



COALITION FOR  
COMMUNITY  
**SOLAR  
ACCESS**



# SHINING LIGHT ON MASSACHUSETTS' SOLAR LAND USE TRENDS

GREGORY HERING & JEFFREY S. LORD | OCTOBER 2019

## ABOUT THE COALITION FOR COMMUNITY SOLAR ACCESS

The Coalition for Community Solar Access (CCSA) is a national coalition of businesses and non-profits working to expand customer choice and access to solar to all American households and businesses through community solar. Community solar refers to local solar facilities shared by multiple community subscribers who receive credits on their electricity bills for their share of the power produced. Community solar provides homeowners, renters, and businesses equal access to the economic and environmental benefits of solar energy generation regardless of the physical attributes or ownership of their home or business. Community solar expands access to solar for all, including low-to-moderate income customers, all while building a stronger, distributed, and more resilient electric grid. For more information, visit our website at [www.communitysolaraccess.org](http://www.communitysolaraccess.org).

## ABOUT COMMUNITY SOLAR

Although over two million solar energy systems have been installed in the U.S.,<sup>1</sup> most customers remain without access to the many benefits of solar energy or the ability to install their own system onsite. For example, a property owner may have unsuitable roof space, an old roof needing replacement in the near future, or too much shading. Similarly, millions of tenants and renters lack the permission to install a solar system at their home or business.

Community solar provides equitable access to clean and affordable solar energy to anyone with an electric bill. By participating in community solar, someone unable to install solar onsite can still take advantage of its benefits. Community solar works by allowing multiple individuals, groups, or businesses to own a portion or subscribe to the output of a single solar facility located offsite. Community solar projects can improve the resiliency of the electric grid and provide a predictable, safe and clean source of energy. Nineteen states and Washington, D.C.<sup>2</sup> have enacted policies that enable community solar arrangements between subscribing organizations and participating subscribers. Community solar has grown exponentially in the last six years, going from just a handful of projects installed before 2010 to a gigawatt (GW) by the end of 2018,<sup>3</sup> enough to power around 150,000 homes.<sup>4</sup> Community solar installations are on track to grow exponentially in the coming years – the Smart Electric Power Association (SEPA) estimates there will be 2GW of community solar installed nationwide by 2021. States that enable community solar are seeing significant growth in jobs, economic investment, tax revenues to local communities, and upgrades to grid infrastructure as a result of the construction of community solar projects in their communities.

<sup>1</sup> Solar Energy Industries Association (SEIA) & Wood Mackenzie Power and Renewables. (2019) See: <https://www.woodmac.com/news/feature/the-united-states-surpasses-2-million-solar-installations/>

<sup>2</sup> Vote Solar and GTM Research. The Vision for U.S. Community Solar. (2018) See: <https://votesolar.org/policy/policy-guides/shared-renewables-policy/csvisionstudy/>

<sup>3</sup> SEIA. See: <https://www.seia.org/initiatives/community-solar>.

<sup>4</sup> Assumes an average subscription size of 6.67 kW.

## LAND USE IN MASSACHUSETTS – THE INTENT & NEED FOR THIS REPORT

The Commonwealth of Massachusetts is the 3<sup>rd</sup> most densely populated state in the nation, as well as the 8<sup>th</sup> most densely forested. This unique combination of factors creates a dynamic in which virtually any activity of the human population will have an impact on trees. Meanwhile, the need to transition the state’s electric grid to one that is clean, renewable and secure is urgent. Striking the right balance between human activities, climate change and land use impacts is important and should be approached in a manner informed by data. By understanding the actual land use trends in the Commonwealth, policymakers and other stakeholders can quantify the impacts and better approach the discussion of best practices and policies for the future.

## ABOUT THE AUTHORS

**Gregory Hering** is the founder of Bright Lite Energy. Since 2006, Greg has consulted on and developed renewable energy, specializing in developing high-value, low impact projects. At Bright Lite, he leads the development of next-generation siting technologies that Bright Lite uses to prospect, design, and develop projects. Prior to starting Bright Lite, Greg co-founded Solventerra, a Boston-based renewable energy development company. At Solventerra, he led the company’s prospecting, designing, and permitting efforts. Greg also founded Emergent Energy Group, a renewable energy consulting and development company. Greg graduated from Tufts University with a BSE in Engineering Sciences.

