MEMO

Date:	Monday, March 30, 2020
To:	The City of Kingston, New York
From:	Megan Day, Jal Desai, Emma Elgqvist, Sika Gadzanku, Kosol Kiatreungwattana, Katie Richardson, James Salasovich, Ella Zhou, National Renewable Energy Laboratory
Subject:	Kingston, New York Energy Efficiency and Photovoltaic Measures Analysis and Workforce Development Potential Summary

The National Renewable Energy Laboratory (NREL) conducted detailed modeling to identify optimized building energy efficiency measures and photovoltaic (PV) potential for a subset of residential, commercial, and city buildings in Kingston, New York. NREL then extrapolated findings to model efficiency savings potential at a larger set of city-owned buildings and conducted modeling of energy consumption and PV potential in the Franklin Street Revitalization District and Midtown District. This memorandum summarizes the optimized efficiency measures and associated energy savings potential, PV potential, and the number of full time equivalent (FTE) jobs generated if all efficiency measures were implemented and all potential PV systems were installed at the building subset and district scales; and defines the characteristics of and training resources for the workforce necessary to complete this work.

15013 Denver West Parkway
Golden, CO 80401
Phone 303-275-3000

NREL is a national laboratory of the U.S. Department of Energy
Office of Energy Efficiency & Renewable Energy
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Table of Contents

Tables

Figures

Executive Findings

In 2017, the city of Kingston, New York, committed to meet 100% power consumption with renewable energy sources by 2050. Leading by example, Kingston has already made significant strides in energy efficiency in city buildings; however, meeting the new, ambitious goal means that maintaining energy and housing affordability could be a challenge. The poorest residents of the city face a significant energy burden, spending up to a quarter of income on power and heating bills. NREL collaborated with city leadership to identify project priorities, which include going green while decreasing energy bills for low-income residents; promoting practical local investment; and creating community jobs. This in-depth analysis took a layered approach to realizing the city's vision, including residential, city-led, and district-scale analyses.

NREL finds that implementing optimized energy efficiency measures addressing building envelope and energy usage, including mini-split heat pump heating and cooling systems, across 15 Land Bank properties would result in an average of $2,400 in annual energy savings per residence, at a total estimated project cost of $695,000. In addition, a conservative estimate of energy efficiency retrofit costs for nine city-owned buildings shows that a $533,000 investment in building upgrades across a total of 144,492 square feet could yield approximately $76,000 of annual energy savings for the city. Depending on labor costs, these residential and city-building energy efficiency projects would likely generate between 5 and 28 FTEs.

Photovoltaic installations totaling 416 kW on these residential and city buildings, where not inhibited by shading, would cost approximately $1,247,000, generate an additional 12 FTEs and meet a significant portion of annual load. Extrapolating to the 39 single-family homes in the Franklin Street Revitalization District, NREL approximates that between 8 and 42 FTE energy efficiency jobs would be created and $93,000 in annual savings in energy usage costs would be achieved by investing $1,808,000. A detailed model of rooftop PV potential in the Franklin Street Revitalization District indicates an estimated $1,430,000 investment in rooftop PV would cover 100% of annual, modeled electric load. Layering in efficiency measures together with rooftop PV would enable the electrification of heating within the district, reducing overall energy demand, while still meeting 100% of the modeled load.

Table 1: Summary of Estimated Building Efficiency, PV, and Job Creation Potential at Various Scales in Kingston, New York

Buildings	Efficiency Annual Energy Savings Potential	Efficiency Investment	Efficiency Job Creation Potential (FTEs)	PV Potential (kW)	PV Investment	PV Job Creation Potential (FTEs)
Land Bank (15)	$36,000[1]	$695,000	3-16	38.6	$116,000[2]	0.9
City Owned (9 EE, 5 PV)	$76,000	$533,000	2-12	177	$531,000[5]	5.3
Metro	$52,000[3]	$300,000[4]	1.5 – 6.5	200	$600,000[5]	6
Franklin Street	$93,000	$1,808,000	8 - 42	640	$1,430,000[6]	10
Midtown District	$968,000	$18,731,000	54-299	4,400	$9,980,000[6]	70

Energy Efficiency Costs and Savings

NREL evaluated 15 buildings, 14 Land Bank houses and the 124 Franklin Street building, which will be renovated to become the new Land Bank offices, for residential energy efficiency opportunities.

[1] This estimate is very low as it compares optimized efficiency measures with mini-split heat pumps to a baseline of no efficiency measures but a lower efficiency mini-split heat pump. None of the residences currently have heat pumps.
[2] $3.00 / W_{DC} residential rate.
[3] This compares to an 80,000 sq. ft. building, modeled with annual baseline heating oil and electric costs with efficiency measures and a water-loop heat pump system.
[4] Based on a very rough approximation of $3.67/square foot for commercial energy efficiency implementation costs and an 80,000 sq. ft. building. Note that county assessor data shows that the Metro building is 70,268 square feet.
[5] $3.00 / W_{DC} commercial rate.
[6] $2.40 / W_{DC} residential and $1.60 / W_{DC} for commercial properties used per the REopt model inputs.

Table ***2*** summarizes the optimal energy conservation measures identified and the approximate costs of materials, equipment, and labor to implement each measure derived from the Building Energy Optimization Tool BEopt (version 2.8), which reflects cost data from January 2018.

