Solar Implementation Task Force
Minutes Draft v2
August 8, 2023

Pursuant to a notice duly filed with the Town Clerk, the Solar Implementation Task Force convened a meeting both in person at 22 Monument Square (Select Board Room) and via Zoom at 8:00 AM on August 8, 2023

Present: Task Force members Dean Banfield (Chair), Gavin Colbert (CAC liaison), Stephen Newbold, Charlie Parker, Wendy Rovelli, Phil Villers. Also in attendance were Laura Scott (CMLP Power Supply and Rates), Eric Simms (Director of Sustainability), Mary Hartman (Select Board liaison), Brian Foulds (CMLP Board Chair), Tanya Gailus, Mark Gailus and Pamela Dritt.

Call to Order
As Select Board liaison, Ms. Hartman called the meeting to order at 8:10. She reminded task force members to complete their swearing in and public body member certification with the Town Clerk.

In response to a request by Ms. Hartman, Ms. Rovelli volunteered to manage minutes for today's meeting.

Review Charge
Ms. Hartman had previously distributed the task force charge and asked members if they had questions or comments.

- Mr. Villers commented that it is the work of the group to identify particular goals and timeframes for the implementation.
- Mr. Banfield noted that the task force has a short time frame for completing a report and this includes the identification of an installation that can be done quickly to demonstrate progress. This could involve a warrant article for the 2024 Town Meeting which has an early January deadline for submission. Mr. Newbold noted that there may be various ways to demonstrate progress.
- Ms. Rovelli raised a question about voting membership and possible chair responsibilities for finalizing any decisions for tie-breaking since there are eight voting members (based on language in the distributed task force charge. Ms Hartman will review the task force charge to confirm it is the final version and will redistribute if needed.

Review Prior Studies
Ms. Hartman asked Ms. Scott to provide a high level summary of the previous studies she had disseminated to members regarding solar siting and implementation. Ms. Scott indicated she would not review the details of each study, but suggested that based on those finding this group should consider the following:

1. Given the issues and expenses identified, is it worth implementing solar in Concord?
2. If yes, focus on priority locations and complete a full due diligence. Previous efforts to implement solar, identified issues late in the process that could have been avoided had more research been completed up front. Recent implementations have confirmed that roof top and canopy installations are very expensive in contrast to ground mounted installations. Input on the expense differences and other citizen concerns need to be considered.

3. There are current technical infrastructure limitations that will require investment before significant solar expansion can be implemented.

Mr. Banfield suggested that we all needed to understand more about the technical limitations. Mr. Villers also suggested that the group needed to explore financing options for implementation.

Housekeeping items

- Meeting time & frequency: After some discussion and concerns about citizen participation, the group agreed to meet on the 1st and 3rd Thursday of each month from 6:30 – 8:30 PM.
- Meeting format: The group agreed that meeting in person is preferable (given the complexities of topics for review and discussion). While in person is preferred, virtual participation (Zoom) would also need to be available. Ms. Hartman will take the lead in finding a room location for the hybrid meetings.
- Chairperson: Based on a recommendation from Mr. Parker, Mr. Banfield was nominated for chair. The motion was made by Mr. Parker, seconded by Ms. Rovelli, and approved based on a unanimous roll call vote.
- Minutes: Mr. Banfield suggested that minutes could be rotated across all members. The task force members agreed and Mr. Banfield will put a schedule together.
- Public comments: The group reviewed various options for taking citizen comments including the approach the Select Board has recently adopted. In the end the group agreed to the following:
    - Take public comments at the end of the meeting.
    - The Chair will have the prerogative to collect citizen input during the meeting.
    - The Task Force will endeavor to only take action (vote) on critical issues in a subsequent meeting following an initial discussion. This will allow for citizen comment at the end of the 1st meeting and to allow members additional time for review.

Next Steps

Mr. Banfield identified the following focus for our next meeting:

1. Learn about limitations – In the draft CMLP report, the document discusses the limitations related to "bus bars". Mr. Banfield would like information on the geography associated with each, so that the group can better understand where the risks are relative to potential solar sites.
2. Review historical documents – Group members should review these reports and come prepared with questions and potential follow-up items for discussion. (Documents were previously distributed to member by Ms Scott on 7/7/23.)

Mr. Banfield noted that he is hopeful that the group can identify a pilot site and concurrently work on the longer-term strategy.

Public Comments

Ms. Gailus asked how citizens should communicate with the committee. Mr. Banfield suggested emailing the chair at dean.banfield@gmail.com. In response to a question, Ms. Hartman confirmed that Gavin Colbert was a voting task force member. Ms. Gailus then noted a quorum would require 4 members. Ms. Gailus also reaffirmed her preference for open sites and discouraged option involving tree removal.

Ms. Dritt asked that a links be added to the web site for public access to meeting documents and town reports. She commented that the agreed upon meeting time is late for town employees. She also suggested that battery storage should be included along with any electric generation systems.

Mr Gailus encouraged the task force to consider the cost of alternative solutions when assessing and comparing options (e.g. what is alternative to the cost of reverse power splitting).

Mr. Foulds suggested that the task force focus on locations for solid arrays; don't exclude sites and consider sites where we could create partnerships within the town. Find locations for battery storage.

A motion to adjourn the meeting was made by Ms. Rovelli, seconded by Mr. Parker, and was unanimously approved based on a roll call vote. The meeting adjourned at 9:10 AM

Respectfully submitted by
Wendy Rovelli

Power Output Efficiency Scenarios	Watts per sq ft of solar panel
Moderate	15

Toggle via drop down button on right side above ^

Table Totals	MW
Total Potential Output (if solar built to maximum on sites listed)	18.27
Current Solar Output	7.57
Total with max potential output + current solar	25.84
Difference from 20MW goal	5.84

Context of Solar Deployment	MW
2030 Goal	20.00
Need to build	12.43

Criteria: Town owned-land, no cutting down trees, no conservation land (*Virginia Road lot exception), no wetlands

Site Name	Approx. Sq Ft	Estimated Power Output (kW) Scenario-based watts per sq ft * 85% Space Efficiency / 1000 **Linked to Solar Efficiency Scenarios**	Latitude	Longitude	Type	Satellite Photo	Notes
CCHS Rooftop	46,000	**586.5kW**	42.44731	-71.34817	Rooftop	Link	Scaled down due to equipment on rooftop, could be around 50k on main rooftop alone elvated above utility equipment, difficult with roof equipment, school grant potential
CMLP Rooftop	30,000	**382.5kW**	42.46913	-71.40264	Rooftop	Link	****Pre-authorized in Article 64 from 2010 for solar deployment**** Flat roof, limited equipment, limited tree shadow, southern orientation -- great option
Ripley Rooftop	25,000	**318.8kW**	42.46496	-71.32705	Rooftop	Link	Good southern orientation, multiple flat rooftops, limited equipment
Concord DPW Rooftops	21,000	**267.8kW**	42.46302	-71.35437	Rooftop	Link	****Pre-authorized in Article 64 from 2010 for solar deployment**** Multiple buildings, advantageous for southern orientation and limited rooftop equipment
Alcott Rooftop	20,000	**255.0kW**	42.45334	-71.34621	Rooftop	Link	Suitable rooftop on multiple levels
Beede Rooftop	15,000	**191.3kW**	42.2292	-71.34673	Rooftop	Link	Two levels, upper is wide flat space with no utility equipment
Willard Rooftop	6,200	**30.7kW**	42.42934	-71.38194	Rooftop	Link	Already existing rooftop array and can fit more, space to place solar around existing equipment or elevate on arrays over equipment to increase available area
Thoreau Rooftop	12,000	**153.0kW**	42.45158	-71.39735	Rooftop	Link	Good southern orientation, mutiple roof-faces, largest rooftop is flat with limited equipment to interfere
Harvey Wheeler Rooftop	10,000	**127.5kW**	42.4577	-71.39399	Rooftop	Link	Relatively flat, southern orientation potential but need to watch out for clock tower shadow
Concord Housing Office, 115 Stow St	7,500	**95.6kW**	42.45692	-71.43955	Rooftop	Link	Have to navigate around rooftop equipment but there is advantageous flat southern orientation space
Concord Police and Fire	4,500	**57.4kW**	42.45645	-71.34396	Rooftop	Link	Difficult with sloped roofs and equipment
Transporation Dept. Rooftop (next to Acton border)	4,000	**51.0kW**	42.44648	-71.42325	Rooftop	Link	Rooftop space with limited equipment, optimal for southern orientation
Concord Players Rooftop	3,500	**44.6kW**	42.45900	-71.34898	Rooftop	Link	Good southern orientation, multiple slopes, limited rooftop equipment, have to work around tree shadow
CMLP Ornac Rooftop	2,000	**25.5kW**	42.45501	-71.37426	Rooftop	Link	Three levels, some equipment, some tree shadow, southern orientation potential
Concord Firehouse 2	2,000	**25.5kW**	42.45621	-71.39133	Rooftop	Link	Good potential southern orientation, lots of sloped roofs but limited equipment interference
Hunt Gym Roof	1,500	**19.1kW**	42.45673	-71.35086	Rooftop	Link	Only southward orientation sloped roof

