Tigard Microgrid Feasibility Study

Winter/Spring 2022

Tigard

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MGMT 607 Sustainable Business Seminar

UNIVERSITY OF OREGON

CITY OF Tigard

SCI Sustainable Cities Institute

SCYP Sustainable City Year Program

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About SCI

The Sustainable Cities Institute (SCI) is an applied think tank focusing on sustainability and cities through applied research, teaching, and community partnerships. We work across disciplines that match the complexity of cities to address sustainability challenges, from regional planning to building design and from enhancing engagement of diverse communities to understanding the impacts on municipal budgets from disruptive technologies and many issues in between.

SCI focuses on sustainability-based research and teaching opportunities through two primary efforts:

1. Our Sustainable City Year Program (SCYP), a massively scaled university-community partnership program that matches the resources of the University with one Oregon community each year to help advance that community's sustainability goals; and

2. Our Urbanism Next Center, which focuses on how autonomous vehicles, e-commerce, and the sharing economy will impact the form and function of cities.

In all cases, we share our expertise and experiences with scholars, policymakers, community leaders, and project partners. We further extend our impact via an annual Expert-in-Residence Program, SCI China visiting scholars program, study abroad course on redesigning cities for people on bicycle, and through our co-leadership of the Educational Partnerships for Innovation in Communities Network (EPIC-N), which is transferring SCYP to universities and communities across the globe. Our work connects student passion, faculty experience, and community needs to produce innovative, tangible solutions for the creation of a sustainable society.

About SCYP

The Sustainable City Year Program (SCYP) is a year-long partnership between SCI and a partner in Oregon, in which students and faculty in courses from across the university collaborate with a public entity on sustainability and livability projects. SCYP faculty and students work in collaboration with staff from the partner agency through a variety of studio projects and service-learning courses to provide students with real-world projects to investigate. Students bring energy, enthusiasm, and innovative approaches to difficult, persistent problems. SCYP's primary value derives from collaborations that result in on-the-ground impact and expanded conversations for a community ready to transition to a more sustainable and livable future.

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Tigard Microgrid Feasibility Study

A CASE FOR COMMUNITY RESILIENCE AND RENEWABLE ENERGY

Presented to:

The City of Tigard

Presented by:

University of Oregon

CITY OF Tigard

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Presented To:
The City of Tigard

Presented By:
The University of Oregon

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Lundquist College of Business
Center for Sustainable Business Practices

Sustainable Cities Institute
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ACRONYM LIST

AC	Alternating Current
AV	Assessed Value
BEF	Bonneville Environmental Foundation
BESS	Battery Energy Storage System
BRIC	Building Resilient Infrastructure and Communities (Grant)
CO2e	Carbon Dioxide Equivalent
CREST	Cost of Renewable Energy Spreadsheet Tool
DC	Direct Current
DER	Distributed Energy Resource
DG	Distributed Generation
DOE	Oregon Department of Energy
EIA	Energy Information Administration
EOC	Emergency Operations Center
EPBT	Energy-Payback Time
ETO	Energy Trust of Oregon
EV	Electric Vehicle
FEMA	Federal Emergency Management Agency
ISA	Integration Service Agreement
IOU	Investor-Owned Utility
ITC	Investment Tax Credit
kW	Kilowatt
kWh	Kilowatt-hour
LCOE	Levelized Cost of Energy
LIHTC	Low Income Housing Tax Credit
MADE	Maintain, Advance, and Diversify Employment (Code)
MUM	Multi-User Microgrid
MW	Megawatt
MWh	Megawatt-hour
NPV	Net Present Value
NREL	National Renewable Energy Lab
PGE	Portland General Electric Company
PG&E	Pacific Gas and Electric
PUC	Public Utility Commission
PV	Photovoltaic
SSG	Sustainability Solutions Group
SUM	Single User Microgrid
ROW	Right-of-Way
TIF	Tax Increment Financing
VoLL	Value of Load Lost

1.0 EXECUTIVE SUMMARY

The information presented in this report was collected through interviews with significant stakeholders from the City of Tigard, Portland General Electric (PGE), real estate developers, business owners, and specialists from the Energy Trust of Oregon (ETO). The University of Oregon, in partnership with the City of Tigard, has synthesized this information to build a feasibility study for the deployment of solar microgrids in the city.

This project seeks to answer the fundamental question: How can Tigard deploy microgrids using distributed renewable energy generation and battery storage at both the building and district scale to provide equity, resiliency, economic, and sustainability benefits to the public, local businesses, the city, and the utility company and its grid?

Across the world, renewable resources are being deployed at ever increasing rates to replace fossil fuel generation sources in the race to achieve net-zero carbon emissions. This adoption has been encouraged in the United States by a rapid decrease in technology costs and favorable policies at the federal and state levels.

Solar power's low cost, limited maintenance demands, and infinitely renewable energy source make it a perfect solution for building resilience in preparation for emergencies. Tigard and the rest of the Pacific Northwest are under the constant threat of wildfires and face the possibility of a massive Cascadia earthquake, which was famously reported on by *The New Yorker* magazine in 2015 (1). To prepare for this possibility, Tigard is exploring the case for creating a single user microgrid (SUM) that would provide energy to the public library, which will serve as the emergency operations center in times of need.

In an effort to achieve Tigard's sustainability objectives and transform the city into a clean energy leader in Oregon, the team is also exploring the expansion of this microgrid to include the Hunziker Core, a light industrial and manufacturing district located just north of the library. The core is dominated by warehouses and large commercial buildings with vast surface parking lots that provide opportunity for rooftop and ground mounted canopy solar.

The district scale application of microgrid technology creates benefits for the grid, the utility, the owner of the generating assets, the City, and local businesses, particularly those that value resilient power. This multi-user microgrid (MUM) is, however, the most complex system to fund and manage because of the potential number of generating facilities, owners, and user profiles. The implementation of the district scale MUM could be facilitated by the City's enthusiastic endorsement and extensive cooperation from the utility, PGE.

2.0 WHAT IS A MICROGRID?

A microgrid is a local cluster of energy resources within a defined footprint, such as a building, campus or neighborhood that offer energy reliability, sustainability and cost savings. A microgrid is a group of electricity sources and loads that can ‘run in parallel’ to the traditional (macro) grid, but are also able to separate from the grid and “run in island mode" to function autonomously when economic or environmental factors dictate. The ability to connect and disconnect from the grid is coordinated through the use of a smart controller. Microgrids are typically applied to critical facilities or in remote locations and are often run by utilities to help manage loads across grids While there are multiple financing scenarios available including leasing, microgrids are increasingly financed under energy-as-a-service models, where the host puts no money down and pays a monthly charge for the services.

Single User vs. Multi User Microgrids

Single User Microgrids (SUMs) are owned and operated for the benefit of a single party like a hospital, college campus, or military base. Multi-User Microgrids (MUMs), on the other hand, have multiple owners and operate for the benefit of multiple parties, for example a neighborhood, town, or city block.

Tier 1, 2, and 3 Tigard Microgrids

In the context of our project, the Tier 1 microgrid at the Tigard Public Library is a SUM. In this scenario, rooftop and parking lot solar and battery storage would be deployed at the library and owned by a single entity, either the city or a private solar developer. The solar and battery backups would provide resilient power to the Library, which will act as the Emergency Operations Center in the case of a natural disaster. In non-emergency times, the microgrid can help save the city money on utility bills.

The Tier 2 microgrid would also be classified as a SUM, as it would have the same ownership structure as Tier 1. This microgrid would expand the vision of Tier 1 to include other public assets, such as the proposed Red Rock Creek Trail Bridge. These resources could potentially bolster the Library microgrid and provide other services such as battery charging for Tigard residents and public lighting.

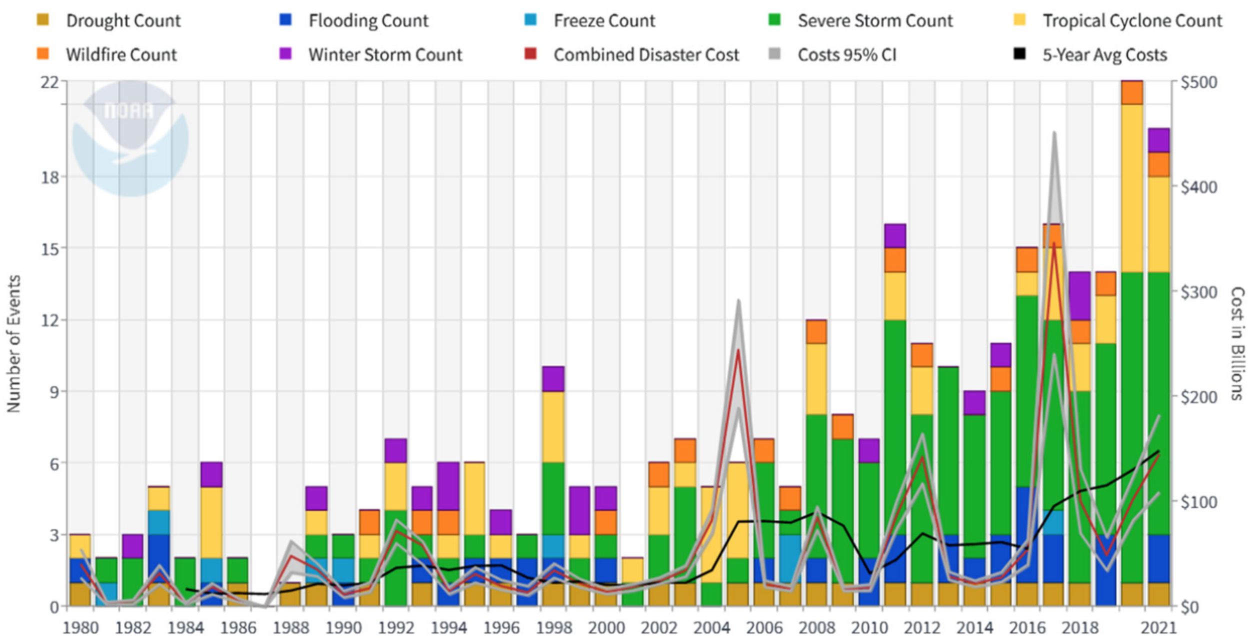
The Tier 3, district scale microgrid in the Hunziker Core is a MUM as it would involve the partnership and coordination of multiple, independent owners on adjacent properties. Distributed solar generation and battery storage at this scale would aid in reducing greenhouse gas emissions and cleaning Tigard’s energy mix, support Tigad’s sustainability objectives, create resilient power for local businesses and residents in emergency and non-emergency situations, and potentially reduce costs.

3.0 COMMUNITY BENEFITS

Resiliency

The National Renewable Energy Lab (NREL) defines resilience as the ability to "prepare for, absorb, adapt to and recover from low-probability, high-consequence disruptive events." These unpredicatble events have long electrical "outage durations, large geographic areas of impact…and lead to cascading impacts in critical infrastructures and the economy." (2) Natural disasters are occurring more frequently and more intensely as a consequence of global warming (3):

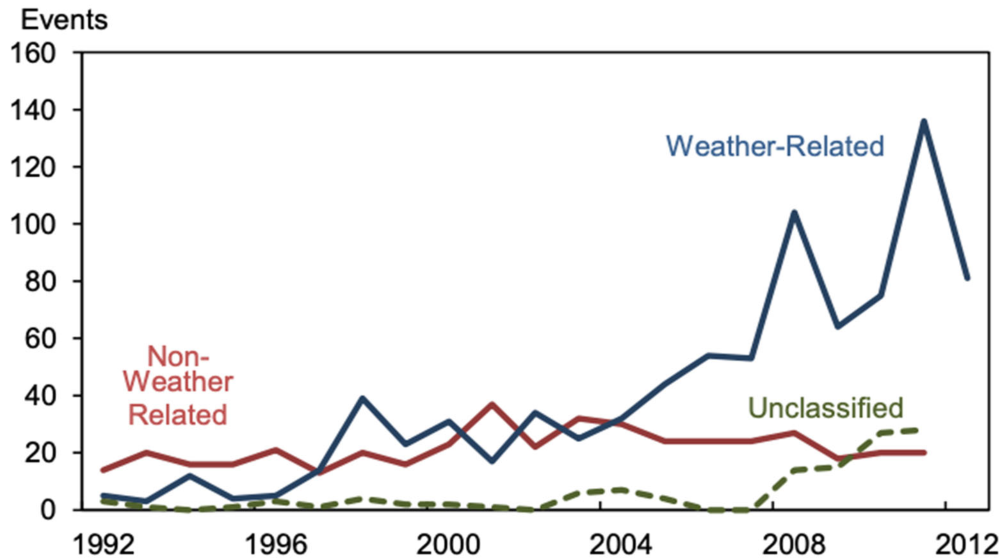
Figure 1. US Billion-Dollar Disaster Events 1980-2021 (CPI Adjusted)



Superstorm Sandy killed 159 people in New York City - 50 of which can be attributed directly to power outages, specifically hypothermia from lack of building heat and carbon monoxide poisoning from improperly vented generators (4). Cities with updated grids and smart metering, like Philadelphia and Washington D.C., were able to pinpoint outage locations and deploy repair crews effectively to restore power to electric customers more expediently and save lives (4). While Tigard is immune from hurricanes, it is at great risk of floods, forest fires, and earthquakes. These natural phenomena pose a threat to Tigard even if they do not occur within its borders as any grid infrastructure disrupted upstream of the City will have impacts to any interconnected service areas downstream. Tigard's emergency services could be called upon to assist other communities and displaced populace might seek refuge in Tigard if it escaped damage. Like Sandy, these events can and will cause extensive damage to the electric transmission and distribution network and leave residents without power for extended periods of time. In addition to these extreme cases, rapidly fluctuating weather patterns are being seen across the country, which add more stress to this electric infrastructure. Oregon, for example, has experienced both summer heat domes and freezing temperatures in the spring.

The nation's electric grid is also aging - 70% of the grid is over 25 years old (4). The older lines are inefficient and lose more electrons during power transmission, are subject to more frequent outages outside of weather related events, and incur longer repair times given the dearth of automated sensors (4). In addition, even with widespread improvements in energy efficiency, electrical demand is surging faster than expected in the Pacific Northwest as air conditioning becomes a necessity. As a result, it has never been more essential for Tigard to have access to power generation and backup systems, both of which microgrids provide. Figure 2 from the federal Energy Information Administration (EIA) shows the dramatic increase in observed grid outages since 1992 (4).

Figure 2. Observed Outages to the Bulk Electric System, 1992-2012



Communities across the Pacific Northwest must do everything in their power to immediately prepare for the existential threat of the Cascadia earthquake. Preparation for such an abstract natural disaster is difficult to convey to the community but is critical for the protection of Tigard's citizens and overall resiliency of the city. By utilizing the Tigard Public Library as the emergency operations center (EOC), the City can provide the community a refuge capable of temporarily housing hundreds of displaced residents. This seismically rated building provides a centrally located and well known establishment to gather for updates, moral support, medicine, food, and water distribution. Equipping the Library with solar photovoltaic panels and batteries will allow the EOC to provide greater comfort and services to community members and emergency service personnel alike. Maintaining power in the building will give refuge seekers access to lights, refrigeration, temperature controlled interior spaces, and power to charge devices and even electric vehicles (EVs). It will also allow the command center to have telecommunication capabilities in order to coordinate emergency services as expeditiously as possible.

Microgrids have already proven to be a vital resource during natural disasters. On March 11, 2011, the Tohoku district of Japan was struck by a devastating earthquake, known as the Great East Japan Earthquake. This disaster caused massive damage to Japan's infrastructure, including a partial meltdown of the Fukushima nuclear power plant leading to blackouts for large swaths of the country. However, despite this, customers of a microgrid installed on Tohoku Fukushi University were able to receive continuous power, including the university hospital, which was able to maintain operations and continue serving patients. This was a tremendous resource for the community that also is an effective case study for cities across the western United States preparing for a similar scenario (5).

If the district scale Hunziker Core microgrid can function as an 'oasis' microgrid in times of emergency, it will expand the capabilities of the Library EOC. A microgrid of that size would ensure that mission critical personnel and the most immediately impacted residents in Tigard and neighboring communities have a safe and electrified haven to survive, organize, and begin operations to aid the rest of the region. Extending emergency shelters and microgrid functionality into Hunziker acts as a failsafe, redundancy to the Library shelter. If the Library were rendered inoperable due to an earthquake, having multiple backup locations increases the chance that some local building will have resilient power and be able to provide services. The 'oasis' community microgrid concept has been demonstrated to work across the nation providing safe havens within cities during emergencies.

The presence of a microgrid will immediately increase the reliability of the local energy infrastructure and reduce Tigard's reliance on PGE, who in the face of catastrophe, will be limited in their ability to provide relief as they focus on rebuilding and reconnecting the macrogrid widely. In addition to the municipal microgrid model found in Beaverton, San Diego, and Chicago, military installations are also rapidly developing microgrids at bases such as Ft. Drum in NY. Each of these examples serve to demonstrate the need, feasibility, resilience value, and local regulatory acceptance of microgrids. Stakeholders across Tigard, from business owners, the City itself, citizens, etc. will all benefit from the resilience provided by the microgrid. During a catastrophe, the first priority will always be survival. With the emergency operations center microgrid, Tigard's emergency medical services and police force will be better equipped to locate, respond to, and ultimately save lives. It is difficult to calculate a monetary value for resilience. Although deploying a microgrid can be an expensive financial endeavor, empowering a community to continue operations in the face of catastrophe and protecting human life has merits far exceeding any dollar value.

Reputation

Tigard has aggressive initiatives proposed for decreasing the city's carbon impact and the microgrid supports these climate goals. Deploying a SUM or MUM would establish a reputation for Tigard as a progressive leader in terms of sustainability and emergency preparedness. This would be a public relations and marketing opportunity to establish a brand for the city and attract new investment and new businesses. As Tigard continues to consider the redevelopment of the Hunziker Core into a business and housing district, Tigard can add benefits to both existing and future stakeholders by enhancing its clean energy image. Companies no longer focus solely on the bottom line. With ESG practices taking center stage in the business world, Tigard's implementation of solar microgrids will serve as a sign that the community is ripe for the relocation of an existing business or the establishment of a new one. As the population of the Willamette Valley continues to rise and real estate trends and TriMet extensions drive growth to Portland suburbs, Tigard has an opportunity to capitalize. The microgrids would bring in new mission-aligned residents and residential developers drawn to a modern, forward thinking and healthy urban area. City regulations, such as allowing solar photovoltaic (PV) panels to be visible on both city and private property, also help Tigard's objectives and reduce barriers to microgrid deployment.

Social and Racial Equity

If directed properly, microgrids have the ability to greatly benefit underserved and BIPOC communities, who have historically been the victim of power outages and poor public infrastructure. Microgrids can empower these longstanding and often neglected residents by bringing them reliable, resilient, cheaper and autonomous power. MUMs, however, can also represent the vanguard of gentrification and drive out under-resourced populations as they encourage redevelopment and raise property values. These distributed generating resources therefore might be met with distrust initially. It is essential that all stakeholders are engaged at the start of the planning process so the solar development aligns with the real needs of the community, not just those of the developer. Since utilities are sometimes perceived in a negative light by underserved community members, it will be necessary to communicate messages clearly and repeatedly through a trusted messenger using different mediums in order to ensure the details are understood clearly by all those affected. By starting with the community's desires, for example not building more substations in residential neighborhoods, and reverse engineering the design through multiple stakeholder charrettes, the planning team can build true community consensus.

Global Warming

A microgrid in Tigard would provide environmental benefits for the community. Adding solar to the grid would help clean and improve the state's energy mix and thus would reduce overall greenhouse gas emissions in the region, which would help both global and local climate. Microgrids also create a positive feedback loop in regards to global warming mitigation. They are often pursued in tandem with energy efficiency and building upgrades, which would decrease load and help further reduce regional emissions. In addition, switching from natural gas appliances and HVAC systems to electric ones like heat pumps and solar water heaters would reduce local, point-specific emission sources. These retrofit improvements would reduce smog and lower PPM rates for local residents, which could lead to lower rates of asthma, pulmonary disease and reduced healthcare costs.

