in 1966 when the United States Army Corps of Engineers created a levy along the Columbia. The Park now includes 19, mostly light-industrial buildings with nearly 250,000 sf of total leasable space as well as open parcels

The Guide addresses four primary topics that support building decarbonization: energy efficiency, building electrification, renewable energy, and electric vehicle charging. It includes the fundamentals of these approaches to decarbonization as well as strategies and practical guidance for pursuing them. Recognizing the challenges of the changing and growing nature of the Port, the content is tailored to apply to both the kinds of buildings that exist at the Port today and the kinds of buildings that will likely be part of the Port's future.

The Port Decarbonization Guide is meant for multiple audiences and multiple purposes. It offers guidance to the leadership and staff of the Port itself to help inform future planning and building decisions for Port buildings and properties moving forward. It also serves as a resource and reference about building decarbonization for Port tenants and partners to help them make decisions that will support building decarbonization in the buildings they occupy and the buildings they may be constructing in the future. For this reason, the Guide includes content tailored specifically for multifamily buildings. Even though the Port does not currently have any residential buildings, the master plan for the waterfront indicates that this will be an important building type moving into the future. Finally, while the Guide focuses on the Port of Camas-Washougal specifically, the guidance it contains is relevant to other ports and even buildings that are not related to ports at all.

How to Use This Guide

This guide addresses both new construction and existing buildings. While the technologies and applications for decarbonization are largely the same for both types of buildings, the strategies needed for successful implementation—planning, design, cost considerations, etc.—can be very different. This section offers a framework for implementing the approaches and concepts contained in the sections that follow for both new construction and existing buildings.

New Construction

In new construction projects, it is critical to make decarbonization goals a part of the project planning as early as possible, preferably even before conceptual design begins. Many of the strategies and technologies discussed in this guide have an impact on building design beyond just equipment specification. As the design process proceeds, it can become more difficult to incorporate decarbonization strategies without making changes to that design. For example, heat pump water heaters (HPWH) can require more physical space than other water heating equipment, and those space requirements will need to be accommodated in the building design.

Therefore, it is important to clearly communicate decarbonization goals to all the members of the project team early on and incorporate those goals into project expectations and even professional contracts. Decarbonization goals should be included in the Owner Project Requirements (a document that lays out an owner's needs and priorities for a project) so that they become an official part of the scopes of work for all the members of the project team. The *New Construction Guide* from New Buildings Institute includes a section on Design Intent which offers a process for this kind of early planning in projects (see the Additional Resources section at the end of the Guide for more information and resources).

Existing Buildings

Existing buildings can pose unique challenges for decarbonization. One key to successful decarbonization retrofits is to identify building life-cycle events that provide opportunities to cost-effectively decarbonize while minimizing disruption to occupants. This section identifies the events in the life-cycle of a building that provide the greatest opportunities for decarbonization retrofits.

Equipment replacement provides one of the most cost-effective opportunities to both improve efficiency and to electrify. When equipment still has usable service life, the cost of an equipment retrofit effectively includes the total cost of new equipment. However, when equipment has failed or is near the end of its service life, the cost of a decarbonization retrofit is only the cost of moving from a like-for-like, minimally code compliant piece of equipment to high-efficiency or electric equipment.

Figure 3: Parks, trails and play areas.

Figure 4: Grove Field is a small airfield with two runways for small aircraft. The airfield includes both storage and commercial hangars.

Figure 5: The interior side of a gas-fired RTU in a light industrial building at the Port.

Reroofing provides an opportunity for both envelope improvements and renewable energy system installation. Reroofing is a broad term that includes both the addition of a new roofing layer on top of the existing roofing layer (roof recover) and full removal of the existing roofing layer and replacement with a new roofing layer (roof replacement). These present different opportunities for efficiency improvements:

- **Roof replacement** can create opportunities to add insulation (particularly continuous insulation on top of the roof deck for flat roofs), reduce air infiltration through the roof assembly, and to increase the solar reflectance and thermal emittance of the roofing materials.

- **Roof recover** also creates opportunities to increase solar reflectance and thermal emittance and may also present some limited opportunities to improve infiltration through improvements to roof detailing. Due to the additional efficiency opportunities available, it can make sense to increase the scope of a roof recover to a full roof replacement.

Regardless of the scope of the reroofing project, there are good reasons to coordinate roof replacement and rooftop renewable energy system installation. Equipment and crews are already onsite. Coordinating the two also ensures that the roof service life is synced with the renewable energy system service life, preventing the need to replace roofing under the renewable energy system.

Figure 7: This new construction just adjacent to the industrial park is typical of contemporary light industrial construction that will likely be utilized at the Port.

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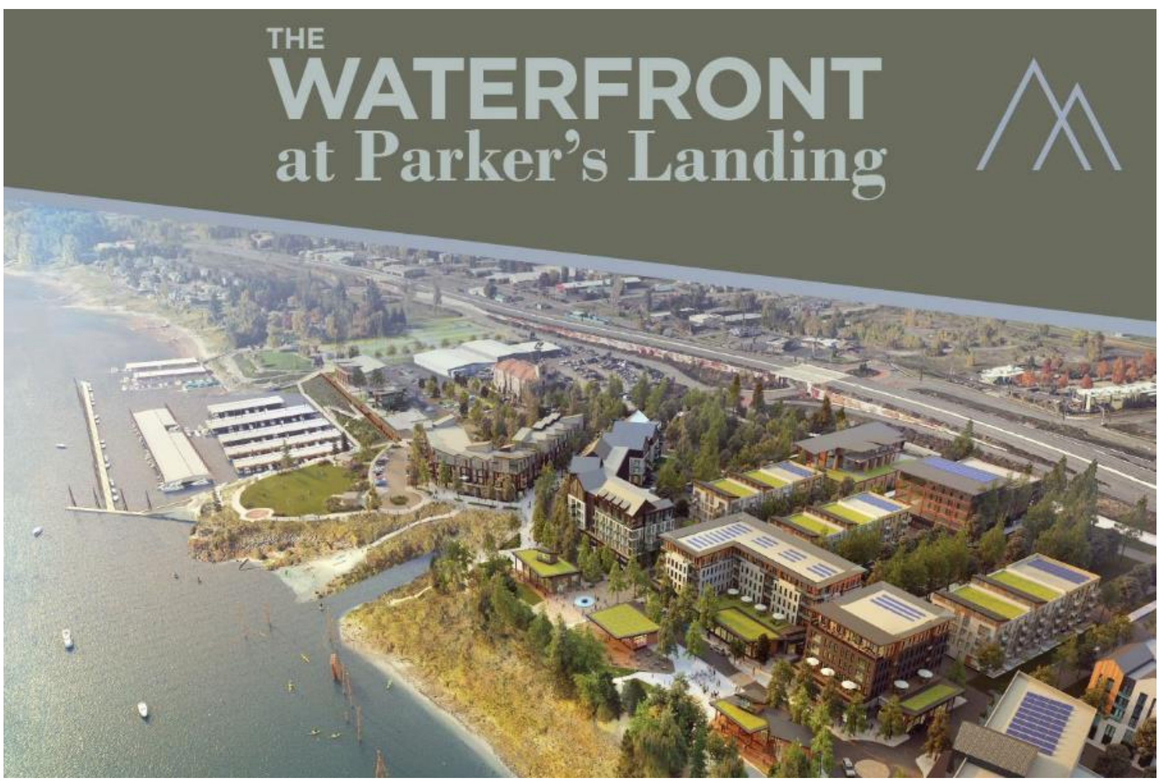

Figure 6: Port of Camas-Washougal Vision and Master Plan. (Port of Camas-Washougal).

Tenant turnover is a commonly used opportunity for building retrofits in general and provides a particularly good opportunity for decarbonization retrofits. The absence of tenants provides an opening to take on projects that would disrupt typical occupant use, particularly projects that may have a longer execution time or a more disruptive scope.

Market Repositioning is when a building is moved from one market to another. The most common example of this is when Class B or C offices are renovated to place them in the Class A office market. Repositioning creates two opportunities for efficiency improvements. The first is that repositioning almost always includes (sometimes extensive) remodeling or rehabilitation projects. Retrofits can be combined with these projects to reduce the costs of the retrofits. Second, retrofits can be used as an essential part of the market repositioning itself. Decarbonization retrofits increase the sustainability of the building, which can be used to increase the green marketability of the building.

Refinancing the debt on the building provides the opportunity to pay for capital improvements like decarbonization retrofits through wrapping their cost into long-term financing. When retrofits are funded out of capital funds or from shorter-term financial instruments, building owners often need a very short payback period for the potential cost savings from the retrofit to make the economics work. As a result, it can be difficult for retrofits with more modest savings to meet cost-effectiveness tests. By paying for retrofits over the longer timeframes found in mortgages, the cost can be distributed over a longer period of time. This in turn allows for a longer period of potential cost savings to be considered.

Utility replacements and upgrades provide an opportunity to address one of the larger potential costs of electrification retrofits: electrical capacity.

Figure 8: Tilt-up concrete construction like this is typical of some of the oldest generation of light industrial buildings at the Port.

Figure 9: Example of existing onsite electrical infrastructure.

Electrification retrofits can increase electrical capacity needs in the building—such as the size and/or quantity of panels, onsite transformers and electric utility services—increasing total project costs. These costs can be reduced by making those upgrades a part of replacements that are otherwise needed. When replacing electric infrastructure, the capacity of that new infrastructure can be sized for a fully electrified building that takes into account anticipated electric building equipment as well as solar, storage, and electric vehicle (EV) charging. However, this opportunity is not limited to just electric infrastructure replacements and upgrades. When gas infrastructure on the site requires replacement or substantial repair, it creates an opportunity to electrify the load rather than maintaining the gas infrastructure. The cost savings of capping rather than replacing gas infrastructure can be invested in an electrification retrofit instead of gas infrastructure that will become an abandoned asset once the building is electrified in the future.

Building sales often combine multiple lifecycle events such as financing, tenant turnover, market repositioning, and capital improvements. For all of these lifecycle events, it is important to have a decarbonization plan in place ahead of time. Decarbonization retrofits can expand the scope of timeframe for these events and by the time they come around, there may not be time to incorporate the additional planning required. It is therefore important to have the decarbonization retrofits planned and designed so that they are ready to implement once the lifecycle event comes along. It might even be necessary to take on preparatory projects ahead of time—such as electric infrastructure upgrades—in order to manage the scope of the retrofit.

Efficiency

Efficiency is the first step in pursuing decarbonization in buildings. Reductions in energy use lead to direct reductions in carbon emissions. Reductions in energy use are also a key element to addressing ongoing utility costs. Natural gas can be a relatively inexpensive energy source compared to electricity—however, recent volitivity in the natural gas market has narrowed that cost advantage –so the transition to electric equipment can result in higher utility costs if that transition does not also include additional efficiency. Efficiency can also reduce capital costs. Efficiency retrofits that reduce building loads allow the installation of smaller, less expensive space conditioning equipment during an electrification retrofit.

The landscape of energy efficiency strategies is well established. Multiple guides and resources are available for project teams to utilize to improve the energy efficiency of the buildings they design such as the ASHRAE Advanced Energy Design Guides and the New Buildings Institute's New Construction Guide and Multifamily Guide (see the Additional Resources section for more). This section gives a high-level overview of some of energy efficiency strategies that have typically been found to be the most cost effective, with a focus on retrofits. Many of these strategies are eligible for incentives from Clark Public Utility District (PUD). At the time of writing, Clark PUD has incentive programs for lighting, space heating and envelope efficiency improvements as well as a program for custom efficiency projects.[1] It also offers programs and tools to support energy management. Clark PUD's "On-site Energy Assessment" service is an effective way to evaluate efficiency improvement opportunities and connect with service providers.