**Jeffrey Lord** has devoted his 34-year career to the energy and telecommunications industries, with both utilities and non-utilities. A veteran of several start-ups as well as Fortune 500 firms, his specialty has been bringing new and emerging products and services to traditional utility markets. Jeff has collaborated with stakeholders in 32 states and on 4 continents to solve the challenges of bringing vital energy and communications services to where they’re most needed. Jeff has held executive positions with Citizens Utilities (now Frontier Communications) and Green Mountain Power. He is currently Senior Vice President of Project Development for Clean Energy Collective where he leads the company’s development activities nationwide.

## EXECUTIVE SUMMARY

As Massachusetts has strengthened its commitment to renewable energy production and to policies reducing greenhouse gas (GHG) emissions in recent years, there has been increasing discussion regarding the impact of ground-mounted solar farms on land use; however, that discussion has taken place in the absence of detailed, current and accurate data to guide the discussion. The goal of this report is to determine the actual land use trends in the Commonwealth to better inform the discussion of best practices and policies for the future.

For this report, we utilized geographic information systems (GIS) and located all of the solar installations in Massachusetts through 2016 by manually tracing their fence lines in Google Earth. We also used the most up-to-date National Land Cover Dataset produced by the US Geological Survey (USGS) and its various datasets.

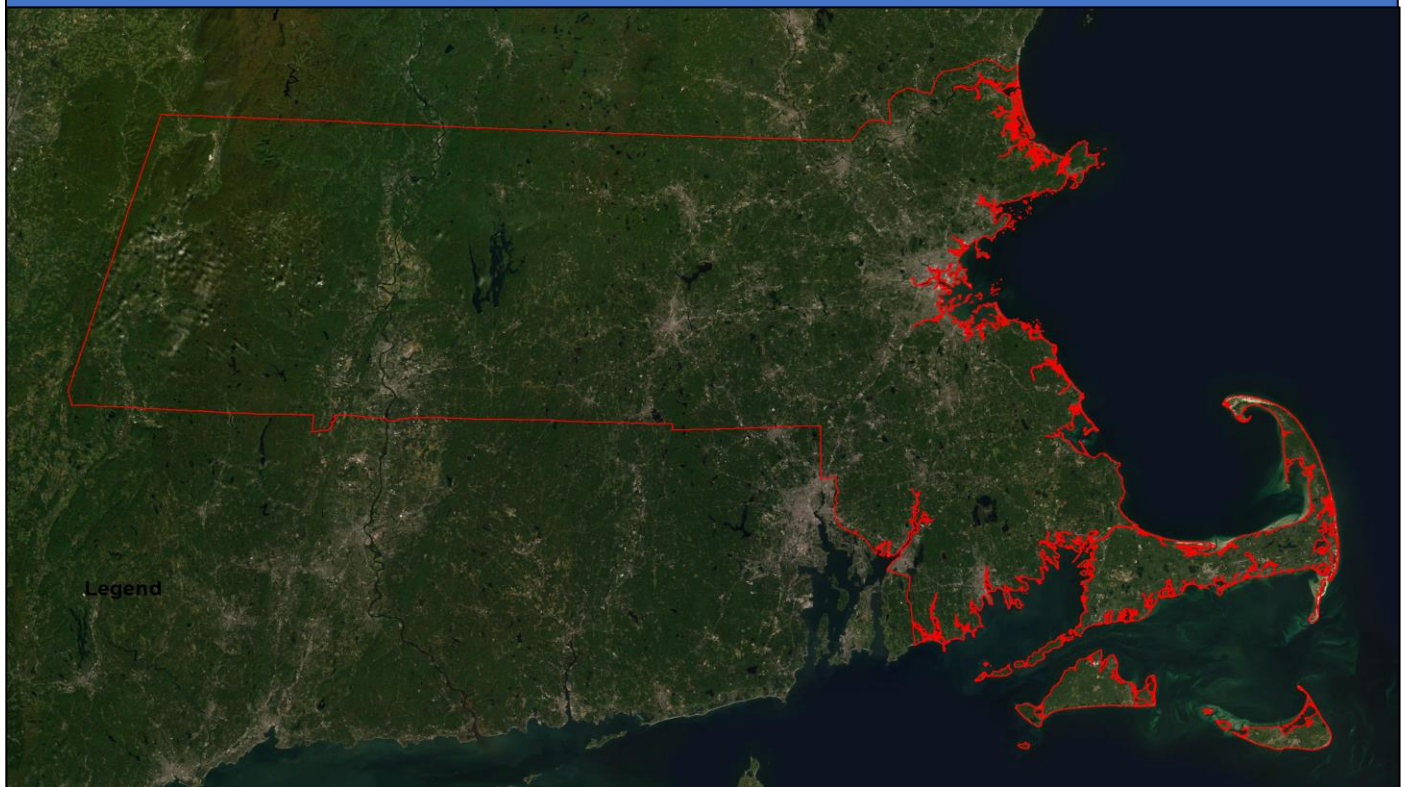
Our findings can be summarized as follows:

