June 26, 2019
via e-mail

Mr. Michael Capuano, Chair
Somerville Planning Board
City Hall
93 Highland Avenue
Somerville, MA 02143

Reference: **D2.2-D2.3 – 20, 50 Prospect Street**
Resiliency Questionnaire Supplement

D2.2-D2.3 | PATHWAY TO NET ZERO EMISSIONS

The City has been engaged in a multi-year planning process to achieve carbon neutrality by 2050. Steps taken to date include the development of the City's first Greenhouse Gas Inventory (2016), the Carbon Neutral Pathways Assessment (2017), and the Somerville Climate Change Vulnerability Assessment (2017). The planning steps most recently culminated in Somerville Climate Forward (SCF – 2018), Somerville's first comprehensive climate change plan. The plan represents a set of implementable actions that will reduce Somerville's contribution to GHG emissions while increasing city resiliency to unavoidable impacts of climate change. Somerville's buildings, mobility, environment, community, and leadership are identified as distinct categories that will drive 13 identified action areas, all of which maintain relationship to the D2 Projects.
Buildings, both new and existing will play a significant role in achieving the City's carbon neutrality goal. Consensus around compliance objectives for Somerville Climate Forward are still being explored but are described as potentially including:

- High energy efficiency design, such as achieving Passive House or other recognized building certification programs;
- Electrification of building systems, including heating, hot water and cooling;
- On site and/or off-site renewable energy development; and
- Purchase of verifiable carbon offsets.

Although compliance objectives have not yet been defined, this report provides US2's approach to addressing each of the potential target areas of energy efficient design, electrification, on and offsite renewable energy, and green power purchasing. These achievements through buildings are further supported by mobility and public realm enhancement actions described in summary below that position the project as a resilient model. (These are expanded on in further detail elsewhere in the Design and Site Plan Review application and the applicant's Final Environmental Impact Report EEA# 15889.)

- Mobility Actions: reduce vehicle trips, incentivize green and electric vehicles, encourage bicycle use, and increase MBTA ridership

- Public Realm Enhancements: increase walkability, expand tree canopy, combat the urban heat island effect, implement green infrastructure, etc.

Somerville Climate Forward also identifies the role of the City to incentivize and facilitate Net-Zero buildings. While not yet enacted, identified development incentives of relaxed building height, increased density, reduced off-street parking requirements, reduced fees and expedited permitting may be considered to further guide and incentivize future development projects. Since there are not any specific incentives in place to support these objectives for D2, US2 has not assumed the availability of any City incentives in the analysis that follows.

1) An update to the Energy Use and GHG emissions modeling from the DEIR incorporating any changes to the building design that have been made since the modeling was initially completed.

The D2.2-D2.3 building design has been advanced since the filing of the DEIR. In the interest of eliminating envelope trade-offs and improving energy performance, D2.2-D2.3 was modified to reduce its window opening from 45% to 40% of its wall. This change brings the building's overall enclosure performance to better-than prescriptive code levels. All other modeling inputs remain unchanged from DEIR levels. In summary, the envelope performance details are shown in **Table 1** below with associated updates to GHG reduction achievements in **Table 2**.

Table 1 D2.2-D2.3 Envelope Performance Summary

Measure	Proposed	
	R Equiv	U
Roof	35	0.029
Insulated Wall	20.8	0.048
Window	2.4	0.420
Percent Window		40%
Aggregate Vertical Assembly	5.1	0.197

Table 2 D2.2-D2.3 GHG Reductions

Measure		Baseline	Proposed
EUI	kBtu/sf/yr	100.9	76
GHG Emissions	tons/yr	3,398	2,899
GHG Reduction		0	-14.7%

2. A description of the building's envelope performance as compared to code, including a comparison of designed window area with code specified window area.

Table 3 provides a comparison of the proposed envelope performance as compared to code.