Equipment Replacement

Replacement of equipment that is at the end of service life or has failed is an opportunity to implement some of the most cost-effective energy efficiency retrofit measures. There are three different energy saving strategies that can be implemented:

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[1] https://www.clarkpublicutilities.com/business-customers/reduce-waste-in-your-business/all-programs/

Equipment Efficiency

Federal equipment efficiency standards have steadily improved the efficiency of new equipment. The minimum efficiency for new HVAC or water heating equipment is notably higher than today than older equipment currently in buildings. Additionally, the performance of most equipment degrades over time, which can increase the performance gap between new and existing equipment even more. And while equipment efficiency standards have advanced, those standards are still far below the most efficient equipment available on the market. For example, federal standards require a unified efficiency factor (UEF) of around 2 for heat pump water heaters, while models with UEFs close to 4 are readily available on the market. Specifying higher-efficiency equipment is a cost-effective way to gain substantial energy savings.

For both new construction and existing building, the highest efficiency equipment that is cost-effectively available should be chosen. Electric resistance, gas furnace systems, and gas infrared systems used for space heating and freeze protection should be replaced with high-efficiency heat pumps. Many of the water heaters used at the Port for lavatories have small tanks with less than 20 gallons of capacity, especially those in the light-industrial and warehouse buildings. While it does not make sense to replace these with heat pump water heaters (HPWHs), all larger storage water heaters used for lavatories and kitchenettes, as well as water heaters used for any future residential developments should make use of high-efficiency HPWHs.

System Sizing

During replacement, it is important to avoid using existing equipment to size new equipment. System oversizing has been a common practice historically. Some existing equipment was installed to be more than twice the size it needs to be to meet heating or cooling loads. Additionally, many buildings have received energy improvements during their lifetime (lighting and equipment upgrades that reduce waste heat, insulation upgrades, etc.) that have changed the space conditioning needs of the building. Oversized equipment will run for a short period of time and then shut off, known as short-cycling. Short cycling equipment spends a larger portion of its run-time ramping up. Longer periods of runtime outside of peak efficiency reduces the total actual efficiency of the system. Finally, short-cycling equipment tends to wear out faster. As a result, oversized equipment costs building owners and occupants in three ways: the larger size increases first costs, running less efficiently results in higher utility bills, and short-cycling reduces service life and increases replacement frequency.

Therefore, it is important to size equipment based on actual current building loads. This will require doing heat loss calculations based on the actual building envelope, surveying actual internal loads, etc., and not using assumptions or rules-of-thumb for sizing calculations. While this is important in new construction, it is critically important in existing buildings where equipment sizing is typically oversized based on upgrades and renovations that have occurred since its initial sizing and installation.

System Selection

Some system types have inherently better performance than others, even when the rated efficiencies of the systems are comparable. This is because other system characteristics, particularly the distribution system, have a significant impact on total system performance. For example:

- Systems that have air-based distribution systems require much more energy to move heating and cooling around a building than water- and refrigerant-based distribution systems.
- Systems that combine space conditioning and ventilation in the same duct system also tend to have higher total energy consumption than when independent systems are used for space conditioning and ventilation (i.e. decoupled ventilation such as dedicated outdoor air systems (DOAS)).
- Systems that utilize reheat at distribution terminals—such as most variable air volume (VAV) systems—consume energy once to cool air and then consume more energy to heat it to meet the different air temperature needs of each space.
- Some system types are also capable of achieving much higher efficiencies than others. High performance heat pumps (HPs) can have rated efficiencies 4-6x the most efficient gas equipment available or even technically possible. (HPs are discussed in greater detail in the Electrification section below.)

Figure 10: Heat pumps are already common for office spaces in newer light industrial buildings at the Port. These outdoor units show a diversity of equipment performance.

- Single zone systems use more energy than multi-zone buildings since multi-zone systems make it possible to turn parts of the system down or off when those zones are not in use.

New construction projects should use these inherently more efficient systems like heat pumps, multizone systems and decoupled ventilation systems. Mini- and multi-split systems combined with decoupled ventilation should be prioritized in smaller commercial buildings and smaller conditioned spaces in light-industrial and warehouse, as well as in residential spaces in future mixed-use developments. Variable Refrigerant Flow (VRF) systems with DOAS—preferably with heat/energy recovery—should be considered for medium-scale offices that are too large for mini- or multi-split systems. Although the Port does not have any current plans for large offices, if those come in the future, they should implement reverse chillers for central heating combined with a DOAS that includes heat recovery and heat pumps for outdoor air tempering.

In existing buildings, changing the system type is generally more costly than a like-for-like replacement and may not always be feasible. However, changing the system type should be considered for every equipment replacement project since it provides an opportunity to achieve much higher efficiency gains (as well as an opportunity for electrification, see Building Electrification section below). Changing the system type should be given even greater attention when equipment replacement is being undertaken as part of a larger project such as a market repositioning or a major renovation.

Controls

Whether equipment is efficient or inefficient, it is still wasting energy if it is running when it is not needed. Modern controls allow more granular and comprehensive control of equipment. They also often offer more intuitive, user-friendly and accessible control of equipment.

Additionally, most of the buildings at the Port are subject to peak charges and rates (higher rates during peak electricity demand and/or charges based on peak usage). According to Clark PUD, peak-related charges can account for up to 70% of the total utility cost of buildings like those at the Port. Equipment that runs unnecessarily during the peak increases costs in two ways. It increases the amount of usage subject to any peak rates and it contributes to the magnitude of the peak. Controls upgrades are often a low-cost retrofit measure that can address these energy use, peak demand, and energy cost issues. There are several types of controls, and while most of them are available for all kinds of building loads, some are building load specific:

Time clock: These control loads on a time-based schedule. Simple time controls utilize just the time of day; however, time controls can be more sophisticated and take into account the day of the week or even the date to control the loads. Astronomical time controls are even more sophisticated and can take into account changing daylight hours and daylight savings time. Time clock controls are ideal for loads that have very predictable schedules such as site lighting and signage.

Occupancy/Vacancy: These control loads based on whether or not the control senses a person in the space. Occupancy controls can turn loads on when a person is detected and turn the load off when a person is no longer detected. Vacancy controls do not automatically turn a load on and require the load to be manually activated, but do

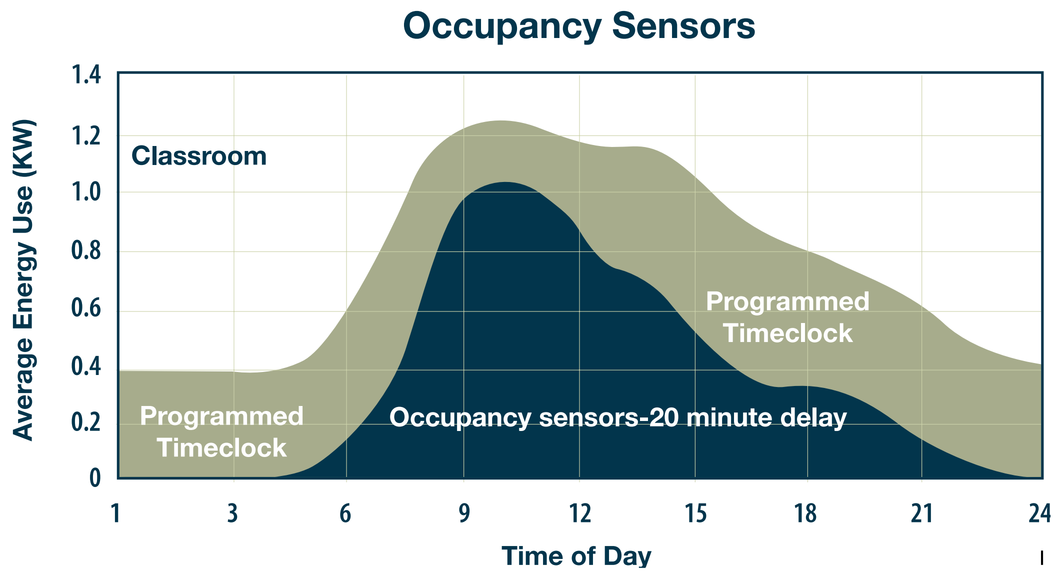

Figure 11: Savings potential of occupancy controls versus a simple time clock (Courtesy NBI).

automatically turn it off. Occupancy controls are ideal for loads that are needed for safety or where occupants may be very still. For example, bathroom lighting should utilize occupancy controls since the manual-on switch may not be readily accessible. Vacancy controls are ideal for loads that may not be needed just because a person is detected, but never needed when no person is present. For example, small offices, storage rooms (or storage spaces in a warehouse) and conference rooms where occupants are typically shifting around and where manual-on controls are readily available are well-suited for vacancy controls.

Dimming/multi-level: These vary the brightness of lights, allowing them to increase or decrease lighting loads. These controls can be paired with other controls to make them automatic. For example, lighting could be maintained at a low level until a certain time of day or until person is detected and then lighting levels can be increased. Or, electric lighting levels can be reduced in response to a demand responsive control or daylighting control. Multi-level controls can be used in spaces that need a low level of lighting for navigation and another level of lighting for active use, spaces like an unevenly occupied open office or a storage space. Multi-level lighting is also well-suited to spaces where lighting is used for security, but where people might not actually be present. For example, parking lot lighting can be configured to have a lower level of general lighting with higher levels of lighting controlled by occupancy. For the many parking lots at the Port, this kind of strategy could deliver significant overall savings.

Demand Response (DR) / Grid Integration: These control loads based on signals from a utility or other third party. Demand responsive controls do less to impact the amount of energy and more to impact when that energy is used. They modify loads in order to reduce energy use during periods of peak demand, which can also provide energy cost savings. More advanced versions of these controls can respond to a signal to actually use more energy in order to utilize excess electricity production on the grid or to pre-condition space or water ahead of a demand reduction.[2] DR controls are ideal for loads that are flexible because the load is not time-critical, the equipment has an associated buffer, or the load can be modified without having a detrimental impact on operation. Examples include space conditioning or water heating setpoints, lighting levels, EV charging rates, etc.

These different kinds of controls can be applied to improve the operation of all the energy systems in a building:

- **HVAC Controls:** Existing equipment may have only very basic controls, even fully manual controls. The current Washington state energy code requires commercial buildings to have thermostats with 7-day programmability.[3] This means that they must be capable of having a different schedule for each day of the week. As work schedules get more flexible—especially in spaces like offices—this granularity is important for ensuring that equipment is only running when the building is occupied. Many modern controls also have features that can help generate greater energy or cost savings, particularly through schedules or demand responsive controls that take into account peak pricing.

Demand Response

Demand Response controls play another key role in building decarbonization. As the sources of electricity on the grid continue to shift to less carbon-intensive sources, time of production and time of use become far more critical. Many sources of renewable energy, such as solar and wind, do not have consistent production output. The power sources that come online to meet peak loads, such as gas turbine plants, are often some of the more carbon-intensive power sources. Therefore, controlling building loads so that they better coincide to when low-carbon electricity is available, and so that they better avoid creating peak demand, is an important part of decarbonizing the grid.

[2] Clark PUD does not currently have a demand response program, but these programs are anticipated to become more common as utilities bring more renewable energy sources into their generation mix.
[3] 2018 Washington State Energy Code, Section C403.4.1.

While some thermostats used in Port buildings are fully-functional modern models, others are very simple. This is not driven by building or system vintage alone, the small office spaces in the industrial buildings tend to be more likely to have these simple controls which then provide an opportunity for upgrades to more fully-featured controls.