1. **THE IMPACT OF SOLAR DEVELOPMENT ON MASSACHUSETTS' LAND HAS BEEN MINIMAL.** Of the 3.1 million acres of open space in Massachusetts, only 4,100 acres — 0.13% — of all open space — has been used for solar development.
2. **COMMERCIAL DEVELOPMENT PRESENTS A FAR GREATER RISK TO OPEN SPACE THAN SOLAR.** Of the 78,000 acres of open space developed between 2001 and 2016, nearly 74,000 acres were for commercial, non-solar development — almost 95% of developed open space.
3. **COMMERCIAL DEVELOPMENT IS RESPONSIBLE FOR NEARLY ALL—96 PERCENT—OF FOREST LOSS.** By contrast, only 0.08% of total forest area in Massachusetts was converted to solar development between 2001 and 2016. (See Figure 5 for detailed chart).
4. **WITH PROPER PRACTICES, GROUND-MOUNTED SOLAR HAS A NET POSITIVE IMPACT ON FARMLAND PRESERVATION.** Some 92.5% of development on fields, presumably farms, has been from non-solar uses — and our analysis shows little correlation between forest loss and solar development on farms. However, there is evidence that ground-mounted solar may have the effect of preserving open space by enabling farms to avoid selling land to a commercial developer. Unlike commercial or housing development, a solar installation does not permanently convert land and can provide a vegetative habitat with proper installation practices for bees, butterflies, and other pollinators. Once the solar farm is removed, the land can again be used for agriculture or forest.
5. **MEETING CLEAN ENERGY GOALS WILL REQUIRE MORE SOLAR THAN ROOFTOPS AND BROWNFIELDS CAN PROVIDE.** While the need for additional rooftop and brownfields solar is clear, both have significant limitations. Three-quarters of all rooftops in Massachusetts are not

suitable for solar panels for various reasons including shade, structural issues, and lease complications. And while the Commonwealth is a national leader, hosting 40% of all brownfields solar in the country, to date this has produced a total of 258 MW of installed capacity. Further, the Department of Energy Resources (DOER) found in 2016 that most large closed landfills suitable for ground-mounted solar had already been developed.

6. **OPEN SPACE CAN BE PROTECTED WITHOUT COMPROMISING CLEAN ENERGY GOALS.** Going forward, the impact of additional solar on open space is expected to remain minimal, both in terms of land used, and in comparison to commercial development. According to our analysis, if all of the additional 800 MW of ground-mounted solar (projected to be built under the current phase 1 of SMART) were built entirely in forests, solar would still utilize less than one-quarter of one percent—0.23%—of forested land in Massachusetts.