15013 Denver West Parkway
Golden, CO 80401
Phone 303-275-3000

Table 2: Optimized Land Bank Building Residential Energy Efficiency Measures and Cost Metrics

Type of Measure	Measure	Materials & Equipment Cost	Labor Cost
Wall Insulation	R-23 Closed Cell Spray Foam	$1.30 per Sq. Ft. of Exterior Wall	$7.91 / Framing Factor-Sq. Ft. Exterior Wall
Attic Insulation	Ceiling R-60 Cellulose	$3.52 per Sq. Ft. Ceiling	$0.043 per Delta R- Sq. Ft. Ceiling
Basement Insulation	Ceiling R-30 Closed Cell Spray	$2.34 Sq. Ft. Ceiling	Not Available
Windows	Low-E, Double, Non-metal, Air, M-Gain	$13.88 per Sq. Ft.	Not Available
Doors	Fiberglass	$11 per Sq. Ft.	Variable: $3 per Sq. Ft.
Air Leakage	0.07 ACH	Not Available	$0.65 per Sq. Ft. finished floor
Mechanical Ventilation	ERV	Fixed: $260 Variable: $4.75 per CFM	Fixed: $618
Water Heating	Electric Tankless	Fixed: $1,075	Fixed: $565
Water Heating Distribution	R-2, TrunkBranch, Copper	$4.61 per foot pipe Pipe Insulation: $0.22 per Sq. Ft.	$6.45 per foot pipe
Lighting	100 % LED lights	$0.119 per Sq. Ft. (Living + Garage)	Not Available
Plug Loads	0.5 Watts per Sq. Ft.	Not Available	Not Available
Dishwasher	290 Rated kWh, DR Control	$800	Fixed: $283
Clothes Washer	Energy Star	$582	Fixed: $80
Clothes Dryer	Electric, Premium	$840	Fixed: $80
Refrigerator	Top Freezer EF: 21.9	$890	Fixed: $40
Ceiling Fan	Premium Efficiency	$202 per fan	Variable: $243 per fan

Additionally, NREL compared the energy savings realized through two heating, ventilation, and air conditioning (HVAC) options: either the installation of air conditioners and upgrades to the existing heating systems or the electrification of home heating and cooling through mini-split heat pumps. NREL found that the mini-split heat pump option uses approximately half the energy of HVAC systems with air conditioner units, saving considerable energy across all residences evaluated. Ductless mini-split heat pumps run at very high efficiencies, are a proven, modular technology, and are relatively easy to install. Furthermore, electrification of heating (and elimination of natural gas, heating oil, and propane heating fuels in these buildings) supports the city goal of 100% renewable energy by 2050.

Table 3: Residential Energy Efficiency Cost Assumptions for Air Conditioners and Mini-Split Heat Pump HVAC Options

Measures: Option 1 (Air Conditioner)

Type	Measure	Materials & Equipment Costs	Labor Cost
Heating	**Furnace, Gas 92.5 % AFUE or**	$/Unit: 1164 Variable: $3.86 per kBTUh Input	$1229 per unit
	Fuel Oil condensing boiler 96% efficient or	$41.77 per kBTUh	Fixed: $1993
	Natural Gas condensing boiler 96% efficient	$42.52 per kBTUh	Fixed: $1993
AC	**Air Conditioner SEER 24.5**	$42 per kBTUh $3149 per unit	$435 per unit
Insulation	**7.5 % Leakage, R-8**	Insulation: $0.34 per Sq. Ft. Ducting: $3.75 per Sq. Ft.	Fixed: $3.392 per Sq. Ft. Duct Surface Variable: $0.06 per Sq. Ft. Duct Surface

Measures: Option 2 (Mini-Split Heat Pumps)

Type	Measure	Materials & Equipment Costs	Labor Cost
HVAC	**Mini-Split Heat Pumps 9kBTUh/unit - SEER 33, 14.2 HSPF**	$96 per kBTUh Fixed: $415	Fixed: $1100 per unit

If the 15 Land Bank buildings are renovated according to the modeled, optimized measures listed in Table 3 and the mini-split heat pump option is implemented, Kingston would achieve an estimated average annual, per house energy savings of $2,400, assuming a residential electricity rate of $0.14/kWh. This represents an average savings of 62% compared to the energy usage of a baseline mini-split home as shown in Table 4.

Table 4: Impact of Energy Efficiency Savings Realized with Mini-Split Heat Pump

Address	Mini-Split Baseline Home [kWh]	Mini-Split Energy Efficient Home [kWh]	% Savings	Annual Savings ($)
169 Hurley	24,402	9,884	59%	$2,033
248 Main	30,239	11,116	63%	$2,677
149 Greenkill	34,140	11,321	67%	$3,195
111 Downs	32,351	11,175	65%	$2,965
20 Stephan	26,514	9,708	63%	$2,353
29 Rogers	28,215	10,412	63%	$2,492
29 Gill	23,346	9,386	60%	$1,955
237 East Union	18,595	8,418	55%	$1,425
174 Hasbrouck	20,824	8,564	59%	$ 1,716
28 Abbey	34,785	11,673	66%	$3,236
46 Grand	36,486	12,876	65%	$ 3,305
488 Hasbrouck	23,082	9,180	60%	$1,946
52 Grand	25,370	10,324	59%	$ 2,106
124 Franklin	31,969	8,066	75%	$3,347
24 Hamilton	16,249	7,714	53%	$ 1,195
Average	**26,757**	**10,125**	**62%**	**$2,396**

NREL also conducted a detailed evaluation of the Metro Building and the Central Fire Station for possible commercial building energy efficiency opportunities. Table 5 lists the optimized measures and costs associated with each on a square footage basis.