- **Hot Water Controls:** In hot water systems, there are controls for both the water heating equipment itself and any pumps on the distribution system. Both provide an opportunity to turn equipment off or down during periods of low or no usage. Controls for equipment can lower water temperature setpoints or turn water heating equipment off entirely based on anticipated schedule. Controls for recirculation pumps can utilize time, occupancy, or demand to ensure that recirculation pumps are only running when needed. There are also demand responsive controls available for water heating equipment that can respond to a signal. While hot water recirculation loop pump controls are currently required by the Washington state energy code,[4] and some limited demand responsive controls may be included in the next edition, controls for water temperature setpoint are not.

- **Lighting Controls:** Many existing buildings have only manual lighting controls, creating a significant retrofit opportunity. Of all the energy systems in a building, lighting probably has the most robust suite of controls available. Automatic controls can turn lighting off or adjust lighting levels based on schedule, available daylight, occupancy, grid demand, etc. The current Washington state energy code includes control requirements for many commercial lighting loads, including time clock, occupancy, and daylighting controls.[5]

- **Daylight Controls:** Many buildings—particularly high-bay spaces like warehouses—have available daylight that can meet lighting needs in at least portions of the building. Automatic daylight controls can be used to turn off or turn down electric lighting in those areas.

- **Occupancy/Vacancy Controls:** It is common for spaces or portions of spaces to have variable use that can't be anticipated with a typical schedule. This is particularly true of offices, lavatories, conference rooms, and storage rooms. Occupancy/vacancy controls allow the lighting in these spaces to be turned off automatically when they are not in use. The difference between occupancy and vacancy controls is that occupancy controls turn the lights on and off automatically while vacancy controls only turn the lights off automatically. Since vacancy controls require the lights to be manually turned on, they are capable of reducing energy use more than occupancy controls.

[4] 2018 Washington State Energy Code, Section C404.8
[5] 2018 Washington State Energy Code, Section C405.2

Figure 12: Occupancy control in an office.

- **Luminaire Level Lighting Controls (LLLC):** The lighting in some existing buildings is not especially conducive to control upgrades. The electrical circuits that serve luminaires may not logically correspond to spaces within the building. Single spaces may be served by multiple lighting circuits or multiple spaces may be served by a single lighting circuit. Or, the level of desired control may be complex. LLLCs allow each luminaire to be controlled individually. This allows the lighting to be controlled in a way that works for the space regardless of how the lighting circuits are arranged. LLLC also allows very granular control of lighting in a space, allowing lighting to be tuned and controlled to meet the needs of the specific space it serves. For example, vacancy controls could be used to control lighting at the workstation level within a larger room so that only occupied workstations are illuminated. Some LLLC controls can even operate wirelessly, eliminating the need to add control wiring.

Remote Access: Controls with remote access capabilities (such as most “smart” thermostats) can help improve performance in a couple of ways. Facility staff can use remote access to quickly modify settings—such as setpoints, schedules and setbacks—without going onsite. If modifications to the controls are easier, they are more likely to be made when needed. Remote access can be used to turn equipment off or down when a building is unoccupied outside of normal schedules. One ancillary benefit of controls with remote access is that they tend to have user interfaces that are more intuitive and easier for occupants and even facilities staff to use. One of the biggest failure points of more comprehensive controls has been that programming the controls is so complicated that controls are not fully utilized or even disabled. The improved usability found in most remote access controls makes it more likely that controls will be consistently and effectively utilized. Historically, remote access was provided through dedicated off-site control equipment, but it is increasingly being made available through secure websites and even app access.

Lighting Efficiency

Lighting is the building system that has seen the most rapid advancement in efficiency in the last couple of decades. Even existing buildings that have had lighting retrofits in the last decade can provide opportunities for effective lighting retrofits utilizing modern LED lighting. Lighting efficacy is measured in lumens per Watt (lm/W), or light output divided by power input. LED lighting can have almost twice the efficacy of even florescent lighting, the technology that it replaced (see Table 1). As a result, it can be reasonable to replace existing lighting that was installed even relatively recently.

Figure 13: LED site lighting at the Port.

LED lighting provides other cost saving benefits. Its longer service life means that it has lower lifecycle costs. LED lighting does not have to be replaced as often and burnout is less common, reducing maintenance costs (both labor and materials). However, it is very important to pay attention to color temperature with LED lighting.

LED lighting, particularly lower-cost products, can have a very high color temperature which results in a very bluish light that is not appropriate for many indoor applications. Specifying ENERGY STAR® Qualified Bulbs or lamps on the Design Lights Consortium's Qualified Product List can help ensure that the quality levels.

TABLE 1: TYPICAL CHARACTERISTICS OF VARIOUS LIGHTING TECHNOLOGIES[6]

Lamp Technology	Efficacy (lm/W)	Service Life (hrs)	Color Temperature (K)	Color Rendering Index (CRI)
Incandescent	12-18	750-1,500	2400-2900	100
Halogen	16-29	2,000-4,000	2850-3200	100
Compact Fluorescent	60-70	6,000-10,000	2700-6500	80-90
Linear Fluorescent	80-100+	20,000	2700-6500	70-90
A-Lamp White LED	40-105+[7]	Up to 100,000	2700-6500	65-95
High Pressure Sodium	40-140	10,000-24,000	1900-2800	20-80
Linear White LED	70-150+	Up to 100,000	2700-6500	65-95

Lighting Design

Luminaire design impacts how the light generated by lamps and bulbs is distributed in a room. Luminaire efficiency accounts for both lamp efficacy and how the luminaire distributes the light. Specifying a luminaire that can more efficiently distribute light and designing a luminaire layout that accounts for how a luminaire distributes light (its photometrics) are also important parts of an efficient lighting design.

Exterior Lighting

Lighting design and lighting levels are particularly important for site lighting. Site lighting brightness should be reconsidered in general. Higher light levels are often desired for safety reasons. However, if care is not taken, increases in luminaire brightness can have a negative impact on safety. Bright light sources in the landscape cause the pupil to contract and let less light into the eye. These overlit pools of light deepen shadows in the landscape and create glare, potentially hiding hazards and dangers. Making the fixtures brighter does not address this problem, and may in fact exacerbate it. The human eye does not adapt well or quickly to large light level changes, so if the person moves from a well-lit area of the site to a less well-lit area, it can take 10-60 minutes for their eyes to fully adapt. The best strategy for security lighting is to design for lower, but uniform, light levels that avoid the creation of high-

[6] This table produced by the Environmental Protection Agency details the total efficacy potential of different lighting technologies.
[7] LED lighting has been rapidly advancing and the theoretical limit of efficacy for white LED is 300 lm/W.

contrast dark zones. The Illuminating Engineering Society (IES) recommends only 0.2-0.5 foot-candles for parking lots.[8]

Site lighting, especially lighting for parking facilities, has very long run times. The Port has significant area dedicated to surface parking, and this will only increase as new developments are added over the coming years. Care should be taken to ensure that new parking facilities are not overlit. For existing parking, it is important for parking lighting retrofits to not fall back on lamp-for-lamp or lumen-for-lumen replacement strategies. Retrofits should include an evaluation of the lighting levels. Replacing lighting fixtures with different fixtures with different photometrics can enable low, even lighting levels that are both more efficient and safer.

Envelope Upgrades

Figure 14:Typical metal building construction of more recent industrial park buildings.

Weatherization

Weatherization is an umbrella term that refers to building tightening and opportunistic insulation retrofits. Washington's energy code has incorporated significant improvements to the air leakage requirement for commercial buildings over the past several code cycles.[9] As a result, many older buildings were built

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[8] See the IES publications RP-20: Lighting for Parking Facilities and RP-33: Lighting for Exterior Environments, as well as the Federal Energy Management Program Resource Guide to FEMP-Designated Parking Lot Lighting for more information on appropriate light levels for exterior lighting applications.
[9] 2018 Washington State Energy Code, Section C402.5

The current requirement is a tested leakage rate of 0.25 CFM/sf of envelope area. Before that, it was 0.40 CFM/sf. Before that was a set of prescriptive requirements for an air barrier that delivered about 1.0 CFM/sf. Buildings built before the advent of air barrier requirements in code have had tested leakage rates of 3.0 CFM/sf and even higher.

without any air barrier or with an air barrier that was not constructed to current standards for tightness. This is particularly an issue for the kind of metal and tilt-up buildings that are used for most of the Port's industrial buildings.

A comprehensive approach to infiltration reduction involves a building leakage pre-test, sealing and then follow-up testing to verify impact and identify whether a more aggressive approach is necessary. The pre-test may also utilize smoke trace testing, where a non-toxic smoke is released in the building that escapes through leaks in the building envelope, allowing those leaks to be visually identified. Building sealing is generally accomplished through the application of sealant caulks to joints and smaller leaks and the use of spray foams to fill larger gaps. Larger gaps may require limited reconstruction of parts of the building envelope.

Aerosol sealing products have emerged as a promising approach to tightening building envelopes. The building is pressurized, and a special aerosol sealant is released in the building. As air escapes, it carries the sealant through cracks where it accumulates and slowly seals the leak. This strategy generally requires a building (or at least building zone) to be unoccupied and free of contents, so tenant turnover is generally the best time for this approach.

It is important to remember that weatherization will deliver less savings in buildings that have lower space conditioning loads—such as the unconditioned warehouses or light-industrial buildings common at the Port—and may not generate enough energy savings to justify the project expense. Therefore, spaces like offices can be better candidates for infiltration reductions. However, even though the majority of the building square footage at the Port is comprised of these un- or lightly conditioned buildings, there are still opportunities for weatherization. Many of the industrial buildings at the Port include enclosed, conditioned spaces like offices. These enclosed spaces can be treated as if they were independent buildings and can be weatherized against both the outside and any un- or lightly conditioned areas of the building.

Some light industrial spaces do require space conditioning which should be prioritized for weatherization. Additionally, if any of the industrial buildings are converted to conditioned space, that conversion should also include envelope improvements, like weatherization and insulation upgrades (see the Opportunistic Insulation Retrofits section below).

Opportunistic Insulation Retrofits

Envelope insulation upgrades are most cost-effective when they capitalize on building lifecycle events that expose insulation locations. These include gut rehabs where interior surfaces are removed, building reskinning when exterior surfaces are removed, and roof replacement. These events allow building envelope cavities can be filled with insulation and some also present opportunities for continuous insulation to be introduced on either the interior or exterior of the building.

Insulation retrofits provide additional benefits. During the retrofit, the building envelope can be tightened to reduce infiltration. Some insulation retrofits, particularly spray foam insulation, will themselves reduce infiltration. Reducing heat losses and gains through the envelope reduces the space conditioning loads for HVAC equipment. In some cases, this can create an opportunity to utilize smaller, less expensive equipment the next time equipment is replaced (see the System Sizing section).

Many of the industrial buildings are metal buildings and insulation products for metal buildings have advanced significantly in recent years, achieving higher insulation levels, greater air tightness and improved durability. By some estimates,[10] nearly 50% of metal building insulation projects are retrofits, so the products for retrofits are well-established and widely available. Insulation retrofits for metal buildings are often less invasive than for other buildings since they generally have no interior finish materials. Adding or replacing insulation in metal buildings has the further benefits of reducing air infiltration rates, reducing the risk of condensation, and improving the overall appearance of the building interior for better tenant marketability.

Figure 15: A metal building where part of the building has received an insulation retrofit and part has not.

Utility Cost Sub-Metering

Utility cost sub-metering encourages conservation by making building tenants responsible for their own energy costs. When energy costs are rolled into rent, there is no direct connection between tenant behavior and energy costs. Energy bills give tenants feedback about their own practices and the explicit energy costs can encourage them to implement practices that reduce energy use. There are two main kinds of tenant-level utility metering: individual utility meters and tenant sub-metering systems.