Ancillary Services

A microgrid in Tigard could also provide ancillary services to the community. A microgrid could provide residents and the local workforce with battery charging for EVs, scooters, and bikes. This could be provided as a free premium service from the City or private owner or be sold to create new revenue streams. Microgrids would also allow Tigard to install lights throughout the public realm without adding operating cost. These lights could provide safety for pedestrians and allow people to utilize public spaces like basketball courts and park paths at night. Additional lighting would also help during emergencies for staging personnel and equipment outside. Depending on the financing arrangement, distributed solar generation and battery storage could be utilized to lower utility rates for owners who have solar on their building, such as the Library. The electricity generated from the sun could be consumed onsite to offset power bought from the utility or could be sold to the utility to generate a consistent cash flow. The addition of a battery and a time-of-use metering plan offered by the utility PGE could allow the City to sell or use solar generated power at times when electricity is most expensive on the grid.

4.0 BUSINESS BENEFITS

All companies benefit from inclusion in a microgrid but certain industries can capitalize on the added stability provided by distributed power generation. As the Hunziker core pursues both a microgrid and employment and housing dense redevelopment, it will attract new businesses, like the ones described below, that align with these initiatives.

Business Type	***Reasoning***
Nursing homes and senior citizen housing	More susceptible population requires carefully controlled internal temperatures at all times. 24-hour access to certain medical equipment (oxygen, heart monitors) is also a necessity.
Medical facilities	Clinics and hospitals have large electrical loads that can never shut off and need to be backed up to provide safe patient care.
Pharmaceutical manufacturers	Require consistent temperature, pressure, and humidity for drug production.
Daycare, schools, and colleges	Schools are often used as emergency shelters and if operational during natural disasters, can provide children with stability and support. Colleges could face lost research and refund requests for students who are not able to use their dorms.
Grocery stores	Food retailers are an essential business in emergency situations and have 24/7 refrigeration needs to prevent spoilage.
Hotels	Hotels must provide their guests with consistent electricity in order to avert refund requests and negative reviews.
Egg and sperm banks	Similar to grocers, these facilities need constant refrigeration and backups to function properly and gain customer’s trust.
Data centers	Cloud computing servers have massive cooling and electrical demands that must run 24/7.

If Hunziker businesses adopted solar and other green building strategies they could generate savings and create a strong value-added proposition for potential customers or tenants. Business owners could take advantage of the public relations and branding opportunities that arise from being part of a microgrid. They could promote a ‘green’ marketing message and draw attention to their on-site renewable energy to win customers. They could also use the microgrid to attract and retain higher quality, mission-aligned employees. In addition, if the businesses owned the solar, they could reduce cost through lower utility bills. Being a part of a microgrid could also help the company achieve its sustainability objectives by reducing its Scope 1 emissions that arise from internal operations. These emission reductions help future proof businesses against taxes and fines that will be applied to greenhouse gas production. As can be seen in New York City, businesses face significant firm-level climate change regulatory risk. Starting in 2024 buildings will be penalized $268 per CO2 equivalent (CO2e) ton per square foot under NYC Local Law 97 for any emissions over their individual limit (6).

Landlords

For landlords, there are a number of specific benefits that arise from solar microgrids as well. Installing solar can increase property values, while reducing mortgage and insurance rates. Estimates for residential solar property premiums vary from a 4% increase in valuation, to $20 per $1 saved in electricity annually (7). Additional premiums can be expected if the building is also part of an islandable microgrid. Hypothetically, Tigard could reduce property tax in order to incentivize solar installation, which would reduce operating costs for buildings and complement federal and state solar rebate and tax credit programs. Marketing a building as environmentally friendly can act as a differentiator to attract high quality, mission-driven tenants. Tenants have limited control over their office space. If the tenant companies have sustainability objectives, office selection is very important as the building performance will factor into their internal operations emissions calculations (Scope 1 emissions). Green buildings require added design and construction cost. In discussions with local real estate developers, they identified that building a roof that can accommodate solar costs on average $1 per square foot more than a traditional roof. This added cost stems from needing larger ceiling joists and installing additional electrical conduits. However, this additional cost can be recouped through lower utility bills if the building owners are occupying the building. If it is a rental property, some of this cost may be recovered from tenants in the form of higher monthly rents. For the tenants, green buildings not only provide a more premium rental experience, they can also save them money by reducing operating costs from utility bills. If the landlords charge higher monthly rates as premium for the quality space, as long as the difference is offset by reduced utility bills, the tenants will perceive that the green upgrades are provided at no added cost.

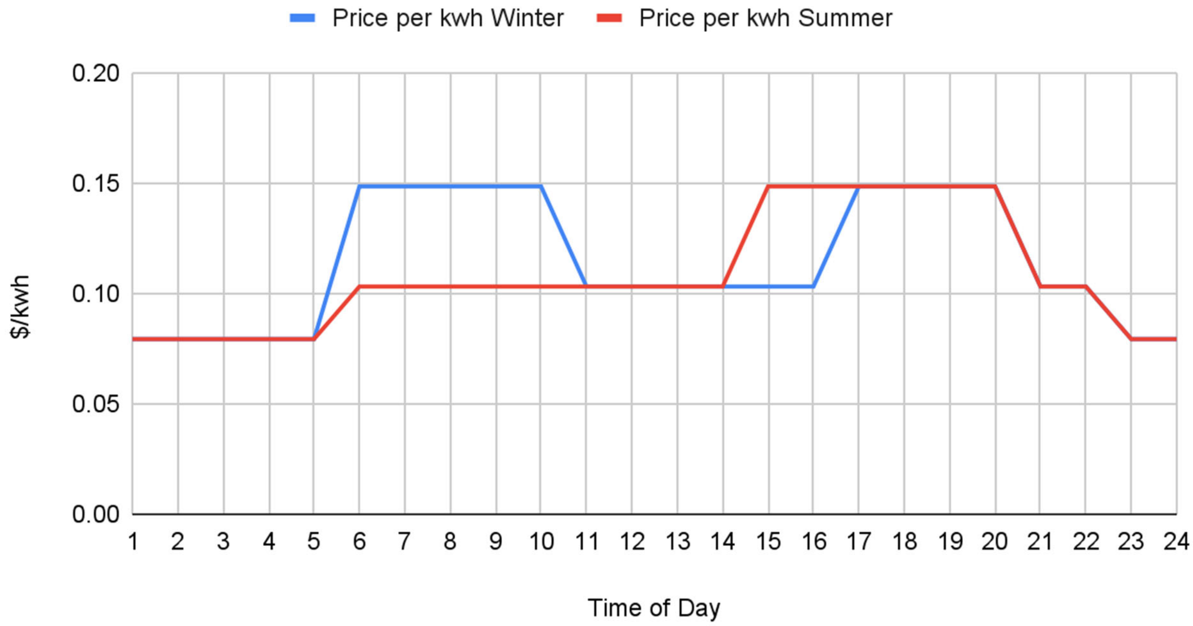
Tariff Rate Structures

Net metering is a tariff rate structure for home- or business-owners with distributed energy generation, usually in the form of solar panels, to send any extra energy not used in the home or business back to the electrical grid. In the case of the Tigard, that would be back to PGE's grid. In retail-rate net metering, PGE would pay the solar energy producer retail rate for providing this surplus energy back to the grid, which will then be sold to other grid customers (8). A net metering application needs to be approved before construction begins on a solar project in order to avoid a costly redesign or delays.

If the building owners or tenants opt for a Time of Day tariff rate schedule from PGE and have battery backup systems, the stored electricity can be leveraged to save money on utility bills. As can be seen in Figure 3 below, the Hunziker businesses should switch to battery power during high rate periods between

6am-10am and 5pm-8pm in the winter and 3pm-8pm during the summer. Additionally, the businesses could sell their PV power to the grid at these times and get higher returns per kWh (kilowatt-hour) via net metering. These options might be limited if the local utility, in this case PGE, helps finance the battery installations. PGE will be looking to draw power from these distributed storage sources during these same periods to help with their own load demand.

Figure 3. Time of Use Price per kWh: PGE



Parking Canopies

Deploying solar in the parking areas of Hunziker lots could increase the generation capacity of properties by up to 4x. Parking lot solar canopies would also enhance the owner or tenant experience - they create shade, which will reduce heat island effect, keep parked cars cool in the summer and dry in the winter, and provide suitable areas for outdoor seating or picnics. Solar panels in the parking lot will allow for easier connection of EV charging ports and encourage building occupants to switch to EVs. EV charging could become another revenue stream for owners or could be considered a free luxury amenity. The adoption of EVs by the building owner's employees would also decrease the company's internal Scope 1 emissions, while the adoption of EVs by tenants would reduce the building owner's Scope 3 emissions.

Public Relations

Landlords could also opt to use their resilient microgrid power for the public good. They could choose to be a public refuge in times of crisis. The choice to sign up to become a shelter could be incentivized through a tax break for any participating business. Providing this public service would also serve as a great public relations opportunity for the business.

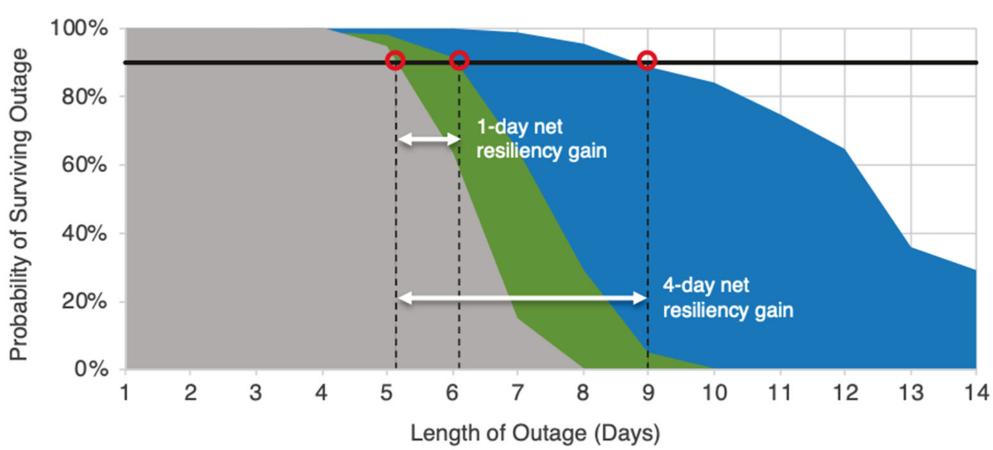
Resiliency

During an emergency, businesses located within a microgrid will be able to utilize solar energy and battery storage in order to continue operation. These businesses will be able to take advantage of the market during a power outage when non-resilient competitors are sidelined. While it is slightly easier to determine the dollar value of resilience for a business compared to a community, the calculation is still complex because it is context specific and involves knowing the likelihood of a specific emergency situation occurring and its consequences. In general, this calculation would include the loss of assets and perishables, business interruption costs and recovery costs. The sum of these costs is often referred to as the Value of Lost Load or (VoLL), which is a metric used to "describe the cost of grid outages and represent an approximate price consumers are willing to pay for uninterrupted service." (2) VoLL's range from $1/kWh to $300/kWh depending on the geographic location and type of business and also fluctuate over the course of the power outage (2). The Interruption Cost Estimate Calculator created by the Berkeley National Laboratory that can be found here is a useful tool to help calculate the total cost of electric power disruptions. The Obama administration released a report in 2013 that cited that annual average costs for power outages caused by severe weather events over the preceding decade ranged from 18 to 33 billion. In 2008, Hurricane Ike caused an additional $42 billion in outages related costs in the form of "lost output and wages, spoiled inventory, delayed production, restarting industrial operations, inconvenience and damage to the electric grid." (4)

In addition to difficulties valuing resilience, there are similar complications in monetizing resilience for cash flow calculations to help finance a microgrid project. A study by NREL at Figure 4 below shows how resilience can be factored into a techno-economic optimization model for solar and battery storage (BESS) to design cost-optimal solutions for project developers (9). By adding a $/hour value for resilience, researchers were able to create a positive net present value (NPV) and increase the capacity of the system. The following diagram highlights one of the major findings of the study, namely that on a life-cycle cost basis adding a large solar and battery system to a diesel based microgrid does not increase cost but doubles the number of days victims can be expected to survive a power outage (2).

Figure 4. Resilience Benefit of Adding Solar and Storage to Diesel Generator Microgrids

	Generator	Solar PV	Storage	Life Cycle Cost	Outage
1. Base case	2.5 MW	-	-	$20 million	5 days
2. Lowest cost	2.5 MW	625 kW	175 kWh	$19.5 million	6 days
3. Proposed system	2.5 MW	2 MW	500 kWh	$20 million	9 days



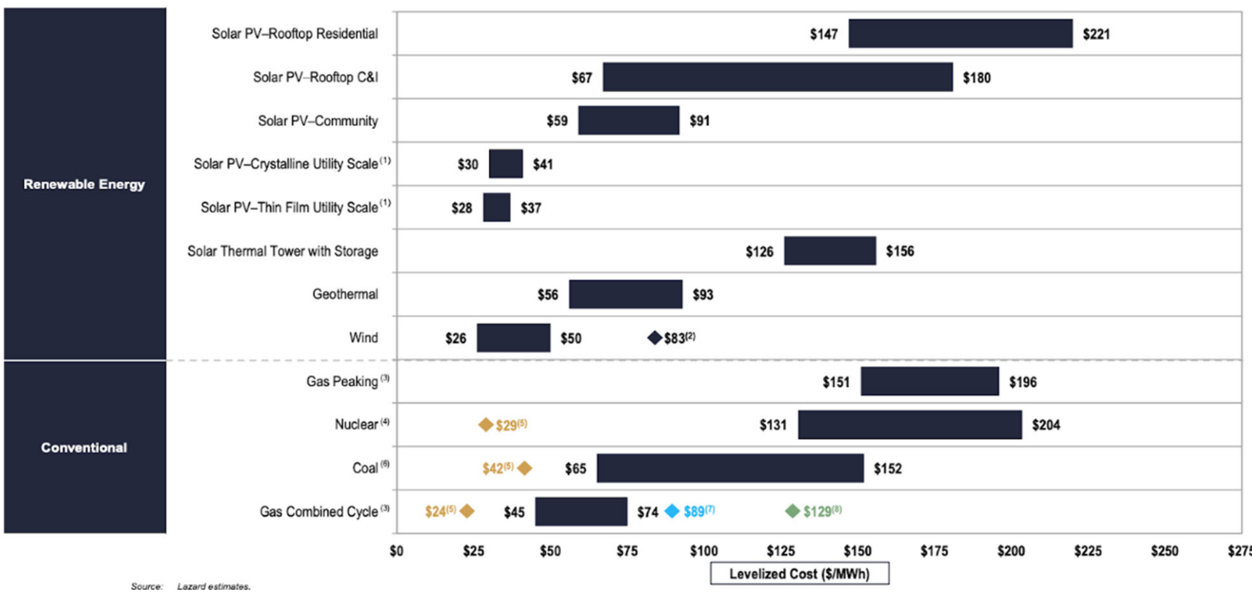
5.0 OPPORTUNITIES FOR TIGARD MICROGRID

The opportunities highlighted below provide a compelling case for Tigard to consider pursuing microgrids to meet its energy resilience and sustainability objectives.

Solar Macroeconomic Environment

The cost of installing solar has fallen 65% since 2010 as technology has improved, PV production capacity has increased, PV production costs have decreased and competition has intensified (10, 11). It is important to consider these solar costs relative to other types of power generation. Figure 5 from Lazard shows the levelized cost of energy (LCOE) - the revenue per unit of electricity produced needed to cover the cost of building and operating the power generation system during its lifetime - of different energy types (12).

Figure 5. Lazard's Levelized Cost of Energy



The average LCOE of commercial solar has fallen to $123.5 nearly reaching parity with coal and is cheaper than natural gas and nuclear. Currently, commercial solar also qualifies for both the Investment Tax Credit (ITC), which can decrease the LCOE by another $5-$14. Natural gas, on the other hand, is beholden to volatile fuel prices and faces ever increasing pressure from regulators in the form of carbon market pricing, both of which can drive its LCOE up by $21-$30. This means increasingly that solar is a cheap, efficient source of energy for a microgrid.

While solar has not reached the low LCOE of wind, it does have other noted benefits as an energy source. It is not subject to the same restrictive zoning rules given that it is mostly hidden from view and is noiseless. In some jurisdictions, solar installations are actually viewed favorably because they align with a positive, environmental mission. Solar is also modular, and space efficient. Relative to other energy sources, it can be interwoven within the communities existing infrastructure without much disruption. It can be placed on reinforced rooftops or parking canopies to provide distributed energy at scale more easily than any other source of energy - renewable or nonrenewable. While solar may be reaching a price floor in the coming decade, the other important component in a microgrid - batteries - still are catching up in terms of technological maturity and have significant room for decreasing costs and efficiency improvements. NREL notes that the average price for utility scale lithium ion battery capacity was $420/kWh in 2020 and is projected to drop to between $150 and $250 per kWh by 2030 (2).

Life Cycle Perspective of Solar

In addition to the financial considerations, a decision to deploy solar must also weigh the sustainability impact. Solar power is heralded as a renewable clean energy because it produces no emissions during operation. This distinction requires that the production inputs used to create a solar panel are outweighed by the benefit the panel produces while in use. When considering a life cycle analysis of a solar system, it is necessary to identify the energy needed and emissions produced when mining and refining the subcomponents, the fuel mix used to manufacture the panels and the support structures, the transportation, packaging and installation footprint, and the impacts of end of life decommissioning and recycling. The energy-payback time (EPBT) of a photovoltaic system or the "period required for the renewable energy system to generate the same amount of energy that was used to produce the system itself" is extremely location-specific (13). EPBT depends on where the production occurred and where the module will be deployed, however, rough global estimates have been established ranging from 1 to 5 years with 2.8 as the mean (13). EPBT has been decreasing over time, however, continued exponential growth of photovoltaic production might cause new fossil fuel burning manufacturing plants to be brought on-line to cope with demand, which ultimately might cause a spike in EPBT (13). Given the 25 year lifespan of a PV system, however, it is safe to assume that any EPBT will be covered and that solar panels are in fact a 'sustainable' option.

Alignment with PGE, Tigard, and Oregon Goals

As Oregon's largest utility, PGE is responsible for generation, transmission, and distribution of electricity to roughly 900,000 residential, commercial, and industrial customers in 51 cities and 7 counties including the City of Tigard. PGE is an investor-owned utility (IOU), meaning that the company operates as a large electric distributor that issues stock owned by shareholders (14).

PGE has recognized the need to reduce its own greenhouse gas emissions and recognizes that providing clean electricity to its customers is critical to an emissions-free future. PGE has established the following greenhouse gas reduction goals:

- *By 2030: At least an 80% reduction in greenhouse gas emissions from power served to customers.*
- *By 2040: Zero greenhouse gas emissions from power served to customers.*
- *By 2040: Net zero greenhouse gas emissions across company wide operations.*

PGE has stated that they plan to change every part of their business: "*from the power we supply to our customers, to the vehicles we drive, to the materials we purchase, to how we operate our buildings.*" PGE plans to work together with their customers and communities in order to reduce their emissions and continue building a clean energy future. To this end, they have an active request for proposal for over 1 gigawatt of glean generation resources (15). PGE's minimum size threshold for supporting solar generation is around 50 MW, which is higher than Tigard's Tier 3 capacity, however, the utility has stated specifically that they will help finance battery energy storage systems (BESS) in Tigard's microgrid to help with the load demand smoothing process.