Concord Town Hall Rooftop	1,000	**12.8kW**	42.46112	-71.34866	Rooftop	Link	Rooftop space on both eaves with limited equipment, might be some historic preservation to work around and it's a small area but it could be a powerful statement putting it on the town hall in the middle of Concord center
CCHS Parking Lot	75,000	**956.3kW**	42.44803	-71.34767	Parking Canopy	Link	Might need to scale down estimate for building shade
Concord School Bus Depot	37,000	**471.8kW**	42.44601	-71.4235	Parking Canopy	Link	Parking canopies over school buses -- could work with electric school buses and also shade their batteries from overheating
Willard Parking Lot	25,000	**318.8kW**	42.43023	-71.38176	Parking Canopy	Link	Parking canopies over spots and driveway in front of school
West Concord Center Parking Lot	17,000	**216.8kW**	42.45723	-71.39337	Parking Canopy	Link	Good potential for southern orientation and limited tree shadow
Harvey Wheeler Parking Lot	15,000	**191.3kW**	42.45603	-71.3942	Parking Canopy	Link	Limited tree shadow and southern orientation, great siting potential
Beede Parking Lot	12,000	**153.0kW**	42.44848	-71.34548	Parking Canopy	Link	Best on north side of lot for southern orientation and limited tree shadow
CCHS Upper Fields Parking Lot	10,000	**127.5kW**	42.44652	-71.34981	Parking Canopy	Link	Northern side of lot
Ripley Parking Lot	10,000	**127.5kW**	42.46537	-71.32656	Parking Canopy	Link	Might need to reconfigure lines in the lot for optimal southern orientation
Concord Center Back Lot (near Post Office)	8,000	**102.0kW**	42.45900	-71.3508	Parking Canopy	Link	Parking with limited tree shadow
Concord Center Town Parking Lot	7,500	**95.6kW**	42.46052	-71.35135	Parking Canopy	Link	Have to work out southern orientation and around tree cover
Rideout Parking Lot	5,000	**63.8kW**	42.45804	-71.39897	Parking Canopy	Link	Limited area due to tree shadow and not well oriented towards south, but decent location to pair with EV charger
Alcott Parking	4,000	**51.0kW**	42.45444	-71.34667	Parking Canopy	Link	Limited space w/out trees and southern orientation
Former Ammendola Land, Old Bedford Rd	315,000	**4016.3kW**	42.66755	-71.32541	Ground	Link	****Pre-authorized in Article 64 from 2010 for solar deployment**** Huge area for solar panels -- could also sub-divide to enable farming on some of the land, good southern orientation potential, might have resistance from farmers
Concord Wastewater Treatment Plant	230,000	**2932.5kW**	42.47221	-71.33757	Ground	Link	****Pre-authorized in Article 64 from 2010 for solar deployment**** Large area with good southern exposure on grass fields next to plant -- need to clarify if this is solid ground and if solar can be built on these without interference
Alcott Adjacent Fields	180,000	**2295.0kW**	42.45109	-71.34492	Ground	Link	Non-conservation lands around Alcott not used for recreation
CCHS Adjacent Field	150,000	**1912.5kW**	42.44787	-71.34476	Ground	Link	Old town landfill lot - sensitive installation to not disturb land, opportunity cost if CCHS wants to expand parking lot here
Rotary field	60,000	**765.0kW**	42.46796	-71.39896	Ground	Link	Next to CMLP, rotary near MCI Concord behind gas station, has tire tracks but not sure why
White Pond Field	45,000	**573.8kW**	42.42861	-71.38533	Ground	Link	Field near White Pond adjacent to Plainfield Rd, this section of the fields has no conservation restrictions listen
Virginia Road Field	20,000	**255.0kW**	42.46778	-71.31914	Ground	Link	*This lot is conservation land but not part of the adjacent wetlands, no trees, and appears to be vacant lot - would have to get allowance to build on conservation land or petition to remove it from town's conservation register

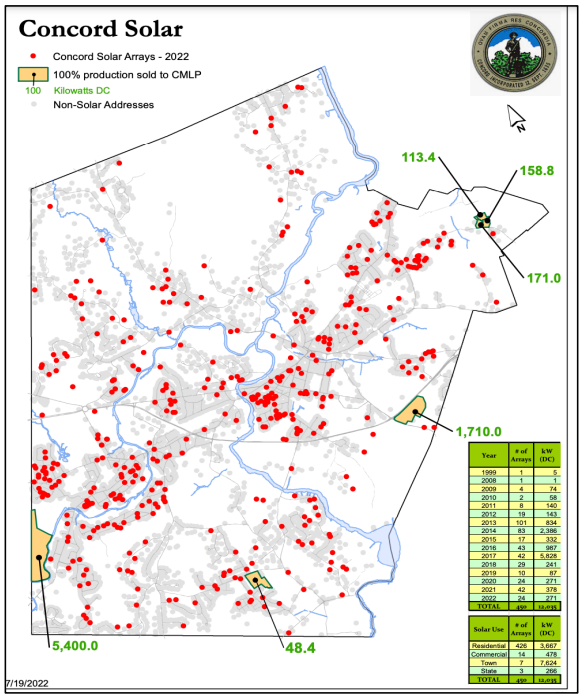
Total	**1,436,700**	**18269.53kW**

Questions?	Answers
Can solar be built on conservation land? If so, lots more possibilities	
How much storage is needed? Can ESB's do it?	
Does grid infra need upgrades? If so, where?	
Should we build micro-grids?	
Has CMLP forecasted increase in electricity demand due to beneficial electrification (ex. EV charging at home and electrified heating via heat pumps)?	
What is the overall goal? Is it still 2030 20MW? Need 12.5MW to cover	
Can we still build on Ammendolia land--what about other farm land owned by the Town?	
Can solar be sited on private rooftops like with Middlesex Green Array -- if so -- look at Concord Corporate Meadows	
Is Startmet Superfund site a possibility in the future?	

Scenario names:

Click link here for PDF map of existing arrays and outputs from CMLP
Click link here for 2022 Article 38 Draft Response from CMLP

Site Name	Approx. Sq ft	Solar Output (kW)	Watt per Sq Ft	Solar Storage	Latitude	Longitude	Type	Satellite Photo	Notes
WR Grace Site	650,000	5,400kW	8.3	?	42.44938	-71.42642	Ground	Link	Huge area, good southern orientation, likely removed trees
Concord Town Landfill	190,000	1,710kW	9.0	?	42.44467	-71.33462	Ground	Link	In 2014 a third-party company was awarded the right to develop 1.7 MW DC of solar panels at the former Town landfill site. CMLP purchases the unit contingent output of this facility under a 20-year purchase power agreement.
Middlesex Green Rooftops	38,000	443.2kW	11.7	?	42.46766	-71.30428	Rooftop	Link	*sited on private rooftops* In 2015 .45 MW DC of rooftop solar was constructed at Middlesex Green, a suburban office park. CMLP purchases the unit contingent output of this facility under a 20-year purchase power agreement.
Willard Rooftop	5,800	48.4kW	8.3	?	42.42934	-71.38194	Rooftop	Link	*room for more panels; only listed in CMLP map not in write-up PDF for Article 38
Emerson/Umbrella Building				?			Rooftop		*not listed -- who is getting that power?
Concord Middle School				Yes			Rooftop + Parking Canopy		*not yet built
Total		7,602kW 7.60 MW							



Site Name	Approx. Sq ft	Solar Output (kW)	Watt per Sq Ft	Solar Storage	Latitude	Longitude	Type	Satellite Photo	Notes
Lincoln Sudbury HS		1,238			42.397803	-71.397871	Solar Canopy	Link	
Lawsbrook Solar (Action)		4,690		Yes (4MWh)			Ground	Link	
Walden Visitor Center		100			42.440571	-71.333039	Solar Canopy	Link	

Expanding Solar Generation on the CMLP system

A Report prepared by CMLP staff in response to 2022 Town Meeting Article 38

… To urge the Concord Municipal Light Plant to develop an action plan and schedule for the achievement of the Town's 2030 solar capacity targets focused on development of new power generation on Town-owned properties…

Expanding Solar Generation on the CMLP system

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Executive Summary

The Sustainable Concord Climate Action and Resilience Plan 2020[1] published a 2030 target for solar generation on Town property of 20 megawatts (MW.) To date 7.7 MW has been constructed. At 2023 Town Meeting, an additional 1.3 MW was approved for construction at the new Middle School, leaving 11 MW to meet the target.

A number of studies and committees have recommended various sites for PV solar systems over the years. Those locations will be discussed in this report. The bottom line, however, is that most Concordians do not want to see greenfield ground-mounted systems on land that could serve other purposes. People prefer to site solar panels on rooftops and parking canopies where there is a dual land use.

Rooftop and parking canopy solar arrays are more expensive to construct in Concord than ground-mounted systems located elsewhere in New England. However there are several benefits to locating generation locally.

First, Concord would be demonstrating its willingness to be part of the climate solution by siting generation here and not asking a different, potentially economically disadvantaged, community to do so. Second, there would be decreased costs from ISO-NE imposed capacity and transmission rates. The Town will need to decide if the additional expense associated with rooftop and parking canopy systems is justified by the benefits.

At this time, it is not possible for the Town's electric utility to incorporate the electrical output from the new Middle School solar PV system nor any additional solar generating facilities to be built, without improvements to the local electrical grid.

Either a large-scale battery or batteries could absorb excess solar production during hours when the local grid cannot incorporate it; or the CMLP distribution system could be re-engineered to allow electricity to flow back out to the grid.

When the required local improvements to the local electrical grid are added to the already higher cost of constructing small scale solar on rooftops and canopies, the premium for locating solar in Town is about X times the cost of buying solar from larger systems located elsewhere. A value judgement must be made as to whether the additional cost is justified by the benefits the Town believes local generation provides.

[1] https://concordma.gov/DocumentCenter/View/25318/Sustainable-Concord-Climate-Action-and-Resilience-Plan-2020

Introduction

Article 38

Article 38 was passed at the 2022 Town Meeting. The article reads:

> *Mr. Banfield moves that the Town urge the Concord Municipal Light Plant to develop an action plan and schedule for the achievement of the Town's 2030 solar capacity targets focused on development of new power generation on Town-owned properties and present the plan and schedule to both the Select Board and FinCom before the end of 2022. The plan should prioritize open sites and include a public process to evaluate any possible tree removal.*

The Town's 2030 Solar Capacity Target

The Sustainable Concord Climate Action and Resilience Plan 2020 published a 2030 target for solar generation on Town property of **20 megawatts (MW.)**

Indicator	Baseline Data	Baseline Year	2030 Target
GHG Emissions from electricity generation[16]	54,234 $MTCO_2e$	2016	0
Percent carbon-free electricity[17]	54%	2018	100%
Total MW capacity of residential renewable generation installations in Concord[18]	3.5 MW	2020	5.44 MW
Number of homes with rooftop solar[19]	358	2020	558
Number of homes with battery storage[20]	9	2020	109
Total MW capacity of solar generation on town property[21]	7.57 MW	2020	20 MW
Total MWh capacity of battery storage on town property[22]	0	2020	60MWh

Developing Utility-Scale Solar Generation on Town-owned Property

Previous Studies and Strategies

Beginning in 2010, a number of studies and strategies were developed focused on expanding solar generation on Town-owned land including: the 2010 Article 64, the 2010 CMLP Utility-scale Solar Strategy[2], the 2011 report prepared by the Solar Siting Committee[3], and the 2020 Cadmus Report[4].