Where each tenant space has its own utility service, tenants can be directly billed for their energy use without involving the building owner. The Port is

[10] According to Steel Building Insulation, a manufacturer of metal building insulation products. (https://www.steelbuildinginsulation.com/retrofit.html. accessed January, 2021.)

currently including individual utility meters for each tenant space in new construction and should continue to do so as the ideal practice. Any remaining master-metered buildings should also be retrofit with tenant utility meters as practical.

Where a building is master metered—a single utility meter for multiple tenant spaces—and retrofitting the building with individual utility meters is not possible now or in the future, a sub-metering system can be used to pass utility costs to the tenants. A metering system with multiple tariff-grade[11] submeters is installed on electrical panels or even individual circuits to meter the energy going into each tenant space.

Each tenant space may require multiple sub-meters to capture all of the loads. Some circuits may serve loads in multiple tenant spaces. These circuits would either need to be reconfigured to separate the loads for the individual tenant spaces or treated as a common area load that cannot be directly charged to an individual tenant. Another reason to avoid master metered buildings and/or retrofit them is that master-metered buildings are likely to incur higher demand charges since they capture the peak of all the tenant spaces on a single meter.

Figure 16: Older interior switchgear with subpanels versus newer onsite switchgear with tenant utility meters.

Spreading the peak between multiple customer meters isolates the peak costs to the tenants driving them the most. It also brings the metered peak closer to the peak demand threshold (currently 30kW for Clark PUD commercial customers) which will decrease the peak demand charges for each tenant space.

[11] Tariff-grade meters are meters that are certified to be sufficiently accurate to measure energy use for billing purposes. They are generally more expensive than more basic monitoring meters.

Tenant space metering retrofits can be combined with electrification retrofits to provide both additional capacity for electrification and add individual utility meters for tenant spaces to encourage conservation. This will be discussed further in the Building Electric Infrastructure Capacity section below.

Marina Loads

The marina poses unique challenges for efficiency. Lighting is the primary load that can be attributed to the Port at the marina, and all of the guidance listed above for lighting would apply to marina lighting. Moored boats pose a different set of challenges. The efficiency of the systems on the boats are out of the control of the Port, but sub-metering can have the same conservation benefits for marina slips that it does for building tenants. While most of the slips at the marina are sub-metered, the remaining few that are not should be upgraded. Although the marina does not currently allow live-aboard boats, if that policy were to be changed in the future, individual slip metering would become even more important for encouraging conservation.

Building Electrification

Buildings at the Port use primarily two fuel-sources: natural gas and electricity. Electricity has two advantages for the decarbonization of buildings. The first is that Washington state already has a low carbon-intensive electricity generation mix. With 69% carbon-free generation in 2018, the state has a goal of full decarbonization by 2030.[12,13] The second is that onsite electricity consumption can be directly offset by onsite renewable energy production.

These factors make building electrification one of the most effective and cost effective decarbonization strategy for buildings at the Port of Camas-Washougal today, with that effectiveness and impact only growing over time. Although the Port does not currently include any multifamily buildings, the Vision and Master Plan for the Waterfront includes plans for mixed-use commercial/multifamily development.

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[12] "Washington State Electric Utility Fuel Mix Disclosure Reports: For Calendar Year 2018" (Washington State Department of Commerce, 2019), https://www.commerce.wa.gov/wp-content/uploads/2020/04/Energy-Fuel-Mix-Disclosure-2018.pdf.

[13] Renewable Natural Gas (RNG) presents some opportunity to decarbonize the natural gas supply. However, according to the most optimistic estimates, even full utilization of potential RNG sources will be unable to provide more than 16% of the demand for natural gas in Washington state ("Harnessing Renewable Natural Gas for Low-Carbon Fuel: A Roadmap for Washington State"). From a decarbonization standpoint, it is therefore important to reserve RNG for loads that are particularly difficult to electrify, such as industrial loads.

Therefore, this section includes guidance for the electrification of both commercial and multifamily residential building loads.

Decarbonization is not the only benefit of building electrification:

- **Air Quality:** Combustion of gas in buildings has an impact on both exterior and interior air quality. Gas cooking can release levels of pollutants that, if they were measured outside, would violate the Clean Air Act.[14] As a result, households with gas cooking have nearly three times the rate of treatment for asthma.[15] The unbalanced ventilation strategies used in many residential buildings (exhaust only without mechanical make-up air) have the potential to pull combustion exhaust from gas equipment back into the building.

- **Construction Cost Savings:** The elimination of the gas service to all-electric buildings comes with substantial cost savings to construction projects. Combined with the fact that the price difference between gas and electric equipment has been narrowed—and even eliminated in many cases—all-electric buildings generally cost less to construct than mixed-fuel buildings.

One important consideration for the electrification is the potential impact of future building codes and legislation in the state of Washington. The State is currently considering new code requirements that would require the electrification of space and water heating equipment in new commercial buildings and even in some existing building alterations. As Washington state continues to pursue its climate goals, the scope of electrification requirements is likely to expand.

Heat Pumps

Not all electric equipment is equal. Heat pumps do not generate heat, they move or "pump" it from one location to another. In this way, heat pumps are capable of achieving levels of efficiency three to four times their electric resistance counterparts and four to six times as efficient as their gas counterparts. For electrification. For this reason, it is important to utilize heat pumps as part of decarbonization, the benefit of heat pumps is two-fold: efficiency and building electrification and only use resistance heat for small, specialized loads.

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[14] Gillis, J. and Nilles, B. (2019). "Your Gas Stove Is Bad for You and the Planet" The New York Times. www.nytimes.com/2019/05/01/opinion/climate-change-gas-electricity.html

[15] Jarvis et al. (1996) "Evaluation of asthma prescription measures and health system performance based on emergency department utilization." https://www.ncbi.nlm.nih.gov/pubmed/8618483

The Promise of Heat Pumps

Heat pump technology has advanced rapidly in the last decade with significant advancements in even the last five years. Many practitioners and consumers may have impressions about heat pumps that are no longer applicable (if they ever were). One of the biggest and most common misconceptions is that heat pumps can't really meet heating needs during the winter. However, many manufacturers have released cold climate models that can efficiently deliver heat down to -17 °F. These heat pumps are being successfully utilized in climates much colder than the relatively mild Pacific Northwest. These models also tend to be more efficient in all temperature ranges. The Northeast Energy Efficiency Partnership has a cold climate heat pump initiative[1] and has both guidance and product lists[2] that are relevant.

Most heat pumps deployed in the U.S. use outdoor air for heat exchange. A ground source heat pump (GSHP) uses a well in the ground as the heat exchanger for the heat pump, ejecting heat into the ground during cooling and extracting it during heating. GSHPs are capable of greater efficiency since the ground is a fairly constant temperature (around 50°F) as opposed to the outdoor air which tends to be much further from desired indoor temperatures. However, GSHPs are not often a good fit for Southwest Washington. The climate is generally temperate and air-source heat pumps have seen significant gains in efficiency in the last few years, closing the performance gap with GSHP. The greater engineering costs and increased construction costs (particularly the well) mean that GSHPs are unlikely to be a cost-effective solution for buildings at the Port.

[1] neep.org/ASHP-Specification
[2] neep-ashp-prod.herokuapp.com/#!/product_list/

Space Heating

There are several different kinds of heat pump equipment used for space heating:

- ***Packaged Heat Pump:*** A packaged heat pump system includes all the heat pump components in a single piece of equipment. The most common examples of this are roof top unit heat pumps (RTU-HP) and Package Terminal Air Heat Pumps (PTHP). RTU-HPs can be used in place of typical gas RTUs and are a good fit for the same applications. RTU-HPs can also be used for dehumidification or outdoor air tempering in de-coupled ventilation systems and make-up air systems. RTUs are common for conditioned industrial buildings and warehouses, low-rise offices and retail buildings, and for make-up air in multifamily buildings. While none of these are currently common at the Port, they could become more common under plans for future development.

Figure 17: This office space serving a light industrial building originally only had electric resistance heat. Through-the-wall air conditioners were later added for cooling. Both systems have been decommissioned in favor of ductless mini-split heat pumps. The circuits for the resistance baseboard heaters provided enough power for the new heat pumps.

Package Terminal Heat Pumps (PTACs) Vertical Terminal Heat Pumps (VTACs) are often found in multifamily and hotel buildings since they provide a very cost-effective way to provide highly zoned space conditioning. PTACs and VTACs often include internal electric resistance or hydronic coils to provide heating or are paired with a central heating system. PTHPs can be used in place of PTACs and VTACs to provide heating as well as cooling. As multifamily buildings are incorporated into future Port development, PTHPs should be used in place of traditional PTACs and VTACs

- ***Split system heat pump:*** Split system heat pumps have an indoor air handler connected to an outdoor unit with a compressor and heat exchanger by a refrigerant line. Split system heat pumps are well-matched to any application that would use a warm-air furnace or electric resistance heat such as small commercial buildings or small spaces within larger buildings with different conditioning requirements than the rest of the building.

The Port has many small offices within or attached to the warehouse and industrial buildings. Many of them are served by electric resistance heat from baseboard heaters or Cadet-style heaters. Split-system heat pumps can replace these less efficient electric systems as well as warm-air furnaces. This kind of retrofit has the additional potential benefit of adding air conditioning to previously un-cooled spaces, which can improve the marketability of the tenant space. Additionally, even though the majority of the industrial spaces in the Port's industrial park are un-conditioned, they do still have freeze protection systems. These are often natural gas infrared heaters that could also be replaced by split-system HPs.

- ***Multi-split heat pump:*** A multi-split heat pump is a variation of the split-system HP where a single outdoor unit is connected to multiple indoor air handlers. Multi-split systems allow independent control of different zones allowing for different schedules or space conditioning conditions. One advantage of multi-split HPs is that multiple zones can be served with a single outdoor unit, reducing the number of outdoor units in the landscape or on the roof. Multi-split HPs are a good fit for buildings with multiple spaces with different conditioning needs or buildings with more limited outdoor space.

  As the Port considers including smaller office and retail spaces on the ground floor of mixed-use developments, multi-split HPs can be a good alternative to furnaces and traditional Variable Air Volume (VAV) solutions.

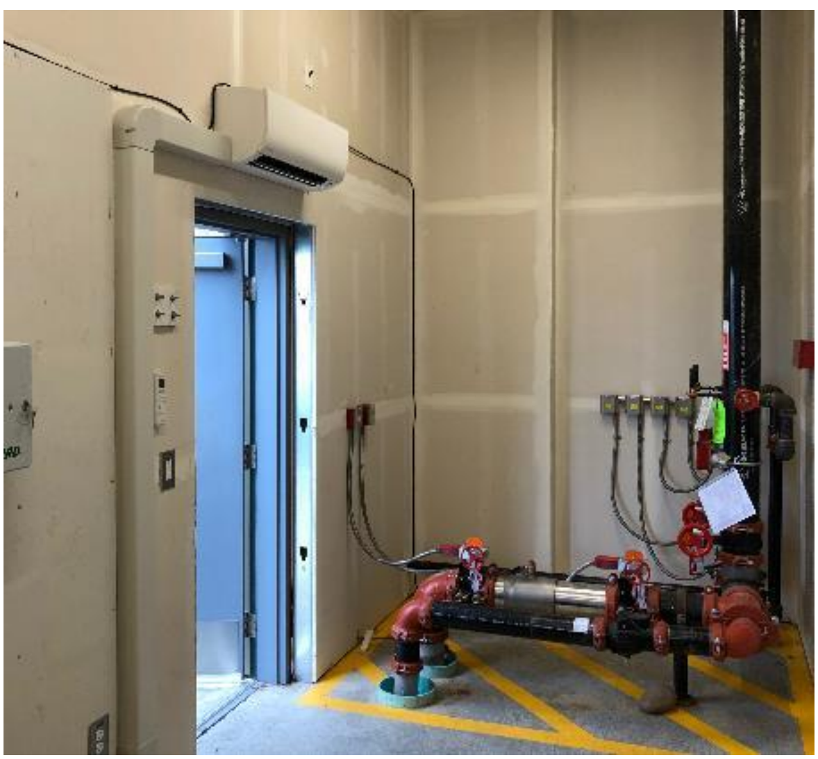

Figure 18: Gas infrared, gas furnace, electric resistance, and ductless mini-split HP, all used freeze protection.