Table 5: Savings and Costs of Energy Efficiency Measures Identified for City Buildings

Energy Efficiency Type	Energy Efficiency Measure	Savings ($ per Sq. Ft.)	Implementation Cost ($ per Sq. Ft.)
Envelope	R-11.4 ci plus 2-inch board insulation	0.06	1.30
	R-40 roof insulation	0.01	0.44
	0.38 U-factor, 0.40 SHGC windows	0.12	1.69
	0.25 U-factor, 0.40 SHGC, IG windows	0.14	2.25
	Weather stripping	0.07	0.64
Lighting	30% lighting LPD reduction	0.07	0.25
	Occupancy sensors	0.02	0.16
HVAC & Controls	Programmable thermostat	0.03	0.10
	Condensing boiler[7]	0.13	0.64
	High efficiency VAV system	0.06	0.49

[7] A condensing boiler is used as an example here. However, detailed analysis of the Central Fire Station indicates that a retrofit package with mini-split heat pumps would deliver approximately 66% energy savings compared to 37% with a condensing boiler and AC system. Cost savings would be lower under a mini-split heat pump package (29% versus 40%) due to the higher cost of electricity compared to natural gas currently.

Total Project Costs

Using the cost assumptions outlined above, NREL modeled the final energy efficiency project costs across the 15 Land Bank residences evaluated (see Table 6).

Table 6: Residential Building Energy Efficiency Retrofit Costs

House Address	Total Initial Cost ($)	
	Option 1: Air Conditioner	Option 2: Mini-Split Heat Pumps
169 Hurley	$47,500	$44,100
248 Main	$58,100	$49,100
149 Greenkill	$69,700	$60,900
111 Downs	$62,900	$56,600
20 Stephan	$51,000	$47,200
29 Rogers	$53,700	$49,900
69 Gill	$42,100	$37,700
237 East Union	$35,300	$30,700
174 Hasbrouck	$39,500	$35,000
28 Abbey	$71,000	$64,100
46 Grand	$77,300	$68,200
488 Hasbrouck	$44,900	$41,400
52 Grand	$50,600	$43,800
124 Franklin	$44,800	$41,000
24 Hamilton	$30,000	$25,700
Total Cost	**$778,500**	**$695,500**

NREL found that the city will save approximately $75,800 annually at an estimated cost of $532,700 by implementing energy efficiency measures on the city-owned buildings NREL analyzed, as well as those included in the 2010 energy audit report (Malcolm Pirnie, Inc., 2010), as shown in

Table ***7***. Please note that this estimate based on 2020 costs is a conservative estimate compared to the previous report, which included additional information from direct energy audits. Detailed energy audits are necessary to obtain further information before any specific work is begun.

Table 7: City-owned Building Energy Efficiency Costs and Savings

Potential Energy Efficiency Measures Identified		City Hall	Police Station & Courthouse	Central Fire Station	Wiltwyck Fire Station (Uptown)	Rondout Fire Station
Envelope	R-11.4 ci plus 2-inch board insulation					
	R-40 roof insulation		x	x	x	x
	0.38 U-factor, 0.40 SHGC windows					
	0.25 U-factor, 0.40 SHGC, IG windows					
	Weather stripping	x	x	x	x	x
Lighting	30% lighting LPD reduction	x	x	x	x	x
	Occupancy sensors	x	x	x	x	x
HVAC & Controls	Programmable thermostat			x	x	x
	Condensing boiler	x		x	x	x
	High efficiency VAV System	x	x	x	x	X
Summary	Area (Sq. Ft.)	22,500	25,907	10,140	6,603	7,341
	Estimated Total Cost	**$106,600**	**$75,900**	**$35,800**	**$23,300**	**$42,400**
	Estimated Annual Savings	**$11,000**	**$9,300**	**$6,000**	**$3,900**	**$5,400**

Table 7, continued: City-owned Building Energy Efficiency Costs and Savings

	Potential Energy Efficiency Measures Identified	Public Work Garage	Rondout Neighborhood Center	Midtown Neighborhood Center (Andy Murphy)	Everette Hodge Community Center	Total
Envelope	R-11.4 ci plus 2-inch board insulation					N/A
	R-40 roof insulation	x	x	x	x	N/A
	0.38 U-factor, 0.40 SHGC windows					N/A
	0.25 U-factor, 0.40 SHGC, IG windows					N/A
	Weather stripping	x	x	x	x	N/A
Lighting	30% lighting LPD reduction	x	x	x	x	N/A
	Occupancy sensors	x	x	x	x	N/A
HVAC & Smart Controls	Programmable thermostat	x	x	x	x	N/A
	Condensing boiler	x	x	x	x	N/A
	High efficiency VAV System		x	x	x	N/A
Summary	Area (Sq. Ft.)	11,070	26,950	30,381	3,600	144,492
	Estimated Total Cost	**$33,500**	**$95,100**	**$107,200**	**$12,700**	**$532,700**
	Estimated Annual Savings	**$4,300**	**$15,900**	**$17,900**	**$2,100**	**$75,800**

NREL also calculated the total PV system costs using the System Advisor Model (SAM) for 14 residences, the 124 Franklin Street residential conversion, and six city/commercial buildings, assuming a cost of \$3.00/W_{DC}, which aligns with the CADMUS Group's pricing assumptions (Energy Sage, 2020). Please note that prices can vary from market to market and over time. Current market prices can be determined by issuing a Request for Proposal to installers.[8] Additionally, a 30% price contingency is a usual margin for projects although this analysis does not include such a contingency. A PV system size of zero kilowatts is shown where shading prevented a viable installation. Note that NREL modeled maximum potential photovoltaic capacity on these rooftops rather than optimizing system capacity for economic viability.