2010 Town Meeting

Article 64 was passed at the 2010 town meeting authorizing the Town Manager to enter into a long term lease or purchase power agreement for solar production at specific Town-owned sites. The sites identified included the wastewater treatment plant, the CMLP building at 1175 Elm Street, the Public Works facility, and the former Ammendolia land. The article read:

> *AUTHORIZATION OF LONG TERM LEASE FOR SOLAR ENERGY*
>
> *ARTICLE 64. To determine whether the Town will vote to authorize the Town Manager to enter into a long-term license, lease and/or contractual agreements, subject to terms and conditions approved by the Board of Selectmen, involving the property at 509 Bedford Street, the Wastewater Treatment Plant site (Assessors Parcels 1195, 1196, 1197, 1198, 1199, 1200, 1201, and 1213), the property at 1175 Elm Street, the Light Plant headquarters (Assessors Parcel 1999-1), the property at 133/135/141 Keyes Road (Assessors Parcel 1682), and/or the property at 33X Old Bedford Road, the former "Ammendolia land" (Assessors Parcels 4209 and 4210-2), for the purposes of installing solar energy facilities and supplying solar energy, and further to authorize the Selectmen and Town Manager to take such action as may be necessary under State law to effectuate said agreements, or take any other action relative thereto.*
>
> *The purpose of this article is for the Town to enter into a long term lease and/or purchase power agreement for the purposes of supplying solar energy in Concord.*

2010 CMLP Utility-scale Solar Strategy

In 2010 CMLP published a long-term strategy for Utility-scale solar power. It called for the development of approximately 25 MW of solar generating capacity in Concord in units of approximately 5 megawatts deployed incrementally at intervals of about 5 years.

[2] Insert hyperlink to 2010 CMLP Utility-scale Solar Strategy report in the Appendix
[3] Insert hyperlink to 2011 Solar Siting Committee report in the Appendix
[4] Insert hyperlink to 2020 Cadmus report in the Appendix

It suggested utilizing leases and PPA's until installation costs dropped to $2/watt, then owning and operating solar sites, financed by bonds authorized by Town meeting.

It assumed solar arrays would require five acres per megawatt of capacity, resulting in the need to find 125 acres of land to produce 25 MW.

The Strategy identified two immediate options:

- The W. R. Grace land in the southwestern end of Town
- The Massport land located in the eastern end of Town bordering aircraft flight paths

The Strategy identified three "longer term" options:

- The Landfill
- The Starmet Superfund site in the southwestern end of Town
- Town well sites. It was acknowledged that the Town well sites could only be pursued if the State were to allow passive solar arrays in combination with well use.

2011 Solar Siting Committee

The Select Board established and charged the Solar Siting Committee in early 2011 to identify and evaluate municipally owned land for the purpose of hosting ground-based solar arrays.

The Committee found sites (mostly forested) that could accommodate approximately 12–19 megawatts of photovoltaic solar arrays.

The Committee concluded that the suitable municipally owned sites they identified would be insufficient to meet the Light Board's goal of generating 25 MW of power within the Town's boundaries.

The Solar Siting Committee identified six parcels that could support at least one megawatt of power production and that were not designated as conservation land and/or are not protected by deed restrictions or other legal instruments.

Solar Siting Committee's Top Six Site Potentials with Power Production Ranges

Site	Power Production Potential (MW)
Concord–Carlisle High School	1-2
White Pond Reservation	3-5
former Town landfill	5
Sanborn School	1-2
Wastewater Treatment Plant	2-3
Concord Municipal Light Plant	1-2
Total	13-19

2020 Cadmus Report

In May 2020 the Town's Sustainability Director hired a consulting company, the Cadmus Group, to evaluate the feasibility of solar and storage at Concord-Carlisle High School, the Beede Swim & Fitness Center, the Free Public Library and the Harvey Wheeler Community Center. The consultant's report, "Solar and Energy Storage Feasibility Assessment" found a potential for **1.6 MW DC** if all the sites were developed.

Cadmus Report Solar Feasibility

Location	Type	Nameplate kW DC	Annual Production MWh	# Panels	Tree Removal
CCHS	Rooftop	365	443,000	1,000	No
CCHS	Carport	323	425,000	885	Yes
Beede Swim	Rooftop	90	111,200	247	No
Beede Swim	Carport	167	222,200	484	Yes
CCHS East Field	Ground	236	308,000	684	No
CCHS Center Field	Ground	354	479,000	970	Yes
Library	Rooftop	9	11,300	32	No
Harvey Wheeler	Rooftop	13	16,600	37	No
Total		1557	1,988,400	4,339	

Cadmus used an optimization model to identify the locations and systems that create the most savings over a 25-year period using a net present value methodology. They were the 365 kW DC rooftop array at CCHS and the 90 kW Dc rooftop array at the Beede Center under a solar PV design only – no batteries. Cadmus found limited financial benefit for batteries under CMLP's current rate structure. They acknowledged that batteries might be more cost effective if CMLP adopted a Time of Use rate.

Cadmus reported a financial summary for the highlighted systems in Table 5.

Table 5 Financial Summary CCHS and Beede

CCHS and Beede	Solar Size kW DC	Battery Size	Operating Costs ($/year)	Net Present Costs (25 years)	Capital Cost	IRR	Payback (years)
Base	0	0	$522,000	$9,970,000	$0	0%	0
Solar PV	450	0	$442,000	$12,020,000	$1,000,000	6.1%	13

It is difficult to understand how the Solar PV scenario could return a positive 6.1% IRR and 13-year payback when the Solar PV net present cost is higher than the base case. This was not explained in the report. It should be noted that Cadmus used a 1.34% discount rate.

Solar Capacity Additions 2014-2016

Between 2014 and 2016 7.7 MW DC of solar capacity was constructed on three different land parcels located in Town. Third parties financed, built, and own the solar panels. The Town leases the land to the third parties. CMLP contracts for 100% of the electrical output.

Landfill

In 2014 a third-party company was awarded the right to develop 1.7 MW DC of ground-mounted solar panels at the former Town landfill site, a location identified in both the 2010 CMLP Utility-scale Solar Strategy and the 2011 report prepared by the Solar Siting Committee. CMLP purchases the unit contingent output of this facility under a 20-year purchase power agreement.

Virginia Road

In 2015 .425 MW DC of rooftop solar was constructed by a third party at Middlesex Green, a suburban office park. CMLP purchases the unit contingent output of this facility under a 20-year purchase power agreement.

WR Grace

In 2016 a third-party developer won a competitive bid to develop 5.6 MW DC of ground-mounted solar panels at the WR Grace Superfund site, a location identified in the 2010 CMLP Utility-scale Solar Strategy. This brownfield site was a part of the former chemical manufacturing facility owned by W.R. Grace. After years of remediation, the Town of Concord took the Concord parcel of land by eminent domain in order to develop the solar array, to build the bus depot and for future groundwater injection. CMLP purchases the unit contingent output of this facility under a 20-year purchase power agreement.

The total capacity of the three sites is 7.7 MW DC.

Solar Capacity Additions Needed to meet 2030 Goal

To achieve 20 MW of solar generation on Town-owned land, an additional 12.3 MW would need to be developed on top of the 7.7 MW already under contract. If the Middle School is built with 1.3 MW of solar production capability, the remaining total required is **11 MW**.

Possible Locations

The **2010 Article 64** authorized the Town Manager to contract for solar production at four sites: 1) the wastewater treatment plant, 2) the Concord Municipal Light Plant, 3) the CPW office park, and 4) the former "Ammendolia land *subject to terms and conditions approved by the Select Board*.

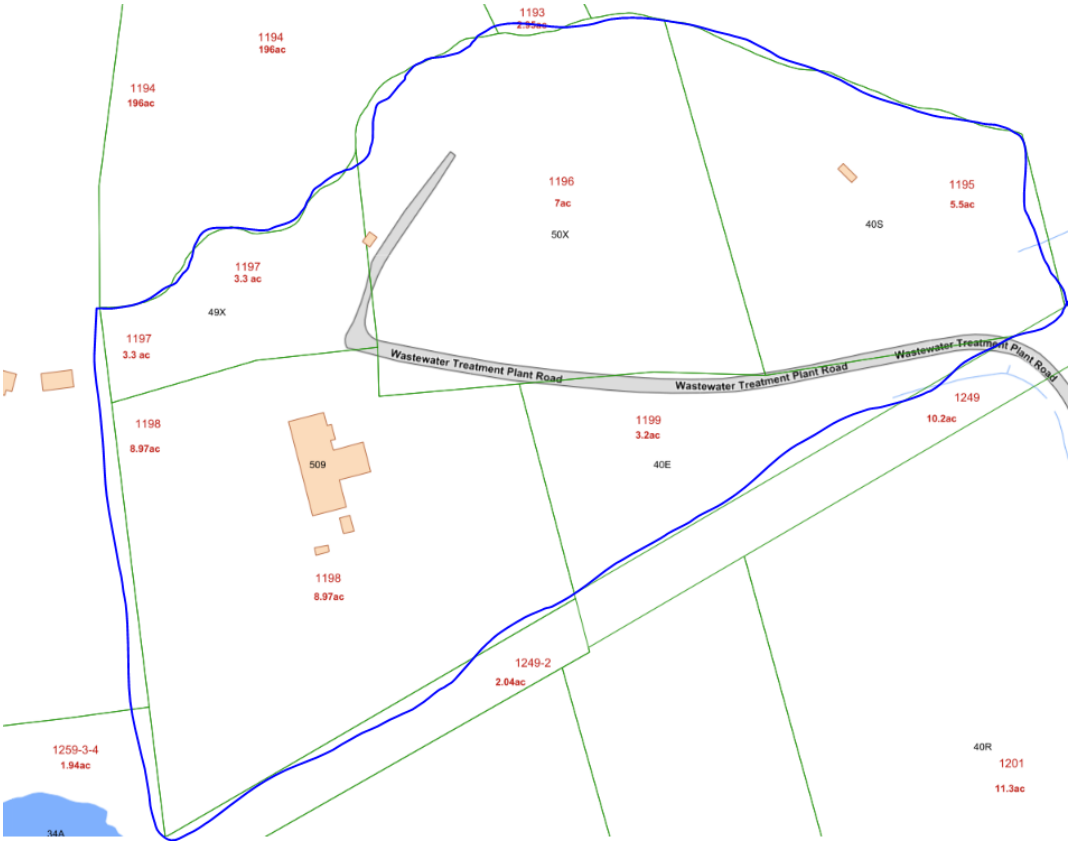
1. Wastewater Treatment Plant

There are three potential areas of interest near the wastewater treatment plant that have been identified:

Name	Parcel
Wastewater Treatment Plant	1195, 1196, 1197, 1198, 1199
C. Courtney Comeau Land	1200, 1201
Sleepy Hollow Cemetery	1213

Located next to the Sewer Department operations building between route 62 and the Concord River lie five parcels: 1195, 1196, 1197, 1198, and 1199. Parcels 1195, 1197, and 1199 are mostly wooded. Parcel 1198 hosts the operations building and the clarifiers and is otherwise mostly wooded. One parcel, 1196, is entirely cleared. On it are five sand filtration beds that, until 2007, were used as _____. The potential to use parcel 1196 for solar production is partially dependent on the way the Town is able to solve its insufficient wastewater treatment capacity.