Table 3 D2.2-D2.3 Envelope Performance as Compared to Code

Measure	Baseline		Proposed	
	R Equivalent	U Value	R Equivalent	U Value
Roof	31.3	0.032	35.0	0.029
Framed & Insulated Wall	18.2	0.055	20.8	0.048
Percent wall	60%		60%	
Window	2.4	0.420	2.4	0.420
Percent Window	40%		40%	
Aggregate Vertical Assembly	5.0	0.201	5.1	0.197

3. A technical description of how the building will transition to net zero emissions, including how and when systems can be transitioned in the future to carbon-free alternatives (provide timeline including 2030, 2040, and 2050 targets). Description must include whether any remaining emissions will be offset with on-site or off-site renewables and at what quantity.

<u>D2.3 Tower | 50 Prospect Street</u>

The D2.3 HVAC system utilizes water source heat pumps for space heating and cooling. The building heating is provided by three (3) 3500 MBH natural gas fired condensing boilers, as well as the heat of rejection from the heat pump compressors. Cooling for the condenser water loop is provided by a 700-ton, 30-hp cooling tower. Fresh air ventilation units will be provided with energy recovery wheels for energy savings.

The project will be investigating the implementation of a hybrid boiler plant that converts to electric boilers for heating over a period of time. This will allow the cost of operation of the building to benefit from advances in technology and optimization of the power grid for renewable source energy.

Initially the boilers will be gas fired. Over time, a replacement strategy from gas fired to electric boilers will be implemented with the intention of having the primary source for heating to be electric with gas fired as emergency backup should heat recovery systems fail.

Boiler replacement is proposed to begin in 2040 where one of the three 3500 MBH boilers would be replaced. The gas-fired boiler would be replaced with one (1) 825 KW electric boiler. Space will be allocated in the penthouse to support this replacement. Power feeds to the penthouse would be designed now to support this transition.

Domestic water heating is provided by two (2) 1,300 MBH natural gas fired storage type water heaters. Initially the water heaters will be gas fired. Over time, a replacement strategy from gas fired to electric water heaters will be implemented.

Replacement is proposed to begin in 2040 where one of the two 1,300 MBH water heaters would be replaced with two (2) 198 KW electric water heaters. Space will be allocated in the penthouse to support this replacement. Power feeds to the penthouse would be designed now to support this transition.

Incoming electric service will be coordinated with Eversource to support the incremental increase associated with supporting the future electric boilers. The electrical distribution infrastructure would need to accommodate an additional 1000 amps at 480V for the (1) 825 KW electric boiler and 477 amps at 480V for the (2) 198 KW electric water heaters. The combined future load would require a separate 1600 amp electric service at 480V.

D2.2 Midrise | 20 Prospect Street

The D2.2 HVAC system utilizes high efficiency DX split systems for cooling and Aquatherm condensing domestic water/boilers for heating. One single zone system is provided for each apartment. Fresh air ventilation units will be provided with energy recovery for energy savings. Unit domestic water heating and space heating (indirect through the AHU) is provided by one (1) 199 MBH natural gas fired, instantaneous water heater.

The project will be investigating the implementation of single zone VRF heat pump outdoor units that directly replace the DX split systems over time. This will allow the cost of operation of the building to benefit from advances in technology and optimization of the power grid for renewable source energy.

HVAC replacement strategy would begin in approximately 2040 as the initial DX outdoor units begin to need replacement. The new VRF outdoor units are envisioned as one-to-one drop in replacements and would provide both heating and cooling as cold climate heat pumps. The indoor air handlers and refrigerant line sets would remain, but the heating coil will be disconnected from the domestic water heaters.

Initially the water heaters will be gas fired. Over time, a replacement strategy from gas fired to electric water heaters will be implemented. Replacement is proposed to begin in 2040 where the units will be phased over to storage type hybrid-electric water heaters. The 199 MBH water heater would be replaced with one (1) 4.5 KW electric heat pump storage water heater. Space will be allocated in the units to support this replacement. Power feeds to the units would be designed now to support this transition.