- ***Variable Refrigerant Flow (VRF or Variable Capacity Multi-Split Heat Pump):*** VRF is a variation on the multi-split HP. Standard multi-split HPs are limited in that all of the indoor units need to be in either heating or cooling mode. A VRF makes it possible for some indoor units to be in cooling mode while others are in heating mode. This allows a VRF system to effectively move heat from one space into another for even greater efficiency. VRFs are a good fit for buildings with conflicting conditioning needs. For example, one building may have exterior heat gains concentrated in one part of the building that create a cooling demand while the rest of the building has heating demand. Some larger commercial buildings (particularly in colder climates) may need cooling toward the center of the building due to internal heat gains from people and equipment while simultaneously needing heating at the perimeter to deal with heat loss through the envelope. Or, a building might include a use with year-round high cooling demand—like a commercial kitchen or data center—while the rest of the building may still need heating during the winter. VRFs are well-suited to these applications and can be used in place of VAV or four-pipe fan coil systems.

  As the Port considers including restaurant space (particularly restaurant spaces on the ground-floor of mixed-use developments) VRF systems should be considered to address the diverse space conditioning needs to that occupancy. VRF systems should also be considered for larger office developments that are too large for mini- or multi-split HPs.

- ***Reverse Cycle Chiller:*** A reverse cycle chiller is a large heat pump that heats water instead of cooling it. These can be used in place of boilers in many buildings for both space and water heating. None of the buildings planned in the current Vision and Master Plan for the Waterfront are likely to utilize this kind of system, but if plans change and larger buildings become a part of the Port's future, it will be important to remember that there are electric options for these buildings as well.

Heat pump systems can also use different distribution systems within the building, such as:

- ***Central Air:*** Heat pumps can be configured with the same kind of central ductwork system used by warm-air furnaces and constant volume air conditioners.

- ***Ductless:*** Ductless heat pumps have only an air handler with no duct work. This is a particularly efficient approach since ducts increase the fan energy consumed by an HVAC system. Ductless heat pumps are particularly well-suited to small spaces and to retrofits since they can be introduced into a space without expensive ductwork.

- ***Low-Pressure Ducted:*** A low-pressure ducted system often has fan energy similar to a ductless heat pump. It uses a low-speed fan to deliver conditioned air through a limited amount of ductwork. This allows the air handler and ductwork to be easily concealed, unlike very visible ductless units. The low-pressure fans mean that duct runs cannot be very long or very complex, so low-pressure ducted heat pumps are limited in the size of the space that they can serve.

- ***Water:*** A heat pump (such as a reverse cycle chiller) can be used to maintain the water temperature of a water loop. The water loop can then be used by indoor fan coils or by water loop heat pumps within the building to condition the air. Water-based systems are well-suited to especially large buildings since all split-system heat pumps have limits on how long the refrigerant run can be between the indoor and outdoor units. Water-loop systems are also particularly well-suited to district systems where a central plant serves multiple buildings.

Water Heating

Rather than pumping heat into air for space heating, heat pump water heaters (HPWHs) pump heat into water. There are two main types of HPWHs: unitary HPWHs where the heat pump is integrated with the storage tanks and split-system HPWHs where the heat pump is located separately from the storage tank. Unitary HPWHs are generally used for smaller systems and split-system HPWHs are generally used for larger central systems (but this is not an absolute distinction). Small water heating loads for spaces like lavatories and kitchenettes can generally utilize HPWHs very easily. Most of the industrial buildings at the Port have only one or two lavatories per tenant space. These have such low water heating needs that a small 20-gallon tank water heater is often sufficient. This is considerably smaller than the typical HPWH, so it likely won’t make sense to move away from current electric resistance models. For buildings with larger lavatories or kitchenettes, a HPWH is a much better fit.

Large central water heating systems such as those found in many multifamily buildings can be some of the most difficult loads to electrify. The Port does not currently have any of these systems, but with future plans for multifamily development, this will be a critical load to consider for electrification.

There are a handful of high-level technical considerations in the use of heat pump equipment for water heating:

- ***Storage Tank Size.*** Heat pump water heaters are generally slower at heating water than electric resistance or gas water heaters, therefore they tend to require larger storage tanks to act as a buffer against demand. For example, a load that could be served by an electric resistance or gas water heater with a 30-gallon tank would generally require a 50-gallon tank with a heat pump water heater, or a 65-gallon tank for a heat pump water heater replacing a 40-gallon gas or electric resistance water heater. These space requirements could have impacts on building layouts if not considered early in the design process and can be a barrier to retrofits.

Figure 19: Small water heater serving a single-person lavatory.

- ***Access to air source.*** Since HPWHs move and concentrate heat instead of creating it, they need a source of heat. Most HPWHs simply use ambient air, so generally the source of heat is the air around the heat pump. The heat pump therefore needs access to a large enough volume of air to provide the heat to “pump” into the water. If heat pumps are located in a traditional water heater closet or “boiler room”-sized spaces, they will require venting or ducting to give them access to additional air volume. Most unitary HPWHs have options for ducting to another space or the outdoors. Split-system HPWHs allow the compressor to be located outside of conditioned space. When HPWHs (or just their compressors) are not located in conditioned space, it is best to locate them in unconditioned spaces such as garages. In addition to protecting the equipment, these spaces generally provide more favorable operating conditions than a sheltered exterior location.

- ***Impact on space conditioning.*** When located in conditioned spaces, HPWHs will increase the heating load and decrease the cooling load. However, a HPWH’s impact on space heating when located within conditioned space is much less than the efficiency gains. This is true even in colder climates. Taller buildings and commercial buildings tend to be more dominated by internal heat gains than shorter residential buildings, so those buildings may even see a space conditioning benefit from the HPWH's cooling and dehumidifying impact.

- ***Other sources besides air.*** Some HPWHs utilize water source heat pumps that use another source of water (such as a ground source loop that pulls heat from underground, or warm wastewater) and therefore do not need access to a minimum volume of air.

- ***Dehumidification***. Since air-source HPWHs take heat from the surrounding air, they will cool and dehumidify the area where they are located. This can actually be advantageous in some circumstances, especially in buildings dominated by cooling loads.

- ***Acoustics***. Heat pump water heaters generate noise, similar to chillers, air-handlers, refrigerators and other types of equipment. The level of noise varies considerably, but is lower than earlier generations of HPWH equipment. Noise can be an issue in some applications—such as apartments—but water heaters are often located in locations where noise is not a significant issue.

- ***Efficiency***. Some heat pumps are far less efficient when heating warm versus cold water. This has an impact on the design and equipment selection in central water heating systems. When HPWHs will be reheating warm water, it is important to specify multi-pass rather than single-pass units since they reheat warm water more effectively and efficiently.

- ***Temperature***. Most HPWHs cannot heat water above 180°F. This means that they cannot be used for some process and sanitation loads. High-temperature heat pumps are beginning to become available for these applications, but are not yet common in the market.

Central HPWHs

Central HPWH systems are generally more complex than their gas boiler counterparts and will pose an important challenge for any future multifamily development at the Port. Gas boilers are generally effective at both heating cold make-up water and re-heating warm recirculation water; however, different kinds of HPWHs are effective at heating cold water versus heating warm water.[16] This creates a need to handle cold water heating and recirculation loop maintenance separately.

The large storage tank of hot water used in central heat pump water heating systems act as a buffer for demand and can also pose a design issue. Gas systems typically use large-capacity gas boilers instead of buffer tanks to meet hot water demand. With electric HPWH systems, designers will need to

[16] This is also an issue for high-efficiency gas boilers. They are less efficient when heating warm water and efficiency can drop to the same level as conventional boilers.

Figure 20: Central HPWH equipment with 2,500 gallons storage located in a parking garage in the Batik Apartments, Seattle, WA. (Courtesy of Ecotope)

accommodate larger tanks—which could contain thousands of gallons of water in some buildings—in their designs. Ideally, this is done very early on in order to minimize the cost to change the layout of the mechanical rooms.

Heat pumps cannot be located in the same kind of small rooms typically used for boilers without making provisions for access to additional air volume. The ambient air simply will not have sufficient heat for the larger water heating loads. Therefore, mechanical rooms might be vented to bring in air through louvers or ductwork. The heat pumps themselves can be vented to the outside or another space, and most split system units are designed to accommodate this venting. Heat pumps can even be ducted to the exhaust air of the building and recover the waste heat and improve efficiency. Parking garages provide more temperate air than the outdoors, and can be an ideal location for central HPWH equipment.

Individual HPWHs

Individual HPWHs do not have a central recirculation loop like central systems. They are generally, but not always, unitary HPWHs. They are frequently used in commercial buildings for larger lavatories or kitchenettes and can also be used for commercial kitchens and laundries.

They are also frequently used in low-rise and some mid-rise multifamily buildings for domestic water heating. Individual water heaters generally become less common as multifamily buildings get taller and space becomes more valuable. This holds true for HPWHs and the larger space required for HPWHs only exacerbates that issue. The need for access to a volume of air can be an issue in multifamily applications. However, water heater closets can be located adjacent to corridors or exterior walls to provide access to air and to address noise issues. Water heater closets can even be located completely outside the thermal envelope on balconies as is common practice in California.

Clustered HPWHs

Central water heating systems really developed in response to the particular strengths and weakness of gas water heating. A new “clustered HPWH” approach has emerged as an alternative to central systems in multifamily and hotel buildings. In this approach, HPWHs are distributed throughout the building. Hot water loads are arranged in clusters so that multiple dwelling units can be served by a single HPWH without a recirculation loop.

The recirculation loop poses one of the biggest engineering challenges for central HPWH systems, and this approach eliminates the recirculation loop. This design can also be more energy efficient. Hot water distribution piping, including recirculation loops, is effectively a big radiator and can account for 40%[17] of the energy use in hot water systems. Therefore, eliminating the recirculation loop eliminates most of those losses. And since the HPWHs in a clustered system only heat cold water, they avoid the impact on equipment efficiency from re-heating war recirculation loop water.

Cooking

Gas cooking is very inefficient. Only about 30% of the energy consumed in gas cooking is actually used to cook the food and the rest is released as waste heat, while electric cooking equipment efficiency can approach 90%. Electric equipment already exists for both residential and commercial kitchens. Portions of the United States do not use gas (for example, in parts of Florida where ground conditions preclude gas infrastructure), but rely primarily on electricity for their energy needs.

Residential Cooking

Some consumers express a preference for natural gas for residential cooking since electric resistance stoves do not provide the same level of temperature control and responsiveness of gas stoves. Gas cooking is often seen as an amenity, and sometimes an essential amenity in higher-end projects. Consumers and tenants sometimes believe that “gourmet” is synonymous with gas ranges. Anticipated mixed-use developments at the Port will make this a critical issue for electrification.