Wastewater Treatment Plant Parcel View



Wastewater Treatment Plant Satellite View

The Town is currently constrained in its ability to offer new wastewater treatment service because of insufficient treatment capacity. New low-income housing and other developments have been blocked as a result. The Town's National Pollutant Discharge Elimination System ("NPDES") permit limits the amount of wastewater that can be released into the Concord River. Concord Public Works ("CPW") is trying to negotiate an increase in the discharge capacity limit with the EPA; however, the outcome of those negotiations is uncertain. In the event that the discharge capacity into the Concord River cannot be increased, the most immediate option to expand wastewater treatment capacity is the sand filtration beds at the wastewater treatment plant.

The CPW has prepared a contingency plan that is more expensive than adjusting the NPDES permit limit. The contingency plan, prepared by Weston & Sampson, calls for using the southerly three beds, one, three, and five for groundwater discharge (see map on page X.) The contingency plan would be used only if negotiations with the EPA fail. Fields two and four on

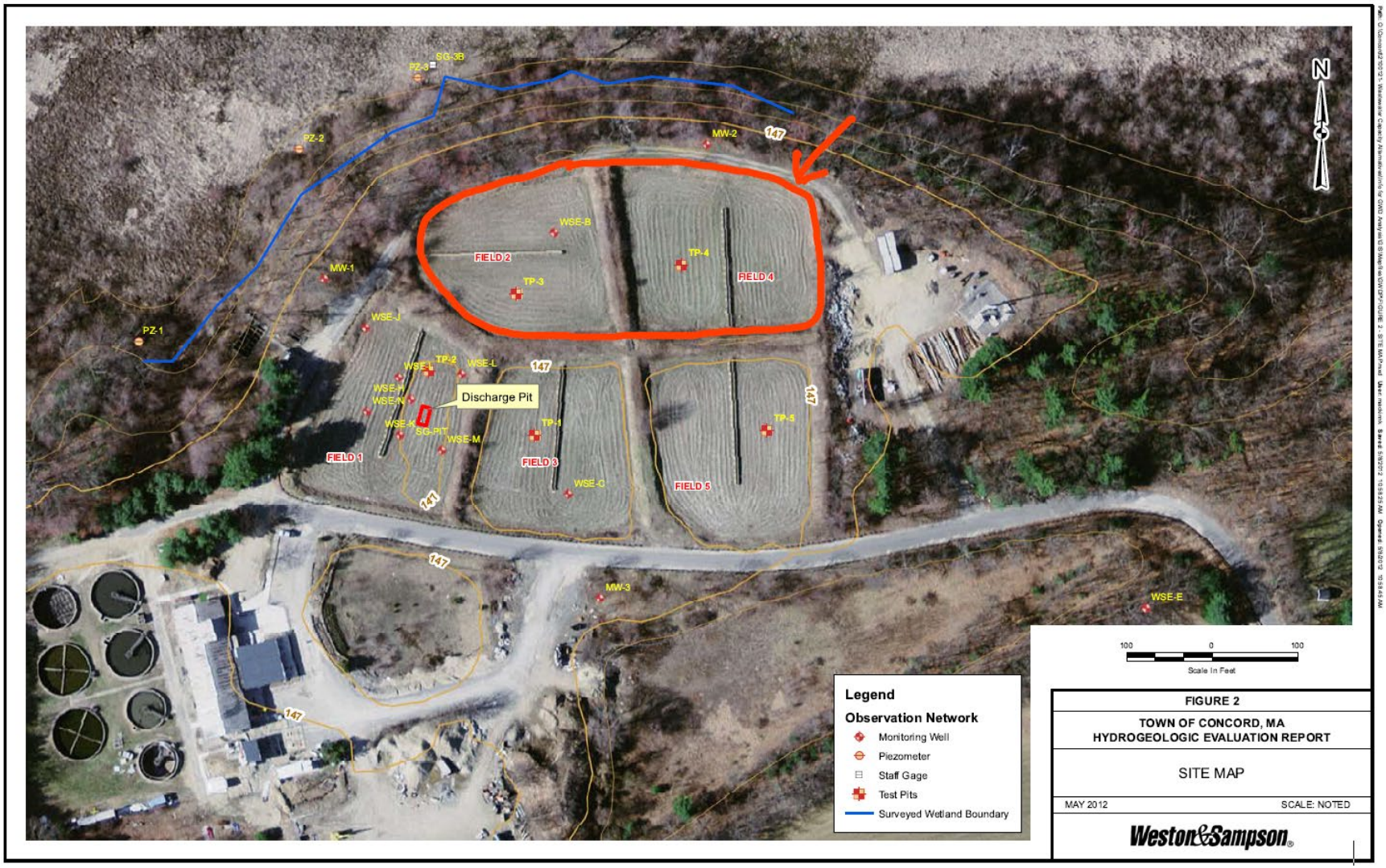
the north side could host solar panels regardless of whether the CPW needs to use fields one, three, and five. A very rough estimate based on square footage only suggests that fields two and four might be able to support a ground-mounted system that could generate 1.2 MW DC.

In fields one, three and five it might be possible to locate solar panels over the filtration beds in conjunction with their use as wastewater disposal, adding an additional 2 MW of solar generation capacity. However, the wastewater disposal facilities would need to be constructed first. Then the solar panels could potentially be erected. The uncertainty over whether the filtration beds will be needed for wastewater injection necessarily delays construction. Solar panels could not be erected until it is determined whether the filtration beds will be needed for wastewater injection.

Understandably, the CPW wishes to ensure that any solar facilities proposed to be sited at CPW facilities are compatible with, and do not preclude the use of the site for, the delivery of CPW core services.

The wooded area near the Treatment Plant is part of an identified Natural Heritage Endangered Species Program (NHESP) estimated habitat for Blanding's turtles.

Weston & Sampson plan to use fields 1, 3, and 5 for wastewater injection. Fields 2 and 4 circled in red could be used for solar generation



C. Courtney Comeau Land

The properties at 40R, 40W and a portion of 43A Bedford Street are currently used for community gardens, crops and nesting habitat for the endangered Blanding's turtle. Just to the east lies the Peter Spring Road neighborhood. The area encompasses parcels 1200, 1201, and a portion of 1205.

Given its current agricultural use and importance as nesting habitat for the Blanding's turtle[5], the C. Courtney Comeau Land does not appear to be a viable site for a ground-mounted solar array.

Sleepy Hollow

[5] Insert hyperlink to Bryan Windmiller, Ph.D. September 30, 2011 letter attached to the Solar Siting Committee report.

The Solar Siting Committee also identified the wooded area immediately to the north of the Knoll at Sleepy Hollow Cemetery as a potential site for a ground-mounted system. CMLP prepared a site plan for a solar installation here and in fields four and five at the Wastewater Treatment Plant[6]. The cemetery is a part of a much larger 95-acre Parcel 1213. Using this site would require some tree cutting. It would also likely encroach upon the identified Natural Heritage Endangered Species Program (NHESP) estimated habitat for Blanding's turtles. For these reasons, it is unlikely that the Sleepy Hollow land will be viewed favorably as a potential site for a ground-mounted solar array.

2. Concord Municipal Light Plant

The 24-acre site consists of an operations building surrounded by woods. The woods contain wetlands and two Certified Vernal Pools. Approximately 1.4 acres on the east side of the property has been cleared. Wetlands also exist between this cleared portion and the fuel station located at the rotary. Recently the cleared portion has been discussed as a potential site for a water treatment facility.

The 2011 Solar Siting Committee believed that at least five and possibly ten acres of the CMLP site could be adapted for solar arrays, particularly if a permit could be obtained for minimal setbacks from the wetlands.

In response to the Solar Siting Committee report advocating for the development of one or more ground-mounted solar systems on the CMLP land, the Natural Resources Commission

[6] Insert hyperlink to site plan in appendix (page 231)

recommended not cutting down trees at 1175 Elm St. to erect a ground-mounted solar system, but rather to construct panels on the Operations Building rooftop and parking lot.

The operations building was constructed in 1998. The administrative roof cannot support solar panels. The existing roof is not structurally sound to handle the weight of solar panels and snow load. In 2013 an additional warehouse was constructed. The roof over the new warehouse could support solar panels. To add solar panels to the administrative portion of the roof, a new roof would need to be constructed before panels could be placed on it. Given that the main roof is 25 years old, it will likely need to be replaced anyway in the next 5 to 10 years. A very rough estimate based on square footage only suggests that with a new roof, the total potential solar generation for the 1175 Elm Street building might be 730 kW DC.

The Concord Municipal Light site is therefore not an immediate opportunity to add rooftop solar, but could be in the medium term.

3. <u>Concord Public Utilities Campus</u>

The Concord Public Works campus located at 133/135/141 Keyes Road (Assessors Parcel 1682) consists of 9.7 acres. This section to the west of Keyes Road is outlined in red in the satellite photo above. A number of buildings occupy the majority of the space with a 2.5 acre treed section on the west side providing a buffer to the water. Other than clear cutting the treed section to erect a ground-mounted solar array, the other option would be to place panels on the rooftops of the CPW buildings. The CPW plans to renovate the campus in the next X to X years, making an investment in solar panels at this time a bad idea.

4. The former "Ammendolia" land

The properties at 33X and 37X Old Bedford Road, also called the Ammendolia Land, consist of 12 acres of cleared land used for community gardens and agricultural crops and two acres of forested land. The area is surrounded by homes.

CMLP prepared a site plan to locate a ground-mounted solar array on the Ammendolia land[7].

After Article 64 passed and CMLP obtained bids from third parties to construct solar fields, many residents were outraged that the Town would consider erecting solar panels in their

[7] Insert hyperlink to site plan in appendix (page 232)

backyard. The negative residential feedback caused the Select Board to unanimously reject the use of this land for a ground-mounted solar system in the place of the community gardens and cornfields[8].

Possible Locations (continued)

The 2010 CMLP Utility-scale Solar Strategy and the 2011 report prepared by the Solar Siting Committee recommended eight additional sites beyond the three authorized in Article 64:

1. the Landfill,
2. W. R. Grace,
3. White Pond Reservation
4. Concord–Carlisle High School
5. Sanborn School
6. the Massport land located in the eastern end of Town bordering aircraft flight paths
7. the Starmet Superfund site in the southwestern end of Town
8. Town well sites.

Solar arrays were constructed at the Landfill and W. R. Grace sites. If approved at Town meeting a rooftop and canopy system will be built at the Sanborn School, leaving the other five locations to consider.

White Pond Reservation

The 2011 Solar Siting Committee received more negative feedback about using the White Pond Reservation area for a ground-mounted solar array than any other potential site received. The White Pond Advisory Committee responded that solar panel site preparation, maintenance, road construction and connecting wiring would negatively impact White Pond's water quality. The area surrounding the pond provides watershed buffering, an essential mechanism for aquifer protection. White Pond is a spring fed kettle pond with no outlet. Whatever contaminants find their way into the pond have no way of flushing out.