D2.2-2.3 Renewables:

Although future system efficiencies are unknown, US2 would look to renewable energy sources to offset remaining emissions. At the present time, on site renewable energy generation is challenged by the nature of the D2 site (as described in item #6 of this report) suggesting renewable opportunities are best pursued off-site. As such, the project is making a commitment to procure 100% of D2.2-D2.3's energy needs from a qualified green power source for a period of 10 years. This third-party provider will be certified by the Green-E Certification program to ensure the highest level of quality and consumer assurance through the chain of custody. The 10-year time period will allow the assessment of changing market dynamics around renewables and inform the best path towards continued emissions reductions and/or offsets over the long term.

4. Evaluation of energy usage and GHG emissions of Passive House building envelope, compared with Code envelope. Passive House will generally be the most effective way to reduce environmental and climate impacts across the site. Refer to DOER comments on the DEIR for guidance and comparable Passive House Projects.

DOER comments to the DEIR were referenced for guidance in the development of the Final Environmental Impact Report for EEA# 15889. In response to this guidance, a thorough Passive House analysis was performed by a certified Passive House Consultant to inform the decision-making process. In advance of this report and at the suggestion of the DOER, US2 undertook considerable due diligence to ensure any assumptions were consistent with those of experts in the field who were familiar with both the opportunities and obstacles associated with what was described by the co-Founder of Passive House Institute US, Katrin Klingenberg, as "an engineering feat." US2 attended conference (PHMass, NAIOP), and engaged owners (Affordable Housing Developers), engineers, and consultants (Building Evolution Corporation, BR+A) to understand the engineering and pre-design challenges associated with Passive House. Subsequently, US2 heard firsthand of the complexities of implementation and the importance of team experience from Commodore Builders, the general contractor of Boston's first certified multi-family project (The Distillery) and a residence hall at Wheaton College. Lastly, together with the Union Square Neighborhood Council, US2 also met with ICON Architecture, the architect and team member with Commodore Builders of the Distillery Project.

This due diligence with subject thought leaders was instrumental in understanding the technical nature of Passive House, its associated hurdles and constraints, in parallel with the opportunities for innovation and the benefits it could provide. In concert with DOER comments, the scope of this Passive House Analysis focused on residential buildings, in particular those in later project phases. The D3.2 project, with high-rise tower and midrise component, is most similar to D2.2-D2.3, and observed emissions reductions of 52.8% relative to the code baseline. Available incentives and operational savings considered; it was estimated that the premium costs to pursue this alternative would be 'paid back' in approximately eight years. (12.7 years without incentives) This pay back would be achieved for the owner, only if the owner were to benefit from the operational savings. Practically, this is contradictory to the market expectation for tenants to pay gas and electric bills. Please see Appendix E3 of the FEIR for the full report and supporting detail.

As it relates to D2.2-D2.3 specifically, a Passive House project would achieve greater GHG emissions reductions as compared to an alternative project built to code. With an Energy Use Index of 20 kBtu per square foot per year and all inputs being electric, GHG Emissions would be 820 tons per year. This would result in a 76% reduction in emissions relative to the code envelope. These outputs are summarized in **Table 4.**

Table 4 D2.2-D2.3 EUI and GHG Emissions Comparison: Code and Passive House

	Baseline	Passive House
Energy Use Index	100.9 kBtu/sf/yr	20 kBtu/sf/yr
GHG Emissions	3,398 tons/yr	820 tons/yr
% Difference from Baseline	n/a	-76%

5. Feasibility analysis of full electrification (fully electrifying space and water heating). Evaluate energy usage and GHG emissions of aggressive electrification design to compare with current design. Must include cost analysis, including operational cost. Include estimate of Alternative Energy Credit value.