Electric induction ranges offer a solution to this issue. These use an electromagnetic field to “induce” heat in ferrous (steel and iron) cooking vessels like pots and pans. They allow the temperature to be changed as quickly and minutely as gas. There are recent studies indicating that customer perception may change with increased exposure to induction cooking. A recent customer research study conducted by the Sacramento Municipal Utility District (SMUD) found that 79% of customers had a negative impression of induction cooking prior to trying it, but a 91% positive impression

[17] Heller, Jonathan, et al. *Multi-Family Hot Water Temperature Maintenance Study.* Bonneville Power Administration, 2017.

afterwards.[18] Additionally, in 2018 Consumer Reports rated induction cooktops far ahead of gas in terms of performance.

The decision to use gas cooking in homes comes at a considerable cost. The impact on indoor air quality discussed above is perhaps the most significant cost. However, the infrastructure required for gas cooking is substantial, especially in multifamily buildings. Gas cooking also creates the need for more indoor ventilation, which increases the size cost and energy impact of the ventilation system.

Commercial Cooking

Like residential cooking, the electric equipment for commercial kitchens is readily available. National food restaurants, for example, have both gas and electric options for their restaurants depending on what utilities are available. However, in many commercial kitchens, the use of gas is more than just a market preference. Commercial cooking is a production process and comprises part of the business model of restaurants. Professional chefs are often trained on gas equipment and the cooking processes in kitchens have often been built around the specifics of gas equipment. Therefore, electrification requires a change to production and business practices, not just market perception.

However, induction cooking is making inroads even in commercial kitchens.[19] Since it only heats the pots and pans, induction cooking is safer than gas or electric resistance cooking. There is less chance of a fire, and less risk of burns for cooking staff. Induction ranges also put less heat into the kitchen, making them more comfortable and more likely to meet the new OSHA indoor occupational heat standards while also reducing cooling loads in kitchens. Many of the commercial kitchens in Silicon Valley tech office buildings are all-electric, and some global tech firms are now working to transition all of their kitchens from gas to electric.

The mixed-use developments that are anticipated at the Port are likely to include restaurants. It will be important to have discussions about electric alternatives to gas cooking in those kitchens. Where gas for restaurant cooking cannot be avoided, it will be important to limit natural gas infrastructure to the kitchen in order to support electrification in the rest of the building.

Electric Clothes Drying

Electric dryers are widely available and heat pump dryers can be an effective alternative to electric resistance dryers. Often marketed as “condensing dryers,” these dryers have the additional benefit that they do not need an exhaust vent. They condense all of the water vapor that is drawn out of the clothes, eliminating the need to release the humid air to the exterior. The lack of an exhaust vent

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[18] http://2019.utilityforum.org/Data/Sites/5/media/posters/smud-induction-infographic-poster2.pdf
[19] Kostuch Media Ltd. (2017). Why Induction Cooking is the Hottest Trend to Hit Restaurant Kitchens. Food Service and Hospitality. www.foodserviceandhospitality.com/why-induction-cooking-is-the-hottest-trend-to-hit-restaurant-kitchens/

reduces building envelope penetrations and allows far more flexibility for laying out laundry spaces in a building. Electric clothes dryers are widely available at the residential scale and can easily be incorporated into future residential development at the Port.

Larger “commercial” electric dryers are also available; however, as commercial dryers approach the very large sizes sometimes used in commercial laundries and hotels, availability of model choices becomes less common. The Port could potentially see a commercial laundry service in the industrial park or a hotel in the new waterfront development. These buildings will likely need to alter their designs to accommodate different equipment layouts that utilize different dryer models than gas-fired laundries.

Process Loads

The rest of this section has addressed building loads, those loads associated with the building itself like HVAC, lighting, water heating, etc. Process loads are the energy loads in a building that are associated with some kind of large activity in the building rather than the building itself. Most process loads are related to

Figure 21: Examples of natural gas and propane process loads at the Port.

manufacturing and include equipment like large tools, kilns, large-scale cooking equipment, high-temperature water heating, etc. Some examples at the Port include the energy used for brewery equipment and glass melting/shaping.

While there are readily available electric options for all building loads, the same is not true for all process loads. There are electric equipment options for some process loads and not for others. And even when there are electric options available, they may not be available for every size (particularly for larger equipment) or every equipment variation. Therefore, it is important to consider whether appropriate electric options are available. Full electrification of process loads may not be currently possible.

The reality of these difficult-to-electrify loads creates a challenge for new buildings constructed at the Port. Eliminating all of the on-site gas infrastructure is a key component of the construction cost savings in new all-electric buildings. Those cost savings are lost if gas infrastructure is still included for potential gas process loads. The Port can address this issue by maintaining the existing gas infrastructure in some existing light industrial spaces for tenants who need gas for some process loads, allowing new light industrial construction to be utilized by tenants that do not have gas process loads.

Onsite Renewable Energy

The installation of onsite renewable energy systems like photovoltaics is another powerful decarbonization strategy. While Washington's electricity supply is relatively less carbon intensive than other parts of the country, it is not yet carbon-emission free. Onsite renewable energy production reduces emissions by directly offsetting energy usage.

Solar photovoltaic (PV) is currently the most cost-effective way for buildings to create energy on-site. Solar panels can be purchased, financed with a loan, or leased. Purchasing panels outright or with a loan allows owners to receive available incentives and/or tax credits. Loans and leasing can reduce the upfront cost of the panels. It is important to note that the contract for leased panels generally gives away the "environmental benefit" of the solar panels. The company that owns the panels sells renewable energy credits (RECS) to others who want to buy the environmental benefit of clean power. The result is that the power from leased solar panels is offsetting someone else's carbon-intensive power supply and the environmental benefits are no longer associated with the building hosting the panels.

The Port of Camas-Washougal provides a particularly good opportunity for installing renewable energy systems. The Port includes many buildings with large, relatively flat roofs that could be used for PV installations. The Port has many buildings with low-sloped roofs with an orientation that is suitable for PV installations. It also includes multiple parking lots that could also be used for awning-style PV installations. Finally, it includes several open areas that could host larger arrays. PV arrays have a predetermined service life; therefore, a PV array may be a way to utilize vacant parcels until they can be permanently developed.

Figure 22: Slip roofs at Parker's Landing.

As PV is installed at the Port, there are several key considerations described below.

Orientation

PV panels are best located in areas with ample sunlight, preferably facing the south or west. Many of the existing buildings at the Port have flat roofs, and these provide flexibility for panel orientation. Buildings with sloped roofs—including the low-sloped roofs found on many of the metal buildings in the industrial park—will generally have at least one roof slope facing south or west. The hangar roofs at Grove field are all oriented south and the slip roofs at the Parker's Landing Marina all have either south or west exposure.

Grid Interconnect

The typical configuration for on-site renewable energy systems is for them to be connected to a building's electrical service and for the utility customer to enter into a net-metering agreement with the utility where the utility agrees to buy surplus production or to credit it against future usage. This configuration creates several considerations for the Port as it pursues renewable energy options on Port property.

Where tenants have their own utility meter and pay their own electricity bill, the economic benefit from net metering flows to the tenant, even though the capital investment falls on the Port. That capital investment may not necessarily translate into higher rents for leased spaces without a concerted marketing and tenant messaging effort.

Figure 23: South-facing hangar roofs at Grove Field. An important consideration for using these roofs will be whether the structure can support the additional loads from PV arrays.

One solution to this issue would be to install a second utility service just for the renewable energy system, or to put the renewable energy system on a utility service that provides common loads for the site (site lighting, etc.). However, it would be important to discuss this option with the utility. The utility may be unwilling to bring in another service connection. Clark PUD does allow for aggregation of multiple meters under a net metering agreement, but there may be limitations when those meters are not located on contiguous premises.

The final issue with net metering in the Clark PUD service territory is that there are limits to the bill credit that can be accumulated. The current net metering agreement includes a provision that any unused energy credit accumulated by the customer is forfeited on an annual basis.

Community Solar

Any large solar arrays at the Port—whether on open Port property or larger roofs—will likely need to be configured under a model other than net metering. A typical onsite renewable energy system can be seen effectively as a building asset that provides power primarily to the building with relatively limited spillover to the grid. A larger array would likely need to be considered a grid asset and be integrated into the grid as such. It is still a substantial opportunity, but it is important to keep in mind that it is a fundamentally different kind of renewable energy asset that will require close coordination and agreements with the utility. An installation at the airfield would likely fall into this category since the hangar roofs offer so much area but the loads of the airfield are minimal.

Electric Vehicle Charging Infrastructure (EVCI)

As the electric vehicle market continues to expand, providing EV charging will become an increasingly important amenity for the market competitiveness of Port properties, particularly for new Class A commercial buildings and new market-rate multifamily buildings.

In the near-future, these buildings may find it difficult to maintain their market positions without providing convenient EV charging on-site. It is therefore important for buildings to consider the inclusion of EV charging infrastructure (EVCI) for both current and future needs.

It is critical to include planning for EVCI in new projects. The cost of retrofitting existing parking lots with EVCI can be substantial. Retrenching and resurfacing the parking lot and electrical capacity upgrades are the biggest sources of retrofit costs. An analysis of the costs of California's EVCI code requirements found that such retrofits would cost approximately $2000-$4600 per space.[20]

EV Charging Terminology

A vocabulary has emerged around EVCI that frames the issue:

- **Electric Vehicle Supply Equipment (EVSE)** is the EV charger that connects the EV to mains power. They can be portable or permanently installed and they can be hard-wired to mains power or utilize a receptacle. Commercial EVSE can include billing, load management, scheduling, and demand response functionality. An EVSE can also provide bi-directional power transfer, which allows the EV to provide energy from its batteries back to a building or even to the grid. Demand response and bi-directional power transfer EVSE can turn parked EVs into a grid asset that can be used for peak demand response and other building-level or even grid-level load shaping.

- **Level 1 charging** utilizes a standard 120V receptacle that provides 1.4-1.9 kW of charging. Every EV on the market comes with a Level 1 charger, making this the most accessible kind of charging. This is a very low level of charging,

[20] "Plug-In Electric Vehicle Infrastructure Cost Analysis Report for CALGreen Nonresidential Update." Prepared by Energy Solutions for the California Electric Transportation Coalition, 2019.

providing only about three-four miles per hour of charging. For many EV drivers, overnight Level 1 charging is sufficient. However, as EV batteries continue to get bigger and drivers look to accommodate longer commutes in a single charge, this low level of charging may prove increasingly insufficient. Level 1 chargers generally do not include any kind of billing, load management, demand response or bi-directional power transfer functionality. Finally, Level 1 charging is 12-20% less efficient than Level 2 charging.[21]

- **Level 2 charging** requires a 208/240V circuit and the EVSE may be hard-wired or use a receptacle. Currently, Level 2 charging can provide 3.3-19.2 kW, and more than 25 miles of range per hour of charging. Demand response and bi-directional power transfer functionality is generally only found with Level 2 charging.

- **Direct Current Fast Charging (DCFC)**, sometimes referred to as Level 3 charging, utilizes DC rather than AC power and is capable of charging much more quickly: 50-150kW and potentially hundreds of miles in an hour of charging. As it is intended for convenience charging, DCFC nearly always has billing functionality, but does not generally include any kind of grid integration such as demand response, load management or bi-directional power transfer. The electricity demand for DCFC is high and electricity needs to be converted from AC to DC, so it generally requires its own electrical service connection and onsite switchgear to handle the high power levels.

- **EVSE Space:** An EVSE space is a parking space that has an EVSE available for immediate charging. All an EV driver needs to do is pull up and plug their EV into the EVSE to be able to charge.