In addition to water quality, citizens cited recreation and wildlife habitat as additional current uses of the area that should not be exchanged for solar production.

The 2011 Solar Siting Committee did wonder if pockets of solar arrays could be scattered throughout the site that would preserve the trail network and much of the wildlife habitat; acknowledging that production capacity would be negatively impacted.

Concord–Carlisle High School

In their 2020 report the Cadmus Group estimated that 1.535 MW of solar could be developed at the Concord Carlisle High School and adjoining Beede Swim and Fitness center. Of that total,

[8] https://www.wickedlocal.com/story/concord-journal/2010/09/28/concord-selectmen-oppose-solar-panels/40617228007/

.945 MW would come from rooftop and parking canopy systems and .590 MW would come from ground-mounted systems located on the fields next to the High School.

Location	Type	Nameplate kW DC	Annual Production MWh	# Panels	Tree Removal
CCHS	Rooftop	365	443,000	1,000	No
CCHS	Carport	323	425,000	885	Yes
Beede Swim	Rooftop	90	111,200	247	No
Beede Swim	Carport	167	222,200	484	Yes
Total rooftop and carport		**945**	1,201,400	2,616	
CCHS East Field	Ground	236	308,000	684	No
CCHS Center Field	Ground	354	479,000	970	Yes
Total Ground		**590**	787,000	1,654	

The CCHS rooftop and carport solar systems were not included as part of the building plans when the new high school was built. The center and east fields still represent a real opportunity to add 0.5 to 1 megawatt of solar generation; although competing uses for the fields exists.

The Beede center is currently evaluating behind-the-meter rooftop solar to lower their operating expenses.

Sanborn School

The Concord Schools have proposed building a new Middle School at 835 Old Marlboro Road with a design enrollment of 700 students. CMLP hired a solar design consultant, Solar Design Associates, ("SDA") to determine the maximum amount of solar production that could be generated from both rooftop and parking canopy arrays on the proposed building given limitations set by the School. SDA calculated the potential for 1.267 MW DC capacity and 1,554,336 kWh per year electricity production. Construction of this new solar facility would commence contemporaneously with the new school, currently expected in 20XX.

Massport land located in the eastern end of Town bordering aircraft flight paths

The Massachusetts Port Authority owns a 100-acre parcel (# 0977) located to the west of Hanscom Air Force base.

The property is mostly forested with homes to the west and south. The 2010 Utility-scale Solar Strategy stated that the Port Authority "has a priority of keeping residential developments away from flight paths, but they seem open to considering other low-level uses of the land." It is unclear whether or not discussion took place with Massport about parcel #0977. Opening or reopening discussions with Massport about placing ground-mounted solar panels on parcel #0977 would seem like a good idea.

Starmet Superfund site 2229 Main St.

This 45-acre site is south of route 62 in the southwestern corner of Town. Formerly a specialty metal research and manufacturing facility that used depleted uranium (DU), beryllium and other hazardous substances to manufacture Depleted Uranium munitions for the U.S. Army, 2229 Main Street has now been designated a Superfund site. It is in the process of being remediated.[9] Should the Select Board decide to use this site for solar generation, it could likely produce the 11 MW needed to meet the 20 MW in-Town solar goal if 100% of the property (including forested areas) were used. If panels were erected on just the cleared potion, the likely generation capacity would be more like 3-4 MW. There may be a financial benefit to using the Starmet site versus greenfield sites for solar generation due to the Brownfield adder for solar projects in conjunction with the Solar Massachusetts Renewable Target (SMART) program. This possibility requires further investigation.

[9] https://semspub.epa.gov/work/01/100023619.pdf

Starmet Nuclear Metals Superfund Site 2229 Main St

The Starmet site at 2229 Main represents the single best opportunity for a ground-mounted PV solar system due to its size. More MW could be built, lowering the cost per unit.

Town well sites

There are six well sites in Town ranging from 13 to 40 acres in size. All are partly or entirely forested.

Although the Massachusetts Department of Environmental Protection now allows solar energy projects to be built on lands owned or controlled by public water systems for drinking water purposes subject to certain limitations and restrictions, the question remains whether Concordians want to disturb any of the Town's existing and potential drinking water supply sources by clearing, constructing and maintaining ground-mounted solar arrays. This is a value judgement that must be made.

Albano Land

CMLP investigated whether it would be possible to locate a ground-mounted solar system on the 28-acre parcel # 4074 known as the Albano Land. Tree cutting would be required.

The parcel has no frontage on Lexington Road. An easement to access the property lies along the eastern edge of U.S. Department of Interior property, part of Minuteman National Park. CMLP proposed placing electric utilities in an underground conduit in the easement. The Park notified CMLP that the proposed facilities would interfere with an historic rock wall.

If Town members are willing to cut down trees for solar arrays, then discussion with Minuteman National Park should be reopened.

<u>In-town theoretical rooftop capacity</u>

The Town Geographic Information Systems department calculated the amount of rooftop space in Concord. There are 45 main buildings[10] in Concord with a Massachusetts Department of Revenue Property Type Classification Codes of "93" indicating municipal ownership. These buildings have 693,735 square feet of rooftop not including outbuildings.

[10] Not including "outbuildings"

Land Use	Number of Buildings	Roof Space (sq ft)
Municipal		
Not Outbuilding	45	693,735
Outbuilding	75	60,651
Municipal Total	**120**	**754,386**
Residential		
Not Outbuilding	5,298	13,229,253
Outbuilding	2,494	1,338,892
Residential Total	**7,792**	**14,568,145**

In a 2016 technical report entitled Rooftop Solar Photovoltaic Technical Potential in the United States: A Detailed Assessment[11] the National Renewable Energy Laboratory (NREL) calculated the average percentage of small buildings suitable for rooftop solar in a "Fringe" town in New England to be 74.12%.

Once the NREL percentage is applied, the total number of buildings and their associated square footage suitable for PV installation are reduced to 33 and 514,196 respectively. Generally a 365 watt solar rooftop panel requires about 17.5 square feet of space. The theoretical total generating capacity of 514,196 square feet is 11 MW (514,176 ÷ 17.5 *0.000365.) When calculating a practical generating capacity, the theoretical capacity must be reduced by as much as 83%, yielding a practical total generating capacity for the municipal buildings of **2 MW**[12]. Spread across 33 buildings, each system size would be 56 kW.

The severe reduction between theoretical and practical generating capacity is borne out by the study prepared by the Cadmus in 2020. Cadmus recommended placing just 63 panels on a fraction of the Concord Free Public Library's roof located at 129 Main Street. The area with panels would cover just over 1,100 square feet of rooftop out of a total of more than 15,000 square feet (7%)

[11] https://www.nrel.gov/docs/fy16osti/65298.pdf

[12] The origin of the 83% reduction factor comes from the actual size that residential customers have installed versus the theoretical residential capacity from the NREL study. The NREL study calculates a total theoretical residential solar generating capacity of 205 MW (13,229,253 ft^2*.7412 ÷17.5 ft^2 per panel*.000365 MW per panel) assuming 17.5 square feet is required for each 365-watt solar panel. The average experienced residential solar system size is 9 kW. Multiplying 9 kW by the theoretical number of buildings suitable for solar installation (5,298*.7412) shows that the actual, practical residential generating capacity based on solar additions to date is 35 MW, just 17% of the 205 theoretical total.

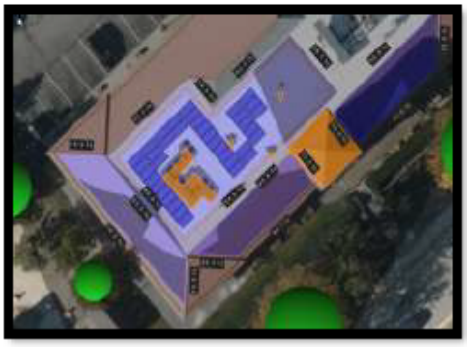
Figure 15: Conceptual PV Design Library

DC Capacity (kW)	17.6
AC Capacity (kW)	15.1
No. Modules	63
PV Module	LG, LG365N2W-B3 (365W)
Inverter	Enphase Micro Inverter
Est. Annual Solar Production (kWh)	21,700

Similarly, Cadmus recommended placing just 37 panels on a small portion of the Harvey Wheeler roof located at 1276 Main Street. The area with panels would cover about 650 square feet of rooftop out of a total of more than 13,000 square feet (5%) Tree shading, clay tile, and HVAC systems reduced the area available for solar panel installation.

> The Harvey Wheeler Community Center is surrounded by trees on the SE and SW sides. Additionally, part of the roof is composed of clay tile, which would increase cost for a solar installation. The flat central roof is suitable for a limited fixed tilt array. Rooftop HVAC equipment, and other structures limits the potential size of the array. Additionally, shading from trees would have to be further assed. Based on our preliminary analysis Cadmus estimates that this building may support a PV array of approximately 14 kW DC. An array of this capacity would generate 16,600 kWh annually.

Figure 19: Conceptual PV Design Harvey Wheeler



DC Capacity (kW)	14
AC Capacity (kW)	12
No. Modules	37
PV Module	LG, LG365N2W-B3 (365W)
Inverter	XGI 1000-65/65-Solectria
Est. Annual Solar Production (kWh)	16,600

<u>In-town parking area theoretical capacity</u>

The Town Geographic Information Systems department calculated the amount of paved parking space in Concord. There are 52 lots with 1,150,119 square feet in Concord with a Massachusetts Department of Revenue Property Type Classification Codes of “93” indicating municipal or county ownership.