**Fig. 1: As the 8<sup>th</sup> most densely forested state, trees cover most of Massachusetts outside of urban areas. More than 98 percent of forests were unchanged between 2001-2016.**



## Recommendations

To maximize the significant economic, clean air and climate change benefits of additional solar generation in Massachusetts, policymakers should ensure careful land use as the need for clean energy increases in the years and decades ahead. As such, this report recommends policymakers:

- 1) ***Protect important land resources.*** While most of the state’s important natural resources are already protected and governed by effective regulations and agencies, policymakers should make necessary improvements to eliminate “loopholes” or insufficiencies in any of these resource protections. Protecting “forest cores” is one example.
- 2) ***Enhance the collection and tracking of data and use cases.*** The state should track specific data regarding the use of different types of forest lands for solar and other purposes. Further, it should engage stakeholders to form an ongoing Working Group administered by the Executive Office of Energy and Environmental Affairs (EEA) that will assess land use issues on an ongoing basis, and make recommendations to DOER that align with observable and documented findings.
- 3) ***Require “greenfield practices.”*** DOER should adopt a set of “greenfield practices” to be utilized in the construction of solar projects on previously undeveloped land. Such practices include minimizing grading, protecting soils, banning herbicides, and seeding with pollinator-friendly plant mixes.
- 4) ***Restructure DOER’s “greenfield subtractor.”*** The state should not increase penalties for solar projects on previously undeveloped land at this time, but instead implement the steps listed above. It could consider replacing the subtractor with a new conservation fund that applicable projects would pay into – on a \$/acre impacted basis.

- 5) ***Simplify the “agricultural dual-use adder.”*** Policymakers should make incentives for agricultural dual-use projects more effective and practical for host farmers and ensure that farmers can continue to host large-scale, ground mounted solar projects to help Massachusetts farms remain economically viable.
  
- 6) ***Better support home rule and municipalities.*** Participation in the state’s solar programs should be contingent upon compliance with “conditions” imposed upon projects in permits issued by municipalities. Further, the state should provide resources to assist municipalities – especially smaller towns – in addressing solar in their local bylaws and permitting processes. Involving the Green Communities program and Regional Planning coordinators is also recommended.

## SOLAR OR STRIP MALLS?

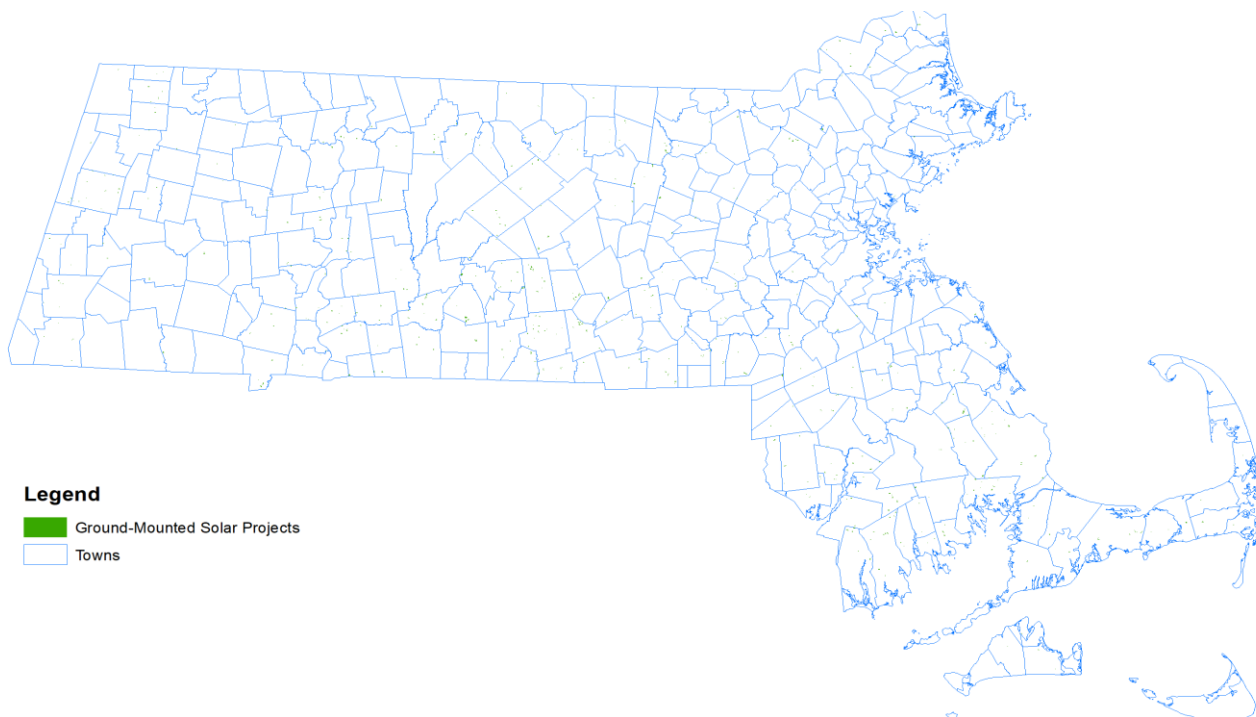
### Putting clean energy development into perspective