With the Massachusetts electric grid projected to continue its downward GHG emissions trend through a greater reliance on renewable resources as time goes, a study investigating the potential of aggressive electrification was developed for the D2.2-D2.3 project. This analysis includes the projected energy use and GHG emissions with a comparison of achievement against the baseline and proposed cases. In order to understand financial feasibility of electric HVAC systems, an economic evaluation was conducted, applying currently available incentives and annual operational savings against increased first costs.

Comprised of both a midrise and a high-rise component, the potential for electrification is considered relative to the constraints presented by each. As a 25-story residential tower, D2.3 is not suited to employ VRF technology as it encounters limits of vertical reach relative to piping length, vertical height, and refrigerant charge limits to meet safety code. Louvered mechanical rooms at each floor's exterior wall in order to limit piping runs might overcome this constraint, however mounted, perimeter equipment presents a challenge in fulfilling zoning development standards while complicating project marketability by displacing the windows and associated views otherwise afforded by the tower's height.

As designed, the midrise component of the project, D2.2, is planned with a hot water/direct expansion (DX) split system utilizing "Aquatherm" air handler units at each apartment. The AHU's are supplied heating and cooling via each apartment's tankless condensing hot water heater and high efficiency air-cooled condensing unit, respectively. A dedicated outside air system with energy recovery will provide fresh air ventilation and a means for central exhaust. At a more appropriate scale for VRF technology, D2.2 was evaluated for electric systems, modeling an alternative case that introduced VRF HVAC systems with heat pump domestic hot water.

A summary of the findings of this approach to electrification is shown in **Table 5**. As identified below, when factoring in all available incentives, electrification of the D2.2 building results in an extended payback period (290 years), while achieving less than 1% of additional GHG reduction against the baseline. The detail of comparable building EUI and achieved GHG emissions reductions is provided as **Table 6**, and contrasts performance of the Baseline building, the Proposed, the DEIR Proposed, and the alternative electrification approach described above.

Table 5 D2.2-D2.3 Electrification Summary

	Baseline	Proposed	With Electrification
Energy Use Index (kBtu/sf/yr)	100.9	76	73.7
GHG Emissions Reduction		-14.7%	-15.6%
Premium Cost			$945,000
MassSave Incentive		$210,204	$238,837
Alt. Energy Credit			$182,250
Effective Cost Increase			$734,118
Operational Savings		$43,996	$46,530
Simple Payback (years)		n/a	289.6

Table 6 D2.2-D2.3 Modeled Alternatives

Modeled Conditioned space	394,694 sf
Design Conditioned space	394,694 sf
Factor	1.0

		Baseline	FEIR Proposed	DEIR Proposed	Alternative 3 VRF w/ DOAS[1] HP DHW
DIRECT (NATURAL GAS)		MMBtu/yr	MMBtu/yr	MMBtu/yr	MMBtu/yr
Space Heating		9,161	961	1,059	645
Domestic Hot Water		7,175	3,915	3,915	2,781
	subtotal	16,337	4,876	4,974	3,426
INDIRECT (ELECTRICITY)		MWh/yr	MWh/yr	MWh/yr	MWh/yr
Space Cooling		1,345	1,195	1,213	1,116
Space Heating		0	155	172	175
Domestic Hot Water		2	0	0	237
Fans Interior		733	997	1,008	984
Pumps		9	330	343	320
Heat Rejection		0	12	13	13
Internal Lighting		1,267	1,148	1,148	1,148
Misc. Equipment		3,525	3,525	3,525	3,525
	subtotal	6,881	7,362	7,423	7,518
ENERGY USE INDEX	PNNL reference[4]	kBtu/sf/yr	kBtu/sf/yr	kBtu/sf/yr	kBtu/sf/yr
	47.6	100.9	76.0	76.8	73.7
	Diff, % (compared to baseline)		-25%	-24%	-27%
GHG EMISSIONS		tons/yr	tons/yr	tons/yr	tons/yr
Direct	Gas-burning	956	285	291	200
Indirect	Electricity	2,443	2,614	2,635	2,669
	Total	3,398	2,899	2,926	2,869
	Diff, tpy		-499	-472	-529
	Diff, % (compared to baseline)		-14.7%	-13.9%	-15.6%