Land Use	Number of Paved Parking Lots	Parking (sq ft)
Commercial	**102**	**3,711,857**
Tax-Exempt	**156**	**2,956,959**
Municipal or County (93)	52	1,150,119
Educational Private (94)	21	337,459
Charitable (95)	9	337,161
Religious Groups (96)	8	175,480
Exempt – Other (all other 9 codes)	66	956,740
Total Commercial & Tax-Exempt	**258**	**6,668,816**

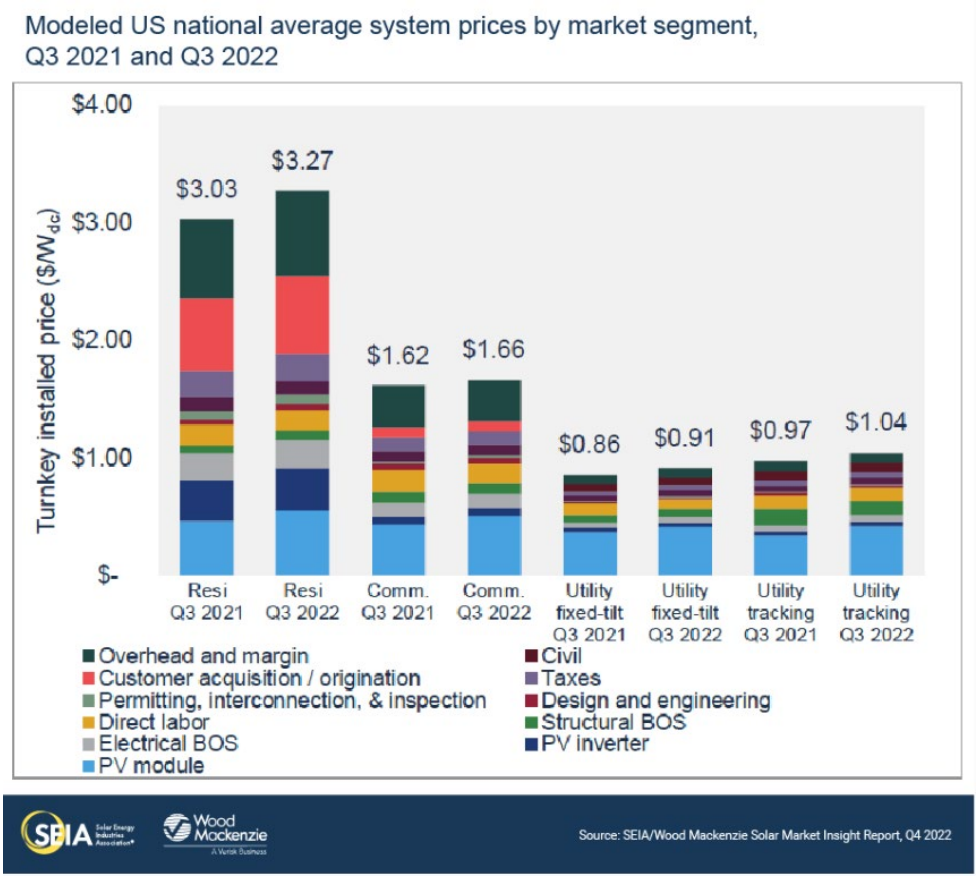
Generally a 470 watt solar canopy panel requires about 24 square feet of space. If all 1,150,119 square feet of parking lot space were used to generate electricity, the theoretical capacity would be about **22 MW**. The practical capacity is less, but likely does not need to be reduced to the same extent as rooftop space due to fewer impediments. Shading, however, and the need to not lose any parking spaces would reduce the total.

Parking canopy solar installations cost more than ground-mounted or rooftop systems in Concord: $3.50 per watt versus $1.00-$1.50 per watt (for a certain size) and $2.50 per watt respectively.

Financial Costs

Below is Wood Mackenzie's Q4 2022 modeled average solar system prices by market segment. It shows a Q3 2022 cost of $3.27 per watt for residential systems; $1.66 per watt for commercial systems and $0.91 per watt for fixed tilt utility scale systems. These are national average prices. Costs for New England are typically higher.

Solar Energy Industries Association (SEIA)/Wood Mackenzie Quarterly Report[13]



The 2011 Solar Siting Committee was charged with identifying and evaluating municipally owned land for the purpose of hosting *ground-based* (emphasis added) solar arrays. In response to their work, many residents commented that they did not want to see land cleared or re-purposed in order to build ground-mounted solar systems. Instead, the predominant sentiment was that solar should be placed on rooftops or over parking lots.

In 2022 SDA, the Light Plant's design consultant, performed an analysis to estimate the cost of installing rooftop and parking canopy panels at the new Middle School (see Appendix X.) They determined the equipment cost[14] of rooftop panels to be $2.50 per watt and that of parking canopy panels to be $3.50 per watt. Recent purchase power agreement offers from solar developers for larger, ground-mounted PV systems located elsewhere in New England imply a cost of about $1.00 per watt.

[13] https://www.seia.org/research-resources/solar-market-insight-report-2022-q4
[14] Does not include engineering, shipping, installation nor interconnection costs

Using the SDA cost estimates and recent purchase power agreement offers, the cost to build out the remaining 11 MW of in Town solar to reach the 20 MW goal can be summarized as follows:

Cost for panels only (not total installed cost)

System Type	Cost/kW	Cost for 11 MW
small rooftop	$2.50	$27,500,000
small parking canopy	$3.50	$38,500,000
large ground-mount outside of Concord	$1.00	$11,000,000

Given the cost premium for smaller rooftop and parking canopy systems, the Town must decide if the benefits of locating solar generation in Concord versus elsewhere in New England outweigh the additional cost.

Conclusion

Utility-scale solar arrays equaling 7.7 MW have been built in Concord since the Town began looking to site such facilities. An additional 1.267 MW of rooftop and parking canopy solar arrays will be constructed at the new Middle School. To achieve the goal of 20 MW of in Town solar, an additional 11 MW would need to be built.

The following tables summarizes sites that have been considered to date and the issues concerning each.

Possible **Ground-Mount**	Parcel No	Discussion
wastewater treatment plant filtration beds	1196	Build ground-mounted system over Fields 2 & 4 now; or wait to build a most cost effective system over all 5 fields pending CPU NPDES permit resolution?
Concord Carlisle High School	0298	Potential for ground-mounted system: 236 kW East field and 354 kW Center field. May be competing uses for the fields.
Massport land located in the eastern end of Town bordering aircraft flight paths	0977	100 acres. Tree cutting required. Massport must approve use of the land for solar development. Requires discussions with Massport.
Starmet 2229 Main St	2970-1	Best opportunity for a low cost ground-mounted PV system due to large footprint: 3 MW no tree cutting; 11 MW full use of site

Possible **Rooftop/Parking Canopy**	Parcel No	Discussion
CMLP building at 1175 Elm Street	1991-1	Tree cutting not recommended for a ground-mounted system. Existing roof cannot support solar panels. Consider a rooftop system when roof is replaced in 5-10 years.
CPU campus	1682	Consider a rooftop system when the campus is renovated.
Concord Carlisle High School	0298	Up to 323 kW potential for parking canopy.
Beede Center	0298	Recreation Department may pursue small behind the meter system to lower costs: 90kW rooftop; 167 kW carport
Municipal rooftop		Possibly 2 MW production capability from 33 buildings, equating, on average, to 56 kW per building. Likely costly.
Municipal Parking Canopy		Somewhere between 10 and 20 MW theoretical capacity, but the most costly to construct.

Unsuitable	Parcel No	Discussion
C. Courtney Comeau Land	1200, 1201, 1205	Unsuitable due to current agricultural use and Blanding's turtle habitat
Sleepy Hollow	1213	Unsuitable due to required tree cutting, Blanding's turtle habitat, and proximity to Sleepy Hollow Cemetery
Ammendolia land	4209, 4208-2	Previous Select Boards have refused to convert land use here from agricultural to solar production
White Pond	3416-1	Unsuitable due to water quality issues, required tree cutting, alternate recreation and wildlife use

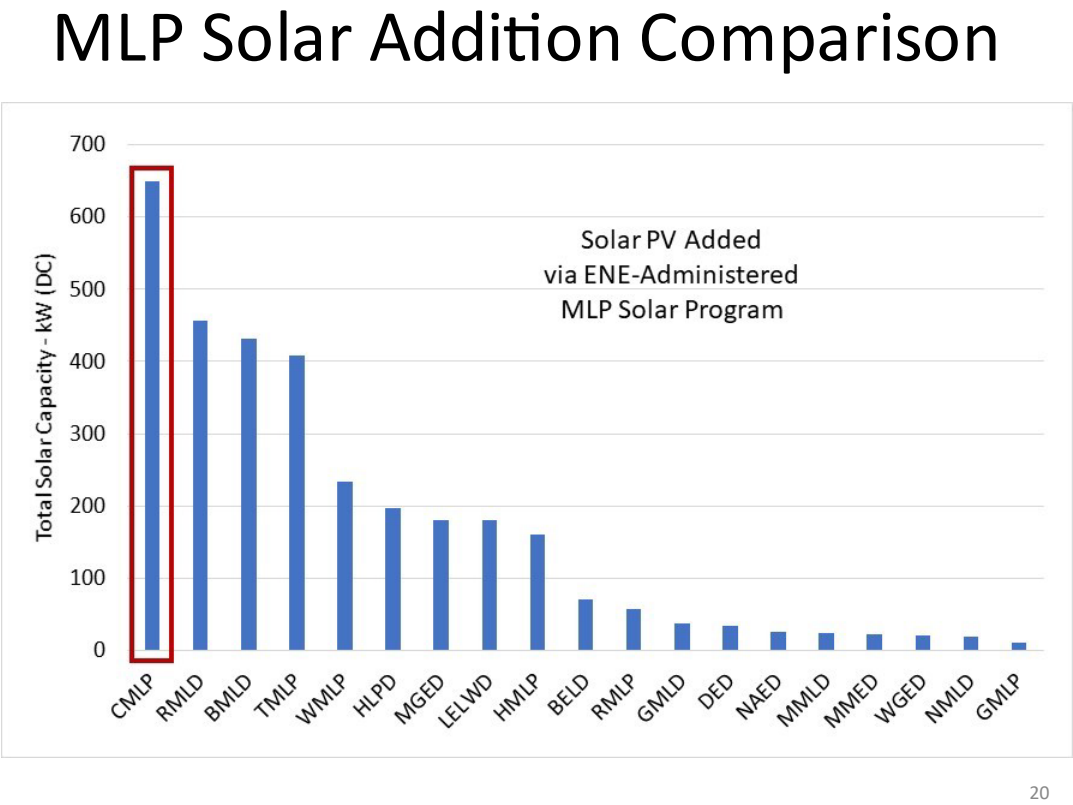
To Be Discussed	Parcel No	Discussion
Massport land located in the eastern end of Town bordering aircraft flight paths	0977	100 acres. Tree cutting required. Massport must approve use of the land for solar development. Requires discussions with Massport.
Town well sites		Good industry practice says no non-water use around ground water sites, even though new laws allow it. Requires a judgement call.
Albano	4074	Tree cutting required. Must resolve Minuteman National Park's concern about the historic rock wall.

Accelerating Residential and Commercial Scale Solar

Type chapter title (level 2

Type chapter title (level 3)

Concord has done a lot to encourage adoption of residential rooftop solar. Generous incentives and a highly favorable net metering rate have convinced 459 customers to date to install solar, totaling 4.6 MW. CMLP has paid out $1.7MM in solar and battery rebates. Concord had the highest adoption of residential rooftop solar compared to any of the other Massachusetts municipal light plants during the course of the Massachusetts MLP solar program – even compared to much larger utilities.



