EV Ready
Economic Analysis

Prepared for
The City of Portland Bureau of Planning and Sustainability

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I. EXECUTIVE SUMMARY

The EV Ready Code Project anticipates a series of changes to the development code that would mandate an increased level of electrical infrastructure to accommodate the installation of Level 2 charging stations. The intent of the EV Ready Code Project is to increase access to charging infrastructure by requiring investment during new construction. The State of Oregon (HB 2180) has already established requirements, and the focus of this analysis is on the proposed incremental increase in requirements relative to statewide mandates.

The cost of installing the conduit and electrical capacity to support Level 2 charging will be borne initially by the property owner and/or developer, but over time these costs will be borne by the market through some combination of higher rents and lower land values.

The literature reviewed includes a number of studies attempting to quantify the costs associated with providing EV Ready infrastructure and charging capacity. These show a significantly higher cost associated with redevelopment/rehab projects relative to new construction, with it more cost effective to provide infrastructure during initial construction. In addition, significant cost savings can be achieved with managed systems, which better match actual power needs with capacity provided. The average installed cost of required infrastructure will be a function of what is mandated. Costs can be significantly reduced by limiting the infrastructure requirements and allowing for managed power systems. Available forecasts of the electric vehicle market anticipate a compound annual growth rate (CAGR) ranging from 14% to 28% through 2027. Over the next fifteen years, electric vehicle demand could grow 11-fold.

The estimated impact on overall development cost associated with EV Ready infrastructure is expected to be significant but still modest relative to the overall cost of development. The proposed mandate will move EV Ready space requirements from 20% to 50% of parking spaces, with an average cost per space ranging from $800 to $4,800 per space depending upon the technical requirements and project-specific variables. The lower cost estimates reflect infrastructure only, with load management as opposed to dedicated circuits. The higher cost estimates reflect a dedicated circuit.

	Estimated Costs		
	Low	**High**	**Average**
Cost per EV Space			
Dedicated	$3,667	$4,791	$4,229
Shared	$824	$1,902	$1,363
Incremental Cost/Unit			
Dedicated	$550	$1,582	$1,066
Shared	$185	$622	$404
Baseline Costs	$275,000	$375,000	$325,000
% Shift in Costs			
Dedicated	0.20%	0.42%	0.33%
Shared	0.07%	0.17%	0.12%

This additional cost would need to be offset by increased revenue, which would be possible through user charges if the infrastructure was demanded in the market but would more likely be reflected in marginally higher rent levels and/or lower underlying land values. The expected percentage impact of this mandate on rent levels is expected to be below 1.0% for new construction.

If implemented, the requirements in the new code would be expected to increase the overall access to EV Ready infrastructure by roughly 5% in the City of Portland by 2041. This may not reflect a net new

addition to the inventory as developers and property owners are likely to increase charging infrastructure significantly over time if the market forecasts are accurate.

II. Background and Assignment

Johnson Economics was retained to prepare an economic analysis of the Bureau of Planning and Sustainability's EV Ready Code Project. The EV Ready Code Project anticipates a series of changes to the development code that would mandate an increased level of electrical infrastructure to accommodate the installation of Level 2 charging stations.

This project includes an assessment of the anticipated marginal impact of a range of EV Ready infrastructure requirements on residential and commercial construction. We use simplified financial analysis tools to assess the expected impact on new mandated infrastructure on variables such as product pricing, investment returns, and overall production levels.

A secondary analysis includes an estimation of the demographic characteristics of impacted populations, including breakdowns by income level. Available demographic data is supplemented by interviews with affordable housing providers and local developers. The research also looks at available income-qualified rebates and available infrastructure grants.

The following table outlines some of the proposed actions being considered in the EV Ready code project:

USE TYPE	PROPOSED CHANGES
Multi-dwelling and mixed-use	100% up to 6 spaces EV Ready 50% of spaces for 7+ spaces EV Ready Electrical capacity and conduit to support level 2 charging
INCENTIVES	
Structured Parking	Condition added to provision that structured parking FAR up to 0.5:1 doesn't count, parking must now be EV Ready
Car-share substitute for required parking	Every car-sharing parking space provided would reduce parking requirement by spaces, up to 25% of spaces, must now also be EV Ready

The intent of the EV Ready Code Project is to increase access to charging infrastructure by requiring investment during new construction and/or renovation. The State of Oregon (HB 2180) has already established requirements that electric service capacity in new construction must be provided for a minimum of 20% of all parking spaces, for commercial properties and residential properties with five or more units. This analysis will assess the proposed incremental increase in requirements relative to statewide mandates. As a result, the focus is on projects with a residential component and the marginal impact of the proposed requirements above and beyond what is above the statewide mandate.

III. Background Research

Literature Review

There have been several useful studies completed in the last several years that are helpful for our analysis, primarily focused on establishing the cost of installing Electronic Vehicle (EV) infrastructure. The following reports were reviewed:

- Pike, Ed, and Kido, Cassidee, and Kamei, Evan, and DoVale, Kate, Energy Solutions, *Plug-In Electric Vehicle Infrastructure Cost Analysis Report for CALGreen Nonresidential Update*, California Electric Transportation Coalition, September 16, 2019
- Pike, Ed, and Steuben, Jeffrey, Energy Solutions, Plug-In Electric Vehicle Infrastructure Cost-Effectiveness Report, City of Oakland, July 20, 2016
- Salcido, VR, and Tillou, M, and Franconi, E, Pacific Northwest Regional Laboratory, *Electric Vehicle Charging for Residential and Commercial Energy Codes*, U.S. Department of Energy, July 2021
- Seattle Department of Construction & Inspections, *Directors' Report*, Electric Vehicle Readiness Ordinance, December 2018
- Pike, Ed, and Steuben, Jeffrey, and Kamei, Evan, Energy Solutions, *Plug-In Vehicle Infrastructure Cost-Effectiveness Report for San Francisco*, City and County of San Francisco, November 17, 2016
- McKinsey Center for Future Mobility, *Charging Ahead: Electric-Vehicle Infrastructure Demand*, October 2018
- Seattle Office of Sustainability & Environment, Electric Vehicle Readiness, Presentation to Seattle City Council Sustainability & Transportation Committee, April 2, 2019
- AES Engineering Ltd., *Electric Vehicle Charging Infrastructure in New Multifamily Developments – Requirement Options and Costing Analysis*, City of Richmond, BC, April 4, 2017