In preparing this report, we utilized geographic information systems (GIS) and located all of the solar installations<sup>5</sup> in Massachusetts thru 2016 by manually tracing their fence lines in Google Earth. We also used the most recent National Land Cover Dataset produced by the US Geological Survey (USGS) and its various datasets including its “Land Cover.” These sophisticated, up-to-date tools allowed the researchers to quantify the development and land impact during this 15-year period. See “Methodology & Data” section for more details.

#### Development Trends in Massachusetts, 2001 thru 2016

The total land area of Massachusetts is 5.2 million acres. Figure 2 shows the town boundaries, along with outlines, in green, of all ground-mounted solar projects installed through 2016, which utilize a total land area of 4,100 acres:

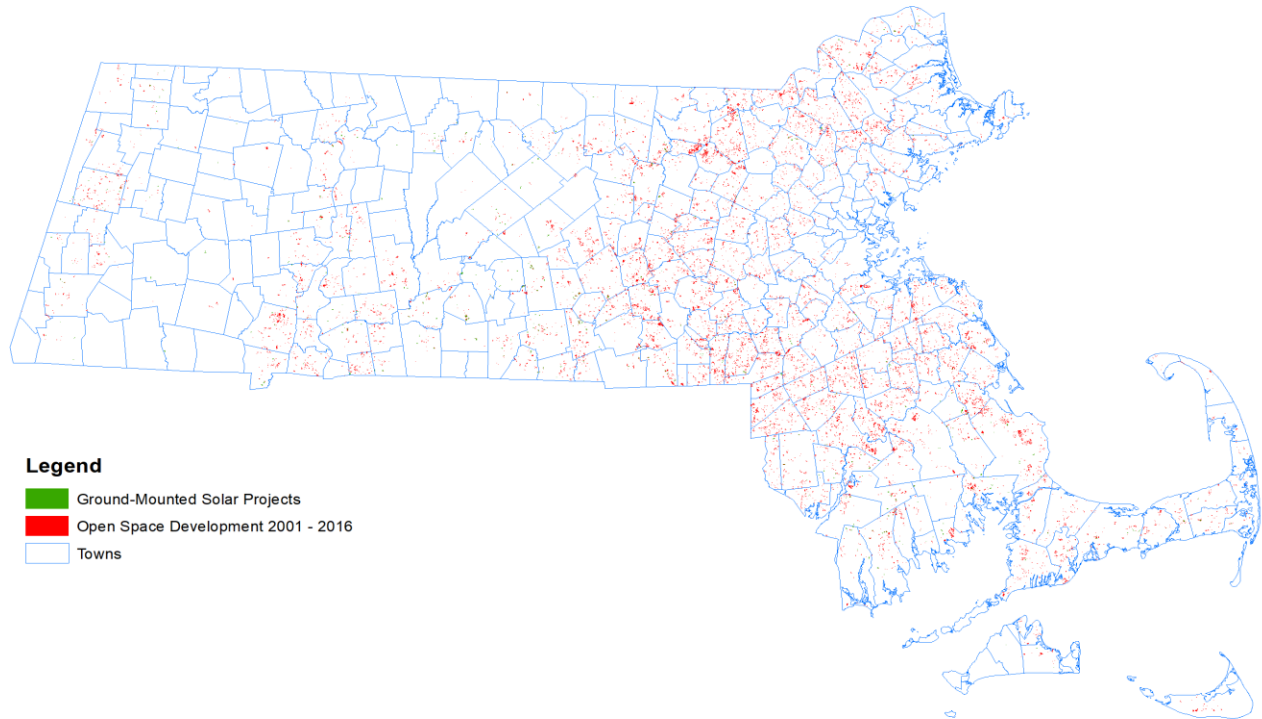
**Fig. 2: Solar takes up just over one-tenth of one-percent of open space (0.13%)**



<sup>5</sup> It should be noted that this includes all "facility types," including but not limited to community shared solar; identifying the specific facility type in the analysis is outside of the scope of this report.