PGE is also part of a broad coalition which supports Oregon state law, House Bill 2021, which establishes an electric sector decarbonization framework. HB 2021 was passed in June 2021 and aims to eliminate carbon emissions from Oregon's power grid by 2040, which is an ambitious goal for reducing greenhouse gas emissions from the state's electricity sector (16).

The PGE climate goals align perfectly with the sustainability objectives of the city of Tigard. Tigard objectives are likewise perfectly suited to encourage the deployment of microgrids. Tigard's Climate Resiliency Plan, which is in development by the consulting firm Sustainability Solutions Group (SSG), seeks to mitigate greenhouse gas emissions and increase the City's resilience through equitable and viable pathways. Specifically, the City wants to have 160MW of installed solar within city limits by 2035. Tigard plans to require all new buildings to meet a net zero energy standard and retrofit existing buildings to reduce 10% of electric load by 2028. In this same timeframe, they also hope to electrify HVAC systems in all new buildings and 30% of existing buildings. This shift will cause an increase in demand for electricity, which could be met by the new generating capacity from onsite solar panels.

There is also overlap between microgrid projects and the City's Maintain, Advance, and Diversify (MADE) Employment Development Code. MADE will be applied in the continual redevelopment of the Hunziker Core and beyond. Goal #3 of this code stipulates the City should develop and implement a bold resiliency plan, to help reduce the carbon footprint of the city. SSG is creating a model to establish a baseline carbon footprint so the City will know how many tons of CO_2e it will need to offset to achieve its goals. An electrified municipal vehicle fleet and a Tier 3 microgrid would go a long way to reduce Tigard's carbon emissions, and make the prospect of achieving carbon neutrality much more attainable. Likewise, the Tigard Energy Conservation Plan drafted in 2008 supports the mission of a microgrid. That document encourages city members to take advantage of and purchase local green energy. Similarly, the Hazards Plan adopted in that same year seeks to protect people and property from flood, landslide, earthquake, wildfire, and severe weather hazards. It also calls for the establishment of facilities required for response services, which parallels Tigard's Tier 1 microgrid strategy.

PGE's Letter of Support

In November 2020, PGE's Larry Bekkedahl, VP Grid Architecture, Integration & System Operations, signed a letter of support to participate in the Federal Emergency Management Agency's (FEMA) fiscal year 2020 Building Resilient Infrastructure and Communities (BRIC) grant, which was awarded to the City of Tigard Resiliency Initiative. A copy of the letter is available in Exhibit B in the Appendix. The letter states:

> *PGE is interested in the prospect of a community resiliency microgrid and its opportunity to serve joint benefits for the City of Tigard as well as to provide energy and grid services value to PGE. PGE*

plans to diligently, and in good faith, work with City of Tigard to plan and develop a resilient microgrid concept that is safe and reliable and can deliver and test the following grid services:

- *Generation Capacity*
- *Regulation*
- *Load Following*
- *Contingency Reserves*
- *Frequency Response*
- *Distribution Upgrade Deferral*

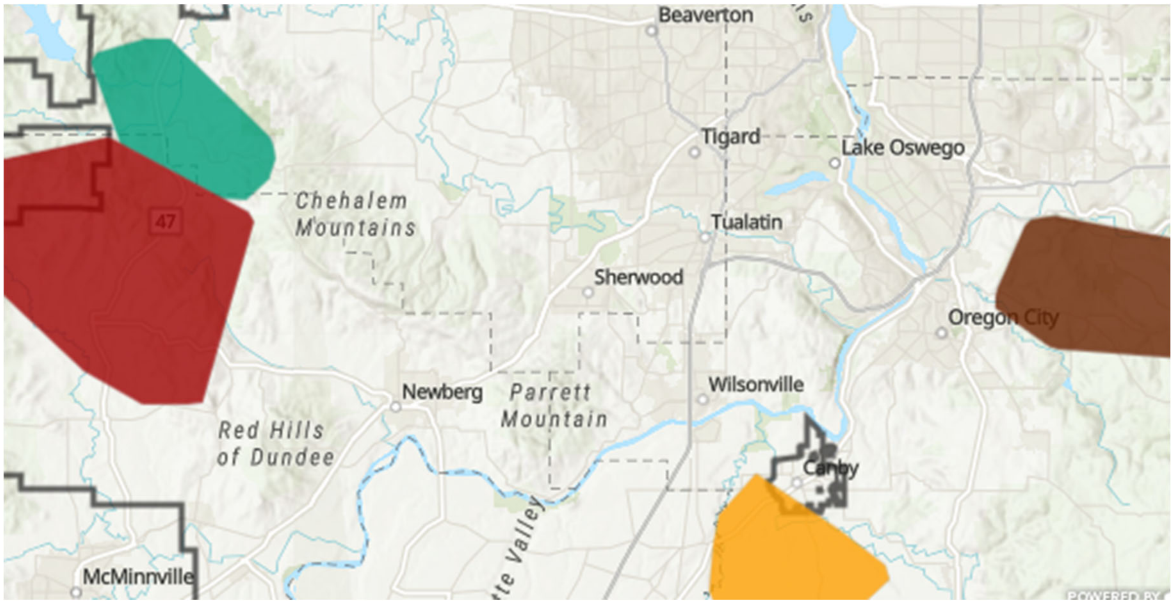
PGE supports the City of Tigard microgrid project, but due to the regulations that mandate PGE service all ratepayers equally, they are limited in their ability to supply funding to pilot a project in the Hunziker core, which would exclusively provide distributed energy generation to the district. Given the size and nature of the Tier 3 microgrid as a MUM and its potential benefit to neighboring communities as an 'oasis' grid, however, it is conceivable that PGE could bill the Tigard project as another pilot project. The Hunziker MUM will yield plentiful new insights that are distinct from the Beaverton Safety Center pilot project and can be used as a model throughout the region for deploying larger, more robust microgrids.

Tigard DER-Utility Integration Process

The integration of distributed energy resources (DERs) onto the grid is complicated and is location and project specific. Large energy projects will often require utility infrastructure to be upgraded in order to support the new generating capacity. This is especially true in the case of DERs or microgrids where the generating resources are nested inside communities that are attached to smaller gauge transmission wires, smaller transformers, and a grid that is not set up to be two way. Utilities are mandated by Public Utility Commissions (PUCs) to upgrade this infrastructure to support new projects, however, they bill the developer or the owner of the generation for the grid improvements. The process begins with the developer paying the utility to conduct an integration study. This study results in an integration service agreement (ISA), which is a contract between the utility and the energy provider. This agreement includes a breakdown of the scope of work, a timeline for completion, and an estimate of the cost of the infrastructure upgrades, of which 25% must be put down before beginning design and construction. Utilities are subject to error in these proposals so consideration must be taken in regards to financing to accommodate for potential budget overages. Disputes over poor estimations have been litigated in the past and the cost overruns either are passed to ratepayers or covered by the energy developer. Furthermore, utilities cannot be held to their projected timelines. Deploying battery (BESS) systems can help make the integration process easier. BESS systems reduce the total amount of kWhs that need to be pushed back to the grid and in some cases enables existing infrastructure to be utilized with the new generating resources.

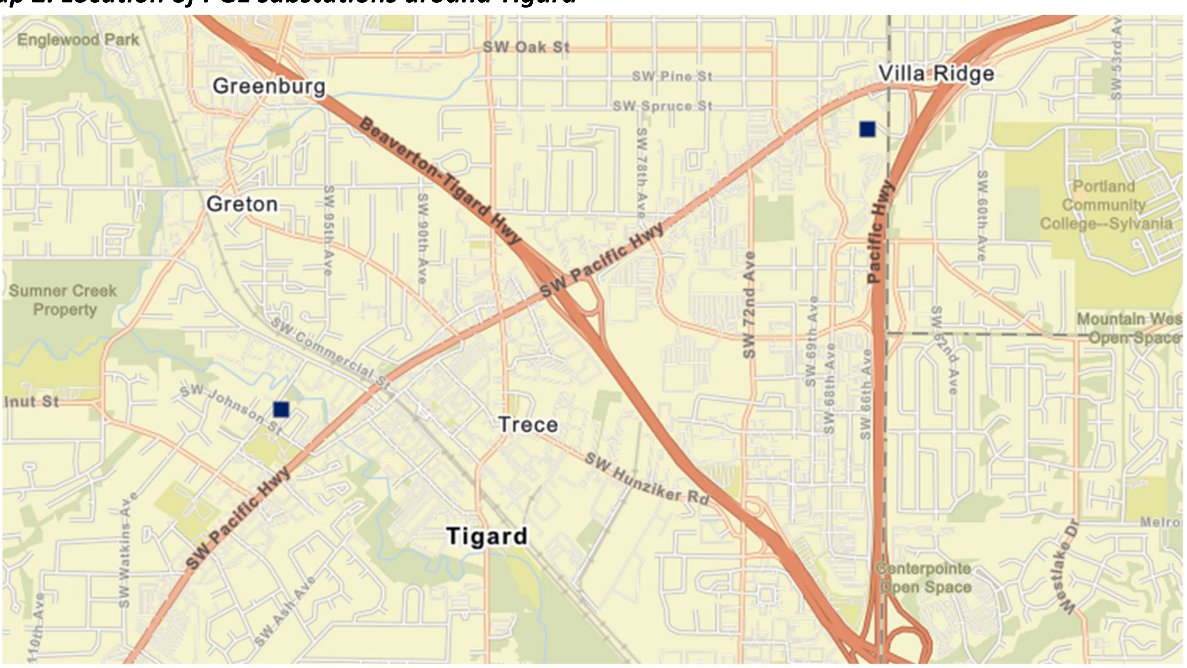
Tigard is located in a region which PGE can easily support and accommodate new distributed generation (DG) projects without design changes to the feeders or the substations. This makes Tigard a good candidate for a microgrid because the existing, local PGE electrical lines and transformers can support additional capacity safely and reliably (17). The colored sections surrounding Tigard in Map 1 below indicate areas that have a limited capacity to connect new generation projects.

Map 1. PGE Generation Limited Feeders



The two blue squares in Map 2 below show PGE's substations in the city of Tigard ([18](#)). Substations help to reduce high-voltage electricity to lower-voltage electricity which can then be distributed to homes and businesses. Substations are equipped to split the electrical current into many distribution lines. The proximity of these substations to the proposed distributed generation resources (DERs) would reduce cost if it was determined that Tigard's electrical wires needed to be replaced back to the substation. It is possible that given the scale of generation in Tier 3 a more detailed ISA by the utility would reveal that the wires do in fact need to be upgraded.

Map 2. Location of PGE substations around Tigard



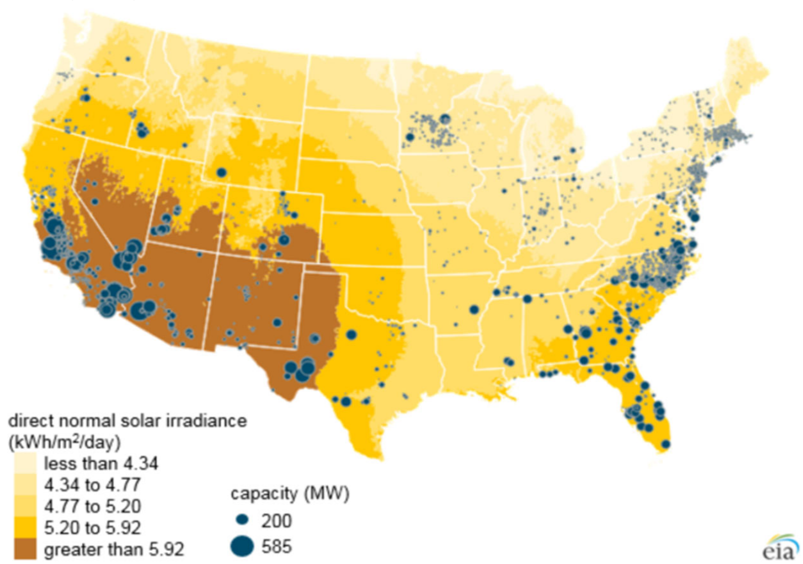
6.0 CHALLENGES FOR TIGARD MICROGRID

While there are tailwinds and significant upsides for the Tigard microgrid projects, there are also obstacles that must be overcome. There are over 2,200 microgrids currently in operation in the U.S and nearly all of them are SUMs. These are most frequently found on a single building (a nanogrid) or across multiple buildings at a single institution like a military base, university, or industrial facility. There is very little precedent for MUMs and the majority of the ones that do exist were led by the local utility. The downside of such a large scale, multi-user deployment is that it involves the coordination and commitment of a myriad of stakeholders. There are over 60 individual business owners or landlord-tenant combinations in Hunziker that each have their own feelings and interest towards renewable power. The PV system and associated costs will also be unique to each building, as will the credit ratings, roof conditions, financial returns, and liquidity of each potential solar customer.

Oregon Solar Conditions and Utility Rates

There are two forces working against solar installations in the State of Oregon. First, Oregon has incredibly low electric utility rates at $0.103 per kWh (19) (compared to $.32 per kWh in California (20). This is due in part to the extensive supply of hydro power in the region. Given the relatively clean energy mix in Oregon, there is also a less desperate call to deploy renewable energy than in other states that have a higher proportion of fossil fuel generation. A low utility rate means a low monthly electric bill for customers and creates a tight margin for a solar system to reduce their bills further. It also limits the returns solar customers can expect if they sell their solar derived electrons back to PGE and the grid. PGE does not reimburse solar customers the full commercial utility rate in an attempt to pass some of the cost of operating and maintaining the transmission network onto ratepayers. Second, Oregon does not receive as much annual sunshine as many other states in the US as can be seen in Figure 6 on the next page from EIA (21). Solar panels in the Willamette Valley in particular are inefficient and can be expected to achieve only a 12.6% capacity factor, compared to 20% in places like Arizona (22).

Figure 6. US Solar PV Capacity and Direct Normal Solar Irradiance



PGE Microgrid Hurdles

While PGE has publicly expressed interest in supporting DG broadly and Tigard's microgrid specifically, there are challenges to implementing this support on the ground. Utilities have a complex bureaucratic structure. They are natural monopolies thanks to the Regulatory Compact that was formed in the early 20th century. Much like the railroad and highway system, it was not efficient for multiple utility providers to build lines that served the same area. It made much more sense to grant utilities a particular service area to serve in order to avoid overlapping transmission lines and redundant investments. The regulatory compact agreement allowed utility providers to be the sole electricity provider for a designated service area and to charge its customers electricity rates necessary to cover utility costs and provide a reasonable rate of return on its investments. In exchange for these rate payments, utilities make investments to be able to continue providing low-cost power to their customers, i.e. rate payers, in the area in which it serves. This responsibility to the ratepayers limits PGE operations and flexibility around distributed energy generation (23).

In order to ensure that utilities make the best investments (i.e. upgrading transmission lines), public utility commissions (PUCs) were set up to protect ratepayers and to monitor the activities of the utility. PUCs must sign off on the rates which the utility charges its' customers. The Oregon PUC is responsible for the rate regulations of a number of IOUs, including PGE. The PUC's mission is *"to ensure Oregon utility customers have access to safe, reliable, and high quality utility services at just and reasonable rates."* (24) The PUC enforces safety standards and handles utility-related dispute resolution on behalf of Oregon residents, as well. The PUC is also part of the Oregon Emergency Response System to coordinate and manage state resources in the event of an emergency. It is important to note that the PUC is *"funded by assessment of the regulated public utilities."* (24)

> *The PUC's Internal Operating Guidelines inform the public of [the PUC's] decision-making process and describes the responsibilities of the PUC. These rules and guidelines help the PUC to:*
> - *Ensure the safety, reliability, and quality of essential utility services*
> - *Scrutinize utility costs, risks and performance to ensure just and reasonable rates*
> - *Manage customer and community choices to ensure value for all customers*
> - *Encourage the community to be engaged and better informed on utility-related issues by participating in regular public meetings or submitting comments on topics of interest* (24)

The utility-PUC relationship adds another layer of complexity because PGE would likely pass the cost of the microgrid onto its ratepayers. Oregon's PUC would have the final word on whether to proceed with the project since it controls utility tariff rates.

Furthermore, PGE is a profit maximizing firm who receives revenue for providing electricity to consumers. A microgrid is fundamentally at odds with their revenue generation as it allows ratepayers to produce their own power and buy less from PGE. Microgrids need to prove that they can offset the lost revenue by saving PGE money that is otherwise put towards outages, repairs, updating infrastructure, and bringing new generating facilities online. PGE benefits from a microgrid because it receives peak load support, reduced transmission and distribution system requirements, and deferred investment on infrastructure updates. SUMs and MUMs increase PGE's reliability and resiliency, improve its customer satisfaction, protect its workforce's safety in times of emergency, and help it achieve its environmental and regulatory obligations. In California, the utility, Pacific Gas and Electric (PG&E), has changed its stance on and streamlined its policy in regards to distributed generation in response to its massive financial liability from recent forest fires. They are now incentivizing community solar with one-time matching funds payments for infrastructure costs related to the islanding function of microgrids.

PGE's monopoly status also limits the effectiveness of a MUM that does not have its full support. Only regulated electric utilities are allowed to distribute and deliver electricity over wires that cross public right-of-ways (ROWs). Owners of the MUM are thus prohibited from delivering power to other members of the MUM because of the 'franchise' rights granted to a utility. This restricts non-utility owned MUMs to including only members on contiguous lots of private property. Any microgrid participants on parcels separated by right-of-ways are by default converted into 'adjacent islandable nanogrids' rather than an 'integrated MUM.' If the MUM wants to avoid being tied up in litigation with the utility over franchise rights, it would need to apply for a special waiver from the PUC in order to bypass these regulations. In some utility jurisdictions, the fact that the microgrid becomes the exclusive supplier of power to electric consumers while in island mode violates state laws that allow ratepayers to choose their electricity supplier.

Politicization of the Tigard Microgrid

Building a microgrid is inherently a political process that requires approvals from elected representatives and support from voters. In particular if a MUM requires public financing, proponents of the microgrid will need to rally political support. Microgrids are a complex topic for city council members and their constituency to digest. It will be critical, however, that proponents of a microgrid engage with all stakeholders so they understand the business and community benefits in detail. This will be especially true if the MUM plans to utilize tax increment financing (TIF) and defer tax revenue away from other worthy projects and city services, such as the school system and fire department.

Financing Microgrids

Financing a microgrid, especially a MUM, is a complicated process with many different potential avenues and capital stacks. It requires coordination among a myriad of financial professionals who are experts in project finance, investing, banking, and forecasting. These individuals must come to an agreement on a large quantity of variables in microgrid projects which means microgrids often have a lengthy planning process which requires additional time and money. Furthermore, microgrids are often organized by public institutions or nonprofits for nonfinancial reasons. This can add to the complexity and price of the project and ultimately increase the financial risk, which has implications for acquiring outside investment to fund the microgrids.

As MUMs grow in size and complexity they become harder to fund. There are no economies of scale to credit risk assessment and it therefore becomes increasingly expensive to perform due diligence as the number of MUM participants rises. As the size increases, so does the financial risk since it becomes more likely that a MUM participant will default or exit at some point during the 25 year (or longer) commitment period. The financial projections for a MUM depend on all participants continuing to produce and buy electricity internally. Any fines that could be imposed to discourage early exits will also hamper efforts to get property and business owners to sign up for the MUM initially. The tradeoffs of microgrid scale vs complexity and other funding scenarios will be discussed in great detail in regards to both a Tier 1 and Tier 3 microgrid in subsequent sections in this report.

Solar Investment Tax Credit

The solar Investment Tax Credit (ITC) is a reduction on the tax liability of an individual or company for a proportion of qualifying costs to construct a solar array. The credit is available to both residential and commercial taxpayers. ITC is an important mechanism for catalyzing growth of the solar industry because it greatly reduces the effective cost of any solar installation.