The cost of installing EV infrastructure varies by land use, construction type, and type of service. The most recent reliable cost estimates we found in the US was in the 2019 Energy Solutions report for CALGreen, which focused on nonresidential construction under CALGreen requirements (conduit and electrical panel capacity for 40 amp, 208/240-volt circuit(s) to support future installation of wiring and electric vehicle supply equipment (EVSE). This analysis produced cost estimates for new construction, alterations and additions, and a stand-alone retrofit.[1] Cost estimates are summarized in the tables to the right, with 2019 estimates

	EV Capable Costs/Parking Space		
	New	Rehab	Retrofit
Small Office/ Retail Surface Parking	$905	$925 - $1,178	$5,540
Medium Office/ School Surface Parking	$901	$928 - $1,322	$4,155
Large Office/Retail/ Hospital Enclosed Parking	$739	$741 - $1,052	$2,779
	EV Capable Costs/Parking Space 2021$s		
	New	**Rehab**	**Retrofit**
Small Office/ Retail Surface Parking	$956	$977 - $1,244	$5,850
Medium Office/ School Surface Parking	$951	$980 - $1,396	$4,387
Large Office/Retail/ Hospital Enclosed Parking	$780	$782 - $1,111	$2,934

[1] The rehab number reflects improvements done during other alterations and additions, such as repaving or rehabilitation of a building.

converted to 2021 dollars based on Mortenson's construction cost index.

The Energy Solutions analysis indicates a significant cost advantage associated with providing EV infrastructure during initial construction vis-à-vis during a retrofit. Key cost factors associated with retrofits include the following: demolition and repair of surface parking; breaking and repairing walls; longer conduit runs; upgrading electrical service panels. The cost numbers do not include branch circuit wiring to EV ready parking spaces or EVSE equipment, as these are not required under CALGreen. The cost differential would likely not be affected by this, as the costs were primarily associated with installing the necessary level of electrical service as well as running conduit. The cost of wiring and EVSE equipment would likely be similar during initial construction or during a retrofit.

The 2017 AES Engineering report for the City of Richmond looked at cost differentials for installing EV infrastructure, with a focus on multi-unit residential buildings. The study used a definition of infrastructure that varied modestly from the Energy Solutions report in that it included cabling in the conduit. The analysis also looked at the impact of load management and load sharing technologies that reduce peak power demand and reduce electrical infrastructure costs. These technologies also provide the capability to control the time of use , which may be utilized to reduce the impact on utilities.

The following table summarizes the estimated cost to provide EV infrastructure from the AES report, with the conclusions converted to current US Dollars. The Level 2 dedicated infrastructure ranged from $3,667 to $4,791 per space, while load sharing options reduced that cost to $487 to $2,600 per space.

	Cost Estimates/Stall 2021 USD		
	L1	L2 Ded	L2 Share
High Rise - City Centre	$2,287	$4,791	$1,204 - $2,600
Mid Rise - City Centre	$1,342	$3,879	$970 - $1,990
Mid Rise - Outside CC	$1,396	$3,667	$897 - $1,691
Townhouse - Outside CC	$200	$4,207	$487 - $1,162

While there are clear cost savings associated with installing infrastructure during initial construction as opposed to a retrofit, providing EV infrastructure will still entail significant costs. A key variable in assessing the impact of these costs is the degree to which future demand supports utilization of this infrastructure for EVSE equipment. As a result, we also looked at forecasts of EV vehicle adoption. As would be expected with emerging technology, there is a wide variance in forecasts. It's also important to keep in mind that future forecasts of EVs are correlated with available EV charging infrastructure. An increased availability of chargers would be expected to support a more rapid adoption of EVs.

A 2018 report by the McKinsey Center for Future Mobility anticipates that the US will have roughly 18 million battery electric and plug-in hybrid vehicles on the road by 2030, with these vehicles representing an estimated 14% of overall sales by 2030.[2] Allied Market Research forecasted a 27.5% CAGR for electric

[2] McKinsey Center for Future Mobility, Charging Ahead: Electric-Vehicle Infrastructure Demand, October 2018

vehicles in North America through 2027[3], while Inkwood Research forecasts a 23.15% CAGR through 2028.[4] BlueWeave Consulting forecasts a CAGR of over 14% in North America from 2021-2027.

INTERVIEWS

A series of interviews was conducted to provide additional context. Interviewees included public agency staff in other jurisdictions, electrical engineers, utilities, and developers. This section provides a general summary of their input followed by some specific comments generally sorted by topic.

Everyone we interviewed expressed an expectation that electric vehicle adoption is likely to increase significantly over the next decade, and that there would likely be an increased need for property owners to accommodate these demands. There was less consensus regarding the scale of adoption as well as longer term sustained charging patterns. This is an evolving technology (particularly for batteries) and there is a high level of uncertainty regarding how vehicle charging needs will be accommodated. Some felt that the eventual pattern would favor fewer higher-rate charging stations, with faster charging times supporting centralized fueling stations similar to current gas stations. On the other end of the spectrum some saw slow overnight charging as a future solution, requiring only three prong outlets and limited additional infrastructure. Recognizing the high level of uncertainty and the risk of stranding investments in the incorrect infrastructure, many respondents stressed a need for flexibility in requirements. With current battery technology there will always be a need for L1 & L2 residential charging. Fast charging results in a quicker degradation of car batteries (https://thenextweb.com/news/is-fast-charging-bad-ev-battery-degradation) so primary reliance on fast chargers is not desirable.