Table 8: Building Photovoltaic Capacity and Costs

Address	Maximum PV system size (kW)	Total Cost
169 Hurley	0	$0
248 Main	0	$0
149 Greenkill	1.7	$5,100
111 Downs	4.1	$12,300
20 Stephan	0	$0
29 Rogers	5.5	$16,500
69 Gill	2.8	$8,400
237 East Union	0	$0
174 Hasbrouck	3.8	$11,400
28 Abbey	3.5	$10,500
46 Grand	4.5	$13,500
488 Hasbrouck	4.1	$12,300
52 Grand	5.5	$16,500
124 Franklin	3.1	$9,300
24 Hamilton	0	$0
Total Residential	**38.6**	**$115,800**
Andy Murphy Community Center	79	$237,000
Metro Building	200	$600,000
Rondout Neighborhood Center	33	$99,000
Rondout Fire Station	36	$108,000
Central Fire Station	19	$57,600
Wiltwyck Fire Station	10	$30,000
Total Commercial	**377**	**$1,131,600**
Total – Commercial, Residential	**415.8**	**$1,247,400**

[8] https://www.nrel.gov/state-local-tribal/basics-solar-rfps.html

NREL also considered the most cost-effective combination of a battery storage system together with an optimized PV system on the Andy Murphy Community Center, which is a designated emergency shelter. A 43 kW PV system together with a 6 kW (10 kWh) battery system would cost an estimated $78,000 to install. The battery would be large enough to provide 1.67 hours of the total building's power needs from a full charge. As shown in Figure 1, the system is sized to provide 100% of the load on an annual basis; excess PV generation (above the building load) during certain hours would be exported to the grid under net metering (pink) or charge the battery (green). The battery would be dispatched to power the building at times when the load is high and generation from the solar system low (maroon). Together this PV/battery energy storage system (BESS) is projected to maximize savings over a 25-year system life and would save $42,000 compared to the business-as-usual scenario. Note that this analysis was based on cost-effectiveness: the building would still frequently be powered from the grid (blue) while taking advantage of solar power (orange) during the middle of the day. If providing the building power for a sustained period in the event of an outage is a higher priority for the city, different system sizes would result.

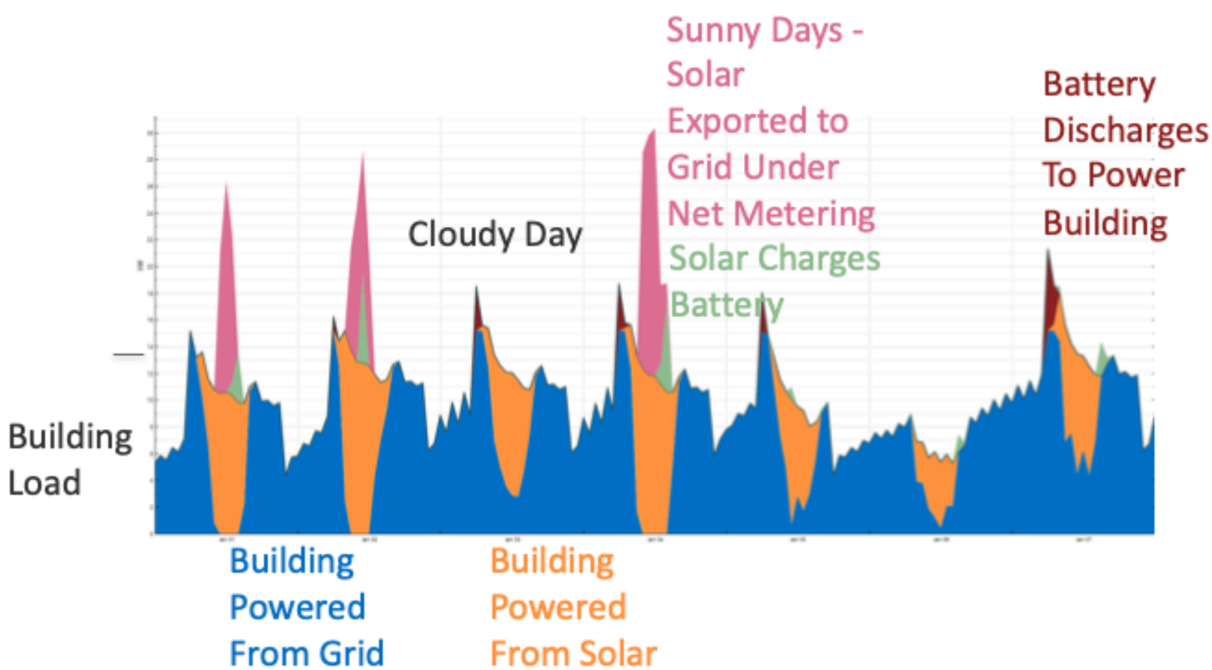

Figure 1: Andy Murphy building energy load over a typical week in January

Estimating Full-Time Equivalent Jobs from Total Project Costs

Because NREL's Jobs and Economic Development Impact (JEDI) model does not address energy efficiency economic impacts, some assumptions are necessary to make an estimate of the number of jobs created by implementing efficiency projects. These assumptions are detailed in Appendix A. By considering a range of prevailing wages in various jobs required to implement energy efficiency as well as a range of total project costs due to labor, between 3 to 13 direct FTEs would be required to complete the modeled Land Bank home efficiency measures and between 3 to 16 direct FTEs would be generated in pursuing the measures identified for the nine city-owned buildings.