CO_2 Emission Factors:

Electricity [2]	710 lb/MWh
Natural Gas [3]	117 lb/MMBtu

[1] VRF, heat pump water heater alternative in mid-rise residential (d2.2) only

[2] 2016 ISO New England Electric Generator Air Emissions Report

[3] EIA Fuel Emissions Factors, Weighted National Average (1029 Btu/scf)

[4] Pacific Northwest National Laboratory study, Massachusetts Zone 5A, ASHRAE 90.1-2013, Mid-Rise Apt.

6. An analysis of the size and cost of on-site and off-site renewable energy generation that would be required to offset the emissions of the building as currently designed.

Offsetting building emissions through on-site renewable energy generation is challenged by the nature of the D2 site. The area achieves limited regional wind productivity, is characterized by a heavily contaminated site that introduces constraints for geothermal opportunities, and has a rooftop area that is small relative to the area needed to offset building emissions through photovoltaics.

Offsite Renewable Energy Generation

As it relates to photovoltaics specifically, should a solar array be conceptualized at an off-site location, it is estimated that it would need to reach approximately 475,500 SF of PV area. The productivity of this area would offset the entirety of the 7,362 MWh of demand from the building. These results, as estimated through *the National Renewable Energy Laboratory* have been attached for reference.

Estimating the cost of such an array is difficult absent both a determined location that permits a study of its solar productivity and the location's land cost. Excluding the cost of land and assuming the found location reflects similar productivity levels to that of the Union Square area, US2's FEIR detail provided in consultation with Solect-Energy, a third-party provider, estimated a project cost of $2.23 per KWh of electricity production. Applied to the production target of 7,362 MWh results in an estimated cost of $16 million. The summary table of the area's PV Productivity Analysis is attached for reference. Please see Appendix E6 of the FEIR for supporting detail.

On-Site Renewable Generation

While implementation of an array of this size and cost is impractical, photovoltaic technology has been improving steadily over the years, and stands to increase in efficiency. In the interest of integrating adaptive-capacity within the project to accommodate this future potential, the D2.2 project will be constructed to be PV-ready, ensuring as the nature of feasibility invariably improves over time, the project will be positioned to employ the renewable energy resource.

In addition to the rooftop being PV-ready, the aforementioned productivity analysis developed for the FEIR assessed rooftop potential across the Union Square redevelopment area as a whole, identifying opportunities to take maximum advantage of solar production. As part of this exercise, US2 committed to an aggregate area of 40,000 SF that would be set aside across project rooftops providing the ability to take advantage of scale and improve the PV opportunity over time. For the D2.2 rooftop, this set aside area is 10,200 SF. With implementation, this area is estimated to generate 119,203 kWh of electricity.

Although this production is meaningful, it would not offset the totality of the building's energy demands. However, US2 has committed to procure 100% of D2.2 and D2.3's energy needs from a qualified resource for green power, carbon offsets or renewable energy certificates for a period of 10 years. This third-party provider will be certified by the Green-E Certification program to ensure the highest level of quality and consumer assurance through the chain of custody. The 10-year time period will allow the assessment of changing market dynamics around renewables and inform the best path towards continued emissions reductions and/or offsets over the long term.

7. Description of incentives, rebates, grants provided by utilities, government organizations, and other organizations being pursued to maximize building efficiency and to reduce emissions. Description must include any incentives that were considered but are not being pursued, including reasoning for each decision.

The proponent has met with Eversource representatives to discuss available MassSave incentives. MassSave incentives are awarded on a "whole-building" basis, where the proposed design is compared to a MassSave baseline. The MassSave baseline is typically calculated by an approved MassSave modeler. The MassSave baseline will be more stringent than the code-compliant baseline utilized in State permitting. However, the code-compliant baseline can be used to approximate incentives.