We interviewed representatives from other jurisdictions on the West Coast that have implemented EV Ready programs. The primary intent of these programs is to facilitate a more rapid adoption of EV Vehicles in their jurisdictions to address climate goals. There was a concern that the relatively higher cost of installing EV infrastructure if not done during initial construction would limit access, particularly for lower-income households. Some jurisdictions have decided not to address renovation/retrofit in their initial efforts as the costs were much higher and the variability in costs was greater. The EV requirements also vary by jurisdiction, with many choosing to allow for power management solutions and shared circuits to reduce costs and electrical load. Many of the programs have limited the requirements to only providing portions of the infrastructure that are difficult and costly to do during a retrofit.

The development industry surveys saw this as an incremental increase in cost that would need to be reflected in higher rents or reduced land prices. Most of them expressed concern that the mandate was unnecessary and/or was mandating the wrong response. There was a strong preference for letting the

[3] Singh, Abhay, Allied Market Research, Electric Vehicle Market by Type, Vehicle Class, and Vehicle Type: Global Opportunity Analysis and Industry Forecast, 2020-2027, April 2020

[4] Inkwood Research, Global Electric Vehicle Market Forecast, 2020-2028

market determine the need for this infrastructure, and that the new requirements would place inflationary pressure on rents and reduce the level of new construction in the City of Portland. There was concern that the cost impact would be worse when included with the cumulative impact of a broad range of mandates and requirements in the City of Portland.

General Comments

- Code Language
  - Don't necessarily need to pull wires initially to realize cost savings
  - There is the potential that wires will be the wrong gauge
  - Copper and aluminum wiring is expensive, and can be salvaged[5]
- The size of service to the building is a major cost, and utilities may not allow that level of service if there is no associated demand.
  - The utilities responded that they would always allow a customer to install a larger service size to accommodate future loads, as long as it is within their service limits for secondary service. They also suggest installing a separate service for the EV charging loads when possible.
- The utilities can't overbuild, as they are regulated, and costs must be recovered in rates and approved by the PUC. The costs can't be shifted to the rate payer.
  - While the preceding comment was made by a utility company representative, we followed up with them on this and received additional clarification. The utilities will design the utility infrastructure (vaults, transformer pads/vaults, primary & secondary conduit) to accommodate full use of whatever service size is installed by the customer. They will size the electrical portion of the installed facilities for the anticipated demand load on that service (i.e., not including future EV loads), so the utility assets wouldn't be "overbuilt". Once the EV charging load is added, the utility can easily upgrade the transformer and wires because the utility infrastructure was designed for the full service size (accounting for the EV charging loads).
- The electrical code needs some work to understand the load requirements for these systems. There is not enough historical data to understand the requirements of these systems, particularly actively managed systems.
- The utility can put in all of the service capacity for a building, but the peak usage in practice is only about one third of the NEC calculated load. NEC allows for derating of EV charging load based on the number of chargers, which we believe to be fairly accurate in the real world.
- Building inspection has been an issue, as code requirements limit flexibility. There is a lot of excess capacity in electrical systems, but inspectors don't want to recognize.
- The State of Oregon allows for a 50% diversity factor for projects with multiple chargers.
- The proposed requirements are missing the point, and planning for yesterday's technology

[5] It does not appear as though wiring is required as a result of HB 2180. If only the conduit is required, the cost of wiring should not be an issue related to these new requirements.

- Lucid Motors has announced ultra-high 900V+ electrical architecture, which the capability to charge at rates of up to 20 miles per minute. This can translate into 300 miles of range in just 20 minutes of charging. Tesla DC Superchargers can recharge up to 200 miles of range in 15 minutes at up to 250 kW. Kia's upcoming EV will provide roughly 300 miles of range with a sub-20-minute recharge time using an 800V system that can hit 250-kW. Porsche already has an 800 V system, while GM is planning 400V and 800V platforms that can add 100 miles of range in 10 minutes.
- The technology is changing rapidly, and projects need flexibility to assure that they will have the correct solution. If the City put this in the code next year, any projects subject to the code wouldn't be delivered until 2025 at the earliest. At this time, the technology will have advanced, and the appropriate EV investment may vary substantively from what is mandated.
- The most likely solution for the longer term now appears to be a limited number of fast charge stations with a smart scheduling system as opposed to overnight charging. Providing a more limited number of fast charging stations costs less and is preferred by tenants.
- This may represent a short-term view and we need to build for the future, but what will the future be?
- We will be put into a situation of spending money on a problem that doesn't exist.
- A really important point for multifamily (as opposed to office or retail) that many developers and jurisdictions miss is that the majority of spaces do not need to be Level 2 charging stations, which are more expensive to install and require more electrical capacity. Most electric car owners in Portland use Level 1 chargers at home, and these are slower for a full charge but most people leave their cars parked overnight anyways. These are much cheaper to install.
- I wish more jurisdictions saw this opportunity and required apartment/residential developers to install some limited number (i.e., 5%-10%) of parking stalls with Level 2 high-speed chargers, then required the balance of the spaces to be equipped with three-pronged outlet chargers or EV-ready.

<u>Experience in Other Markets</u>

- In Washington, the requirements were done at the State level by amending land use codes. This was done for all development types.
- Each charging stall was to be equipped with a Level 2 plug
- The amperage of service is critical. Plugs were required so that the utilities would provide the adequate level of service for assumed future needs.
- The City of Vancouver initially set up the program for new construction, as there are much more complex issues with retrofitting and remodeling.
- The requirement in Vancouver is 100% EV infrastructure with the exception of visitor parking
- The issue of EV readiness in older projects has been pushed farther out, as costs are much higher as is variability.
- The pricing in Vancouver for housing is very high, and as a result it is difficult to push additional costs to the market in terms of higher rents. New projects still need to compete with older stock.