To implement rooftop solar on the 21 buildings analyzed, NREL's JEDI models labor of installation at $24.51 hourly, resulting in a total of 13 FTEs. Table 9 assumes the $3.00 / watt for residential and commercial solar installation. Once again, please note that pricing contingencies have not been applied.

Table 9: FTEs Generated by Implementing Maximum Photovoltaic Systems

Buildings	Photovoltaic System Size (kW)	System Cost	Total (direct and indirect FTEs)
15 Land Bank residences, only 10 systems due to shading	38.6	$115,800	0.9
6 City-owned buildings	377.2	$1,132,000	11.3
Total	**415.8**	**$1,247,000**	**12.2**

The technical scope of this memorandum does not address the indirect economic and societal benefits of implementing these energy efficiency and renewable energy measures. For example, a community-targeted approach would build workforce capability in low- to moderate- income communities, and "policymakers and program implementers can set targets for diversity in job training, contracting, hiring, and accessibility." (Tanabe, 2019). Other city contracting programs might set goals for working with disadvantaged business entities. Additionally, societal benefits might include indoor air quality improvements; increased economic stability from energy affordability; coordination and possible cost savings for community institutions such as schools, nonprofits, hospitals or clinics, small businesses and government entities; and the local and global benefits realized in reducing greenhouse gas emissions in pursuing Kingston's target to achieve 100% renewable energy by 2050.

Economic impact of any program is particularly important in Kingston, NY, where "the share of households receiving SNAP benefits has risen from 15% to 28%" from 2010 to 2015, and "more than half of households earn less than $50,000." In 2015, 17% of households were below the poverty line (Hudson Valley Pattern for Progress, 2018).

District Extrapolation

Using the above analysis on a building subset, in Table 10 NREL finds the following approximate metrics for Kingston, New York, which might be applied as a rough guide to future projects.

Table 10: Summary of Economic Development Findings

Category	Impact	Finding
Residential Energy Efficiency	**Average Energy Savings**	$2,400 / residence / year
	Average Project Cost	$46,000 / residence
	Jobs created	0.2 – 1.1 FTEs / residence
Commercial Energy Efficiency	**Annual Energy Savings**	$0.52 / Sq. Ft. / year
	Average Project Cost	$3.69 / Sq. Ft.
	Jobs created	1.4 – 8.3 FTEs / 100,000 Sq. Ft.
Residential Solar	**Average Project Cost**	$14,000 / residence
	Jobs created	0.09 FTEs / unshaded residence
Commercial Solar	**Average Project Costs**	$3,000 / kW
	Jobs created	0.03 FTEs / kW

In particular, the city has focused on the Franklin Street Revitalization District, defined as 58 properties with Franklin street addresses, including 39 single-family homes. A broader area of interest is defined as the Midtown district between Franklin and Cedar Street and Broadway and Clinton Avenue, encompassing 404 properties, see Figure ***2***2.

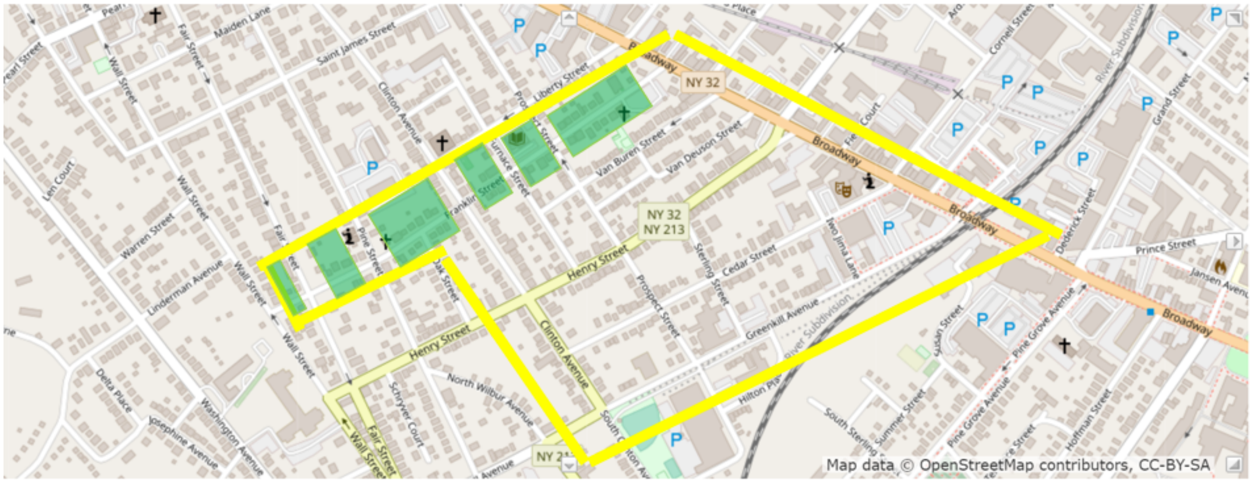

Figure 2: Map of Franklin District (Green) and Midtown District (Yellow)