In 2022 the credit rate stands at 26% of project costs declining to 22% in 2023, 10% in 2024, and zero thereafter. While the City of Tigard is a non-tax paying entity it can still take advantage of ITC benefits through partnerships with tax paying individuals. However, in order to utilize this incentive program a Tier 1 or Tier 3 Tigard microgrid would need to begin construction by December 31 2022, or 2023 for the 26% and 22% credits respectively. The project would also need to be placed in service by December 31, 2025. Projects which do not meet these deadlines would only qualify for the 10% credit or no credit at all if construction begins after December 31, 2024 (25).

In order to take advantage of this incentive the City would need to begin planning and preparing for the project immediately as municipal infrastructure projects can take multiple years to materialize. With the Willamette Valley's poor natural solar resources, and other challenges surrounding microgrid installations, the ITC could be an important leverage point for improving the project viability as discussed in greater detail in following sections of this report.

7.0 TIER 1 - LIBRARY ANALYSIS

As discussed prior, the Tigard Public Library has been identified as the site for an emergency operations center in the event of a natural disaster. This 47,500 square foot structure was completed in 2004 and is seismically rated. The City has retained the engineering consulting firm PAE to do a deep-dive analysis of the process of setting up a single user microgrid (nanogrid) and BESS system at the library. The UO team has done a preliminary analysis in advance of PAE's more robust and technical study.

Aerial view of Tigard Public Library roof

Results

As can be seen in Table 1 below, we determined that an approximate 230 kW solar array could be deployed across 16,000 square feet of rooftop, while an additional 70 kW of photovoltaic (PV) panels could be installed as a canopy in the parking lot. Given the total annual kWh electricity usage of the building in 2021 provided by PGE, we calculated that the rooftop array could power 35% of total building operations, with the parking lot array providing another 11% (26).

Table 1. Tigard Public Library Estimated Solar Capacity

Building	Square Feet	DC System Size (kW)	AC System Output (kWh)	Value per Year ($)	Commercial Energy Use by Type (kWh/sqft)	Energy Use per Building (kWh)	% of Building kWh from Solar	Solar Install Cost ($/watt)	One Time Cost per Building ($)
Tigard Public Library	16,424	228.5	260,136	$28,052	15.7	745,750	34.88%	$2.55	$583,440
Parking	5,037	70.5	80,261	$8,604	0	0	10.76%	$3.45	$243,225
Total	21,461	299	340,397	$36,656			45.64%		$826,665

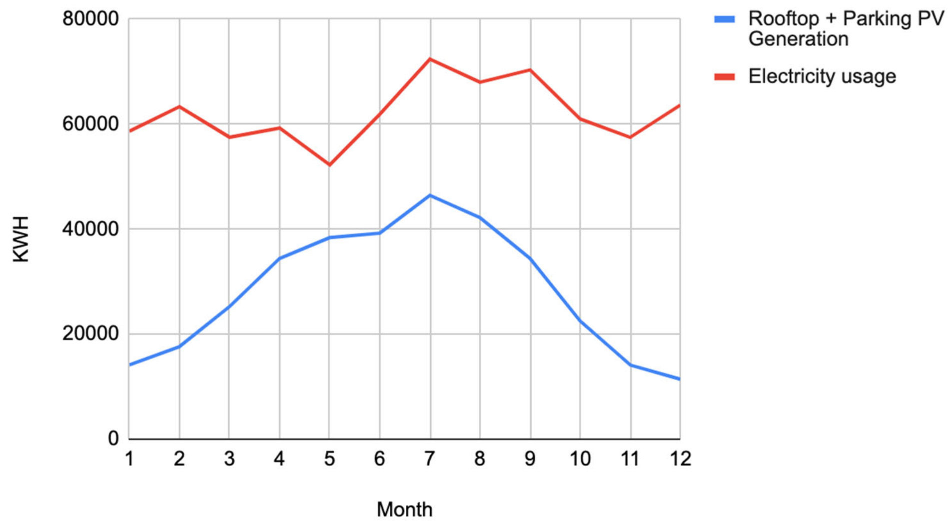
In our discussions with experts and our literature review, we found that the cost of solar installation ranged from $0.80 to $3.30 per watt depending on the application. In 2021, the government agency, NREL, published a report showing the price per watt DC had dropped to $2.65 for residential, $1.56 for commercial installations over 200 kW DC, and $0.89 for utility scale projects over 100 MW DC (27). This cost includes the installation labor, profit, overhead, balancing the system, electrical hardware and components, inverter, and the panels. It does not include engineering and permitting fees, roof improvements, or any electrical transmission and distribution system upgrades required by the utility. This cost also specifically refers to rooftop or ground mount systems. Parking lot canopies range from $3.00 to $4.00 per watt depending on the scale of deployment because of the more elaborate mounting structure required (26). According to the most recent report published by ETO, the rate per watt in Q2 of 2022 is $2.55; this figure will be used throughout our study (28). Given the size of the library array, it qualifies for commercial scale pricing and would cost approximately $600,000 for a rooftop system and an additional $200,000 for parking lot canopy.

There are two major factors working in the favor of the library project - the size of the array and the historical trend of solar installation cost. Solar installation benefits from economies of scale and the price per watt decreases as the size of the project grows. In addition, the cost of solar Installation has decreased by 70% over the last decade as the industry has matured and production has reached global scale. Unfortunately, recent federal regulation has been enacted to try and prop up domestic solar manufacturing and federal solar subsidies are beginning to phase out so the hard costs associated with these projects may begin to level out or inch back up. The ETO report indicates the prices have crept up over 30 cents per watt in the last fiscal year.

Given the current utility rate of $0.103 per kWh, the project will be able to generate annual savings of $36,700 or an equivalent annual cash flow if the energy is sold back to the grid. This results in a payback period of roughly 16 years (not including interest), which falls well within the 25-30 year expected lifespan of a PV system. A more detailed analysis of pricing information of this system can be found in the financing options section below.

Depending on the size and design of the array installed, the library will be able to produce between 34% and 46% of its average everyday energy needs onsite. This percentage varies seasonally as outdoor temperature dictates the building’s HVAC and other electric usage. Electricity consumption increases in the warmer months as air conditioning demands ramp up. During these months, however, the amount of daily sunlight increases and the panels are able to generate more electricity, thus the gap between generation and consumption is lowest. Although energy demand is generally lower in colder months, PV production can drop by as much as 75% and thus the gap between electricity production and consumption is greatest. This phenomenon is illustrated in Figure 7 below.

Figure 7. Tigard Public Library kWh Generation and Use



Energy Resilience and Battery Storage

If a natural disaster disables the grid and the library's PV system finds itself in 'island mode' disconnected from grid supported power, it will be unable to support the building on its own. The City should develop a strategy to shed as much excess electrical load as possible when the library pivots to emergency command status in order to minimize the gap seen in the Figure 1 above. For example, lights could be left off during the day, thermostats could be adjusted, and water heating could be eliminated. Different strategies could be developed that account for seasonal variation in electricity consumption so the city is prepared regardless of when a natural disaster occurs.

Even after load shedding, it will be unlikely that the PV system could provide 100% of the building's needs. The library will need to incorporate a battery 'behind the meter' to back up the PV system. Tesla offers a commercial scale lithium ion battery called a Powerpack that has a storage capacity of 232 kWh and a maximum power output of 130 kW. The Powerpacks can be utilized to help shift load to avoid purchasing energy during high rate periods and to help utilities shave peak demand. They are also designed to act as emergency backups, however they are intended only as an intermediate solution, not a long term one. During normal operation, the battery can be charged by the solar panels since the grid will provide power to the building. Alternatively, the grid can charge the battery directly. However, in emergency situations, the battery will be unable to be charged by the panels if their power is being fully directed to building operations. If a PV array provided more than 100% of its building's power needs, it could simultaneously charge a battery with its surplus electrons.

The Beaverton Public Safety Center is a comparable case study for Tigard's library project. Beaverton was the fortunate recipient of a PGE pilot project in which a microgrid was brought online at the police station to help the city with their emergency preparedness and resilience goals. They deployed a 330 kW rooftop PV array that powers 40% of the building's energy needs. To compensate for this demand differential, Beaverton installed a 1MW battery and 1MW diesel generator, which provides up to 5 full days of continuous power to the building without grid support. The Tigard library consumes on average 80 kilowatts per hour so 1 Powerpack would only provide the library with 3 hours of continuous power or 6 hours if used in conjunction with power from the solar panels. In order to reach 1MW of battery power like Beaverton, Tigard would need to acquire 8 Tesla Powerpacks. This is easily accomplished as the Tesla units are modular and designed to be infinitely scalable. With 1 megawatt of Powerpacks, the library would still only be able to power the building 24 to 48 hours depending on solar utilization. Although fossil fuel backups are subject to finite amounts of emergency backup fuel, it appears that with almost any battery backup configuration, Tigard will still need to implement diesel generators. Doing so will add longevity in the face of a potentially multi-week grid outage that could result from a large-scale earthquake.

Example installation of Tesla battery controller and 4 Powerpacks on concrete slab

A Tesla Powerpack with an inverter included costs $172,000, which is approximately $744 per kWh (29). They offer bulk purchase discounts such as 3 Powerpacks for $350,000, which brings the per kWh cost down to $500. NREL notes that by 2020 the average price for utility scale lithium ion battery capacity has dropped to $420/kWh and is projected to reach between $150 to $250 per kWh by 2030 (30). A careful analysis of the utility scale battery landscape should be done to compare Tesla to competitors. There are a number of players in this market who might offer cheaper prices than Tesla, notable brands include ABB, PowerSonic, Fluence, RES, Nidec ASI, and Powin Energy. It is also worth noting that immense funds are being funneled into utility scale battery research and development to create new technologies for large capacity storage. There are a number of old and new technologies vying for utility scale battery dominance - including lead acid, nickel-cadmium, and sodium sulfur. These options may help decrease the cost per kWh of storage further. As will be discussed later, PGE also has immense interest in bringing battery storage capacity onto the grid in order to help with daily demand load smoothing and they will be actively looking to help finance these energy storage projects. It also seems plausible that PGE could convince the

Oregon Public Utility Commission that another microgrid pilot project is necessary and that Tigard would be a willing and eager participant.

Another compelling strategy for Tigard's deployment of an EOC microgrid is the addition of electric vehicles. Electrifying the municipal fleet is already a priority in Tigard and this initiative has great synergy with distributed power generation. Currently, Ford is the only manufacturer that has a vehicle able to connect to the grid. The Lightning Extended Long Range is a pickup truck, which retails for $55,000 and has a 132kwh battery capable of powering a house for 3 days (31). This could be a great option for Tigard as forecasters expect the Lightning's prices to fall in line with the greater battery cost trends. In the long term, these could replace the Ford F150s and other vehicles currently in operation in Tigard's fleet. In times of emergency, these EVs could act as mobile batteries to bolster energy resilience and unlike BESS would not be affected by damaged utility infrastructure. EVs with bidirectional charging capability can also help the community more broadly and improve microgrids in both normal and emergency conditions by providing extra battery storage and helping utilities reduce peak load. Tesla has historically been opposed to bidirectional charging citing that it could degrade batteries and that their primary responsibility is to be a reliable mode of transportation. Recently, however, they added bidirectional charging hardware into their Model 3 even though the software required to utilize it has not been activated. This signals a potential shift across the whole EV industry, a shift that stands to benefit Tigard immensely.

Tier 1 Financing: Overview

In this section, we continue the discussion of the business landscape the Tigard microgrid project exists within. We identify and report on a variety of financing sources available to the City of Tigard and private individuals and discuss the benefits and drawbacks of each. We model three different financing arrangements for the Tier 1 - Tigard Public Library EOC microgrid.

According to ETO, the average price of commercial solar installations in Oregon is $2.55 per installed watt before any incentives or rebates, and we have used this price when modeling financial scenarios in this report. While the installed cost of solar panels is relatively consistent throughout the country, the cost of solar power is not. Solar panel efficiency or capacity factor changes based on the availability of sunlight. Generally, solar installations have higher capacity factors nearer the equator, and in the northern hemisphere solar panels are more efficient when tilted towards the south.

As discussed previously, the Willamette valley has notoriously poor natural solar resources. Solar installations in Tigard and the surrounding area can expect to see capacity factors between 12 and 15% depending on shading, soiling, aspect towards the sun, and other variables unique to each installation including limitations of the solar installations themselves. For scenarios in the section below, we have used 13% when modeling output from potential solar installations. This can have a large effect on the profitability of the installations and require individuals to seek nontraditional sources of financing for funding their solar installations.

There are myriad strategies for financing a solar installation for both public and private entities, which involve a combination of grants, debt, tax incentives, and equity. It can also be very advantageous to include multiple parties in a solar development as it can unlock the maximum amount of value in any potential solar project. Individuals with different expertise, risk profiles, and liquidity preferences often can fund profitable solar developments that would be infeasible for a single party to take on individually. The City of Tigard will almost certainly benefit from a mixture of the financing strategies as it explores solar projects at the Public Library, the Hunizker core, and elsewhere within the city.

Tier 1 Financing: Strategies

The microgrid's planned location on the roof of the Tigard Public Library and its function as an emergency operations center limits the available sources of funding the City of Tigard can utilize. The City may want to be the sole owner and operator of the project's solar panels and grid infrastructure and thus would miss out on the tax credit and bonus depreciation incentives available to tax paying individuals. On the other hand, the project is for the benefit of the Tigard general public, and thus the City is not beholden to the profit maximizing ways of private investors. Still, reducing the financial outlay for the CIty is an incentive for any infrastructure spending project. With these limitations in mind the team explored 3 scenarios for financing the Tier 1 microgrid.

Description of Model and Assumptions

The model used in the below sections is an adaptation of the Cost of Renewable Energy Spreadsheet Tool (CREST) developed by NREL, amended to include factors specific to the Tier 1 scenarios. NREL describes the CREST model as a tool that is designed to aid policy makers in determining cost-based renewable energy incentives (32). The CREST model aims to determine the minimum price of electricity needed for a project to meet an investor's required rate of return (32). For purposes of the project, the price of energy is fixed. Thus, the team has amended the model to account for this difference and other changes necessary to optimize the model output for purposes of the Tigard project. The amended model presents an array of net present values (NPVs) for each scenario. Unless explicitly stated otherwise, the team used the following assumptions for each scenario presented:

Description	Amount
Capacity factor (ratio of actual energy generated to theoretical capacity)	13%
Price of electricity	¢10.3/kWh
Installed solar capacity	228.8kW
Cost per watt installed	$2.55
Battery storage capacity	1,000kWh
Cost per kWh of battery storage	$420
Percentage of battery storage costs covered by PGE	100%
Interest rate	3.62%
Discount rate	7.50%
Life of the project	25 years
Soiling rate (decline in efficiency of solar panels)	0.50%

Months of debt service reserve required by lender	12
Months of operations and maintenance reserve required	6
Interest earned on reserves	2%
Installed solar parking canopies	None

PGE has a complex tariff rate structure for selling electricity back to the grid that varies based on customer size, type and monthly peak demand. In general, our assumption of ¢10.3/kWh is safe for any Tigard microgrid because no individual solar deployment linked to a single meter would be larger than 2 MW and qualify for the reduced wholesale energy price.

Scenario 1: Bond Financed

If the City assumes the role as the sole owner and operator of the microgrid, the city may want to finance the project entirely with Bonds. Tigard has a great bond rating, recently reaffirmed as Aa1 by Moody's in April of 2020 (33). Assuming the rating is still valid today, Tigard could theoretically issue municipal bonds with an interest rate around 3.6%. This interest rate could be even lower if the City were to issue non-taxable bonds. The emergency operations center is a stellar use-case to qualify as a public benefit in order to certify the bonds' tax-exempt status. However, certifying the tax-exempt status of such a prospective bond raise was outside of the scope of this report. Furthermore, the cost and effort of hiring a bond attorney to ensure the bonds do indeed qualify for tax-exempt status may not be worth the marginally lower interest rate attained for a bond raise well below $1 million. With that in mind the team has modeled a Bond-Financed scenario and all subsequent scenarios using a prospective future taxable bond raise with a 3.62% interest rate.

Given the inputs in the previous section and financing costs at 3.5% of the face value of the bonds, the model generates an array of NPVs based on changing discount rates, and capacity factors.

Library Scenario 1: Bond Financed - NPV Sensitivity Analysis

Capacity Factor	Discount Rate: 3.0%	4.5%	6.0%	7.5%	9.0%	10.5%	12.0%
11.0%	(425,323)	(369,131)	(323,914)	(287,184)	(257,069)	(232,153)	(211,354)
11.4%	(411,671)	(357,463)	(313,821)	(278,355)	(249,266)	(225,191)	(205,091)
11.8%	(398,019)	(345,796)	(303,728)	(269,526)	(241,463)	(218,230)	(198,827)
12.2%	(384,367)	(334,128)	(293,636)	(260,697)	(233,660)	(211,269)	(192,564)
12.6%	(370,714)	(322,461)	(283,543)	(251,868)	(225,857)	(204,308)	(186,301)
13.0%	(357,062)	(310,794)	(273,450)	(243,040)	(218,054)	(197,347)	(180,038)
13.4%	(343,410)	(299,126)	(263,358)	(234,211)	(210,251)	(190,385)	(173,774)
13.8%	(329,758)	(287,459)	(253,265)	(225,382)	(202,448)	(183,424)	(167,511)
14.2%	(316,106)	(275,791)	(243,172)	(216,553)	(194,645)	(176,463)	(161,248)
14.6%	(302,453)	(264,124)	(233,079)	(207,724)	(186,842)	(169,502)	(154,984)
15.0%	(288,801)	(252,457)	(222,987)	(198,895)	(179,039)	(162,540)	(148,721)

As can be seen in the table above, each NPV here is negative. It should also be mentioned that the cost per watt of commercial-scale installed capacity is subject to error as it may be as high as $3.00, or as low as $1.56 (27). Therefore this represents a moderate view of what the City could expect to return on a Tier 1 microgrid over the 25 year life of the project. The table above also does not include any canopy parking as these installations are much more expensive and would raise the overall cost per generation of the project.

In total the project would cost approximately $583,000 in year 1 and would require $20-22,000 annually over the 25 year life of the project in net cash expenditures to make interest payments on the bonds and maintain operations of the facilities. This recurring annual cash requirement is almost exclusively the result of interest payments on the bonds the City issued to finance the installation. While $20-22,000 is not zero, it would only represent about 0.015% of the city's $139 million expected annual revenues for 2023 (34) or about 0.25% of the Library's $8,185,027 proposed budget for 2023 (35).

While the NPVs shown above are negative, there are real advantages to pursuing a bond-financed option solely owned and operated by the City. The City would have full direction of the project and could make decisions about the design and operation of the project without consulting outside stakeholders. Finally, as discussed more extensively elsewhere in this report, there are clear benefits to the Tier 1 microgrid that extend well beyond the dollars and cents it would generate in return.

Scenario 2: Grant + Bond Financed

The second scenario we have chosen to model takes advantage of one or more grants to be deployed to the city to partially fund the microgrid. Currently, federal and Oregon state governments are actively incentivizing the installation of solar to decarbonize and improve the resiliency of the grid as a whole. The team has identified three such instances of governmental support potentially available to the City of Tigard for a solar installation.

1. PGE - Renewable Development Fund Grant

The Renewable Development Fund is an annual program administered by PGE wherein PGE grants money to solar photovoltaic and other renewable energy projects in their service area. ETO will aid in preparation of the project's application wherein it will be graded on the following criteria (36):

1. Community Impact – does the project benefit historically underserved communities?
2. Thoroughness of project design.
3. Feasibility of project budget and timeline.
4. Qualifications of project team.
5. Project complexity and technical feasibility.
6. Project "readiness" - project is well-developed with a known size, impact, timeline and budget. (37)

The fund requires the project owner to self-fund at least 15% of the total eligible budget among other requirements. The fund also gives priority to projects sponsored by public entities, projects that provide a substantial benefit to the community in the form of educational engagement and public visibility, projects that support BIPOC communities, projects wherein the administrator has done substantial work to identify all available funding opportunities and have put together a comprehensive design plan. Further priority is given to projects self-sponsored in excess of 15% requirement. The Tier 1 microgrid meets all listed requirements and many of the preferences posted in the published 2022 guideline document. While the deadline for 2022 applications has passed, the Renewable Development Fund is an annual program and the City should consider applying in subsequent years (37).