- Vancouver's program was intended to support and accelerate EV vehicle adoption, and the hope is that lower income households will also benefit from EV ownership advantages.
- Gas prices in British Columbia are comparatively high (approximately $7.00 per gallon) and electric power costs are low. This makes EV vehicles relatively more attractive.
- The program increased the requirement to Level 2 charging capabilities but offset these costs by allowing for energy management systems.
- Performance standards were reduced. The average driver in Vancouver was assumed to require 8 kwh per day to keep an electric vehicle charged, so the requirement was set at 12 kwh per space.
- Required charging infrastructure will not likely be needed for a while. In other words, developments are likely to have more charging infrastructure than demand for a period of time. This will allow for greater power availability if not all spaces are being used.
- The development community no longer pushes back against the mandates, particularly since the performance standards were changed to allow for managed power solutions.
- There has been a lot of overcompliance in Vancouver. Since the standards were introduced a total of approximately 11,000 spaces were required and developers delivered 17,000.
- There is a concern of favoring a particular technology, and the City' intent is to keep standards general enough to allow for multiple systems and technological innovation.

Cost of Installation

- California recently completed updated cost estimates in 2019
- The cost to install charger infrastructure is $2,000 to $5,000 per space in new construction
- Costs increase to $12,000 to $13,000 per space for retrofits
- Load management has a big impact on pricing
- Larger garages have the ability to power share, with reduces costs significantly.
- Utilities are hesitant to increase service sizes. Larger requirements can trip vault requirements, which increase costs substantially.
- There has been a lot of progress in managed power and chargers.
- Firm is involved in the design of EV systems
- The costs can be highly variable, and the code requirements are somewhat vague
- A Level 2 charger typically requires a 40 to 50-amp circuit, and provides approximately 20 miles of range per hour in charging
- Distributed systems can split a dedicated circuit, with software allowing a managed allocation of a 40-amp circuit. This limits the level of charging available to any one space on the system depending upon how many vehicles are charging
- Not every car needs to be charged every night, so the impact is likely limited.
- There is a construction challenge with surface parking lot installations terminating conduit prior to installing a charging station. There is no simple way to cap off the empty conduit.
- There has been an increased interest in providing EV infrastructure to "future proof" projects in anticipation of wider EV vehicle adoption.

- The cost to install a Level 2 charging station per space is approximately $7,000 to $9,500, which includes the conduit, wiring, breaker, installation, and station. The rough-in alone (providing vault capacity and conduit) is $2,000 to $2,500 per space for new construction (pricing is from R&O and R&H).

Impacts on Development

- Interviews were conducted with the Master Builders Association to look for pain points of the requirements.
- Requiring infrastructure that is not needed requires the developer to sit on the cost until the market requires it.
- The Oregon Energy Code requirements are already adding costs, and developers see EV requirements as just adding on to these costs.
- Many developers have been putting charging stations in projects for the last decade, as it provides points for LEED Certification as well as some demand from tenants.
- Developers and/or property owners will not lose tenants for a lack of charging stations. If they are demanded by the tenants they will be provided.
- A recently completed project has 200 parking spaces, 8 of which have EV charging stations. At the current time there are only 5 electric vehicles using the garage.
- Charging doesn't need to happen every night for most tenants, maybe once per week. This can be easily scheduled for a lower number of fast charging stations.
- The City of Portland keeps adding costs to projects as well as making it more difficult to develop. The cumulative impact of the ongoing code and policy changes discourages anyone from developing housing in Portland.
- People will buy electric vehicles when they see the value proposition, and property owners will add the necessary infrastructure when needed. They won't lose tenants over this issue.
- The City should let the market figure it out and put their time and efforts into developing ultra-fast charging stations and infrastructure.
- The capital markets are interested in emerging EV usage patterns and are looking to assure that investments will remain competitive. They want flexibility as they are unsure as to what the future will look like.
- The market will have incentives to provide the correct type and number of spaces to meet demand. Buildings included charging infrastructure before requirements.
- Investments such as a larger transformer vault would provide flexibility while remaining capable of meeting multiple future scenarios.
- Rent levels are fixed for income-restricted projects, so there is no ability to recover additional costs through rents.
- Most affordable housing in an urban context does not provide any parking, so EV mandates will have no impact. Close in projects assume tenants use bikes or transit.
- If in a suburban context, parking ratios are quite small (0.2 to 0.3 per unit), and most of that parking is for staff as opposed to residents.

- It will be very difficult to make any market rate projects work in the City of Portland that are subject to the inclusionary housing mandates, and additional mandates will just make it less likely.
- None of their current projects have any charging stations, although there are some that are EV-Ready.
- Let the market create demand for these, if needed they will be provided
- OHCS has added some guidelines that require a developer of affordable housing to at least address their ability to provide solar and charging stations in new units
- The City of Portland should stop doing things that increase the cost of providing housing
- The increased cost will place an upward pressure on rents
- Increased costs will have to be offset by some combination of higher rents and lower land values. It is very unlikely in this market that land values will decrease substantively.
- Costs are usually passed on to residents through additional parking rent.
- The cost for additional power usage is almost always passed through to the tenant. When you use a third party, like ChargePoint or Sema Connect, the tenant pays the cost of charging plus the cost of electricity (the system includes a built-in metering system). The third party then pays back the community the cost of the electricity.
- A recent survey provided by Graystar of multifamily projects in the Portland metro area shows monthly fees ranging from $20 to $100 per month for access to charging stations. Most charging is provided through shared stations, with only a few chargers per project.

Equity Considerations

- Requiring the infrastructure would increase access and equity for lower income households
- Who owns the meter? If shared, how is the cost equitably allocated?
- Not many residents of low-income projects have EVs, as they are not really practical.
- EV infrastructure mandates could have a big impact on rehab and renovation projects, which are a large part of affordable housing. Adding EV stations in these projects would be unnecessary and add a lot of costs.