NREL GIS analysis quantified the maximum potential rooftop PV capacity, characterized by size, orientation, and tilt of the various planes. This information was used in the REopt model to evaluate the techno-economic potential of Franklin Street, using a \$2.40 / W_{DC} residential price and \$1.60 / W_{DC} for commercial properties, reflecting the national average (National Renewable Energy Laboratory, 2019). Note that this analysis puts a techno-economic cap on the amount of solar that could be installed on these roofs, and includes non-south facing roofs. Actual capacity would be limited by the structural integrity of the roofs as well as shading for individual roofs. As a rule of thumb, one-third of all roofs in the Land Bank analysis were found to be too shaded for solar implementation, while this analysis takes an upper bound approach, with roofs experiencing 20% or more shading being excluded. Table 11 summarizes these upper-bound results for Franklin Street and extrapolates to Midtown. The JEDI model was applied to calculate the jobs expected for a district-sized solar effort, analyzing the Franklin Street district for 44 residential properties and 3 commercial properties. The remainder of the Franklin district properties are parking and unused lots. It was assumed that Midtown had the same proportion of residential and commercial properties.

Table 11: Extrapolation of Photovoltaic Work to Single-Family Homes in Franklin Street Revitalization and Midtown Districts

Metric	Estimate for Franklin (green) Properties	Estimate for Midtown (yellow) Properties
Total load	771,018 kWh/year	5,370,540 kWh/year
Maximum PV capacity	0.97 MW	6.8 MW

PV Size for 100% RE		0.64 MW	4.4 MW
Investment for 100% RE		$1.43 million	$9.98 million
NPV		$0.99 million	$6.90 million
Approximate direct and indirect FTEs from district-wide local PV installation	**Residential**	8.4 FTE	58.5 FTE
	Commercial	1.6 FTE	11.3 FTE
	Total	10.0 FTE	69.8 FTE

A district-sized energy efficiency scenario generates additional FTEs. This does not include any efficiencies of scale that might be realized with a larger effort. A staggered district development approach would supply fewer jobs, but those jobs generated would be sustained for more years. Scaling to the 39 single-family homes on Franklin Street, NREL finds that a range of 8 to 42 FTEs may be generated. Similarly scaling by the 404 properties in Midtown of which we expect 272 to be single-family, 54 to 299 energy efficiency FTEs may be generated, shown in Table 12.

Table 12: Extrapolation of Energy Efficiency Work to Single-Family Homes in Franklin Street Revitalization and Midtown Districts

Development Impact	Franklin Street Revitalization District 39 single-family homes	Midtown District 272 single-family homes
Total annual energy bill savings	$93,000	$652,000
Total Project Costs	$1,807,000	$12,603,000
FTEs	8 - 42	54 - 299

Conclusion

In 2017, the city of Kingston, New York, committed to meet 100% power consumption with renewable energy sources by 2050. Leading by example, Kingston has already made significant strides in energy efficiency in city buildings; however, meeting the new, ambitious goal means that maintaining energy and housing affordability could be a challenge. The poorest residents of the city face a significant energy burden, spending up to a quarter of income on power and heating bills. NREL collaborated with city leadership to identify project priorities, which include going green while decreasing energy bills for low-income residents; promoting practical local investment; and creating community jobs. This in-depth analysis took a layered approach to realizing the city's vision, including residential, city-led, and district-scale analyses.

Residential

NREL examined a subset of 15 vacant residential buildings set aside to preserve housing stock affordability by the city of Kingston's Land Bank. NREL discovered the following:

- Deep energy efficiency retrofits could save an average of $2,400 in energy costs annually per home, bringing meaningful new economic security for those with the highest energy burden;
- Mini-split heat pumps provide the most efficient and cost-effective heating and cooling system in these buildings, utilizing half the energy of other heating and air conditioning approaches, while improving indoor air quality, health, and safety, and supporting the city's goal to eliminate fossil fuel consumption; and
- Installing rooftop solar was economically favorable for those homes not significantly shaded by trees.

City-Led Transformation

Evaluating immediate opportunities for city action, NREL found:

- Efficiency retrofits could save the city $76,000 annually across nine city-owned buildings;
- An analysis demonstrating efficiency and solar potential for the Central Fire Station that could deliver energy savings of up to 66% is informing current renovation plans; and
- The Andy Murphy Community Center, which serves as an emergency shelter, could cost-effectively implement a battery storage and rooftop solar system to create sustainable yet affordable resiliency.

District Horizon

NREL modeling of the rooftop solar potential of 58 properties in the Franklin Street district demonstrates that with energy efficiency implementation, rooftop solar generation can meet annualized electricity consumption in the district while creating energy savings and 18 to 52 full time equivalent jobs. When these findings are extrapolated to the Midtown District, efficiency retrofits and rooftop PV could generate nearly $1 million in annual energy savings and 120 to 370 full time equivalent jobs.

Long-term Vision

The electrification of transportation and heating (and elimination of natural gas, heating oil, and propane consumption in these buildings) supports the city goal of 100% renewable energy by 2050.

Appendix A – Workforce Development Calculations

Two separate methodologies were applied to assess the employment impact of energy efficiency measures: an employment multiplier approach and an approach applying ranges of wages and project labor percentages.