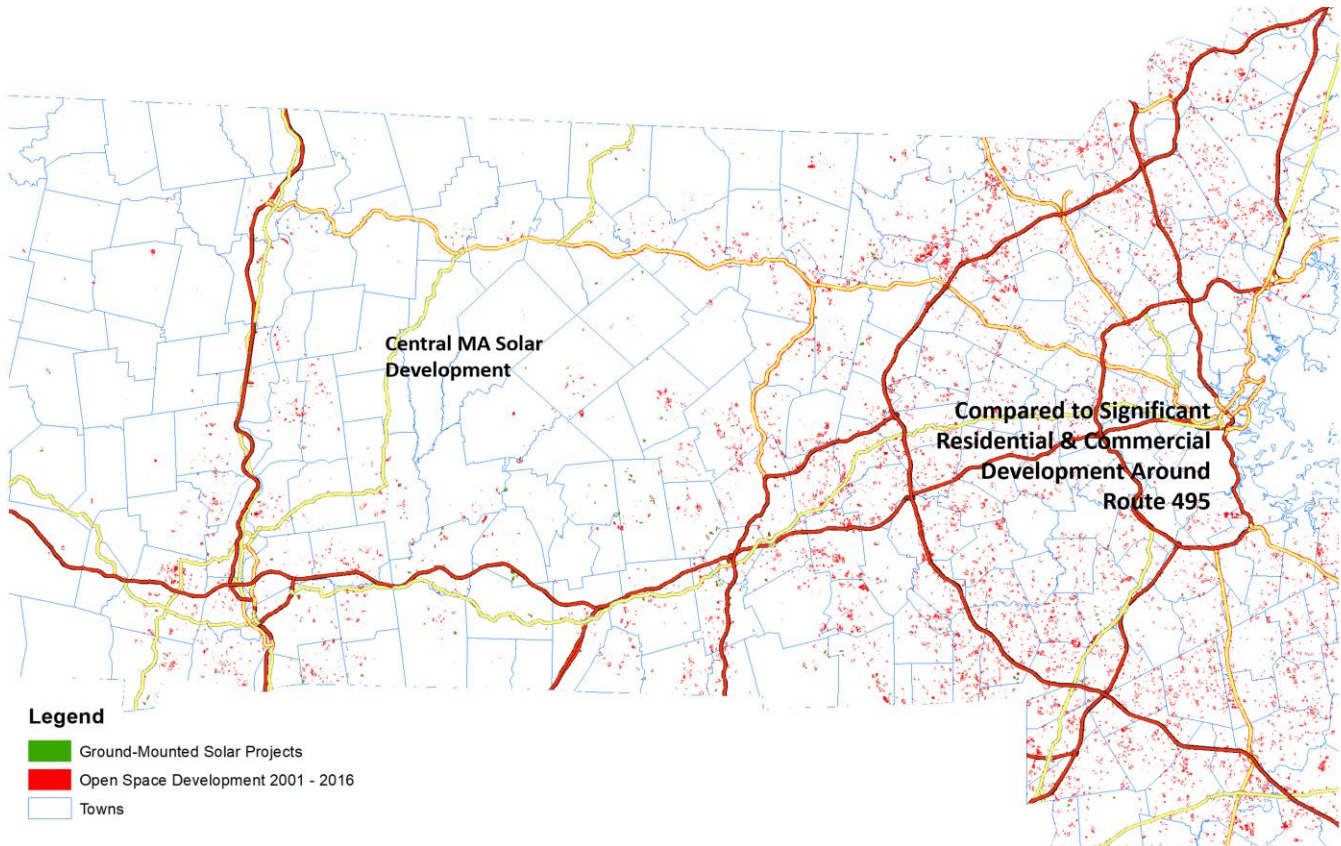
Figure 3 shows the total amount of open space development that occurred during the study period. Between 2001 and 2016, a total of 78,000 acres of open space was converted to other uses, of that 4,100 acres (or 5%) was for solar:

**Fig. 3: 95% of development on open space was for non-solar activities**



A closer view shows ground-mounted solar installations, in green, along with the commercial and residential developments shown in red.