Estimated as part of the DEIR, the proposal expects to pursue the approximate $210,000 in available MassSave gas incentives, as depicted in **Table 7**.

State Alternative Energy Credits (AECs) would be available with the incorporation of VRF systems. While this system alternative and incentive was studied and valued, VRF technology will not be employed in the project and so the incentive is not available.

Similarly, MassCEC credits for heat pumps have been phased out and are no longer available.

Table 7 **D2.2-D2.3 Approximate Mass Save Incentives**

		Baseline	DEIR Proposed
DIRECT (NATURAL GAS)		MMBtu/yr	MMBtu/yr
Space Heating		9,161	1,059
Domestic Hot Water		7,175	3,915
Misc. Equipment		0	0
	subtotal	16,337	4,974
	Dif from Baseline		11,362
INDIRECT (ELECTRICITY)		MWh/yr	MWh/yr
Space Cooling		1,345	1,213
Space Heating		0	172
Domestic Hot Water		2	0
Fans Interior		733	1,008
Pumps		9	343
Heat Rejection		0	13
Internal Lighting		1,267	1,148
Misc. Equipment		3,525	3,525
	subtotal	6,881	7,423
	Dif from Baseline		-542
MassSave Incentives	Gas		$210,204
	Electric		-
	Total		**$210,204**

Incentive Rate		
Electricity	$0.35	per kWh
Natural Gas	$1.85	per Therm

Green Vehicles

8. The applicant does not include plans for any additional EV ready spaces beyond the 10 spaces that will have access to installed EV charging. Most charging of electric vehicles takes place at home or at work. Given that the shared garage will serve both residential and workplace uses, and the adoption of electric vehicles is expected to continue to grow each year, it is likely that there will be an increased demand for EV charging within the garage. Electric vehicles produce less pollution and therefore will help improve local air quality as well as reduce climate change-causing greenhouse gas emissions. Examples from other leading cities have shown that installing "EV ready" or "EV capable" spaces during construction is more cost effective than retrofitting after construction. Evaluate and compare the upfront and retrofit costs of installing conduit, dedicated circuit, wiring and outlet in 10 years to serve 10%, 25%, 50%, and 100% of the spots with the assumption that panel capacity could be added over time. Analysis should consider financial incentives that are available from Mass DEP or from Eversource's Make Ready Program. DEP currently has incentive programs for multifamily & workplace charging.

As currently planned, 10 electrical charging stations are proposed within the D2 garage. Since filing of the DSPR application, the applicant has met with Eversource representatives to discuss available Electric vehicle (EV) programs and incentives, and continued research into the potential to accommodate additional capacity for future charging stations. This additional capacity would provide the flexibility to respond to any increase in demand for electric charging- an expectation of the automotive market over time.

It has been found that incorporating adaptive capacity into newly constructed parking garages is more cost-effective than retrofitting parking garages after they have been built. A study from the City of San Francisco[1] found significant cost savings in conduit and raceways installed early, with circuit balancing, demolition and construction management also proving as areas for savings. In summary, their findings suggest that installing adaptive capacity for one additional EV charging space during new construction saves between $1,500 and $2,800 over a similar space retrofitted after construction has been completed. **Table 8** below summarizes the retrofit cost premium assuming it is applied to the outstanding D2 garage parking spaces. This summary does not value the necessary increased panel capacity but assumes it is added over time.

---

[1] Pike, Ed, et al. *Plug-In Electric Vehicle Infrastructure Cost-Effectiveness Report for San Francisco*. 17 Nov. 2016.