Available Offsets

- Clean fuel standard credits are generated and can be sold/transferred.

IV. Assessment of Impacts

As part of our analysis, we looked at the impact of the proposed new requirements from a financial perspective. A series of simplified pro formas were used to test the marginal impact of the incremental associated costs on project viability. Our approach assumes a threshold rate of acceptable return, which implies that changes in construction cost are reflected in some combination of higher rents (revenues) or reduced land values (costs).

The incremental increase in cost from the proposed requirements was derived from the cost estimates generated by CALGreen and the City of Richmond, previously outlined in the literature review section of this report.[6] Costs were assumed for either dedicated or shared infrastructure, with cost estimates ranging from $800 to $4,800 per parking space. This does not include the cost of providing the actual charging station, which was estimated to increase cost to between $7,000 to $10,000 per space. The analysis only considered the net increase in cost associated with the City's proposed code project, above and beyond the new statewide requirements.

The following charts show the expected impact of the requirements for a range of residential prototypes. Cost increases associated with the EV infrastructure requirement ranged from $62,000 to $394,000 in these projects. The marginal cost increase would be expected to increase total development cost by between 0.2% to 1.2%. Assuming that these types of projects would require a 6.50% return on cost, annual project income would need to increase from $4,000 to $26,000 to offset these additional costs. If the additional income requirement is applied across the entire inventory of units, the incremental increase in rent levels to offset this cost would be less than 1%. The incremental income requirement per unit line item reflects the marginal annual change in income required to maintain the same level of return.

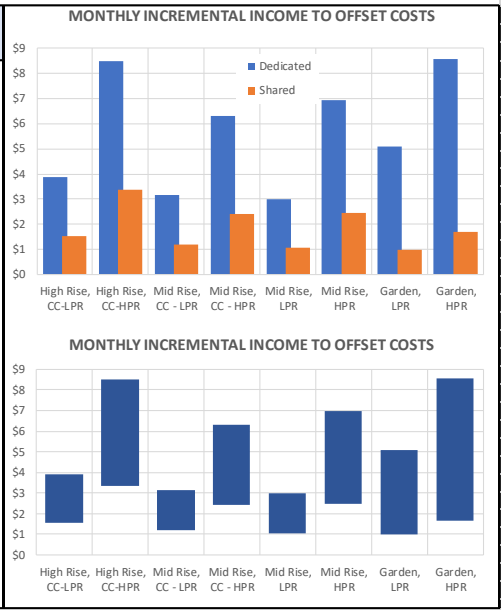
Some of the developers interviewed indicated that projects have successfully found ways to directly monetize EV infrastructure investment through charging higher parking rates for dedicated circuits or charging for time at a rapid charge station.

6 The most reliable cost estimates available were from Oakland, CA and Richmond, BC. The report assumes that these costs are consistent with what would be experience in the City of Portland, there can be significant variance in construction costs across metropolitan areas. Overall construction costs in the Oakland area were estimated to be roughly 20% higher than those in Portland, while costs in Vancouver, BC were estimated to be only 1% higher. The CALGreen costs were used to establish the high end of the range, and as a result may overstate the top end cost impact.

Summary of Estimated Impacts on Project Viability, Residential Prototypes, Baseline Costs[7]

INCOME-DRIVEN IMPACT USING BASELINE ASSUMPTIONS

	PROTOTYPE							
	High Rise CC-LPR	High Rise CC-HPR	Mid Rise CC - LPR	Mid Rise CC - HPR	Mid Rise LPR	Mid Rise HPR	Garden LPR	Garden HPR
PROJECT DETAILS								
Number of Units	220	220	180	180	60	60	250	250
Average SF/Unit	675	675	700	700	720	720	750	750
Average Rent/Month	$2,363	$2,363	$2,065	$2,065	$1,872	$1,872	$1,388	$1,388
Total Parking Spaces	110	242	90	180	30	70	188	313
EV READY COSTS								
Mandated EV Ready Spaces								
Baseline	22	49	18	36	6	14	38	63
New Standards	55	121	45	90	15	35	94	157
Marginal Change/Spaces	33	72	27	54	9	21	56	94
Average Cost/Space								
Dedicated	$4,791	$4,791	$3,879	$3,879	$3,667	$3,667	$4,207	$4,207
Shared	$1,902	$1,902	$1,480	$1,480	$1,294	$1,294	$824	$824
Marginal Cost Increase								
Dedicated	$158,088	$344,919	$104,742	$209,485	$33,003	$77,007	$235,613	$395,493
Shared	$62,766	$136,944	$39,960	$79,920	$11,646	$27,174	$46,144	$77,456
IMPACTS ON REQUIRED RENTS								
Assumed Capitalization Rate	6.50%	6.50%	6.50%	6.50%	6.50%	6.50%	6.50%	6.50%
Required Annual Income to Offset Costs								
Dedicated	$10,276	$22,420	$6,809	$13,617	$2,146	$5,006	$15,315	$25,708
Shared	$4,080	$8,902	$2,598	$5,195	$757	$1,767	$3,000	$5,035
Incremental Income Requirement per Unit								
Dedicated	$47	$102	$38	$76	$36	$83	$61	$103
Shared	$19	$40	$14	$29	$13	$29	$12	$20
Incremental Income Per Unit/Per Month								
Dedicated	$3.89	$8.49	$3.15	$6.30	$2.98	$6.95	$5.11	$8.57
Shared	$1.55	$3.37	$1.20	$2.41	$1.05	$2.45	$1.00	$1.68
Percentage Increase Per Month								
Dedicated	0.16%	0.36%	0.15%	0.31%	0.16%	0.37%	0.37%	0.62%
Shared	0.07%	0.14%	0.06%	0.12%	0.06%	0.13%	0.07%	0.12%