- **EV Ready Space:** An EV Ready space is a parking space that has an electrical circuit for EV charging but no EVSE. An EV driver would need to connect their own EVSE in order to charge. An EV Ready space could support either Level 1 or Level 2 charging. An EV Ready space can terminate at either a receptacle or a junction box.

- **EV Capable Space:** An EV Capable space is future-oriented. It does not include an EVSE or a complete electrical circuit. However, it does include wiring raceways and (sometimes) electrical capacity to support installation of an EVSE in the future. The cost of retrofitting an EVSE space can be very expensive, particularly in parking lots where the retrofit will require tearing up the parking lot to retrench for wiring. EV Capable spaces include the costliest retrofit components (conduit and capacity) during new construction to make future retrofits far more cost-effective.

[21] "Steady State Vehicle Charging Fact Sheet." INL/EXT-15-34055. Idaho National Laboratory, 2015.

Medium/Heavy-Duty EV Charging

Most of the information in this section applies to passenger EVs. However, medium and heavy-duty vehicles are also electrifying. This could be very important to industrial buildings at the Port that are more likely to see medium- and heavy-duty vehicle use. Since this market segment is still very nascent, standards for appropriate charging strategies and charging levels are currently emerging. It is therefore difficult to predict what their charging needs will be. In fact, not even the location of the charging point has been standardized for larger vehicles. Therefore, medium and heavy-duty EV charging design will be very specific to the vehicles being utilized for the time being. This makes planning for EVCI to meet future heavy and medium-duty needs very difficult. However, some limited future-proofing can be included in new construction and major electrical infrastructure projects at the Port:

- Ensure that new utility-level infrastructure built for buildings and sites that might incorporate this kind of EVCI is planned with these future substantial loads in mind.
- Since the power demand is likely to be very high, site planning should incorporate a separate electrical service entrance for the EV charging as well as locations for the onsite transformers and switchgear that will be necessary for these large loads.

Load management

Load management is addressed more broadly in the Building Electric Infrastructure Capacity section below. For EV charging, load management is generally provided at the EVSE rather than at the panel. These systems can reduce the charging rate at the EVSE to ensure that the peak or total charging load of all EVs remain below a certain level.[22]

Some load management systems are very simple, typically a single EVSE with multiple EV connectors balances the load between the connected EVs. If an EV connection is un-used, or if the EV connected to it is charged, the additional capacity is distributed to the other connected EVs. The main advantage to this approach is cost. A multi-head EVSE often has a cost per EV connection that is similar to the cost of a stand-alone EVSE. The main disadvantage is that it can only provide limited load management. The multi-

[22] It is possible to manage loads at the circuit level by simply turning off circuits with EVSE based on a schedule or total load. However, completely cutting charging to a parked EV is likely to lead to complaints from EV drivers. When power is cut, it will just look like the EVSE is broken.

head EVSE is blind to all other loads at the site, and cannot be used as part of a system-wide management approach. The available capacity at one multi-head EVSE cannot be utilized by another EVSE.

Other load management systems for EVs are far more sophisticated. Generally called networked EVSE, each EVSE is connected through a network to a central control point either on site or in the cloud. These systems can manage loads for each EV connection, allowing the system to fully distribute available capacity among connected EVSE. Some systems can even take into account building loads and available capacity beyond just the EV charging system. Since most buildings generally have unused capacity most of the time, these systems monitor total available electrical capacity and allow the EVSEs to use this capacity in addition to the capacity specifically dedicated to EV charging.

The downside of more sophisticated networked EVSE is expense. A networked charger costs 10-15 times more than a “dumb” EVSE. As this technology is just now coming on the market, these costs should come down substantially in the future, but remain high for now. Since the additional capacity will generally cost less than a full-featured load management system, it will not make sense to utilize load-managed EVSE just to manage electrical capacity. However, these networked EVSE systems are often also able to handle metering and billing, and that often drives the adoption of these systems.

Demand Response

EV charging is going to represent an increasingly large load on the electrical grid. This has often been raised as an objection to EVs and the inclusion of EV charging at buildings. However, when considering grid impacts, peak load and time of use are bigger considerations than total capacity. Having too little load on the grid can be as much of a problem as too much load since it requires power generation to be turned on and off, which increases the cost of generation. EV charging is a very manageable load, and can even include transfer of energy back to the grid, which means that EV charging can provide a net benefit to the grid. EVs can be used to soak up excess production from sources like wind and solar and curtailed during peak periods to help level loads on the grid.

Many EVSE include scheduling or demand response functionality that can allow them to be more responsive to grid and price considerations. These EVSE can reduce or even stop EV charging based on a demand response signal or schedule.

In some situations, it could be acceptable to put EVSE circuits on a time clock that turns off power during peak rate periods. Since it is on a schedule, EV drivers may find it more acceptable than a load management system that turns off power unpredictably. This approach may be a reasonable approach in any EV parking situation with longer dwell times—residential, workforce, or fleet parking—where limited charging availability has less of an impact.

Managing Charging Costs

One of the biggest concerns for building owners is managing EV charging utility costs. EV charging can represent a significant cost and it may be important to pass costs along to EV drivers. There are several options with varying levels of expense and functionality:

- **Networked EVSE** are connected to a central billing system. The system handles billing and charges the EV driver for the power they use. Some of these are large networks of chargers such as Blink, ChargePoint or Tesla Superchargers that have their own customer base. These are more common in commercial parking lots. Since the EV charging company owns the chargers, this model can provide a way to partner with a company that specializes in EV charging to meet charging needs while limiting capital and operation costs. Other systems are site specific and are meant only for the users of a particular building. This might be an attractive option for multifamily buildings with a specific set of users.

- **Submetering** can be used to measure the amount of energy used at a space for later billing to the user. This approach is low-cost. Tarif-grade sub-metering equipment that can be used for billing is already common in multi-tenant buildings. The sub-meter will work with any kind of EV space and any kind of EVSE. However, this approach only works when the space is dedicated to a specific person and it is reasonably certain that other people charging at the space will not be a concern.

- **Direct wiring** is another option when the EV space is dedicated to a particular building space. The wiring for the EV space can be directly wired to the panel that serves the space associated with the EV driver. This solution can be appropriate for some multifamily settings where the distance between the EV space and the dwelling unit panel is limited, or for workforce parking associated with a particular business.

- **Parking fees** (sometimes called EV pet fees) are a very low-tech approach to managing charging costs. Where parking spaces are dedicated to a certain person, that person can be charged an additional fee to cover the cost of charging. This approach works when there is reasonable certainty that other people won’t surreptitiously use the available charging for their own EVs or other purposes (such as an RV).

Choosing the Right EVCI

It is important to match the current and future EVCI needs of a building with the different levels of EV charging and different kinds of EV spaces. Information about demand for EV charging is driven by many factors and is very specific to an individual building. Washington state has set goals for all new passenger vehicle sales to be EV by 2030. As the service life of most passenger vehicles is shorter than the service life of a building or building site, it is reasonable to assume that most new parking lots will need to accommodate significant levels of charging for spaces before the end of their service life. It will be important for the Port and its partners to engage stakeholders and potential tenants to gauge the level of immediate, near-term, and even long-term EV charging needs for each project.

Ownership

One of the most basic questions for EV charging is who will own and maintain the EV charging equipment and infrastructure, whether it will be the building owner or a third party. There are several companies—such as those mentioned above—that will install Level 2 or DCFC EVSE in a parking lot and then bill EV drivers for charging, sometimes even with some kind of arrangement for revenue sharing with the building owner. These arrangements remove the burden of installing and maintaining the EV chargers from the building owner. However, this comes at the cost of the loss of control. The spaces will only be available and useful to the customers of the EV charging company and their value as a building amenity will be decreased, especially since charging costs at these stations are generally substantially higher than just the cost of the electricity.

Space Type

The selection of space type is based on the balance of current versus future EV charging needs. EVSE and some EV Ready spaces provide immediate access to charging, while EV Capable and some other EV Ready spaces are more future-needs oriented. If near-term needs are low, it would make sense to include fewer EVSE spaces and more EV Capable spaces.

Level 2 EV Ready spaces can be problematic in parking lots. Where only a junction box is available, an electrician is needed to connect the EVSE before the space is useful for EV charging. Where a receptacle is available, it is much easier for a user to attach their own portable EVSE, but there are some important issues. While the charging connectors are relatively standard on the car side of EVSE, they are not standard on the mains power side. There are as many as 14 different receptacles that could support Level 2 charging, many of which support different electrical circuit capacities. Even if an EV Ready space includes a receptacle, that receptacle may not be compatible with the plug on an EVSE or with the charging rate of the EVSE. Many of these receptacles are also used by RVs, creating the potential for RVs to utilize EV Ready receptacles for uses other than EV charging.

Due to these factors, EV Ready spaces are really only a good solution for situations where the EV driver has exclusive control over the parking space or where the pool of EV drivers is relatively stable and uses the spaces regularly. In these circumstances, EV drivers can select a portable Level 2 EVSE with a plug that matches the available receptacle at the EV Ready space. In condos, where tenants may have full control over their parking space, it can even make sense to invest in installing a permanent EVSE. Where parking is not dedicated, or the EV driver pool is not relatively stable, only Level 1 EV ready spaces (a simple 120V outlet) are appropriate since only those will provide dependable charging compatibility. For the Port, these could be a good fit for workforce and residential parking in existing, and potentially future, Port buildings.

EV Capable spaces are fully future-oriented. When including EV Capable spaces, the amount of reserved capacity is a critical issue. Reserving full capacity per space will increase on-site infrastructure costs. Future EV charging is much more likely to include load management, so it might make sense to reserve lower levels of capacity per space, with the expectation that all of those spaces will be load managed by the time they are put into service. The most important consideration for this is generally the penetration rate (the percentage of the total parking spaces that are EV spaces) for EV spaces in the parking lot. Where that penetration rate is low, then reserving closer to full capacity is more reasonable since it will be important to maximize the charging utility of each of the limited number of EV spaces. Where the penetration rate is higher, maximizing charging utility per space is less important because there are more spaces.

Figure 24: Parking, EV charging and onsite PV can be implemented together. EV charging at the Civic Center Parking Structure in Santa Monica (Courtesy of City of Santa Monica).

Charging Level

When choosing the charging level, parking patterns are the most important consideration. Will park-times be longer or shorter? Are parking spaces dedicated or open to different drivers? Is the EV charging for residents, customers, or workers?

When dwell times are longer—residential parking, workforce parking, fleet parking—then lower levels of EV charging can be effective. At the same time, a larger number of EV spaces may be needed since EVs will need to spend a longer length of time in the parking space in order to get a reasonable amount of charging. A lower capacity Level 2 or even an outlet that can provide Level 1 charging may provide sufficient charging for parking with long dwell times. These lower-capacity charging connections can also minimize electrical infrastructure costs. A significant portion of the parking at current and planned Port buildings is workforce and residence parking. Therefore, this level of charging may be most appropriate for existing and future workforce and residential parking at the Port.

For buildings with customer dwell times that are not extended, but are still more than an hour—professional offices, larger retail, gyms, sit-down restaurants—then either Level 2 or DCFC will generally be the best fit. As the Port moves forward with mixed-use development, this will likely be the best fit for the ground-floor retail. The Port also has recreational uses, including the boat launch, parks, and trails. Dwell times in these parking lots is likely to be somewhat longer and well-suited to Level 2 charging.

For building types with very short dwell times—such as convenience stores, dry cleaners, quick-serve restaurants, etc.—even higher-powered Level 2 charging may not provide enough charge to make a meaningful difference for customer parking. For these building types, only DCFC may make sense for customer parking. The Port does not currently have, nor have plans for, this kind of usage; however, it might find that providing convenience DCFCs for Highway 14 and the Camas and Washougal communities does make sense.