Table 8 Estimate Cost of Incorporating Adaptive Capacity for EV Charging

Parking Garage	Total Spaces	Proposed % of Spaces with EVCS	Total EVCS Ports Proposed	Added EV-Ready Spaces	Est. Cost for Additional Capacity During Construction	Est. Cost for Additional Capacity as Retrofit	Est. Retrofit Cost Premium
D2	270		10				
		10%	27	17	$ 15,130	$ 51,680	$ 36,550
		20%	54	44	$ 39,160	$ 133,760	$ 94,600
		40%	108	98	$ 87,220	$ 297,920	$ 210,700
		50%	135	125	$ 111,250	$ 380,000	$ 268,750
		100%	270	260	$ 231,400	$ 790,400	$ 559,000

Panel capacity is important to ensure functional, future charging spaces and was also studied to understand the potential to accommodate future spaces. **Table 9** identifies projected peak loading under each potential future condition, incorporating a load diversification assumption to better understand requisite number of electrical panels to serve this future demand.

Table 9 D2 Electric Vehicle Charging Station Analysis

Parking Garage	Total Spaces	Proposed % of Spaces with EVCS	Total EVCS Ports Proposed	Input Power per EVCS Port [kVA][1]	Peak Load on Landlord Service [kVA]	Total Demand Load with 50% Diversity [kVA][2,5]	Total Added Service Amps at 480V/3ph[A]	Total # of Electrical Panels Required [3]
D2	270	2%	6	6.24	37	19	23	1
		4%	10	6.24	62	31	38	1
		5%	14	6.24	87	44	53	1
		7%	20	6.24	125	62	75	1
		10%	27	6.24	168	84	102	2
		20%	54	6.24	337	168	203	3
		40%	108	6.24	674	337	405	6
		50%	135	6.24	842	421	506	7
		100%	270	6.24	1,685	842	1,011	13

Footnotes
1 EVCS input per port = 30.0 A
2 50% diversity for EVC's is typical. National Electrical Code contains no diversity requirements
3 Two poles per port, 42 poles max per panel
4 MA amendments to IECC 2018 expected to be issued in 2019, implemented January 2020
5 Demand below 400-kVA use dry-type transformer; above 400-kVA requires larger electrical switchgear lineup

Adjusted D2 Proposal

In combination, these studies have prompted the applicant to incorporate additional adaptive capacity into the garage. In addition to the proposed 10 EV charging spaces available at commencement of operations, an additional 10 EV-Ready spaces will also be incorporated. The project will also plan to make use of Eversource's Make Ready program to fulfill the infrastructure needs of the project. Together, these 20 ports will ensure 7% of garage spaces are allocated for electric vehicles, double the amount previously proposed. Further, additional capacity can also be added in the future by paying the modest premium to retrofit.

The D2 garage will support the Commonwealth's goals articulated in the 'Multi-State ZEV Action Plan' for zero emission vehicles. Together with allocations for carpool (5) and carshare spaces (2), preferences for low-emitting and fuel-efficient vehicles (14), and EV Charging and EV-Ready spaces (20)- the D2 garage incorporates the green infrastructure that will incent the use of sustainable modes, and accommodate changing consumer preferences over time.

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Caution: Photovoltaic system performance predictions calculated by PVWatts® include many inherent assumptions and uncertainties and do not reflect variations between PV technologies nor site-specific characteristics except as represented by PVWatts® inputs. For example, PV modules with better performance are not differentiated within PVWatts® from lesser performing modules. Both NREL and private companies provide more sophisticated PV modeling tools (such as the System Advisor Model at https://sam.nrel.gov) that allow for more precise and complex modeling of PV systems.

The expected range is based on 30 years of actual weather data at the given location and is intended to provide an indication of the variation you might see. For more information, please refer to this NREL report: The Error Report.

The energy output range is based on analysis of 30 years of historical weather data for nearby , and is intended to provide an indication of the possible interannual variability in generation for a Fixed (open rack) PV system at this location.