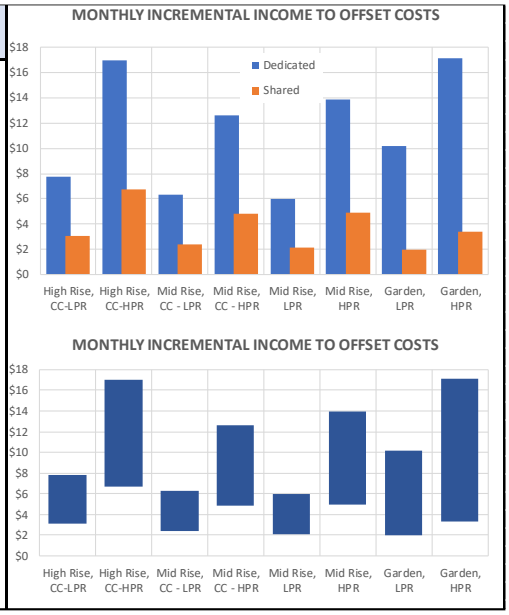


SOURCE: Johnson Economics

The same analysis was run doubling the cost assumptions, which also doubles the impact on rents assuming all of the cost is pushed forward to the market.

Summary of Estimated Impacts on Project Viability, Residential Prototypes, High Costs

	PROTOTYPE							
	High Rise CC-LPR	High Rise CC-HPR	Mid Rise CC - LPR	Mid Rise CC - HPR	Mid Rise LPR	Mid Rise HPR	Garden LPR	Garden HPR
PROJECT DETAILS								
Number of Units	220	220	180	180	60	60	250	250
Average SF/Unit	675	675	700	700	720	720	750	750
Average Rent/Month	$2,363	$2,363	$2,065	$2,065	$1,872	$1,872	$1,388	$1,388
Total Parking Spaces	110	242	90	180	30	70	188	313
EV READY COSTS								
Mandated EV Ready Spaces								
Baseline	22	49	18	36	6	14	38	63
New Standards	55	121	45	90	15	35	94	157
Marginal Change/Spaces	33	72	27	54	9	21	56	94
Average Cost/Space								
Dedicated	$9,581	$9,581	$7,759	$7,759	$7,334	$7,334	$8,415	$8,415
Shared	$3,804	$3,804	$2,960	$2,960	$2,588	$2,588	$1,648	$1,648
Marginal Cost Increase								
Dedicated	$316,176	$689,839	$209,485	$418,969	$66,006	$154,014	$471,226	$790,987
Shared	$125,532	$273,888	$79,920	$159,840	$23,292	$54,348	$92,288	$154,912
IMPACTS ON REQUIRED RENTS								
Assumed Capitalization Rate	6.50%	6.50%	6.50%	6.50%	6.50%	6.50%	6.50%	6.50%
Required Annual Income to Offset Costs								
Dedicated	$20,552	$44,840	$13,617	$27,233	$4,291	$10,011	$30,630	$51,415
Shared	$8,160	$17,803	$5,195	$10,390	$1,514	$3,533	$5,999	$10,070
Incremental Income Requirement per Unit								
Dedicated	$93	$204	$76	$151	$72	$167	$123	$206
Shared	$37	$81	$29	$58	$25	$59	$24	$40
Incremental Income Per Unit/Per Month								
Dedicated	$7.78	$16.98	$6.30	$12.61	$5.96	$13.90	$10.21	$17.14
Shared	$3.09	$6.74	$2.41	$4.81	$2.10	$4.91	$2.00	$3.36
Percentage Increase Per Month								
Dedicated	0.33%	0.72%	0.31%	0.61%	0.32%	0.74%	0.74%	1.23%
Shared	0.13%	0.29%	0.12%	0.23%	0.11%	0.26%	0.14%	0.24%



SOURCE: Johnson Economics

[7] LPR and HPR refer to low and high parking ratio prototypes.

As noted previously, increased costs can be shifted to the market through higher rents or deducted from land values as an alternative means of reducing costs. In our experience this is very difficult to do in the City of Portland as the market is highly competitive and property owners are often inflexible.

A similar analysis was done for a series of commercial and industrial prototypes. In this case we assumed a marginal cost of $1,200 per space for a shared loop, increasing to $4,800 for a dedicated circuit. These costs do not include the installation of a charging station, which would increase costs substantially. The capitalization rate for commercial and industrial was increased to 7.5%, reflecting the higher rates of return demanded for these product categories in the market.

SUMMARY OF ESTIMATED IMPACTS ON PROJECT VIABILITY, COMMERCIAL AND INDUSTRIAL PROTOTYPES

INCOME-DRIVEN IMPACT USING BASELINE ASSUMPTIONS

	PROTOTYPE					
	Office High Rise	Office Mid/ Structure	Office Mid/ Surface	Office Low Rise	Indust. Distribution	Indust. Flex
PROJECT DETAILS						
Gross SF	300,000	150,000	80,000	12,000	48,000	13,000
Leasable SF	270,000	135,000	72,000	12,000	48,000	13,000
Lease Rate PSF/NNN	$26.00	$26.00	$26.00	$26.00	$8.00	$13.50
Total Parking Spaces	405	202	92	18	48	13
EV READY COSTS						
Mandated EV Ready Spaces						
Baseline	81	40	18	4	10	3
New Standards	81	40	18	4	10	3
Marginal Change/Spaces	0	0	0	0	0	0
Average Cost/Space						
Dedicated	$4,800	$4,800	$4,800	$4,800	$4,800	$4,800
Shared	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200
Marginal Cost Increase						
Dedicated	$0	$0	$0	$0	$0	$0
Shared	$0	$0	$0	$0	$0	$0
IMPACTS ON REQUIRED RENTS						
Assumed Capitalization Rate	7.50%	7.50%	7.50%	7.50%	7.50%	7.50%
Required Annual Income to Offset Costs						
Dedicated	$0	$0	$0	$0	$0	$0
Shared	$0	$0	$0	$0	$0	$0
Incremental Income Requirement per SF						
Dedicated	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Shared	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Percentage Increase Per Month						
Dedicated	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Shared	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

SOURCE: Johnson Economics

As with the residential analysis, we looked at the marginal increase in lease rates that would be necessary to offset the mandated program requirements.