2. DOE - Community Renewable Energy Grant

The Oregon Department of Energy (DOE) Community Renewable Energy Grant Program is a grant program open to municipal governments, Tribes, and special government bodies. The program has $12 million for eligible community renewable energy and energy resilience projects. The program has four avenues for applying:

1. Planning Renewable and Resilience,
2. Planning Renewable,
3. Construction Renewable and Resilience, and
4. Construction Renewable. (38)

Each application under planning and construction avenues has a maximum award of $100,000 and $1,000,000, respectively. While the Tier 1, or Tier 3 microgrid would likely not have the requisite documentation available to apply under either the construction avenues, the City may consider applying under the planning renewable and resilience pathway. Much of the material in this report including the project description, and financial plan could be applied to the application. This in tandem with the strength of the project team and merits of energy resiliency in the face of natural disaster make the project ideally suited for this grant pathway (38).

3. FEMA - BRIC Grant

The City has secured financing from FEMA under the Building Resilient Infrastructure and Communities (BRIC) program. The team is aware these funds have been committed to the City and therefore will not describe the requirements of the program. The BRIC Grant has been listed here to provide a more complete list of funding sources available for the project (39).

It is unlikely that the City will be able to fund a Tier 1 microgrid using solely grant funding. However, pairing grant funding with bonds provides a more beneficial outlook for the microgrid. Holding each of the variables equal as in the first scenario, and using a discount rate of 7.5% the second scenario provides the following returns over changing capacity factors and grant amounts.

Library Scenario 2: Bond + Grant Financed - NPV Sensitivity Analysis

Capacity Factor (%)	Grant Size ($): -	50,000	100,000	150,000	200,000	250,000
11.0%	(287,184)	(247,829)	(208,474)	(169,119)	(129,764)	(90,409)
11.5%	(276,148)	(236,793)	(197,438)	(158,083)	(118,728)	(79,373)
12.0%	(265,112)	(225,757)	(186,402)	(147,047)	(107,692)	(68,337)
12.5%	(254,076)	(214,721)	(175,366)	(136,011)	(96,656)	(57,301)
13.0%	(243,040)	(203,685)	(164,330)	(124,975)	(85,620)	(46,265)
13.5%	(232,004)	(192,649)	(153,294)	(113,939)	(74,584)	(35,229)
14.0%	(220,968)	(181,613)	(142,258)	(102,903)	(63,548)	(24,193)
14.5%	(209,931)	(170,577)	(131,222)	(91,867)	(52,512)	(13,157)
15.0%	(198,895)	(159,541)	(120,186)	(80,831)	(41,476)	(2,121)

Unsurprisingly, as the size of the grant increases, the NPV of the project improves. Notably, it would require a grant in excess of $250,000 for the project to reasonably expect to pay for itself. A $250,000 grant represents 40% of the total funds that are estimated to be required. If the capacity factor is held constant at 13% and the discount rate is changed, a similar table of net present values is generated.

Library Scenario 2: Bond + Grant Financed - NPV Sensitivity Analysis

Discount Rate	Grant Size ($): -	50,000	100,000	150,000	200,000	250,000
11.5%	(185,475)	(156,228)	(126,980)	(97,733)	(68,486)	(39,238)
10.5%	(197,347)	(166,042)	(134,737)	(103,432)	(72,128)	(40,823)
9.5%	(210,725)	(177,084)	(143,444)	(109,804)	(76,164)	(42,524)
8.5%	(225,857)	(189,554)	(153,250)	(116,947)	(80,643)	(44,340)
7.5%	(243,040)	(203,685)	(164,330)	(124,975)	(85,620)	(46,265)
6.5%	(262,626)	(219,758)	(176,889)	(134,021)	(91,153)	(48,285)
5.5%	(285,041)	(238,107)	(191,173)	(144,239)	(97,305)	(50,372)
4.5%	(310,794)	(259,132)	(207,470)	(155,808)	(104,146)	(52,484)
3.5%	(340,500)	(283,310)	(226,121)	(168,932)	(111,743)	(54,553)

Each of the previous two tables uses $2.55 per watt of installed costs as stated in the table of assumptions. This is a moderate estimate; as costs decrease below $2.00 as is expected in the future, the likelihood of a positive NPV increases dramatically. Additionally, the cost of covered parking with solar canopy installations is not included in the model which would have the opposite effect and lower the likelihood of a positive NPV. The key takeaway from this analysis is that it would require a substantial sum of grant funding from outside agencies for the Tier 1 microgrid to actually become a net revenue generating asset for the City of Tigard.

While pursuing grants can be a source of cheap capital, it also comes with drawbacks. Grant requirements can influence project design to not be optimized for the City's use. Grants often stipulate limitations over what types of costs the funds can be used for, and there is no certainty with grants. The City may apply for grants and not be awarded any money, or only a fraction of the anticipated sum, or the City may have to wait for months on end to receive funds promised to them. With grants as with any outside stakeholder providing capital, the City will surrender some sovereignty over the project to get their support. The City must evaluate whether their proposal meets the conditions of the grants above, and decide whether the money received from the grant is worth the potential loss of sovereignty over a Tier 1 microgrid project.

Scenario 3: City Partnership with Investor

The third scenario modeled leverages some of the advantages partnering with a private entity can bring. While this scenario is more complicated than the previous two, there are significant gains to be realized. An investor is able to take advantage of tax incentives offered by the federal government that a nontaxable municipal entity cannot. In short, this scenario models a partnership where an investor funds the purchase and installation of the solar panels and other infrastructure, holds the equipment for six years, and then sells the system to the City at a discounted rate at the end of year six. This is a common structure for solar ITC deals.

During the first year of the project, the investor is able to generate ITC credits from funding the installation, and they can also take advantage of bonus depreciation on the project's depreciable assets during the hold period. As such, the investor can unlock value for the City that would ultimately be lost as a municipality does not pay taxes. In this arrangement the City would likely enter into a series of custody agreements over the assets. For example, the City might pay for and be responsible for all the maintenance of the solar installation, or the City might sign an agreement with the investor to purchase power from the panels at an agreed upon rate (this model assumes market rate). And finally, the investor would need to lease the rooftop from the City for an agreed upon (nominal) amount.

It is important to note that In order for this method to be viable the investor would need to make a positive return on their money. Also note that the NPVs in the tables below are calculated using a 7.5% discount rate. Investments in solar projects are frequently valued using discount factors as low as 3%. This is due to the incredibly reliable nature of the projects themselves, and the vast quantities of historically accurate weather data available. 7.5% was chosen for ease of comparison to the above tables in Scenarios 1 and 2. The following table shows the change in the net present value of the investors stake in the partnership, as capacity factor and price of the sale to the City change.

Library Scenario 3: Partnership - NPV Sensitivity Analysis

Capacity Factor	Discount on Sale: 60.0%	55.0%	50.0%	45.0%	40.0%	35.0%	30.0%
11.0%	(39,044)	(25,420)	(11,795)	1,830	15,455	29,080	42,704
11.4%	(36,800)	(23,175)	(9,551)	4,074	17,699	31,324	44,949
11.8%	(34,556)	(20,931)	(7,306)	6,318	19,943	33,568	47,193
12.2%	(32,312)	(18,687)	(5,062)	8,563	22,187	35,812	49,437
12.6%	(30,068)	(16,443)	(2,818)	10,807	24,431	38,056	51,681
13.0%	(27,824)	(14,199)	(574)	13,051	26,676	40,300	53,925
13.4%	(25,579)	(11,955)	1,670	15,295	28,920	42,545	56,169
13.8%	(23,335)	(9,710)	3,914	17,539	31,164	44,789	58,414
14.2%	(21,091)	(7,466)	6,159	19,783	33,408	47,033	60,658
14.6%	(18,847)	(5,222)	8,403	22,028	35,652	49,277	62,902
15.0%	(16,603)	(2,978)	10,647	24,272	37,896	51,521	65,146

In the table above, the investor return is positive in scenarios where the investor sells the installation back to the City for a 45% discount or less. This is a stark contrast to the returns modeled for the City in the above scenarios. The investor is able to add value to the deal by claiming tax benefits otherwise inaccessible by the City of Tigard. The following table shows City of Tigard returns for the same scenarios. The City still has a negative NPVs across the board, but the NPV is significantly improved from Scenario 1 with all else held constant.

Library Scenario 3: Partnership - NPV Sensitivity Analysis

Capacity Factor	Discount on Sale: 60.0%	55.0%	50.0%	45.0%	40.0%	35.0%	30.0%
11.0%	(55,966)	(70,656)	(85,346)	(100,036)	(114,726)	(129,416)	(144,107)
11.4%	(50,969)	(65,659)	(80,349)	(95,040)	(109,730)	(124,420)	(139,110)
11.8%	(45,973)	(60,663)	(75,353)	(90,043)	(104,733)	(119,423)	(134,113)
12.2%	(40,976)	(55,666)	(70,356)	(85,046)	(99,736)	(114,426)	(129,116)
12.6%	(35,979)	(50,669)	(65,359)	(80,049)	(94,739)	(109,429)	(124,119)
13.0%	(30,982)	(45,672)	(60,362)	(75,052)	(89,742)	(104,432)	(119,122)
13.4%	(25,985)	(40,675)	(55,365)	(70,055)	(84,745)	(99,435)	(114,125)
13.8%	(20,988)	(35,678)	(50,368)	(65,058)	(79,748)	(94,438)	(109,128)
14.2%	(15,991)	(30,681)	(45,371)	(60,061)	(74,751)	(89,441)	(104,131)
14.6%	(10,994)	(25,684)	(40,374)	(55,064)	(69,754)	(84,444)	(99,134)
15.0%	(5,997)	(20,687)	(35,377)	(50,067)	(64,757)	(79,447)	(94,137)

To assess the efficacy of this deal structure, the table above can be compared to the middle column of the table in Scenario 1. This comparison illuminates that the City could benefit by $150,000 or more when taking the Scenario 3 approach.

Other Opportunities

The scenarios in this section are not an all encompassing menu of options for the City's pursuit of a microgrid, but they provide a good starting point for facilitating discussion around financing a solar installation. After evaluating these scenarios the City may find it most beneficial to pursue another option instead of, or in addition to, the scenarios discussed in this section.

The Oregon Community Solar Program provides an intriguing option the City may consider exploring. To participate in such a program the City would need to build and operate a Tier 1 microgrid project. Customers around the City of Tigard would then subscribe to the program and receive a credit on their utility bills for the power generated by the solar installation. Participation in such a program, however, is unlikely to improve the economic situation of a Tier 1 microgrid. While there is some financial assistance available for community solar program development through ETO, according to the ETO development assistance reimbursement form these funds cannot be used for permit or grid connection fees, construction costs, or closing costs among other limitations. Therefore, it is likely that participating in such a program will worsen the microgrid's economic outlook through increases in overhead to prepare and submit the project application, and manage customer subscriptions once operational. The solar installation must connect to the grid separately, not from behind the Library's meter, and must be electrically separate from the Library itself, which jeopardizes the fundamental mission of establishing a resilient EOC. In addition to hampering the financial viability of the solar project, these hurdles increase the administrative burden on the City (40, 41).

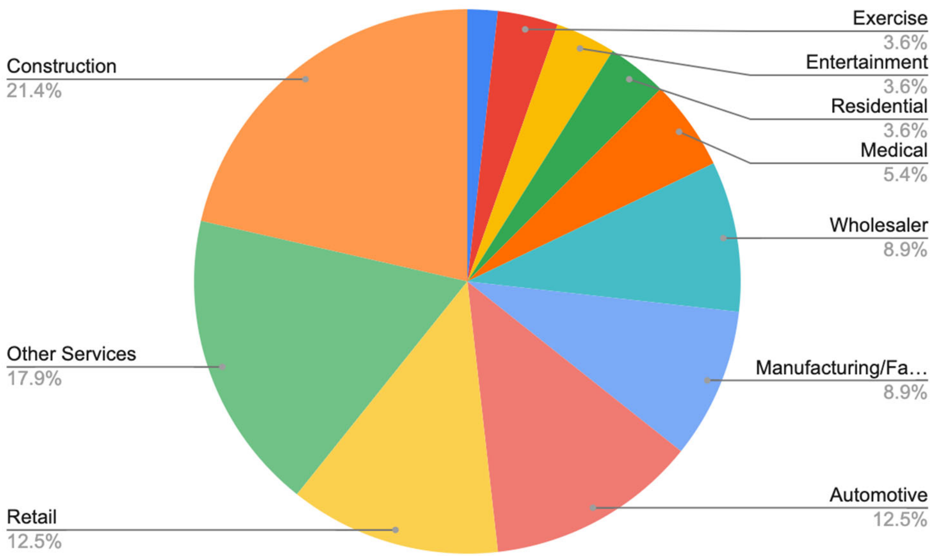
The City may also find it beneficial to partner with PGE when developing the Tier 1 microgrid. The utility has an important role to play in any solar installation project that connects to the grid. In our conversations with PGE, the utility has expressed great interest in increasing the battery storage available throughout the grid which our model has accounted for. In addition, there may be opportunities for financial support from PGE for more than just battery storage costs.

8.0 HUNZIKER CORE ANALYSIS

Overview

The Hunziker core is a 153-acre mixed-use corridor in eastern Tigard bounded by 217 to the north, P&W rail lines to the south, Route 141 and 99W to the west and Wall St to the east. The area comprises 60 businesses housed in approximately 50 building structures that have over 1 million square feet of rooftop. These businesses also own an additional 3 million square feet of lot space that is mostly built out as surface parking. The business landscape in the core is diverse but skews heavily towards manufacturers and fabricators, commercial and residential contractors, automotive service providers and retail establishments. The current mix of businesses can be seen in Figure 8.

Figure 8. Hunziker Core Business Mix



From a city planning perspective, the Hunziker core has significant room for improvement. In its current configuration, the Hunziker core is neither employment nor housing dense. Tigard is pursuing redevelopment in the core in line with the MADE (Maintain Advance & Diversify Employment) code, which seeks to center equity and sustainability in its zoning regulations (42). Given that the supply of developable employment land is very limited, Tigard and its planning department will seek to make the core more mixed-use by increasing the proportion of entertainment and retail options. There are two development projects underway in the eastern section of the core that will add two industrial facilities and two office buildings (*Parcel 2)*, which will increase employment opportunities. MADE code also encourages increasing affordable housing stock. The recent addition of the Fields Apartment complex represented the first low income housing development in the core and the second residential property.

The properties around Hunziker are also too large to conform to a grid pattern, which drives down the area's walkability. In addition, there are few establishments that draw pedestrian traffic. The MADE qualified redevelopment would help promote walking and biking in the core. The pending 2-mile extension of the Red Rock Creek Trail system will provide a safe, active transportation route that connects the core to the rest of Tigard, especially the natural amenities of Fanno Creek Park and the conveniences of the Tigard Triangle. Tri-Met's proposed Southwest Corridor Light Rail Project will also increase public sustainable transportation options for the future residents and employees in the core.

Much of the existing Hunziker core does not align with the objectives laid out in MADE and optimally would be redeveloped. Redevelopment could both accomplish MADE goals and aid microgrid deployment as new developments could be constructed optimally for solar with reinforced and south-facing roofs. However, many of the Hunziker occupants have long standing roots in the area and no intention of relocating in the near term. This creates a dilemma where the short term needs of community-wide resiliency via a microgrid must be weighed against Tigard's long term plan of redevelopment. Installing a solar PV system is analogous to taking out a 25-year mortgage. It will only further entrench the incumbent businesses and delay redevelopment. It is unlikely that outreach to these businesses will yield any substantive insights into their 20-year plans. It is also impossible to know when the Cascadia subduction zone will decide to produce a grid destabilizing earthquake. Therefore it is impossible to know whether it is optimal for the city to pressure existing stakeholders to leave by incentivizing redevelopment or move forward with a plan to put solar installations on the roofs of current structures.

Solar Deployment and Generation Capacity

In general, the faster solar is deployed the sooner its benefits can be realized. The prevalence of solar in an area creates a natural cascade effect leading to more solar installation. Rates of solar adoption increase as neighbors see PV panels in their daily lives, network with one another, provide installer referrals, and get more familiar and comfortable with the idea of distributed generation (DG) (43). The authors feel it is prudent to prioritize solar deployments over redevelopment in the core in order to secure as much capacity as possible pre-earthquake and trigger the solar installation cascade effect, which could potentially yield DG adoption outside the core as well. At the very least, the AC outputs in Table 2 below can be used as a proxy for generation capacity in the core post-redevelopment as rooftop square footage will likely be similar to current levels.

Table 2. Hunziker Core Rooftop Generation Capacity

Building	Roof Square Feet	DC System Size (kW)	AC System Output (kWh)	Value per Year ($)	Energy Use per Building (kWh)[1]	% Building kWh from Solar	One Time Cost per Building ($)[2]
United Fab Solutions	54,155	753.8	858,165	$91,995	1,570,495	54.64%	$1,922,190
Retriever Towing Tigard	53,004	739	841,316	$90,189	1,192,590	70.55%	$1,884,450
Apex Industries & Canteen Vending Services	52,616	733.4	834,941	$89,506	1,525,864	54.72%	$1,870,170
Snyder	15,656	218.3	248,524	$26,642	352,260	70.55%	$556,665
Spruce Box Construction	1,054	14.7	16,735	$1,794	23,715	70.57%	$37,485
Carlson Testing Inc.	9,759	135.9	154,716	$16,586	283,011	54.67%	$346,545
8330	17,302	241.2	274,595	$29,437	389,295	70.54%	$615,060
Solutions Yes	14,644	204.2	232,472	$24,921	329,490	70.56%	$520,710
Centrex Construction Inc	5,240	73	83,107	$8,909	117,900	70.49%	$186,150
Skykart Indoor Racing	29,009	401.6	457,202	$49,012	652,703	70.05%	$1,024,080