Electric Boats and Planes

Not all electric vehicles are road vehicles. Electric boats, particularly electric sail boats, have already emerged on the market. As these boats become more common and as larger all-electric boats enter the market, they will create a need for greater access to power at the marina. Similarly, small electric planes have already emerged on the market. Airfields like Grove Field will be attractive to these small aircraft. Connections for electric airplane charging could introduce a load type with very different power needs.

Infrastructure planning both at and for the marina and airfield should take into account these potential new loads. In fact, providing for these loads would create an amenity that could be used to differentiate the Port of Camas-Washougal and specifically attract electric boat and plane owners.

Building Electric Infrastructure Capacity

As building loads are electrified and EV charging is added to building sites, it is likely that building electrical capacity will need to be increased. In commercial buildings, this can mean larger or more panels, on-site transformers, and electrical service.

Unfortunately, it can be difficult to predict what the impact of electrification on a specific building will be. Onsite electrical infrastructure equipment sizes are not very granular and there can be large increments between standard equipment sizes. The result is that buildings and building designs may or may not be fully utilizing available capacity. For buildings and designs that are already near a size threshold for electrical infrastructure, even a small load increase can necessitate upsizing. Other buildings and designs may have substantial unused capacity, and even the addition of significant loads may not necessitate capacity upgrades. Additionally, the electrification of different kinds of loads will have a different level of impact on capacity:

- Electrification of space heating is unlikely to have an impact on total building electrical capacity for most buildings. Most commercial buildings already have cooling, and heating capacity sizes are comparable or smaller than cooling loads in western Washington's generally temperate climate. Heat pumps that provide both heating and cooling can usually be accommodated within the same electrical capacity used by air conditioning equipment. However, it may be necessary to utilize cold-climate HPs that do not require additional capacity for significant backup resistance heat.

- Electrification of water heating will likely have a negligible impact on buildings with low water heating loads like offices, warehouses and most industrial buildings. However, electrification of water heating is likely to have a significant impact on buildings with higher hot water usage such as multifamily and hotel buildings. This will be a significant issue for the planning of future mixed-use residential developments at the Port.

- Electric Vehicle charging can have a significant impact on electrical capacity needs if a large number of EV spaces or even a small number of DCFC spaces are being installed. DCFC equipment is usually served by its own utility service since the capacity requirements are so large. A large number of Level 2 EV spaces could face a similar situation.

- Electrification of commercial kitchens is likely to have a significant impact on electrical capacity needs since electric cooking equipment typically has high power draws. While the Port currently only has one restaurant, future mixed-use development will likely include additional restaurants in the ground-floor commercial space. Since these will be located in larger buildings, the impact on the total building electrical capacity may not be significant.

Strategies for Managing Capacity

With the exception of some process loads, the gas loads in most of the industrial buildings at the Port are quite low. Therefore, building electrification is less likely to have a significant impact on the electrical infrastructure of these buildings. However, the mixed-use development planned as part of the Vision and Master Plan for the Waterfront includes building types like multifamily and restaurants that typically have large gas loads. Electrifying the building loads in these buildings could have a significant impact on the buildings' electrical capacity.

Also, the addition of EVCI at any scale could have significant electrical infrastructure capacity in both new and existing buildings at the Port. There are several strategies for managing these capacity impacts.

Load Management

Load management can be a very useful strategy for managing the impact of electrification on the needed capacity of the electric infrastructure. The electrical infrastructure in buildings is designed to ensure that a substantial portion of the building loads can operate simultaneously without overloading the system. This results in electrical infrastructure that is very safe, but also oversized for the total operating loads most of the time. Energy management systems (EMS) are used to control loads by either reducing or completely turning off certain loads. This allows more load to be added to a building while ensuring that the total loads never overload the system. Through using an EMS, non-critical or time-flexible loads can be curtailed to essentially free up additional capacity for the addition of new electric loads due to electrification. This strategy depends on having flexible loads in the building that can be curtailed when the capacity is needed elsewhere.

Load management can be utilized to manage the source of electricity, not just its consumption. Energy storage can be added to a building to provide a source of electricity other than the grid, so that when coincident loads are high, the building can draw some energy from energy storage. Energy storage has additional uses. It can be used for emergency power instead of generators.

Load management and storage can also be used to manage peak demand charges by reducing the amount of electricity used during peak rates or reducing the total peak load of the building.

New Construction

Ideally, new buildings at the Port will be all-electric and the impact of any additional building loads or EVCI will be planned into the design of the site electrical infrastructure and accommodated with additional capacity or load management. Washington's energy code is moving toward mandatory electrification of specific building loads, but process loads are unlikely to be included in the near future. If gas loads are unavoidable in new construction, then it will be important to design the electrical infrastructure so that it has enough capacity for the future electrification of those gas loads. This means creating reasonably accurate alternate designs for the electric equipment that would replace those gas loads and building capacity into the building's electrical infrastructure to support that future electrification.

Existing Buildings

The Port has many buildings already on site, making capacity considerations for existing buildings especially important. There are several additional strategies that can be used to reduce impacts on electrical capacity during electrification retrofits and can help control costs.

Figure 25: Existing onsite transformer.

Infrastructure upgrades may be necessary to create additional electrical capacity. This can include upgrades to the electrical utility service, panels, onsite transformers and switchgear and even the wiring connecting them. However, there are ways to minimize the impact of infrastructure upgrades:

- Electric infrastructure upgrades can add time to electrification retrofits. Particularly in the case of emergency upgrades, this can create project delays. Pre-emptive infrastructure upgrades can be used to better manage both the capital expenditure and time disruption of electrification retrofit projects. It also allows for the infrastructure upgrades for all of the planned electrification retrofits, or even for multiple buildings. The economies of scale from combining multiple projects can reduce total costs compared to a piecemeal approach.

- The section above discussed how utilizing an independent utility service for each tenant space can promote conservation. If additional capacity needs to be added to a master-metered building, it can be added in the form of a new electrical service and utility meter for one or more of the tenant spaces. This allows the existing electrical infrastructure to serve a smaller portion of the building, effectively freeing up capacity and eliminating the need to upgrade the service. This strategy allows two decarbonization strategies to be implemented through a single retrofit.

- When additional load is coming from the addition of EVSE, a dedicated service for the EVSE loads may be less costly than a service upgrade. This will need to be assessed on a project-by-project basis.

Load reconfiguration can sometimes be used to avoid infrastructure upgrades. Many existing buildings actually have un-used or poorly utilized capacity. If an electrician just looks at the main panel, it may look like all of the building's capacity has been taken up when it actually has not. Previous energy conservation retrofits may have reduced electrical loads. New electrical infrastructure (such as circuits or sub-panels) may have been added in a way that does not effectively utilize existing capacity. There are many events that can happen in the life of a building that can change the loads and the resulting available capacity. It is important to run load calculations based on an accurate survey of the current loads in the building to assess actual available capacity and not just the capacity apparent at a panel. It may be that the building has more capacity than is readily apparent or that even more capacity can be freed up by reconfiguring or combining loads onto fewer circuits. The Port should be sure to contract highly qualified electrical engineers and electricians to both accurately and safely assess the capacity opportunities in existing Port buildings.

Marina

Boats, particularly sailboats, are also making the transition to electric power. This could increase demand for electricity at the marina. One way to manage total capacity is to limit the electrical capacity available at each slip. Currently, 30A at 120V is provided at each slip. Some boats may be undergoing work that requires more power for tools, but many boats only need minimal power to maintain a few systems on the boat or to charge batteries over an extended period of time between uses. This means that there is significant unused capacity at the slips most of the time. To address these differences in electrical needs, the shore power offered at the slips could be broken into different tiers of electrical capacity. This way, boats that only need minimal power at the slip are not taking up capacity that is needed elsewhere.

Figure 26: Shore power connection and meter at Parker's Landing.

Appendix

Acronyms

COMMON ABBREVIATIONS

DR: Demand Response

EV: Electric Vehicle

EVCI: Electric Vehicle Charging Infrastructure

EVSE: Electric Vehicle Supply Equipment

GHG: Green House Gas

GSHP: Ground Source Heat Pump

HP: Heat Pump

HPWH: Heat Pump Water Heater

HVAC: Heating, Ventilation and Air Conditioning

LED: Light Emitting Diode

OSHA: Occupational Safety and Health Administration

PV: Photovoltaics

REC: Renewable Energy Certificate

RTU: Roof Top Unit

VRF: Variable Refrigerant Flow

Additional Resources

Efficiency

- ***ASHRAE Advanced Energy Design Guides:*** ASHRAE has developed a series of guides that contain strategies for achieving levels of efficiency that are substantially better than code and even achieve Zero Net Energy. These guides cover multiple building types, but probably only the office guide will be relevant to the Port.[23]
- ***ASHRAE Design Guide For Low- to Mid-Rise Multifamily Residential Buildings****:* ASHRAE has also developed a design guide for multifamily buildings. This is a broad-based resource for multifamily, but it includes

[23] https://www.ashrae.org/technical-resources/aedgs

content on energy efficient multifamily building design that will be relevant to planned multifamily development at the Port.[24]

- ***NBI Multifamily Building Guide:*** NBI developed this guide to provide a prescriptive path to achieving very high levels of energy efficiency in multifamily buildings. The measures in this guide will be directly applicable to planned multifamily developments at the Port.[25]
- ***NBI New Construction Guide:*** This guide includes a prescriptive path for highly efficient small commercial buildings. The measures will be broadly relevant for new commercial buildings at the Port. It also includes a section on successfully incorporating energy efficiency into the design process that would be very applicable to all-electric design as well. [26]

Electrification

Redwood Energy has produced a series of guides to support the design of all-electric buildings. The Zero Carbon Commercial Construction Guide[27] and Zero Emissions All-Electric Multifamily Construction Guide[28] are particularly relevant to planned developments at the Port.

NBI's Getting to Zero Resource Hub[29] also offers various electrification resources including these guides.

Renewable Energy

The US Department of Energy's "A Guide to Community Solar"[30] includes information about community solar that would be useful in pursuing that model for renewable energy projects at the Port.

EVCI

The Pacific Northwest National Lab has produced a technical brief titled "Electric Vehicle Charging for Residential and Commercial Energy Codes."[31] While energy codes are the primary topic of this technical brief, it also includes good background information on EVCI and information about market trends that can also be useful in making the case for incorporating EVCI in projects.

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[24] https://www.techstreet.com/standards/ashrae-design-guide-for-low-to-mid-rise-multifamily-residential-buildings?product_id=2108456
[25] https://newbuildings.org/resource/multifamily-building-guide/
[26] https://newbuildings.org/resource/new-construction-guide/
[27] https://www.redwoodenergy.tech/wp-content/uploads/2019/09/Pocket-Guide-to-Zero-Carbon-Commercial-Buildings-2nd-Edition.pdf
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[29] https://gettingtozeroforum.org/resource-hub/
[30] https://www.nrel.gov/docs/fy11osti/49930.pdf
[31] https://www.energycodes.gov/sites/default/files/2021-07/TechBrief_EV_Charging_July2021.pdf

Port of Camas-Washougal visitor center.

New Buildings Institute (NBI) is a nonprofit organization driving better energy performance in buildings. We work collaboratively with industry market players—governments, utilities, energy efficiency advocates and building professionals—to promote advanced design practices, innovative technologies, public policies and programs that improve energy efficiency and reduce carbon emissions. We also develop and offer guidance and tools to support the design and construction of energy efficient buildings. Learn more at newbuildings.org.