Our understanding is the current proposal sets the commercial rate at 20% of all parking, consistent with the new statewide requirements. This varies from the residential impact, where the City of Portland code would add incremental requirements beyond the statewide mandate. Since the proposed requirements

will be consistent with HB 2180 there is no anticipated net impact associated with the City's proposals for commercial space.

EQUITY ISSUES

While the proposal is supportive of the City's climate goals, there is also hope that the mandated EV infrastructure investments will increase the access to EV charging facilities across the household income spectrum. As the number of EVs in the market increase and access to these vehicles becomes more competitive at lower price points through the new and used vehicle market, it is hoped that less affluent households will be able to benefit from the lower operational and maintenance costs of these vehicles.

The proposed regulations will impact new construction. These types of projects are expected to command generally higher rent levels and be occupied by disproportionately higher income tenants. Lower income residents are more likely to be housed in older as well as income-restricted projects. New income restricted projects are expected to provide limited if any parking, so access will not be substantively improved under the proposed code.

An equity concern is the potential for the increased costs to translate into higher market rent levels for lower income households. As outlined in the preceding section, the marginal impact on rents to offset anticipated costs associated with EV infrastructure is expected to be relatively small for new construction, but it would be greater for renovation/rehab projects which are often a source of affordable housing in the market. While assumed rent levels in our analysis were relatively high, the costs will be higher in a rehab building while the market rent levels will likely be lower. As a result, the percentage shift in necessary rents to offset costs will be higher.

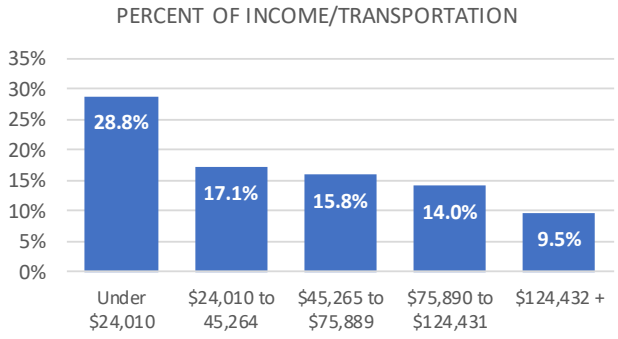
Another potential equity concern that arises is the extent to which this requirement provides a benefit with more value to higher income residents, who are more likely to own electric vehicles in the short and intermediate term. The incremental cost of the infrastructure investment could potentially be reflected in higher lease rates, which would negatively impact lower income households that would not benefit from the charging infrastructure.

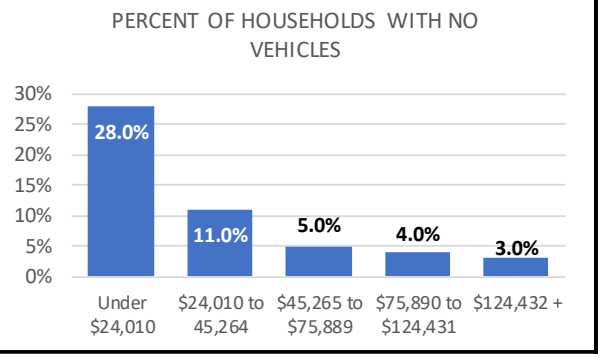
The average transportation spending per household is lower among lower-income households, while the percentage of income spent on transportation is significantly higher. A significant share of lower income households own no vehicles. While lower income households are typically assumed to purchase used vehicles, an estimated 39% of new sedans in the United States were purchased by households with incomes below $50,000 per year. An estimated 90% of new car buyers own their home though, providing little overlap for lower income renter household buying new cars.[8] Over time it is expected that used EVs will become increasingly available on the market, with lower price points and a broader acceptance rate among lower income households.

8 Hedges & Company, 2018 & 2019 model year vehicles.

AVERAGE HOUSEHOLD TRANSPORTATION EXPENDITURES BY INCOME QUINTILE (2020)

Quintile	Average After Tax Income	Trans. Spending per Household	Trans. Spending/ % of Income	Vehicles per Household	Households with No Vehicles (%)
All Quintiles	$74,949	$9,826	13.1%	1.9	10.0%
First ($0 to 24,009)	$15,140	$4,363	28.8%	1	28.0%
Second ($24,010 to 45,264)	$36,397	$6,218	17.1%	1.6	11.0%
Third ($45,265 to $75,889)	$58,001	$9,189	15.8%	1.9	5.0%
Fourth ($75,890 to $124,431)	$89,766	$12,610	14.0%	2.3	4.0%
Fifth ($124,432 +)	$176,094	$16,796	9.5%	2.7	3.0%





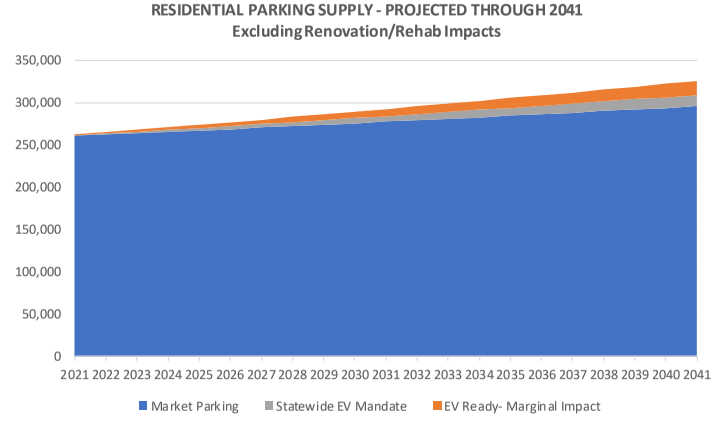
SOURCE: US Department of Labor Statistics, Table 1101, Quntiles of income before taxes, Consumer Expenditures Surveys