Taking an employment multiplier approach, in 2019 every million-dollar investment in energy efficiency projects will yield approximately 5.5 direct jobs, assuming that energy efficiency measures best map to the NAICS code construction sector (Bivens, 2019).[9] Additionally, 10.9 indirect jobs are expected for every million-dollar project due to the spending of wages earned by direct employment, supplier jobs and public-sector jobs created by additional tax revenue. With these assumptions, around 11 full-time equivalents may be needed to do this work for the residences, and an additional nine for the commercial sector, with seven of these total jobs being direct, as shown in Table 13.

Table 13: FTEs Generated by Implementing Measures, Calculated by Employment Multipliers. 15 Land Bank Residences, 9 City-Owned Buildings Listed in Tables 6 and 7.

	Residential, Option 1: Air Conditioner	Residential, Option 2: Mini-Split Heat Pumps	City-Owned
Total Initial Project Cost	$779,000	$695,000	$533,000
Direct Jobs (FTE)	4.3	3.8	2.9
Indirect Jobs (FTE)	8.5	7.6	5.8
Approximate Total Jobs (FTE)	**12.8**	**11.4**	**8.7**

However, the above approach provides only a rough approximation, as energy efficiency and renewable jobs do not all entail construction. These jobs vary in the skill required and in wage compensation. Table 14 provides a summary of minimum, mean, and prevailing wages relevant to energy efficiency projects in the State of New York.

[9] Note that the midtown report indicates that construction contractors are underrepresented in Kingston (City of Kingston, New York, 2019).

Table 14: New York State Hourly Wage Comparison

Wage Type	Hourly Wage
Current Minimum Wage[10]	$11.80
Minimum Wage Jan 1, 2021[10]	$12.50
Minimum Wage Target[10]	$15.00
Construction Laborer[11]	$25.30
Insulators[12]	$35.62
General Building Laborers[12]	$35.95
Electrician, Projects under $250,000[12]	$42.00
Construction Supervisor[11]	$42.06
Plumber – HVAC / Service[12]	$42.50

The percentage of a project's total cost spent on labor may also vary, and for the purpose of this analysis, NREL estimates between 40-70%[13]. Thus, depending on the local labor market and the percentage of the project costs represented by labor expenditures, we can expect 3-16 direct jobs to be created from energy efficiency for 15 residences, as shown in Table 15. This range is consistent with the employment multiplier estimate of 3.8 direct FTEs assuming all jobs are construction jobs.

Table 15: FTEs Generated by Implementing Energy Efficiency Measures in 15 Land Bank Buildings, Calculated by Wage and Labor Cost Percentage, Assuming Implementation of Mini-Split Heat Pumps

Residential, Option 2: Mini-Split Heat Pump	Average salary			
Labor Cost as a % of the Total Cost	**$15**	**$25**	**$35**	**$45**
40%	9	5	4	3
50%	11	7	5	4
60%	13	8	6	4
70%	16	9	7	5

[10] (New York State, 2020)
[11] Mean occupational wage (State of New York, 2020)
[12] Prevailing wages in Ulster County (Department of Labor, 2020)
[13] As a point of reference, NREL's JEDI models photovoltaic project labor costs for residential buildings at 55% and for commercial projects at 46%.

For the nine commercial buildings, we can similarly expect 2 – 12 direct jobs, with ranges demonstrated in Table 16. This range is consistent with the employment multiplier estimate of 2.9 FTEs assuming all jobs are construction jobs.

Table 16: FTEs Generated by Implementing Energy Efficiency Measures in Nine City-Owned Buildings, Calculated by Wage and Labor Cost Percentage

Commercial Buildings	Average salary			
Labor Cost as a % of the Total Cost	$15	$25	$35	$45
40%	7	4	3	2
50%	9	5	4	3
60%	10	6	4	3
70%	12	7	5	4

Appendix B – Workforce Characteristics

Standard Work Specifications (SWS) "define the minimum requirements to ensure that the work performed during home energy upgrades is effective, durable, and safe. The SWS can be used as an industry guide for workers, training instructors, homeowners, and program administrators involved in the home performance industry" (NREL, 2020). "The SWS synthesize more than 30 years of building science expertise within the U.S. Department of Energy (DOE) Weatherization Assistance Program (WAP) and the greater industry by identifying the desired outcomes of the individual measures performed during a whole-house energy upgrade" (NREL, 2020, Section 1).

Using NREL's SWS tool, the specifications in Table 17 will be at least partially applicable to the list of optimized energy efficiency measures. Please note that some of the specifications are designed for multi-family and not all recommendations or standards will apply.

Table 17: Standard Work Specifications Applicable to Optimized Energy Efficiency Measures