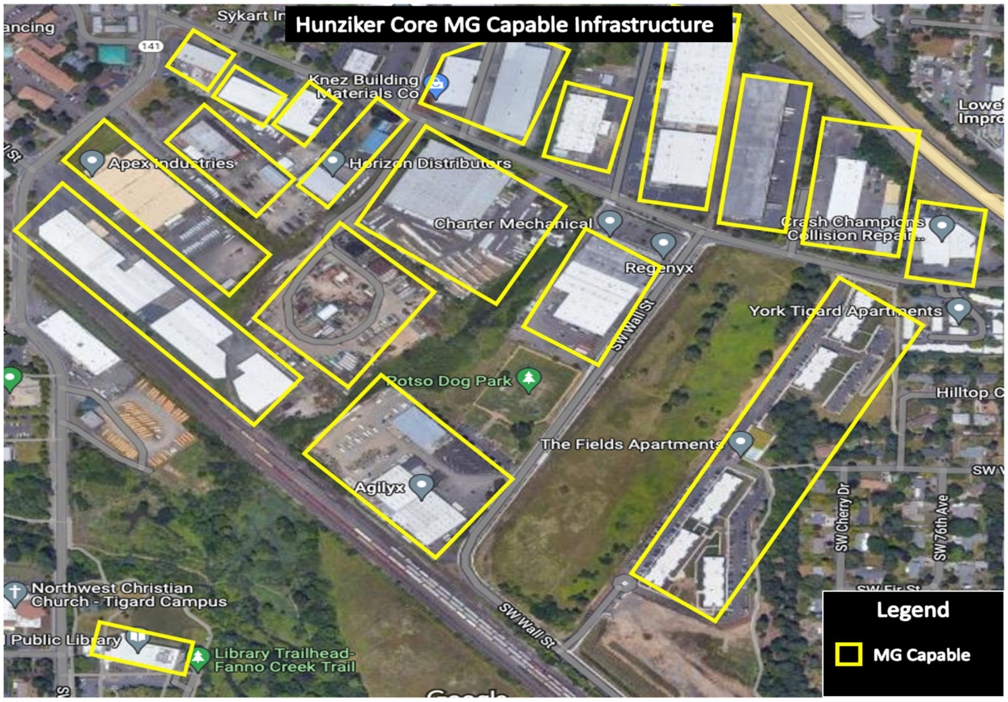
Future Networking	6,273	87.4	99,501	$10,666	141,143	70.50%	$222,870
Summit Pest Management & Junk King Portland	17,313	241.4	274,822	$29,461	389,543	70.55%	$615,570
Horizon Distributors	10,868	152.4	173,500	$18,599	222,794	77.87%	$388,620
8254	6,252	87.1	99,159	$10,630	140,670	70.49%	$222,105
Knez Building Materials Co.	16,839	234.8	267,309	$28,655	345,200	77.44%	$598,740
Fred Shearer & Sons Inc	26,448	368.7	419,747	$44,997	595,080	70.54%	$940,185
Biamp	104,060	1,450.70	1,651,553	$177,046	2,341,350	70.54%	$3,699,285
KEY Home Furnishings Warehouse[3]	71,296	993.9	1,131,508	$121,298	641,664	176.34%	$2,534,445
Huttig Building Products[4]	83,874	1,169.30	1,331,192	$142,704	1,719,417	77.42%	$2,981,715
Charter Mechanical & Regenyx	77,752	1,083.90	1,233,968	$132,281	1,749,420	70.54%	$2,763,945
Terex Services	20,336	283.4	322,637	$34,587	589,744	54.71%	$722,670
Terex Services 2	12,170	283.4	322,637	$34,587	352,930	91.42%	$722,670
Artistic Auto Body - Tigard	26,523	369.7	420,886	$45,119	769,167	54.72%	$942,735
The Fields Apartments	70,664	615.7	632,805	$67,837	1,589,940	39.80%	$1,570,035
TerraFirma Foundation Systems	13,321	221.6	252,281	$27,045	299,723	84.17%	$565,080
Agilyx	39,511	550.8	627,059	$67,221	1,145,819	54.73%	$1,404,540
Knoll at Tigard	10,122	141.9	160,250	$17,147	207,505	77.23%	$361,845
Mannahouse Church	23,861	334.5	377,756	$40,420	489,151	77.23%	$852,975
Office Furniture	110,841	1553.6	1,757,126	$188,013	2,272,241	77.33%	$3,961,680
Worksource	36,166	507	573,419	$61,356	741,403	77.34%	$1,292,850
Enterprise, ELXR Dance	10,486	146.9	166,144	$17,777	214,963	77.29%	$374,595
Mitsubishi	20,340	285.2	322,562	$34,514	416,970	77.36%	$727,260
11880	22,223	311.5	352,307	$37,697	500,018	70.46%	$794,325
Totals	**1,089,978**	**14,990**	**16,971,902**	**1,818,646**	**24,313,174**	**72.83%**	**$39,723,235**

TABLE 2 NOTES:
1) Energy Use per Building is calculated using average energy use by building type based on four distinct types: Manufacturing 29, Retail 20.5, Commercial 22.5, Warehouse 9 (units in kWh/sqft)
2) One time cost per building based on $2.55 estimated cost per installed watt DC
3) Madison Furniture Manufacturing Inc. also located in this building
4) Northwesting Demolition and Dismantling, & Caseday Inc. also located in this building
5) Crossfit, Rokke, & BMW also located in this building

The Hunziker core is an ideal location for a multi-user microgrid given its ample size and its central location in Tigard. There is massive solar generation capacity potential in Hunziker. As seen in Table 2 above, the core could generate 17,000 MWh of AC electricity annually from 15 megawatts of DC rooftop solar PV alone, enough to power approximately 1,300 US homes. This amounts to roughly $1.8M in electricity per year if it was sold back to the grid and PGE.

The roofs in Hunziker core range from 1,000 to 100,000 square feet. The lot sizes vary greatly as well, ranging from .15 acres to 15 acres. There is more than four times as much solar compatible surface area on the ground in Hunziker as the to rooftops - 25 acres compared to 113 acres. Ground deployments, however, tend to be less efficient than rooftop due to shading and are more expensive as a result of the more extensive mounting structures, especially in parking lot scenarios where tall canopies are required.

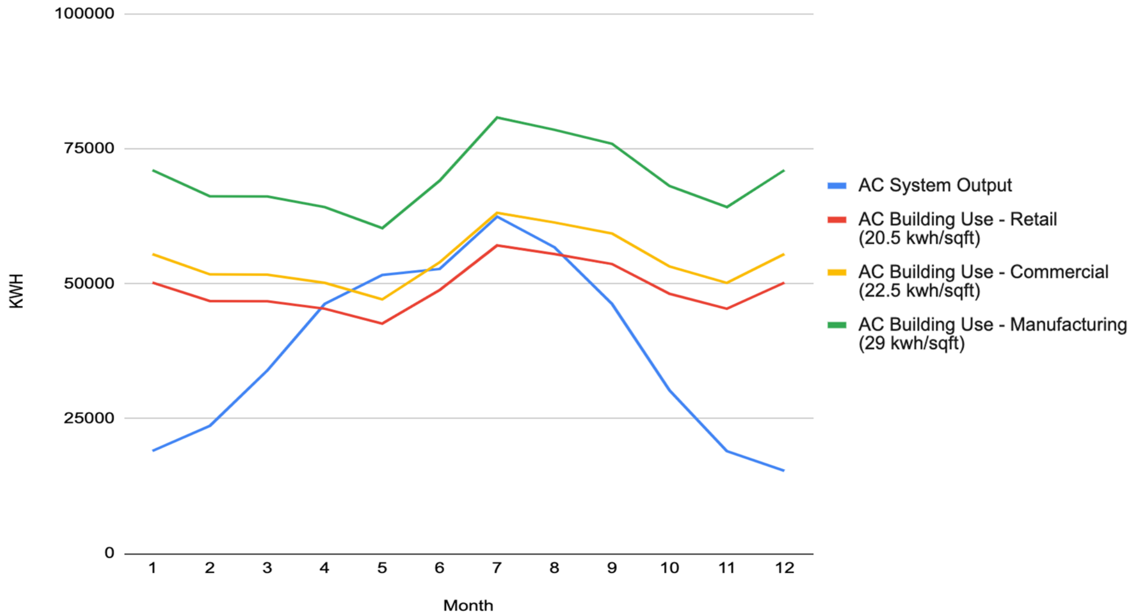
Aerial view of Hunziker Core showing potential rooftops for solar PV and lot lines



There are currently no solar photovoltaic systems in operation in the Hunziker core. There has been no formal analysis done on the condition of the roofs in the area. Satellite imagery and the industrial style of building found in the core, however, support the assumption that many of the roofs are made of metal or concrete. Metal roofs are conducive to solar systems as the panels can be affixed with clamps and do not require any roof penetrations. Concrete roofs are very durable and often have liquid applied roofing membranes that can last upwards of 25 years and can be easily reapplied around PV mounts. The buildings in the core with wood decks are candidates for solar as well, but would require more detailed inspection to check on their condition.

Figure 9 below shows electricity PV generation and consumption patterns for three different types of buildings found in the Hunziker core. In this example, the blue line represents the total kWh electricity generation from a single, average-size rooftop solar PV system each month. The three other lines represent average electricity consumption per square foot for three sample industries. We see that if the building was used for the lowest energy intensive industry, retail, the rooftop PV array would be able to fully power the building for the six warmer and sunnier months. If used as commercial space, the PV system would only be able to power the building for four months around Spring. If the building is used for manufacturing, the PV system would need supplemental power from the grid every month to be able to power the building operations. This example is fairly illustrative of the situation found throughout Hunziker. Similar to the library analysis, this Hunziker core example highlights the need for battery storage deployment and careful integration of the PV system with PGE. These gaps between electric consumption and generation can be shrunk by employing energy efficiency measures, like EnergyStar appliances and LED lights, or by carrying out building retrofits, like adding thicker, thermally efficient windows and more robust insulation.

Figure 9. Solar AC Output vs AC Building Use in Tigard



Fields Apartments Case Study

The Fields are the newest addition to the core so the condition of the roofs is not an obstacle. Furthermore, the Fields will be around for a very long time and sit firmly within the parameters of MADE code initiatives, and are therefore not subject to the dilemma surrounding redevelopment mentioned above. The Fields complex consists of 6 buildings, however, one is excluded from analysis as it features a green-roof. Table 2, below, contains data for the 5 buildings that are candidates for rooftop PV systems.

Table 3. Fields Apartment PV System

Building	Roof Square Feet	DC System Size (kW)	AC System Output (kWh)	Value per Year ($)	Average Residential Energy Use (kWh/sqft)	Energy Use per Building (kWh)	% of Building kWh from Solar	Install Cost Before Incentives ($/watt)	One Time Cost per Building ($)
1	13,906	118.60	130,864.36	$14,028.65	22.50	312,885	35.34%	$2.55	$302,430
2	11,442	100.20	110,561.61	$11,852.20	22.50	257,445	42.95%	$2.55	$255,510
3	14,887	126.30	139,360.64	$14,939.47	22.50	334,958	41.61%	$2.55	$322,065
4	16,533	150.10	165,621.77	$17,754.65	22.50	371,993	37.46%	$2.55	$382,755
5	13,896	120.50	132,960.81	$14,253.39	22.50	312,660	42.53%	$2.55	$307,275
Totals	**70,664**	**615.70**	**679,369.20**	**$72,828.36**		**1,589,940**	**39.80%**		**$1,570,035**

In summary, the Fields complex could deploy a 615 kW system across 70,000 square feet of rooftop, which will offset 40% of their total electricity consumption and generate annual savings of approximately $73,000. The system would cost approximately $1.6 million to install before incentives. Due to the size of this project and potentially long timeframe for deployment, this analysis assumes a 10% federal ITC tax credit, which has no cap and will replace the 22% ITC in 2024 (25). By utilizing the ITC, the Fields' owners could recoup 10% of the solar installation cost through a dollar-for-dollar reduction of income on the federal tax return. This tax incentive would effectively bring the project cost down to $1.47 million.

It is unclear whether the transition to a renewable energy economy will decrease or increase utility rates in the long term, so this analysis assumes that the solar cash flow will remain the same for the life of the system - 25 years. A net present valuation of this annuity is used to determine whether this is a sound financial investment:

$$NPV = -Ce + Cp\,(1/r)\,[1-(1/(1+r)^n)]$$

where:

Ce = upfront expense
Cp = annual cash flow
r = discount rate
n = # of years

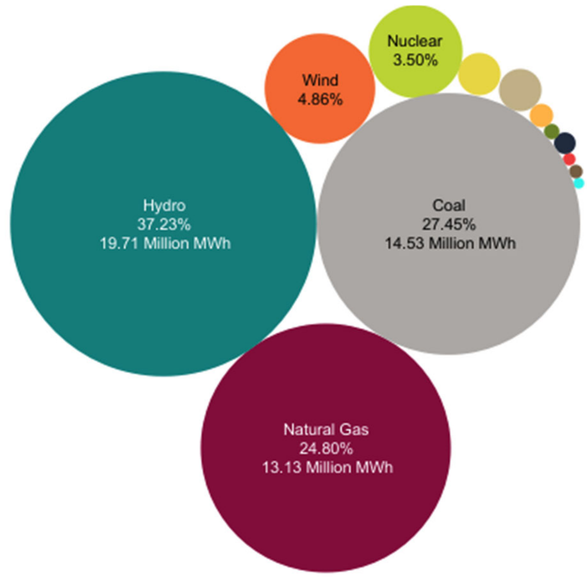
A 5% discount rate was chosen to mimic an alternative low risk investment

$$NPV = -1{,}631{,}605 + (72{,}828.36/.05)\,[1-(1/(1.05)^{25})]$$
$$NPV = -\$605{,}166.13$$

Although the net present value is negative, the Fields Apartment might still consider pursuing this solar project. The system will generate $1.82 million in savings over its life. In terms of accrued savings (or returns from the utility via net metering), the system would pay for itself in 24 years (excluding interest). These projections can also be optimized by adding large scale battery storage that could help throttle the store's electrical demand during peak hours or alternatively sell power back to the grid during high rate periods.

In addition, the above analysis does not consider the fact that solar installations raise property value. As discussed in the Business Benefits section, estimates for residential solar property premiums vary from a 4% increase in property value, to $20 per $1 saved in electricity annually - in this case $1.36 million, or even $5,000 per kW installed - $3.1 million (7). The owners of the Fields could also fully depreciate the asset in 6 years and save money on their federal tax returns. The financing section below provides alternative funding scenarios and analysis for the Hunziker Core MUM, which could be applied to the Fields Apartment by utilizing the companion excel model included in this report package.

On-site solar power in combination with energy efficiency strategies and IOT smart building technology will not only save the Fields owners money, but will also significantly reduce their greenhouse gas emissions by reducing demand for electricity and decreasing the percentage of fossil fuels in the energy mix. According to the EIA, coal fired plants generate 2.23 pounds of CO_2 per kWh of electricity produced, while natural gas plants generate .91 pounds of CO_2 (44).



According to Oregon's 2019 energy mix diagram, shown at right, 28% and 25% of electricity is derived from coal and natural gas respectively (45). This means that at the Fields Apartments 445,000 kWh come from coal and 398,000 kWh from natural gas. Given the kWh production metrics for the on-site solar project at the Fields complex, the PV system would offset a total of 1,354,000 pounds or 677 tons of CO_2. The advantage to the Fields of reducing its carbon footprint is threefold: it helps the climate, it can serve as a public relations talking point, and it could generate large cost-savings in the future if federal and local taxes are extended to carbon emissions. The projected market rate of CO_2 per ton in 2030 is $50 (46); if this materializes the Fields could expect to save over $33,000 annually in emissions based taxes.

The Fields Apartment case study is complicated by its status as a low-income housing project. Although the MADE code encourages development of low-income housing, the unique nature of this type of development faces challenges in when incorporating on-site solar into the project design. The vast majority of affordable housing, including Fields, is financed with Low Income Housing Tax Credits (LIHTC), a very complex and regulatory cumbersome program. While this credit has been successful in spurring development of affordable housing across the county, LIHTC has very strict rules surrounding how projects generate tax credits and these rules do not mix well with the solar ITC or state solar tax credit programs.

In our financial analysis above, the NPV for Fields is still negative even when a solar installation cost is partly offset through ITCs. Due to the cheap cost of electricity and poor solar resources in the Willamette Valley this is the case for nearly all privately funded solar installations in the region. That said, ITC will play a critical role in spurring solar development. As the City of Tigard explores further development of solar and affordable housing in congruence with its stated goals it is crucial to understand the confounding nature of the two credits.

LIHTC and ITC are designed to generate different types of returns for investors. ITCs are designed to provide project developers a reduction of upfront costs in order to allow investors to generate income in subsequent years selling electricity. Conversely, LIHTC utilizes the costs incurred by the development of the project to calculate tax credits and generate operating cash flow and tax losses for investors down the road. Thus the two types of credits have cross incentives when it comes to the project: ITCs are an incentive to reduce costs while LIHTCs are more effective with higher costs (47).

The two incentive programs also have other differences in their structure which make them incompatible. LIHTC investors are required to hold onto the projects for 15 years, which is much longer than the 5 year holds ITC investors generally expect. LIHTC deals run into problems with development grants while ITC projects are often funded with grants that are taxable to their recipients and reduce the cost basis for generating credits.

While affordable housing and solar have confounding tax credit incentive programs, that does not mean the Fields Apartments are disqualified from installing solar on the premises. Many community oriented solar programs actively incentivize service to low-income individuals. To address the confounding situation Fields is in more broadly, not all affordable housing is funded with LIHTCs, and not all solar is funded with ITCs. The Fields Apartments could be an ideal location for a unique mixture of financing that circumvents the hurdles described in this section.

Hunziker-Adjacent Areas

Just north of the Hunziker core lies a big-box commercial district that features a Walmart Supercenter, Lowe's Home Improvement Center, Costco Wholesale, and WinCo Foods. These four properties are vast and have half the roof capacity of and a third as much acreage as the entire Hunziker core combined. Working with 4 owners would be simpler logistically than managing over 60 in the core, however, these companies all have their own sustainability agendas that may be at odds with community microgrid objectives. See Table 4 below.

Table 4. Hunziker-Adjacent Generation Capacity

Building	Square Feet	AC System Output (kWh)	Value per year ($)	Avg. Commercial Energy Use by Type (kWh/sqft)	Energy Use per Building (kWh)	% of Building kWh from Solar	Solar Install Cost Before Incentives ($/watt)	One Time Cost per Building ($)
Walmart	120,512	1,909,689.87	$204,718.63	20.5	2,470,496	77.30%	$2.55	$4,277,480
Lowe's	94,527	1,500,138.27	$160,814.79	20.5	1,937,795	77.41%	$2.55	$3,360,135
Costco	122,675	1,946,980.69	$208,716.32	20.5	2,514,833	77.42%	$2.55	$4,361,010
WinCo Foods	93,741	1,488,412.49	$159,557.83	20.5	1,921,693	77.45%	$2.55	$3,333,870
Totals	**431,454**	**6,845,220.32**	**$733,807.57**		8,844,817	**77.43%**		**$15,331,583**

Tier 3: Financing Strategies

In this section, we discuss a variety of different strategies for the Tier 3 - Hunziker Core microgrid and report on the outcomes for stakeholders in these scenarios. A fully developed Tier 3 microgrid in the

Hunziker Core would have many different rooftops, owners, and customers, and the prospective multi-user microgrid has as many financing pathways as it does rooftops and customers. While each strategy discussed is given a definite scale including nameplate capacity, costs, etc. these amounts are not fixed and could be adjusted larger or smaller to improve palatability for the project's organizers, or accountant for varying degrees of participation for the stakeholders in the Core.

This section of the report defines categories which organize these arrangements by perceived feasibility. In lieu of traditional financial analysis for some of the least viable projects, the authors have instead included a narrative form explanation of the obstacles which contribute to the infeasibility of these projects, with traditional analysis where appropriate. The categories listed from least to most feasible follow.

Not Feasible

Scenario 1: City Owned and Funded

One option for moving forward with a Microgrid in the Hunziker Core is for the City of Tigard to own and fund the entire project. In our estimation this is the least viable option. If solar PV was installed on each identified roof in the Hunziker Core the project would cost about $38 million not including closing costs, interest, and costs to retrofit the roofs to be solar ready. While the city would certainly get a price reduction on the cost of the panels and equipment for purchasing in bulk quantities, it is likely not to be significant enough to offset these additional costs.

At $38 million and a 3.62% interest rate, the project would require between $400,000 and $900,00 in annual cash payments in order to cover the cost of interest and pay back the 25 year loan. Furthermore, this amount does not include the lease payments that would be required for the building owners, as they are assuming risk while installing solar panels on their property making the NPV even lower. The City could attempt to fund the project using the grants discussed in Scenarios 2 above or similar. However, the funds providing for these grants are unlikely to contribute money to a project with such poor economics, and even if funds were awarded it is likely not to be in sufficient quantities to move the needle much on a $38 million project. The City's status as a non-taxpaying entity disqualifies it from the benefits of solar Investment Tax Credits, which are a major source of value for the more viable options discussed later in this section.

The City would face non-fiscal hurdles as well. It is probable that the community of Tigard would not want to fund a capital project which seems to benefit only a handful of stakeholders in any tangible way. The public may see some fractional reduction in the cost of electricity but this would be trivial. One such tangible benefit would be to ask the business to agree to be a fallout shelter in times of emergency in return for increased energy resiliency, however, this too may require the businesses to be compensated and would make implementing such a project even more costly and complex.