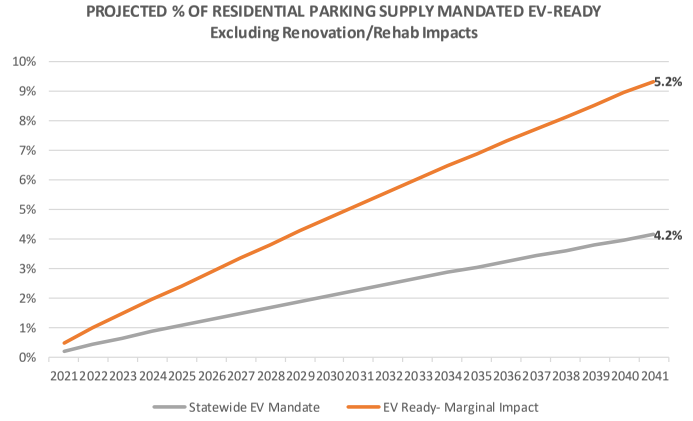
PROJECTIONS

In order to better understand the impact of the program on the overall availability of EV ready spaces, we forecast housing starts through 2041 assuming a 1.1% annual expansion of the local housing base. Using these assumptions, and assuming parking ratios of 1.0 per unit for ownership and 0.7 per unit for rental units, the overall inventory of EV Ready spaces would increase by 16,900 from the City's proposed new code. The program as proposed would be expected to increase the mandated number of EV Ready spaces in residential construction in the City of Portland more than two time what is currently mandated by the State of Oregon. An estimated 5.2% of total residential stock in the City of Portland would be expected to have EV ready spaces attributable to this program's mandates, in additional to 4.2% from the statewide requirements.

The degree to which EV ready infrastructure can be truly attributed to the program is a function of the extent to which the market will provide these improvements without the requirement. At the current time, the mandate appears to be well in excess of what the market would provide. In the future this may not be the case, and the market install infrastructure well above the requirements. As summarized in the interviews, the market has provided 17,000 EV Ready spaces in Vancouver B.C. while the requirement through code was for only 11,000. The value proposition for EV's in British Columbia is significantly better as fuel prices are roughly $7.00 per gallon and electricity costs are low.

	Year																				
	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041
Total Residential Units 1/																					
Ownership	161,820	163,600	165,399	167,219	169,058	170,918	172,798	174,699	176,620	178,563	180,527	182,513	184,521	186,551	188,603	190,677	192,775	194,895	197,039	199,207	201,398
Rental	143,180	144,755	146,348	147,957	149,585	151,230	152,894	154,576	156,276	157,995	159,733	161,490	163,266	165,062	166,878	168,714	170,570	172,446	174,343	176,260	178,199
Total	305,000	308,355	311,747	315,176	318,643	322,148	325,692	329,274	332,896	336,558	340,260	344,003	347,787	351,613	355,481	359,391	363,344	367,341	371,382	375,467	379,597
Parking Spaces 2/																					
Ownership	161,820	163,600	165,399	167,219	169,058	170,918	172,798	174,699	176,620	178,563	180,527	182,513	184,521	186,551	188,603	190,677	192,775	194,895	197,039	199,207	201,398
Rental	100,226	101,329	102,443	103,570	104,709	105,861	107,026	108,203	109,393	110,597	111,813	113,043	114,286	115,544	116,815	118,100	119,399	120,712	122,040	123,382	124,740
Total	262,046	264,928	267,843	270,789	273,768	276,779	279,824	282,902	286,014	289,160	292,340	295,556	298,807	302,094	305,417	308,777	312,173	315,607	319,079	322,589	326,137
New Units																					
Assumed Expansion Rate	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%
Ownership Units	1,780	1,800	1,819	1,839	1,860	1,880	1,901	1,922	1,943	1,964	1,986	2,008	2,030	2,052	2,075	2,097	2,121	2,144	2,167	2,191	2,215
Rental Units	1,575	1,592	1,610	1,628	1,645	1,664	1,682	1,700	1,719	1,738	1,757	1,776	1,796	1,816	1,836	1,856	1,876	1,897	1,918	1,939	1,960
Assumed Parking Ratio per Unit																					
Ownership Units	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Rental Units	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
Net % EV Ready	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%
EV Ready Spaces																					
Ownership Units	801	810	819	828	837	846	855	865	874	884	894	903	913	923	934	944	954	965	975	986	997
Rental Units	496	502	507	513	518	524	530	536	541	547	553	560	566	572	578	585	591	598	604	611	617
Annual Total	1,297	1,311	1,326	1,340	1,355	1,370	1,385	1,400	1,416	1,431	1,447	1,463	1,479	1,495	1,512	1,528	1,545	1,562	1,579	1,597	1,614
Cumulative Total	1,297	2,609	3,934	5,275	6,630	8,000	9,385	10,785	12,201	13,633	15,080	16,543	18,022	19,517	21,029	22,557	24,103	25,665	27,244	28,841	30,456
% of All Parking	0.50%	0.98%	1.47%	1.95%	2.42%	2.89%	3.35%	3.81%	4.27%	4.71%	5.16%	5.60%	6.03%	6.46%	6.89%	7.31%	7.72%	8.13%	8.54%	8.94%	9.34%





1/ Derived based on the US Census, ACS 1-Year 2019 Estimate.
2/ Based on the assumed parking ratios for new projects, which may not represent current parking inventory levels.