Twenty-eight (28) battery systems with a combined usable storage of 380 kilowatt hours have been approved to operate in town. The average size of the Concord residential array is 9.5 kW. Together residential solar produces about 6,300 MWh per year, or about 4% of the Town's current annual electric use. If the remaining 6,150 households installed 9.5 kW of solar capacity, the Town's total residential solar capacity would be 63 MW capable of generating 88,000 MWh per year, or about 50% of the Town's current annual electric use.

In a 2016 study, the National Renewable Energy Laboratory estimated that 74.12% of small buildings in a "fringe" town (on the fringe of a major city) in New England would be suitable for rooftop solar[15].

Locale Type	Census Division	Mean	Median	Min	Max	N
Town Distant	Mountain	72.89	72.89	71.71	74.07	2.00
Town Fringe	Mountain	78.97	77.28	72.26	91.07	8.00
Town Remote	Mountain	86.31	86.31	86.31	86.31	1.00
City Midsize	New England	74.71	80.92	28.90	94.96	45.00
City Small	New England	78.86	79.08	71.59	85.57	18.00
Rural Distant	New England	71.31	70.81	44.44	83.11	12.00
Rural Fringe	New England	67.69	71.48	38.46	89.39	14.00
Rural Remote	New England	89.58	89.58	89.58	89.58	1.00
Suburb Large	New England	74.97	78.38	31.09	100.00	122.00
Suburb Midsize	New England	77.25	77.02	70.00	84.46	6.00
Town Distant	New England	73.80	73.52	59.63	87.95	7.00
Town Fringe	New England	74.12	71.81	66.94	84.52	6.00

Reducing the total number of households by this 74% suggests a more probable total residential solar potential of 46 MW capacity; 65,000 MWh production, or about 37% of the Town's current annual electric use.

Should CMLP invest more to encourage behind-the-meter solar systems for residential and commercial customers? Because a portion of CMLP's fixed costs are recovered from volumetric sales, customers with solar generation who use CMLP's solar net metering rate are subsidized by non-solar customers. Solar customers use fewer kilowatt hours than non-solar customers, therefore solar customers pay less of the Light Plant's overhead. The more customers who adopt solar generation, the larger this cross subsidy will become. A change in the rate methodology could address the cross subsidy but would likely make net metering less financially attractive to solar adopters.

Is it more cost effective to invest in larger scale solar (ground-mount, rooftop or parking canopy) than in small scale residential rooftop solar? Should both be done at any cost?

[15] https://www.nrel.gov/docs/fy16osti/65298.pdf

Developing Utility-scale Solar Generation on Private Property

Need to Build on Private Property

Given the possibility that no combination of the municipally-owned sites discussed in this report will be able to support 11 MW of solar generation, building solar generation on privately-owned property should be considered. One possibility is for CMLP or a third party to lease land from private entities and build/own the solar arrays. Another possibility is for the private property owners, whether commercial or residential, to build and finance the arrays themselves. Incentives and CMLP's solar net metering rate will largely determine whether private property owners would be incentivized to do so.

Identifying Commercial Sites

Type chapter title (level 3)

Integrating More Solar on CMLP's Grid

Overview of CMLP's Distribution System

The only electric generating facility to be located within the Town's confines other than the solar projects developed in the 2010s closed in 1930. Since then, CMLP has either bought power from Boston Edison with whom CMLP shares an electrical interconnect; or it has bought power from regional suppliers post deregulation and had Eversource (Boston Edison's successor) wheel the power from the grid to the Town's borders.

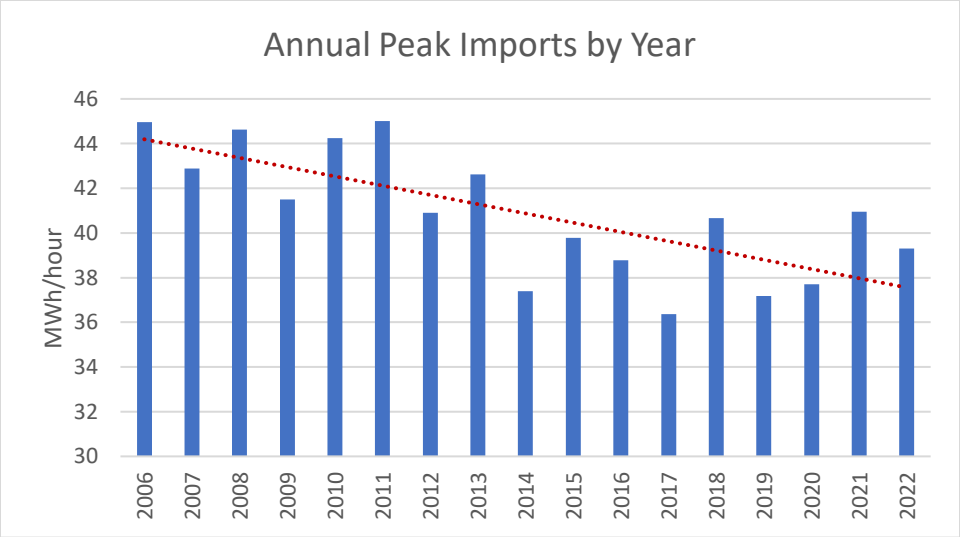
CMLP does not directly interconnect with the regional grid. Eversource is physically situated between CMLP's distribution system and the ISO-NE grid. CMLP pays the ISO to transmit power purchased from facilities around the region to Eversource's point of interconnection with the grid. CMLP has a network transmission services contract with Eversource that requires Eversource to transmit whatever amount of power CMLP purchases from the grid, up to 60 MW, to CMLP's system.

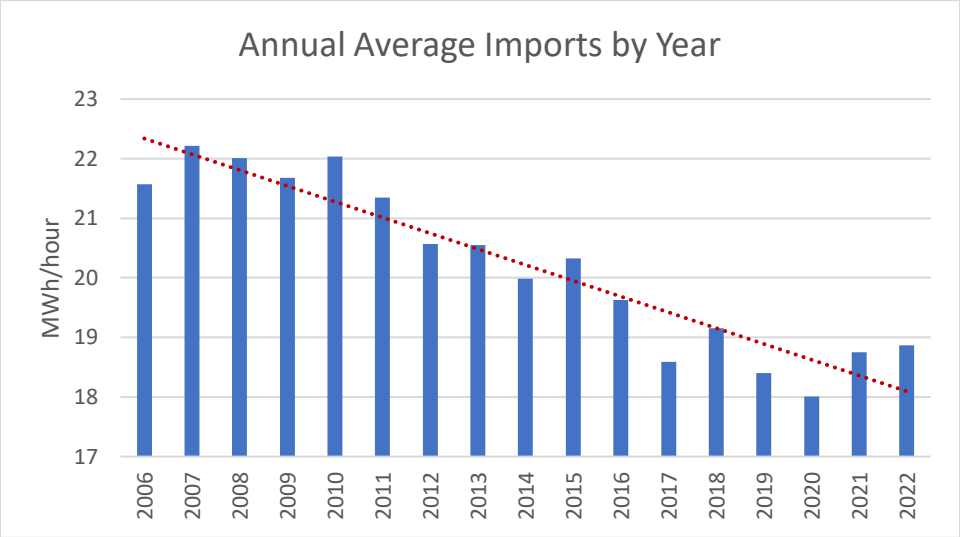
Since the closure of the early power plant, the CMLP distribution system has been engineered to transmit power from the Eversource Sudbury Station to homes and businesses in Concord. CMLP was generally buying a minimum of 12 MW and up to a maximum of 45 MW of power on an hourly basis with power flowing from the Eversource substation to CMLP's distribution system.

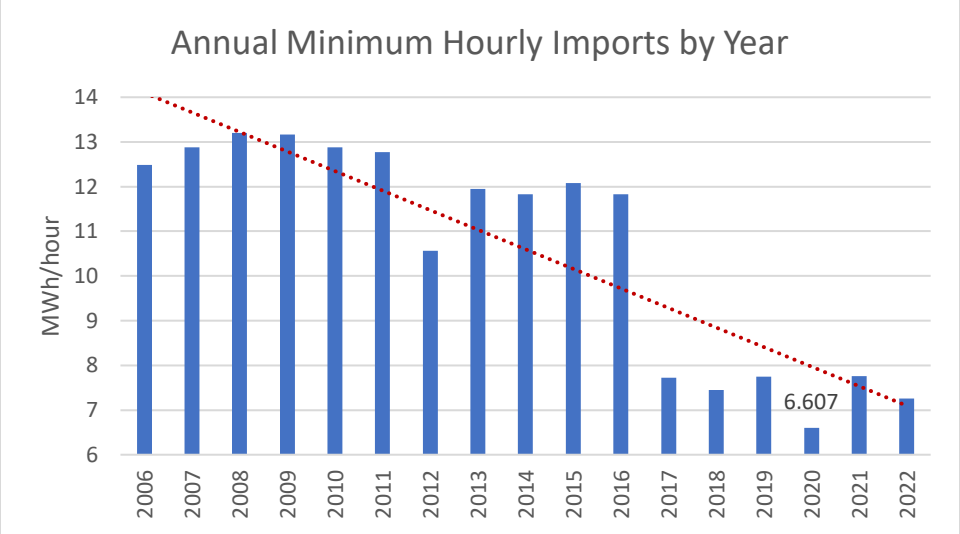
The distribution system was not designed to flow power in reverse, that is from CMLP's system back to Eversource. There are faults and protectors in place to prevent reverse flow. The way CMLP's distribution system would behave if power tried to flow in reverse is: it would shut itself down - creating a Town-wide blackout.

CMLP's Current Load Profile

Over the last 15 years, the volume of megawatts CMLP buys each hour to meet its customers' needs has ranged from 6.6 to 45 MW. The trend has been down. The annual peak has dropped from 45 MW in 2006 to 39.3 MW in 2022. The annual average has dropped from 21.6 MW in 2006 to 18.9 MW in 2022. The annual minimum hourly amount has dropped from 12.5 MW in 2006 to 7.3 MW in 2022.


Annual Peak Imports by Year
MWh/hour
46
44
42
40
38
36
34
32
30
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022


Annual Average Imports by Year
MWh/hour
23
22
21
20
19
18
17
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022


Annual Minimum Hourly Imports by Year
MWh/hour
14
13
12
11
10
9
8
7
6
6.607
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022

The steep decline between 2016 and 2017 in the minimum hourly import volume can be attributed in large part to the energizing of the solar field at the WR Grace property, although increasing amounts of residential solar also played a role.