In short, the City would not be able to self-fund and own a Tier 3 microgrid development.

Scenario 2: Community Funded Solar

The second option for Hunizer Core microgrid development is centered around community funded solar. This option is identical to the first option, with a few exceptions. The City would still be required to take a lead role in coordinating and developing the project and would still foot the bill for the infrastructure investment upfront. However, once operational the City would now be in charge of coordinating payments and rebates for the project's subscribers adding an operational burden. The chief economic difference comes from the payments the project's subscribers make to the city as the project administrator. These payments could theoretically exceed the market rate for electricity which would increase the NPV of the project. However, it seems unethical for the City to ask the public to pay extra on their utility bills. In the end, charging subscribers rate premiums defeats the cost-saving purpose of community funded solar, which means a community funded solar project would be at least as expensive as a self-funded project described above. Thus, this method is also infeasible. Tier 3 is not a candidate for community funded solar.

Scenario 3: Tax Increment Financing

A third option for the Hunziker Core microgrid is to fund the project using Tax Increment Financing (TIF). TIF works by creating a new property tax district in a community, capping the property tax revenues collected by government entities on businesses in that area, and diverting all increases in property tax back to the City to repay bonds that were issued to fund investment in the community. The aim is to increase property tax revenues in the community by more than the up front investment amount so as to be revenue positive for the City, and all other taxing authorities in the area.

TIF is a complex procedure that works best to spur investment in blighted areas of a community. Economic blight is when a community (or part) is experiencing a decline in real income and investment. The cost of maintaining typically aging infrastructure in the community becomes greater than the economic value of businesses operating within that community and so businesses leave the community, population declines, and the cycle repeats. TIF works to break that cycle by investing directly into that aging infrastructure, lowering operating costs and improving the economic value of locating in that community.

Unfortunately the Hunziker Core does not have any of the tell-tale signs of an area experiencing severe economic blight. There are no vacant lots in the Core. There has been recent private investment, and the assessed property values in the Core are well-below the market value for each property.

Further confounding factors limit the amount of tax revenue that could be generated by the project. Oregon law limits the annual increase for assessed property values in the state to 3% per year. Therefore, even if the market value of a property increases by more than 3%, the assessed value is capped. Since this law was passed, property values in the Portland area have experienced significant appreciation, leaving assessed values (AV) a fraction of their market rate counterparts. In the Hunziker Core, in 2021 total AV was $78,551,330, while market rate was $205,282,360 (48). This leads to an issue justifying the need for the TIF rate freeze and infrastructure investment. Each of the taxing authorities in the district would already be seeing a 3% increase in their tax revenues without any investment at all, and the microgrid infrastructure would likely not qualify the properties for reassessment as occurs with new building construction. All in all, if a tax increment zone were created to support the deployment of a Tier 3 project, it could be expected to generate around $3,940,595, or 10% of the estimated project costs over 10 years. A table containing Tax Lot IDs, assessed values, and TIF revenues can be found in Exhibit C in the Appendix.

Due to the unique nature of this financing strategy, we decided to model what a TIF-financed project might look like. Incorporating TIF revenue, and adjusting for the much larger installed solar capacity, 14,900 kW, and all else consistent with the assumptions in our Tier 1 analysis, the model generates the following table of NPVs for a TIF financed Tier 3 project.

Hunziker Scenario 3: TIF+ Financed - NPV Sensitivity Analysis

	Amount of Grant Funding ($)					
Cost per Watt DC ($)	-	1,000,000	2,000,000	3,000,000	4,000,000	5,000,000
0.95	5,168,967	5,956,065	6,743,162	7,530,259	8,317,357	9,104,454
1.15	2,809,249	3,596,347	4,383,444	5,170,541	5,957,639	6,744,736
1.35	449,532	1,236,629	2,023,726	2,810,824	3,597,921	4,385,018
1.55	(1,910,186)	(1,123,089)	(335,992)	451,106	1,238,203	2,025,300
1.75	(4,269,904)	(3,482,807)	(2,695,709)	(1,908,612)	(1,121,515)	(334,417)
1.95	(6,629,622)	(5,842,525)	(5,055,427)	(4,268,330)	(3,481,233)	(2,694,135)
2.15	(8,989,340)	(8,202,242)	(7,415,145)	(6,628,048)	(5,840,950)	(5,053,853)
2.35	(11,349,057)	(10,561,960)	(9,774,863)	(8,987,765)	(8,200,668)	(7,413,571)
2.55	(13,708,775)	(12,921,678)	(12,134,581)	(11,347,483)	(10,560,386)	(9,773,289)

With such a large scale project it is likely that the city would be able to lower the costs of installation below the $2.55 we expected for the Library. However, since each rooftop would come with unique challenges in design, and construction, it's unlikely the costs would be on par with the cheapest utility-scale solar installations. The table above shows that the costs would likely need to be below $1.50 or the City would need to receive a sizable grant for this to be a positive NPV project. We expect this to be outside the range of acceptable project costs for the near future. When considering the hurdles discussed above to implement a TIF district, and the large negative NPV from the tables above, the team does not expect TIF to be a feasible path forward for a Tier 3 project.

Uncertain

Scenario 4: Utility Owned and Organized

Another option for the Hunziker Core microgrid is for the utility to own and be the driving force behind the Tier 3 microgrid's development. The utility is in a unique position. They have access to the fiscal resources, the technical know-how and important legal protections which make their involvement in any microgrid compulsory and their ability to direct and organize one's development much easier.

Chicago's Bronzeville microgrid is a leading example of how a utility company can effectively organize and operate a MUM. The Bronzeville microgrid is of a similar size and scale to the Tier 3 microgrid. Both are in a semi-urban setting with a mixture of residential and non-residential properties dispersed throughout.

Unfortunately, utility companies are not able to take on standalone projects like this in a particular neighborhood, unless they can justify the project benefits all ratepayers. The Bronzeville project was developed as a pilot project that would be used as an example for ComEd for which all ratepayers would benefit from the learning experience. As a result, although the project only benefitted 1000 residents, the cost was dispersed across ComEd's 4.1 million ratepayers. This is the same justification PGE used to construct the Beaverton Safety Center microgrid project. This project was never designed to be economical and according to HB2193 it utilized a million dollars in state authorized funding. It is possible, albeit unlikely, that the Tigard Tier 3 could be considered a pilot project to benefit all PGE ratepayers as a learn-by-doing example. Given PGE has a research and development budget of only $200 thousand, it would require state legislation to secure the necessary funds.

Without a designation as a pilot project a utility owned and organized microgrid would only be viable if the economics supported it, as we have seen in the scenarios above, this is generally not the case. Therefore it is uncertain if a Tier 3 project is feasible under a utility owned and organized pathway.

<u>Scenario 5: Property Owner Coordinated</u>

The next strategy for organizing and operating a Tier 3 microgrid is one coordinated by the owners of the properties themselves. This approach has a high integration and coordination cost associated with it as the property owners may not have experience in taking on capital projects of this kind. Depending on the level of sophistication of their business, a microgrid project could be well outside their comfort level making them feel uneasy and afraid to take on the project. Utilizing this approach would involve some amount of Investment Tax Credits, which adds another layer of complexity and cost to coordinating the project.

The property owners would benefit from a reduction in coordination costs by agreeing on a common choice of developer to construct each of the solar installations on their properties. They would almost certainly further benefit from a reduction in price of the installation as well. If multiple developers were chosen, the microgrid would need a sole motivator - a highly organized party to coordinate between the different owners and developers. This could be a sophisticated developer, business owner, or perhaps a public-private partnership with the City itself. One organization that Tigard should reach out to who could fill this role is the Bonneville Environmental Foundation (BEF), a non-profit that consults and develops renewable projects and has close professional relationships with utilities and other corporate sponsors. BEF has helped deploy community solar projects across the Pacific Northwest that focus on promoting equity in low-income communities. They are actively looking for large rooftops and parking lots and can help write grants, create financial models, conduct site analyses, and manage the project. BEF could become the mouthpiece for the Tigard project and shop it out to capital partners, while also becoming the lead underwriter to backstop for investors. They filled this role for a solar rooftop project at Trimet's bus terminal in Portland.

Unfortunately, due to the increased coordination cost it is unlikely that this method would be able to be developed with the higher ITC rates, 26% and 22%, before they expire in 2022 and 2023, respectively. Furthermore, the tax benefit of depreciation is uncertain with a group of disparate owners. Some businesses may not have taxable net income, or very little, and thus are not motivated by the potential to increase the depreciation deductions on their tax returns. However, assuming businesses do have income, and are able to receive ITC benefits, these are tangible benefits that directly impact the property owners and their businesses.

These businesses also reap non financial benefits as well. They get the benefit of energy resilience, improved public image, and the curb appeal of having solar panels on their rooftops. The installations would have the potential to generate renewable energy credits as well. While the credits themselves are only worth around $1 per MWh and are not a material source of financing when sold, registering and keeping the RECs affords the business owner the ability to claim their business is powered by renewable energy which is good press and can further the company's sustainability goals surrounding carbon emissions.

This method likely benefits from some city participation. The City can act as a conduit for bolstering public interest, a project organizer, and the operator of the microgrid once installed. Furthermore, the city could fill a gap in financing in order to make the expected return of the project more attractive to the property owners. The tangible business benefits, tax benefit value, and potential for a reduction in installation costs by aggregating purchases among many property owners makes this option possible and more viable than the others option listed above.

Feasible (Unlikely)

Scenario 6: Developer/Investor Organized

The final scenario the team investigated incorporates what a project might look like if a for-profit developer were to construct, own, and operate the project for economic gain. Much like Scenario 3, the developer is able to take advantage of depreciation and ITC tax benefits, however, unlike Scenario 3 there is no entity for the developer to sell the project to once these tax benefits have been realized.

The capital stack for this scenario would likely be a combination of debt, equity, grants, and tax incentives. This stack could involve a sponsor equity or general partner who manages the investment, collecting rents for solar, paying lenders, and hiring an operations and management group to take care of the PV system. It would also include an equity partner, which could be a high net worth individual, a mission-aligned investor investor group such as an endowment or pension, or a public company looking to diversify their portfolio with an alternative asset class that is low-risk. The company could be in an adjacent space like AES, an energy company that owns generating assets, or a company like Siemens, GE, and SAP who could provide equipment to the microgrid and potentially financing for the equipment. Alternatively, the company could be completely unrelated to the energy sector and just be cash rich and looking for creative ways to deploy capital - Nike would be an interesting option as they have regional ties and have a history of investing locally. The stack would also involve a debt component, like an insurance company or bank, who would receive monthly cash flow that is not tied to PV system performance. Finally, a tax equity investor - typically a large financial institution like Morgan Stanley, Bank of America, or PNC - would be involved so they could receive an investment tax credit and can capitalize on accelerated depreciation to reduce their taxable income. The permutations of the capital stack are endless, so for simplification we've chosen to depict a single Developer entity in our model.

In order to come to fruition, the Developer would need to enter into agreements with each of the property owners in the Core. These agreements would likely include a rooftop or other property lease, an agreement to construct microgrid infrastructure on their property, and an agreement to sell power back to the businesses. While the microgrid would bring tangible real benefits to these businesses (as discussed extensively earlier in this report), the developer may need to further incentive these businesses by offering a rate on electricity that is below the market rate of electricity. Additionally, as the project grows in scale, the developer may be subject to different tariff rates on the power they sell back to the grid. And while the developer may be sacrificing some revenue from selling power to the Hunizker business they would also likely benefit from cost efficiencies due to their expertise and economies of scale for taking on a project of such scale.

The model the team used to investigate this strategy uses all of the same assumptions as the Tier 1 models, adjusting for the larger 14,990 kW installed capacity of a Tier 3 microgrid. The table below shows an array of NPVs for what a developer-organized Tier 3 microgrid might render. This model represents a project with a 26% ITC rate.

Hunziker Scenario 6: Hunziker Developer - NPV Sensitivity Analysis

	Price of Electricity (¢/kWh)						
Cost per Watt DC ($)	9.10	9.30	9.50	9.70	9.90	10.10	10.30
1.30	1,137,631	1,351,409	1,565,187	1,778,965	1,992,743	2,206,522	2,420,300
1.55	(82,065)	131,713	345,491	559,269	773,047	986,825	1,200,603
1.80	(1,301,762)	(1,087,984)	(874,206)	(660,428)	(446,649)	(232,871)	(19,093)
2.05	(2,521,458)	(2,307,680)	(2,093,902)	(1,880,124)	(1,666,346)	(1,452,568)	(1,238,790)
2.30	(3,741,155)	(3,527,377)	(3,313,599)	(3,099,820)	(2,886,042)	(2,672,264)	(2,458,486)
2.55	(4,960,851)	(4,747,073)	(4,533,295)	(4,319,517)	(4,105,739)	(3,891,961)	(3,678,183)
2.65	(5,448,730)	(5,234,952)	(5,021,174)	(4,807,396)	(4,593,617)	(4,379,839)	(4,166,061)
2.75	(5,936,608)	(5,722,830)	(5,509,052)	(5,295,274)	(5,081,496)	(4,867,718)	(4,653,940)
2.85	(6,424,487)	(6,210,709)	(5,996,931)	(5,783,153)	(5,569,375)	(5,355,597)	(5,141,818)
2.95	(6,912,365)	(6,698,587)	(6,484,809)	(6,271,031)	(6,057,253)	(5,843,475)	(5,629,697)
3.05	(7,400,244)	(7,186,466)	(6,972,688)	(6,758,910)	(6,545,132)	(6,331,354)	(6,117,576)

The table above shows that this scenario would become profitable when costs drop below $1.80 per installed watt DC. As stated earlier in this report, NREL published a report which shows that price per watt DC is $1.56 for commercial installations over 200 kW DC, and $0.89 for utility scale projects over 100MW DC (27). While the Hunizker capacity of 14,990 kW DC sits within this range, the quoted costs for commercial and utility scale projects are for 'typical' projects of this scale. A typical commercial scale project might exist on the roof of a single solar-ready supermarket, and a utility scale project would typically be constructed in an empty lot or greenfield. The Hunziker core microgrid is anything but typical, therefore the costs associated with the project are likely to be higher than $1.56 quoted in the report.

Yet, with the scale of the project and the benefit of expertise, the developer could likely realize a material discount on the $2.55 cost per watt DC modeled in the Tier 1 scenarios. As a result it may be feasible for the project to see neutral, or slightly positive NPVs for the developer.

Unfortunately, the table above also uses the highest ITC rate, 26%, which decreases to 22% in 2023, and 10% in 2024. The decreasing tax credit rates have important impacts for the fiscal viability of the project. Projects in future years would need to see even greater cost efficiencies than what is depicted in the table above to realize neutral or positive NPVs. In order to lock in the 26% rate, the project would need to begin construction in 2022, which is extremely unlikely for a project of this size and complexity. The developer organized strategy may be feasible in future years as costs of solar installations continue to decline, as long as the developer is able to realize significant tax breaks on the costs of installation which is becoming less and less likely with the phase-out of solar ITC.

It is also worth noting that all of the above scenarios assume that microgrid customers will pay market or below market rates for electricity thanks to it being onsite and renewable. Alternative pricing structures, however, could be considered that include an additional flat monthly fee for resilience service to reflect the true and difficult to define value of resilient power provided by a MUM. Alternatively, the MUM could pursue a tiered tariff structure where customers who receive the greatest benefit from resilience are charged premium pricing per kwh each month. During an emergency, these higher tiered customers, presumably hospitals, emergency services, and businesses listed in Section 4.0, would be the first to receive solar and BESS electrical service. Premium pricing schemes would not discourage membership in a MUM as the guaranteed resilient power would be valued by the customers at a still greater $/kwh rate (or a potentially infinite rate) than they are being charged.

9.0 RECOMMENDATIONS

We recommend a phased approach to microgrid implementation in Tigard. The city should start by focusing its efforts on developing a microgrid at the Public Library that includes both solar PV and battery storage. Time is of the essence and deploying initial resources on the Tier 1 project would allow the city to most rapidly prepare for future emergencies. Once Tier 1 is established, resources can shift towards public and private microgrid expansion into the surrounding area. As the Hunziker core continues to redevelop and buildings are designed with resilience, energy efficiency, and solar generation in mind, the Tier 3 multi-user microgrid should be supported. A large-scale MUM will be a public relations success story and attract investment and new businesses and residents to Tigard. The MUM will support the EOC's resiliency objective, while also reducing local emissions and saving money for the local community. Ultimately, its greatest value could come in serving as a model for other urban community microgrid projects around the globe.

In the interim, we recommend for the City to apply to any and all appropriate grants. The funds will provide a much needed boost to the financial viability of the projects and aid in preparing the City of Tigard in its emergency preparedness.

Exhibit A: Description of Tigard Resiliency Initiative

City of Tigard Original Draft Scope:

The Tigard Resiliency Initiative is a three-part, tiered approach to pre-disaster energy resiliency in Tigard including: 1) installation of PV generation and battery storage to support resilient operation of the EOC as a micro grid, 2) public infrastructure and private development PV generation and battery storage for resilient publicly accessible energy and services through a microgrid, and 3) district-scale renewable energy generation and storage through a microgrid for resiliency, climate benefits, and economic development.

Tier 1: Emergency Operations Center Renewable Energy Microgrid

Currently, Tigard's Emergency Operations Center (EOC) electric power is backed up with a propane generator, which is subject to limited resupply in the event of a Cascadia earthquake event. To improve the EOC's resiliency, the City proposes to install solar PV generation and battery storage at the EOC site for operation as a microgrid. The proposed project addresses critical energy infrastructure vulnerability supporting whole-community resilience.

Tier 2: Public Infrastructure and Fields Property Renewable Energy Microgrid

The proposed renewable energy generation and storage microgrid involves the innovative use and design of public infrastructure (pedestrian bridge, water quality facilities, and street rights-of-way) and the cooperation of private development partners including regulated affordable housing providers and commercial and industrial developers. The project would be designed to serve essential city services and functions such as public realm lighting and mechanical systems, communication devices and EV charging, and emergency shelter to further benefit the public in case of catastrophic failure of the energy grid. The proposed project anticipates impacts on vulnerable populations, equitable risk-reduction outcomes, and whole-community approaches to disaster resilience. The proposed project is collaborative and promotes shared responsibility and partnerships. The project would be a major educational opportunity in the heart of Tigard and serve to pilot the community's transition to a renewable energy future.

Tier 3: Hunziker Core District Renewable and Distributed Energy Microgrid

The Hunziker Core is centrally located between Tigard's urbanizing mixed-use Downtown and Triangle Districts and is characterized by an underdeveloped industrial land base. With Tigard's current Employment Lands Tomorrow Code Update Project, the Hunziker Core District will see increasing employment density and a wider mix of uses allowed to support economic development. The district energy concept would underwrite this effort with lower cost energy through coordinated resilient renewable and distributed energy generation and storage facilities through a microgrid. Renewable energy facilities at the district scale could have significant climate change benefits by avoiding fossil fuel emissions from building heating, cooling, and lighting and in support of EV charging. The proposed project is collaborative and promotes shared responsibility and partnerships.