Section: Health and Safety	Section: Air Sealing	Section: Insulation
2.01 Safe Work Practices 2.0100 Safe Work Practices 2.0101 Air Sealing 2.0102 Insulation 2.0103 Heating and Cooling Equipment 2.0104 Ventilation Equipment 2.0105 Baseload 2.0106 Material Safety 2.0107 Basements and Crawl Spaces	**3.10 Attics** 3.1001 Penetrations and Chases 3.1002 Open Stairwells 3.1003 Dropped Ceilings and Soffits 3.1004 Cathedralized Attic Ceilings	**4.10 Attics** 4.1001 General Preparation 4.1003 Attic Ceilings 4.1004 Knee Walls 4.1006 Attic Openings 4.1088 Special Considerations
2.02 Combustion Safety 2.0201 Combustion Safety General 2.0203 Vented Gas Appliances 2.0205 Gas and Oil-Fired Equipment	**3.12 Windows and Doors** 3.1201 Maintenance, Repair, and Sealing 3.1202 Repairing/Replacing Cracked and Broken Glass 3.1203 Replacement	**4.11 Walls** 4.1101 Preparation 4.1102 Accessible Walls 4.1103 Enclosed Walls
2.03 Safety Devices 2.0301 Combustion Safety Devices	**3.14 Basements and Crawl Spaces** 3.1401 Basements Connected to Crawl Spaces 3.1402 Crawl Spaces 3.1488 Special Considerations	**4.13 Floors** 4.1301 Accessible Floors
		4.14 Basements and Crawl Spaces 4.1401 Band/Rim Joists

2.04 Moisture

2.0401 Air Sealing

2.0402 Drainage

2.0403 Vapor Barriers

2.0404 Space Conditioning

2.05 Radon

2.0501 Air Sealing

2.0502 Testing and Evaluation

2.06 Electrical

2.0601 Knob and Tube Wiring

2.0602 Electric Hazards

2.07 Occupant Education and Access

2.0701 Basements and Crawl Spaces

2.0702 Installed Equipment

3.15 Attached Garages

3.1501 Garage Openings

3.1502 Isolating from Living Space

3.16 Ducts

3.1601 Duct Preparation

3.1602 Duct Sealing

3.17 Additions

3.1701 Attached Additions

4.1402 Basements and Crawl Space Walls

4.1403 Slab Foundations

4.16 Ducts

4.1601 Insulating Ducts

Section: Heating and Cooling

5.30 Forced Air

5.3001 Design

5.3002 Site Preparation

5.3003 System Assessment and Maintenance

5.3088 Special Considerations

5.31 Hydronic Heating (Hot Water and Steam)

5.3101 Design

5.3102 Equipment Installation*

5.3103 Piping (Distribution Installation)

5.3104 Equipment Maintenance, Testing, and Repair

5.3188 Special Considerations

Section: Ventilation

6.60 Exhaust

6.6002 Components

6.6003 Fans

6.6004 Exhaust Ventilation Systems *

6.6005 Appliance Exhaust Vents

6.6088 Special Considerations*

6.61 Supply

6.6102 Components

6.6103 Fans

6.6104 Supply Ventilation Systems*

6.6188 Special Considerations

Section: Baseload

7.80 Plug Load

7.8001 Refrigerators/Freezers

7.8002 Electronics

7.8003 Lighting

7.8004 Laundry

7.81 Water Heating

7.8101 Water Use Reduction

7.8102 Installation and Replacement

5.32 Shading 5.3201 Landscaping **5.33 Non-Distribution Cooling Systems** 5.3301 Ceiling and Other Fans	**6.62 Whole Building Ventilation** 6.6201 Air Flow Requirements 6.6202 Components 6.6203 Dehumidifiers 6.6204 System Evaluation 6.6207 Passive Ventilation 6.6288 Special Considerations **6.99 Additional Resources** 6.9901 Codes and Standards Resources	

NREL's "Badges Toolkit for home retrofits consists of 25 "badges" based on the installation portion of the Crew Leader Job Task Analyses. Each badge defines a task or measure an installer could perform on a home," listed in Table 18 (NREL, 2020).

Table 18: Installer Badges Applicable to Optimized Energy Efficiency Measures

Badges
Work Lead-Safe
Air seal attic floor
Seal and dam high-temp heat sources in attic
Treat attic hatch
Insulate the ceiling of a manufactured home*
Seal and Insulate Knee Walls
Install dense-pack sidewall insulation
Install weather stripping and sweep set on exterior door
Air seal floor above an unconditioned subspace (basement or crawl space)
Install or repair vapor retarder in a subspace
Vent clothes dryer to the exterior
Install ducting for a bath or kitchen range fan
Air seal ducted distribution system
Insulate ducted distribution system
Install window or exterior door
Install low-flow faucet aerators or showerhead
Install exterior roof penetration (e.g., roof vents or bath fan termination)

List of Acronyms

ACH	Air Changes per Hour
AFUE	Annual Fuel Utilization Efficiency
BEopt	Building Energy Optimization Tool
BTU	British Thermal Units
CFM	Cubic foot per minute
DOE	Department of Energy
DOL	Department of Labor
DR	Demand Responsive
EE	Energy Efficiency
ERV	Energy Recovery Ventilator
FTE	Full Time Equivalent
GIS	Geographic Information System
HSPF	Heating seasonal performance factor
HVAC	Heating, Ventilation, and Air Conditioning
IG	Insulated Glazing
JEDI	Jobs and Economic Development Impact
JTA	Job Task Analysis
kW	Kilowatt
kWh	Kilowatt-hour
LED	Light-Emitting Diode
Low-e	Low- emissivity
LPD	Lighting Power Density
NAICS	North American Industry Classification System
NPV	Net present value
NREL	National Renewable Energy Laboratory
PV	Photovoltaics
R	Resistance
REopt	Renewable Energy Integration and Optimization
SAM	System Advisor Model
SEER	Seasonal energy efficiency ratio
SHGC	Solar heat gain coefficient
Sq. Ft	Square feet
SWS	Standard Work Specifications
VAV	Variable Air Volume
WAP	Weatherization Assistance Program

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