Technical Details of CMLP's Distribution System

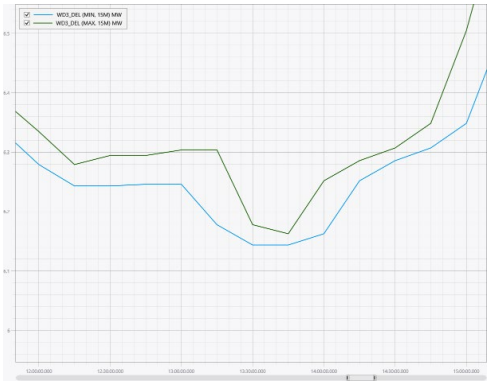
CMLP's distribution grid is split between two busbars. A busbar is a type of electrical junction where electric power is collected from incoming feeders and redistributed to outgoing feeders. The busbar system has an isolator and circuit breaker that work to disconnect a faulty busbar section in the event of a fault. Splitting CMLP's load onto two busbars creates redundancy to reduce the possibility of a system wide outage.

Splitting the load, however, means that the load on an individual bus is less than the minimum combined load shown in the chart. Load is not usually split evenly onto the busbars. On May 1, 2022 CMLP's lowest load hour for 2022 occurred between 1:00 and 2:00 p.m.

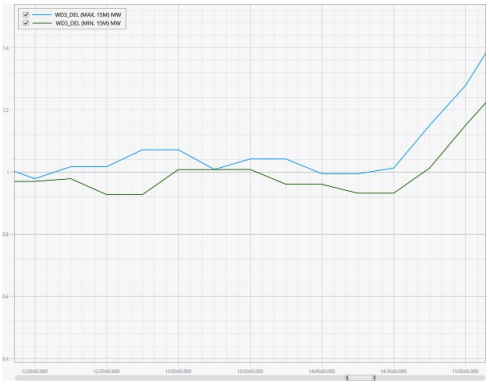
IMPROVE GRAPHICS VISUALS (FONT SIZE AIS, ETC)

Low Load on May 1, 2022

STA 219 Bus 1 Demand



STA 219 Bus 2 Demand



On that day, the load on bus 1 dropped as low as 6.15 MW. The load on bus 2, however, dropped below 1 MW for much of the period between noon and 2:30 p.m.

The bus with the lowest load is at greater risk of causing an outage. Small disturbances on the system, such as a car hitting a utility pole, could wipe out the remaining load on the low busbar and create the Town-wide blackout scenario. The lower the load on the bus, the larger the pool of potential disturbances that could cause the blackout and the higher the probability that a blackout will occur.

Effect of Adding More Solar to CMLP's Grid

Each megawatt of new solar capacity added to the CMLP distribution system reduces the amount of electricity that CMLP must import to serve load. From an environmental perspective, that is a good thing. If the owner of a solar installation does not sell the RECs associated with the solar production, then the power produced is carbon free. Moreover, because the generation is local, CMLP does not have to use energy to transmit electricity from distant places to Concord.

However, from a CMLP distribution stability standpoint, without upgrades to the system each megawatt of new solar capacity reduces the load on the busbars, bringing them closer to the point of zero imports and the potential for a Town-wide blackout, particularly if the solar generation is located on the busbar with the lower load.

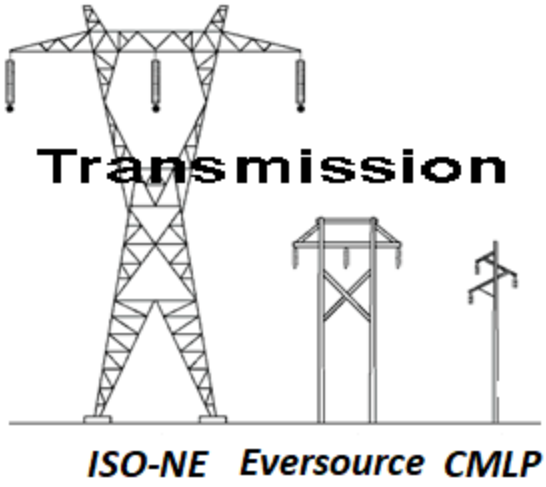
Conceivable Paths Forward

Metering Domain Model

The least costly was for CMLP to export electricity to the regional grid is to use an ISO-NE construct called a "Metering Domain." CMLP would retire its current ISO-NE Load Asset (1724.) CMLP would set up a new Metering Domain within the ISO settlement model. Eversource would need to create a new Tie Line Asset within the ISO Settlement model. The Metering Domain and Tie Line Asset would act together to allow CMLP's net load to settle at the hourly real-time market price.

If CMLP exports during an hour, CMLP receives the real-time market price for the exported MWh. If CMLP is exporting, it would not be assessed any capacity or transmission expenses. To take advantage of the Metering Domain rate treatment, CMLP would need to redesign it infrastructure to allow the MWh to physically flow backwards from the CMLP system to Eversource.

CMLP is not directly connected to the regional transmission system operated by the New England Independent System Operator ("NE-ISO".) Instead, an investor-owned local distribution company lies in between. CMLP contracts with Eversource to move electricity from Eversource's point of interconnection with the NE-ISO to Eversource's point of interconnection with the CMLP distribution system.



Graphic modified from https://www.osha.gov/etools/electric-power/illustrated-glossary/transmission-lines

The terms and conditions of the contract with Eversource are provided pursuant to the ISO-NE Rate Schedule 21.[16] Schedule 21, as confirmed by CMLP counsel Duncan & Allen LLP, does not permit power to flow from CMLP to Eversource. To obtain export transmission service, CMLP would be required to obtain a point-to-point transmission contract with Eversource. The relevant tariff rate schedule is called Schedule 21-ES (Part B) Schedule ES-3 (Part B.) The current rate is $2.9573 per kW-month[17]. If CMLP needed to be able to push back 100% of a new 5-MW array, the annual expense would be $177,438 for transmission.

Redesigning Infrastructure **NEEDS REWORK**

For any amount of exported power, CMLP would need to redesign the distribution system. The new design would include…..Build monitoring, control and protection capability designed for bidirectional flow. Voltage and current monitoring. We monitor with relays and box that pulls all communication into one spot Real time automation controller. Would need to design and Reprogram (expensive part) relays, get additional Rtechs. Put more relays around? At 6 reclosures, solar generation sites, Monitor switching devices in the field, SCADA (>$1MM) Reprogram to look bidirectionally +$500k? at 219 (voltage regulators capacitor banks ($2-$4MM) communicate with Eversource fiber optic with wireless backup. Monitor power quality. Coordinate. Have to upgrade Eversource's substation?

Utility-scale Batteries

[16] https://www.iso-ne.com/static-assets/documents/regulatory/tariff/sect_2/sch21/sch_21_com.pdf §2 page 34
[17] https://www.eversource.com/content/residential/about/transmission-distribution/transmission-rates-tariffs-interconnections/transmission-rates accessed on 4/12/23

Cost Benefit

Rate Impacts

Residential-scale Batteries

Cost Benefit

Renegotiating Transmission

Curtailing Solar Generation

Cost Benefit

Contractual Barriers

Recommendations

Type chapter title (level 2)

Type chapter title (level 3)

Conclusion

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Type chapter title (level 3)

References

Appendices

SITES APPROVED FOR SOLAR EVALUATION AND DEVELOPMENT

22 Monument Street - Town House (parcel 0844)		
133/135/141 Keyes Road - Public Works and Planning facilities (parcel 1682)		
Bedford Street Wastewater Treatment Plant site (parcels 1195,1196,1197,1198,1199, 1200, 1201, 1249, 1249-2)		
Light Plant Operations Center (parcel 1999-1)		
Harvey Wheeler Community Center (parcel 2247)		
Hunt Gym (parcel 0154)		
Walden St. Police/Fire Station (parcels 0240, 0238-1)		
West Concord Fire Station site (parcel 2456)		
91 Laurel Street		
Alcott School site (parcel 0221)		
29 Prairie Street		
Thoreau School site (parcel 2476)		
185 Powder Mill Road		
Willard School site (parcel 3476)		
1231 Old Marlboro Road		
78 Old Pickard Road		
Peabody School site (parcels 2999 and 3000)		

385 Old Marlboro Road		
Sanborn School site (parcel 3010-2-1)		
120 Merriam Road		
Ripley School administrative building site (parcel 4187)		

Onyx Development Group 20 parcels 7.2 MW

Summary of Onyx Site Assessment & Preliminary System Design

			System Size (kWdc)			
Property Name	Parcel ID	Street Address	Ground Mount	Rooftop	Carport	Total Capacity (kWdc)
Town House	0844	22 Monument Square	-	10	-	10
Public Works & Planning Facilities	1682	133/135/141 Keyes Road	-	92	162	254
Bedford Waste Water Treatment Plant #1	1195	509 Bedford Street - NE Parcel	267	-	-	267
Bedford Waste Water Treatment Plant #2	1196	50x Bedford Street - N Parcel	572	-	-	572
Bedford Waste Water Treatment Plant #3	1197	49x Bedford Street - NW Parcel	-	-	-	-
Bedford Waste Water Treatment Plant #4	1198	40S Bedford Street - SW Parcel	134	-	-	134
Bedford Waste Water Treatment Plant #5	1199	40E Bedford Street - SE Parcel	-	-	-	-
C. Courtney Comeau Land - East	1200	C. Courtney Comeau Land - East Parcel	644	-	-	644
C. Courtney Comeau Land - West	1201	C. Courtney Comeau Land - West Parcel	644	-	-	644
Light Plant Operations Center	1999-1	1175 Elm Street	458	183	81	722
Harvey Wheeler Community Center	2447	1276 Main Street	-	11	157	168
Hunt Gym	0154	90 Stow Street	-	42	-	42
West Concord Fire Station	2456	209 Walden Street	-	50	68	117
Alcott Shool	0221	91 Laurel Street	103	192	203	497
Thoreau School	2476	29 Praire Street	-	168	54	222
Willard School	3476	185 Powder Mill Road	343	-	311	654
Peabody School Site #1	2999	1231 Old Marlboro Road	143	165	81	389
Peabody School Site #2	3000	78 Old Pickard Road	644	-	-	644
Sanborn School	3010-2-1	835 Old Marlboro Road	644	227	203	1,073
Ripley School Administrative Building	4187	120 Merriam Road	-	18	203	221
Total			**4,597**	**1,158**	**1,520**	**7,274**

Schedule 21-ES (Part B)

Local Network Service

	NSTAR (East)
Annual Rate (kW-Year)	$35.4875

Long-Term Firm Point-To-Point Transmission Service

	NSTAR (East)
Annual Rate (kW-Year)	$35.4875

Short-Term Firm Point-To-Point Transmission Service

	NSTAR (East)
Monthly STF Rate (kW-Month) Weekly STF Rate (kW-Week) Daily STF Rate (kW-Day)*	$2.9573 $0.6825 $0.0972