RESULTS

7,362,688 kWh/Year*

System output may range from 7,066,708 to 7,630,690 kWh per year near this location.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Value ($)
January	3.10	457,375	68,195
February	3.96	515,529	76,865
March	4.71	654,298	97,556
April	5.51	712,541	106,240
May	5.61	734,998	109,588
June	6.09	755,065	112,580
July	6.50	819,071	122,124
August	5.96	753,148	112,294
September	5.27	658,719	98,215
October	3.89	526,149	78,449
November	2.94	400,249	59,677
December	2.60	375,545	55,994
Annual	**4.68**	**7,362,687**	**$ 1,097,777**

Location and Station Identification

Requested Location	somerville, ma
Weather Data Source	Lat, Lon: 42.37, -71.1 1.3 mi
Latitude	42.37° N
Longitude	71.1° W

PV System Specifications *(Residential)*

DC System Size	5706.75 kW
Module Type	Standard
Array Type	Fixed (open rack)
Array Tilt	20°
Array Azimuth	180°
System Losses	14.08%
Inverter Efficiency	96%
DC to AC Size Ratio	1.2

Economics

Average Retail Electricity Rate	0.149 $/kWh

Performance Metrics

Capacity Factor	14.7%

Rooftop Solar Summary

	PV PRODUCTIVITY ANALYSIS[1]							FEIR COMMITMENT		
Lot	Potential Roof Area (SF)	Studied Roof Area (SF)	Potential kW DC	Potential kWh	Cost per Watt ($)	Project Cost ($)	Simple Payback	PV Set Aside (SF)	Potential Additional Set-Aside (SF)[2]	Note
1.1	6,849	6,849	79.2	89,296	2.68	212,000	8 yrs	6,700		*shading from 1.2 am and pm, from 2.1 in winter*
1.2	17,237	17,237	185.6	198,134	2.25	418,000	7 yrs		16,600	*good exposure*
2.1	-		-		-	-				*planned as lab, no available roof area*
2.2	14,066	10,626	115.4	119,203	2.41	278,000	8 yrs	10,200		*shading from 2.3, mid am to mid pm*
2.3	-		-		-	-				*mechanicals at tower roof, no available roof area*
3.1	15,352	15,352	185.6	198,134	2.25	418,000	7 yrs		14,800	*solar on south east and west, shading from 3.2*
3.2	7,946		-	-	-	-				*too much shading with limited array areas*
3.3	18,332	18,332	214.1	237,191	2.25	482,000	6 yrs		17,700	*shading from 3.2 in PM*
4.1	2,962	2,962	33.9	38,684	3.49	118,000	11 yrs	2,800		*shaded by 2.3, small area with extensive payback*
4.2	-	-	-	-	-	-				*no solar, too small*
4.3	9,897	7,112	93.6	113,537	2.61	244,000	7 yrs	6,800		*good exposure and productivity*
5.2	2,862	2,084	26.5	29,302	3.76	100,000	9 yrs	2,000		*small with shading from 1.1 and 1.2, highest cost/watt*
5.3	3,986		-		-	-				*unproductive, significant shading from 1.1 and 1.2*
6.1	4,487		-		-	-				*limited available area per zoning heigh sensitivities*
6.2	4,393		-		-	-				*limited available area per zoning heigh sensitivities*
7.1	6,680	4,317	60.8	68,123	2.86	174,000	8 yrs	4,100		*shading from 7.2 in am*
7.2	9,237	7,738	95.2	114,497	2.60	248,000	7 yrs	7,400		*good exposure and productivity*
Total	**124,286**	**92,609**	**1,090**	**1,206,101**		**2,692,000**		**40,000**	**49,100**	
kWh/SF				*13.02*						

Avg. Paybacl	8 yrs	
Maximum Potential Set Aside (SF)	**89,100**	*sum of PV Set-aside and Potential Additional Set-Aside*
Imputed Productivity (kWh)	1,160,401	*Maximum Potential Set Aside * 13.02kWh*
Imputed Cost	2,589,999	

[1] Analysis by solect energy provided on following pages

[2] Additional PV set-aside available in event buildings are delivered as office buildings. If lab, limited productive roof area would remain available.