Exhibit B: Copy of PGE's Letter of Support for Tigard Resiliency Initiative

Portland General Electric
121 SW Salmon Street · Portland, Ore. 97204

LETTER OF SUPPORT TO PARTICPATE IN FY2020 Building Resilient Infrastructure and Communities (BRIC) - City of Tigard Resiliency Initiative

Date: 11/24/2020

Applicant: City of Tigard
Number: FEMA – BRIC Fiscal Year 2020
Proposal Title: CITY OF TIGARD RESILIENCY INITIATIVE

Sub-contractor: Portland General Electric Company
121 SW Salmon Street
1WTC1708
Portland, OR 97204

Certifying Official:
Name: Larry Bekkedahl Telephone: (503) 464-7772
Email: Larry.Bekkedahl@pgn.com

Subcontract Amount: $25,000 (in-kind contribution of engineering and professional services)

Portland General Electric Company (PGE) issues this letter confirming our support to The City of Tigard to apply to FEMA's Building Resilient Infrastructure and Communities (BRIC) to develop their "CITY OF TIGARD RESILIENCY INITIATIVE". PGE is interested in the prospect of a community resiliency microgrid and its opportunity to serve joint benefits for the City of Tigard as well as to provide energy and grid services value to PGE. PGE plans to diligently, and in good faith, work with City of Tigard to plan and develop a resilient microgrid concept that is safe and reliable and can deliver and test the following grid services:

- Generation Capacity
- Regulation
- Load Following
- Contingency Reserves
- Frequency Response
- Distribution Upgrade Deferral
- Volt-VAr Support

PGE looks forward to working with City of Tigard in this effort to develop a resiliency solution which provides joint benefit for the City of Tigard and to PGE.

Sincerely,

Larry Bekkedahl

Larry Bekkedahl
PGE
VP Grid Architecture, Integration & System Operations

Exhibit C: Hunziker Core Tax Base - Tax Increment Revenue Projection

Building	Acres	Address	Taxlot ID	Assessed Value (AV)	2022 Max AV Increase (3%)
United Fab Solutions, Retriever Towing	6.45	12700 SW Hall Blvd	2S101CB00400	$3,042,880	$91,286
Apex Industries, Canteen Vending	6.44	12670 SW Hall Blvd	2S101CB00500	$2,715,840	$81,475
Snyder	4.49	12560 SW Hall Blvd	2S101BC02401	$1,994,970	$59,849
Spruce Box Construction	0.22	12540 SW Hall Blvd	2S101BC02300	$93,300	$2,799
Carlson Testing Inc.	0.99	8430 SW Hunziker Rd	2S101BC02202	$1,050,150	$31,505
8330	1.09	8330 SW Hunziker Rd	2S101BC02200	$1,378,520	$41,356
Solutions Yes	1.05	8300 SW Hunziker Rd	2S101BC02201	$1,852,180	$55,565
8254	0.36	8254 SW Hunziker Rd	2S101BC02900	$103,660	$3,110
Centrex , Horizon, Sunrise	1.68	8260/8250 SW Hunziker Rd	2S101BC02100, 2S101BC02800	$1,363,020	$40,891
Skykart Indoor Racing	4.12	8205 SW Hunziker Rd	2S101BC00200	$1,837,440	$55,123
Future Networking	0.82	8255 SW Hunziker Rd	2S101BC00201	$1,051,290	$31,539
Summit Pest, Junk King	3.84	8255 SW Hunziker Rd	2S101BC00101	$1,299,420	$38,983
Knez Building, Star OIl	3.91	8185 SW Hunziker Rd	2S101BC00100	$3,701,850	$111,056
Fred Shearer & Sons Inc	2.14	8015 SW Hunziker Rd	2S101BD00300	$1,972,870	$59,186
Biamp	6.38	8005 SW Hunziker Rd	2S101BD00200	$4,912,800	$147,384
KEY Home, Madison Furniture	4.67	7885 SW Hunziker Rd	2S101BD00103	$4,050,560	$121,517
Huttig Building Products	7.58	8100 SW Hunziker Rd	2S101CB00100	$5,194,820	$155,845
Northwesting Demolition, Caseday Inc.	8.49	8200 SW Hunziker Rd	2S101CB00200	$1,720,860	$51,626
Charter Mechanical, Refenyx	4.67	7930 SW Hunziker Rd	2S101CA00400	$4,619,550	$138,587
Terex Services	3.74	12805 SW 77th Pl	2S101BD00105	$2,320,990	$69,630
Artistic Auto Body - Tigard	1.82	7585 SW Hunziker Rd	2S101AC01800	$1,376,150	$41,285
The Fields Apartments	14.77	7670 SW Hunziker Rd	2S1010001700	$0	$0
Wall St Industrial Development	15.83	13225/13045/12975 SW Wall St	2S101CA00800, 2S101CA00100, 2S1010001100	$2,326,070	$69,782
TerraFirma, Agilyx	6.25	13220 SW Wall St	2S101CA00200	$3,567,950	$107,039
Knoll at Tigard	0.88	12291 SW Knoll Dr	2S101BC01000	$0	$0
Mannahouse Church	2.22	12234 SW Garden Pl	2S101BB01500	$2,607,530	$78,226
Office Furniture, Crossfit, Rokke, BMW	13.24	12060/12078 SW Garden Pl	2S101BB01400	$13,351,830	$398,976
Worksource	3.23	11952 SW Garden Pl	2S101BB01300	$4,294,780	$117,939
Enterprise, ELXR Dance	1.16	11860 SW Pacific Hwy	2S101BB00400	$1,292,070	$37,155
Mitsubishi	2.69	11880 SW Pacific Hwy	2S101BB00401	$2,652,710	$68,346
11880	1.69	1180 SW Pacific Hwy	2S101BB00900	$805,270	$24,158
Totals	**136.9**			**$78,551,330**	**$2,331,218**

Exhibit D: Hunziker & Adjacent Core Current Occupants

Company	Address	Phone #	Website	Description
United Fab Solutions	12700 SW Hall Blvd Bldg D3W, Tigard, OR 97223	503-268-1577	UFS	Metal fabricator
Retriever Towing Tigard	#D4, 12700 SW Hall Blvd, Tigard, OR 97223	503-222-4763	n/a	Towing
Apex Industries	12670 SW Hall Blvd #2, Tigard, OR 97223	503-235-8324	Apex	Plastic fabrication company
Canteen Vending Services	12670 SW Hall Blvd building 3, Tigard, OR 97223	503-285-9166	CFS	Vending machine supplier
Snyder	12650 SW Hall Blvd, Tigard, OR 97223	503-620-5252	Snyder	Roofing contractor
Spruce Box Construction	12530 SW Hall Blvd Suite 150, Portland, OR 97223	503-530-8205	Spruce	Residential contractor
Carlson Testing Inc.	8430 SW Hunziker St, Tigard, OR 97223	503-684-3460	CT	Geotechnical / concrete testing
n/a	8330 SW Hunziker St, Tigard, OR 97223	n/a	n/a	n/a
Solutions Yes	8300 SW Hunziker St, Portland, OR 97223	503-597-0937	SY	Office equipment supplier
n/a	8260 SW Hunziker St, Portland, OR 97223	n/a	n/a	n/a
Centrex Construction Inc	8250 SW Hunziker St # A, Tigard, OR 97223	503-684-0443	CCI	Industrial contractor
Skykart Indoor Racing	8205 SW Hunziker St, Tigard, OR 97223	503-684-5060	Kart	Indoor go kart track
Future Networking	8255 SW Hunziker St Suite 102, Tigard, OR 97223	503-684-9002	FN	Computer security services
Summit Pest Management	8185 SW Hunziker St, Tigard, OR 97223	503-694-4651	Pest	Pest control services
Junk King Portland	8195 SW Hunziker St, Portland, OR 97223	503-549-4734	Junk	Garbage collection services
Horizon Distributors	8250 SW Hunziker St Suite c, Portland, OR 97223	503-670-9949	HD	Landscape and irrigation supply store
n/a	8254 SW Hunziker St, Tigard, OR 97223	n/a	n/a	n/a
Knez Building Materials Co.	8185 SW Hunziker St, Tigard, OR 97223	503-620-6142	Knez	Building materials store
Steeler Inc.	8185 SW Hunziker St, Tigard, OR 97223	503-431-2000	SI	Steel construction company
Star Oil Commercial Fuel - CFN	8185 SW Hunziker St, Tigard, OR 97223	n/a	Oil	Oil service provider
Fred Shearer & Sons Inc	8015 SW Hunziker St, Tigard, OR 97223	503-520-9991	FSS	Wall and ceilings contractor
Biamp	8005 SW Hunziker St, Tigard, OR 97223	n/a	n/a	Business park
KEY Home Furnishings Warehouse	7895 SW Hunziker St #8212, Tigard, OR 97223	503-598-9948	Key	Furniture warehouse

Madison Furniture Manufacturing Inc.	7805 SW Hunziker St, Tigard, OR 97223	503-684-9467	MFM	Furniture maker
Huttig Building Products	8100 SW Hunziker St, Tigard, OR 97223	503-620-1411	HBS	Wholesale building materials distributor
Northwesting Demolition and Dismantling	8200 SW Hunziker St, Tigard, OR 97223	503-638-6900	Demo	Demolition contractor
Caseday Inc.	8200 SW Hunziker St, Tigard, OR 97223	n/a	n/a	Trucking company
Charter Mechanical	7940 SW Hunziker St, Portland, OR 97223	503-691-1700	CM	Mechanical contractor
Regenyx	4 SW Wall St, Tigard, OR 97223	503-217-3160	Reg	Plastic recycling facility
Terex Services	12805 SW 77th Pl, Tigard, OR 97223	503-620-0611	Ter	Truck repair shop
n/a	12805 SW 77th Pl, Tigard, OR 97223	n/a	n/a	n/a
Artistic Auto Body - Tigard	7585 SW Hunziker St, Tigard, OR 97223	503-639-9200	AAB	Auto body shop
York Tigard Apartments	7582 SW Hunziker St, Tigard, OR 97223	971-254-4208	Trion	Apartment complex
The Fields Apartments	7790 SW Hunziker St, Tigard, OR 97223	503-210-9073	Fields	Apartment complex
Wall St Industrial Development				
TerraFirma Foundation Systems	13110 SW Wall St, Portland, OR 97223	866-486-7196	TFFS	Foundation contractor
Agilyx	13240 SW Wall St, Tigard, OR 97223	503-217-3160	Ag	Plastic recycling facility, partner of Regenyx
Parcel 2 Office Building				
Knoll at Tigard	12291 SW Knoll Dr, Tigard, OR 97223		Knoll	Apartment complex
Mannahouse Church	12244 SW Garden Pl, Tigard, OR 97223	503-255-2224	Mann	Place of worship
CTA Pathology	12254 SW Garden Pl, Tigard, OR 97223	503-906-7300	CTA	Medical
Chester Lab Net	12242 SW Garden Pl, Tigard, OR 97223	503-624-2183	Chester	Office
Wunderlich-Malec Engineering	12180 SW Garden Pl, Tigard, OR 97223	503-620-0809	Wunder	Engineering
FastSigns	12176 SW Garden Pl, Tigard, OR 97223	503-994-2865	Fast	Engineering
Nature by Designs	12156 SW Garden Pl, Tigard OR 97223	503-863-7857	Nature	Plant store
Office Furniture	12168 SW Garden Pl, Tigard, OR 97223	503-352-5378	Office	Furniture retail store
Sit Stand World	12158 SW Garden Pl, Tigard, OR 97223	503-863-7316	SitStand	Furniture retail store
Oregon Mobility Solutions	12154 SW Garden Pl, Tigard, OR 97223	503-991-4100	Mobility	Wheelchair vans
SFA Design Group	12112 SW Garden Pl, Tigard, OR 97223	503-641-8311	SFA	Engineering consultant

Crossfit	12120 SW Garden Pl, Tigard, OR 97223	971-344-5826	Crossfit	Exercise studio
3-Point Brand Management	12072 SW Garden Pl, Tigard, OR 97223	503-620-3410	3-PT	Wholesaler
Rokke Performance Therapy	12070 SW Garden Pl, Tigard, OR 97223	503-619-7249	Rokke	Physical therapy
Expressions Printing	12060 SW Garden Pl, Tigard, OR 97223	503-684-3443	Print	Print shop
BMW	12010 SW Garden Pl, Tigard, OR 97223	503-597-7097	BMW	Dealership
Skyhook Ninja Fitness	12008 SW Garden Pl, Tigard, OR 97223	503-352-9608	Ninja	Exercise studio
Skyhook Construction	12008 SW Garden Pl, Tigard, OR 97223	503-352-9608	Skyhook	Construction
Jacuzzi Bath Remodel of Portland	11954 SW Garden Pl, Tigard, OR 97223	503-743-0304	Jacuzzi	Construction
ELXR Dance/Spectra	11959 SW Garden Pl, Portland, OR 97223	971-319-3597	Elxr, Spec	Dance studio
Enterprise	11844 SW Pacific Hwy, Tigard, OR 97223	503-624-7900	Enterpr	Car rental agency
Mitsubishi	11880 SW Pacific Hwy, Tigard, OR 97223	503-777-2886	Mistubi	Dealership
Shell	11834 SW Pacific Hwy, Tigard, OR 97223	503-968-6791	Shell	Gas station
Adjacent Areas of Interest:				
Walmart Supercenter	7600 SW Dartmouth St, Tigard, OR 97223	503-268-5270	WalM	Retail department store
Lowes Home Improvement Center	12615 SW 72nd Ave, Tigard, OR 97223	503-624-2644	Lowes	Home improvement store
Costco Wholesale	7850 SW Dartmouth St, Tigard, OR 97223	503-639-0811	Costco	Warehouse store
WinCo Foods	7501 SW Dartmouth St, Tigard, OR 97223	503-443-3934	Winco	Supermarket

REFERENCES

1. https://www.newyorker.com/magazine/2015/07/20/the-really-big-one
2. https://www.nrel.gov/docs/fy19osti/74673.pdf
3. https://www.globalchange.gov/browse/indicators/billion-dollar-disasters
4. https://www.energy.gov/sites/default/files/2013/08/f2/Grid%20Resiliency%20Report_FINAL.pdf
5. https://ieeexplore.ieee.org/document/6663332
6. https://www1.nyc.gov/site/buildings/codes/greenhouse-gas-emission-reporting.page
7. https://newscenter.lbl.gov/2015/01/13/berkeley-lab-illuminates-price-premiums-u-s-solar-home-sales/
8. https://www.cbinsights.com/research/solar-explainer/#finance
9. https://www.sciencedirect.com/science/article/abs/pii/S0960148118305305?via%3Dihub
10. https://www.solar.com/learn/solar-panel-installation-cost/
11. https://www.solar.com/learn/solar-panel-cost/
12. https://www.lazard.com/media/451881/lazards-levelized-cost-of-energy-version-150-vf.pdf
13. https://www.sciencedirect.com/topics/engineering/energy-payback-time
14. https://www.eia.gov/todayinenergy/detail.php?id=40913#:~:text=Investor-owned%20utilities%2C%20or%20IOUs,the%20East%20and%20West%20coast
15. https://portlandgeneral.com/about/who-we-are/climate-goals
16. https://www.opb.org/article/2021/06/26/oregon-lawmakers-carbon-emissions-reduction-goals-state-energy-grid/
17. https://portlandgeneral.com/energy-choices/generate-power/net-metering/net-metering-map
18. https://www.arcgis.com/apps/webappviewer/index.html?id=959db1ae628845d09b348fbf340eff03
19. https://portlandgeneral.com/about/info/pricing-plans/time-of-use/time-of-use-pricing-business
20. https://www.pge.com/tariffs/electric.shtml#COMMERCIAL
21. https://www.eia.gov/todayinenergy/detail.php?id=39832
22. https://pvwatts.nrel.gov/pvwatts.php
23. https://grist.org/climate-energy/utilities-for-dummies-how-they-work-and-why-that-needs-to-change/
24. https://www.oregon.gov/puc/about-us/Pages/default.aspx#:~:text=Our%20Mission,of%20the%20regulated%20public%20utilities.
25. https://www.energy.gov/sites/default/files/2021/02/f82/Guide%20to%20the%20Federal%20Investment%20Tax%20Credit%20for%20Commercial%20Solar%20PV%20-%202021.pdf
26. https://www.greenlancer.com/post/solar-carports#:~:text=In%20the%20U.S.%2C%20a%20standard,PV%20panels%20costs%20around%20%242%2C500
27. https://www.nrel.gov/docs/fy22osti/80694.pdf
28. https://insider.energytrust.org/wp-content/uploads/solar_status_report.pdf
29. https://electrek.co/2020/03/31/tesla-powerpack-price-commercial-solar/
30. https://www.nrel.gov/docs/fy21osti/79236.pdf

31. https://www.ford.com/trucks/f150/f150-lightning/
32. https://www.nrel.gov/analysis/crest.html
33. https://www.tigard-or.gov/home/showpublisheddocument/1234/637653179525600000#:~:text=For%20the%202015%20Water%20Revenue,Limit%20Oregon%20statutes%20ORS%20287A.
34. https://www.tigard-or.gov/home/showpublisheddocument/2345/637848376834230000H
35. https://www.tigard-or.gov/home/showpublisheddocument/2345/637848376834230000
36. https://portlandgeneral.com/about/who-we-are/community/renewable-dev-fund#:~:text=Interested%20parties%20can%20access%20the,accordance%20with%20established%20evaluation%20criteria.
37. https://assets.ctfassets.net/416ywc1laqmd/7hSId3nsOGyuyvq7n5izNX/41c9027d6908be25b3f22b65a60cd495/2022_RDF_Guidelines_FINAL__002_.pdf
38. https://www.oregon.gov/energy/Incentives/Documents/2022-3-7-CREP-OA-22-001.pdf
39. https://www.fema.gov/grants/mitigation/building-resilient-infrastructure-communities#resources
40. https://www.oregoncsp.org/pim/
41. https://www.energytrust.org/community-solar/
42. https://www.tigard-or.gov/your-government/departments/community-development/planning/projects/tigard-made
43. https://www.vox.com/2014/10/24/7059995/solar-power-is-contagious-neighbor-effects-panels-installation
44. https://www.eia.gov/tools/faqs/faq.php?id=74&t=11
45. https://www.oregon.gov/energy/energy-oregon/Pages/Electricity-Mix-in-Oregon.aspx
46. https://about.bnef.com/blog/carbon-offset-prices-could-increase-fifty-fold-by-2050/#:~:text=New%20York%20and%20London%2C%20January,research%20company%20BloombergNEF%20(BNEF).
47. https://www.novoco.com/periodicals/articles/current-ten-things-know-when-combining-renewable-energy-and-low-income-housing-tax-credits
48. https://washcotax.co.washington.or.us/Property-Detail/PropertyQuickRefID/R458971/PartyQuickRefID

Additional Resources

1. https://pvwatts.nrel.gov/pvwatts.php
2. https://cdn2.hubspot.net/hubfs/5055051/Offers/Energy%20Benchmarking%20Report%20-%20Iota.pdf?utm_campaign=Offer%3A%20Energy%20Benchmarking%20Report&utm_medium=email&_hsmi=72631957&_hsenc=p2ANqtz-95FOgp8oDSo5WcrMfoValbeFqr7fz9L5e2hJICwrT0MHOFOymeJcbbayEiPpfuSLOjj80zWnEg0BtFne3Yg8PLu8frSQ&utm_content=72631957&utm_source=hs_automatio
3. https://news.energysage.com/solar-tax-credit-explained/
4. https://www.oregon.gov/energy/energy-oregon/Pages/Electricity-Mix-in-Oregon.aspx
5. https://www.sciencedirect.com/topics/engineering/energy-payback-time
6. https://news.energysage.com/commercial-solar-benefits-for-business/

7. https://www.solar.com/learn/solar-panel-installation-cost/
8. https://www.solar.com/learn/solar-panel-cost/
9. https://www.lazard.com/media/451881/lazards-levelized-cost-of-energy-version-150-vf.pdf
10. https://www.oregoncsp.org/wp-content/uploads/2021/03/PIM-v20210112.pdf
11. https://insider.energytrust.org/wp-content/uploads/solar_status_report.pdf
12. https://pages.stern.nyu.edu/~adamodar/New_Home_Page/datafile/ratings.htm
13. https://ycharts.com/indicators/10_year_treasury_rate
14. https://emma.msrb.org/OSPreview/OSPreview.aspx?documentId=ER935392&transactionId=ER1195263&fileId=ER1336410
15. https://www.tigard-or.gov/home/showpublisheddocument/1234/637653179525600000