**Fig. 4: Closer View Shows That Most Development 2001-2016 Was Open Space**



Based upon this analysis, 95% of open space developed in Massachusetts between 2001 and 2016 was for non-solar uses. This non-solar development includes housing and retail shopping centers, as well as golf courses and other uses.

## FOREST & FARMLAND IMPACTS OF SOLAR AND OTHER DEVELOPMENT

By examining the various USGS land classifications, the researchers examined how much of each type of land exists in Massachusetts, how much total development took place on each land type between 2001 and 2016, as well as how much of that total development was for ground-mounted solar.

Table 1 below displays this data.

Table 1:

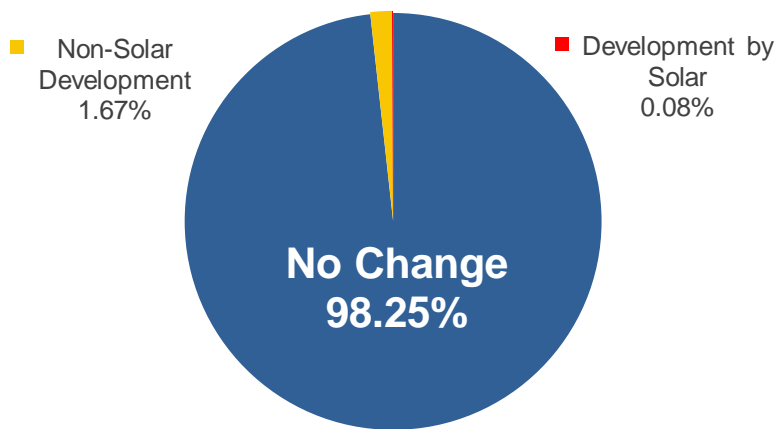
2001 Landcover Category	No Change	Open Space Development Patterns (Acres)				Expected Development of 800MW of Ground-Mounted SMART Solar	Percent of Development by Solar	Percent of Total Area Developed by Solar
		Total Development	Non-Solar Development	Development by Solar to Date				
Forest	2,710,400	52,352	46,188	2,163	4,000	11.8%	0.23%	
Fields	316,905	19,462	18,008	1,454	-	7.5%	0.46%	
Shrub/Scrub/Herbaceous	88,472	6,504	6,330	174	-	2.7%	0.2%	
Barren Land	37,868	3,755	3,442	313	-	8.3%	0.8%	
Total	3,157,644	78,073	73,968	4,105		5.3%		

This data reveals the following notable observations:

- Solar built from 2001-2016 utilized just over one-tenth of one-percent of forested land (0.13%).
- 95% of forest development resulted from non-solar uses.
- 92.5% of development on fields, presumably farms, has been from non-solar uses.

**Figure 5: More than 98% of Massachusetts’ forests have not been touched by any development. Compared with other forms of development, solar development is too small to see in the pie chart below.**

### Massachusetts Forest Development, 2001 - 2016



Taking the analysis further, in addition to the lands that have been used for ground-mounted solar, the researchers examined the land that likely will be used for ground-mounted solar. Based on the GIS analysis, 2,163 acres of land were used for the ground-mounted projects built during 2001-2016 under the state’s SREC-1 and SREC-2 programs. DOER estimates that half of its 1,600 MW SMART program,

800 MW, would be comprised of ground-mounted projects. Typically, five acres of land can accommodate one MW of installed solar capacity. If we conservatively assume that all of that 800 MW would be built on forests, a total of 4,000 acres of forest land would be converted to solar use. Adding these 4,000 acres (under SMART) to the 2,163 acres already built (under SREC-1 and -2) equals 6,163 acres of solar built on forested lands. Together, as shown in Table 1 above, the total historical and SMART solar development totals only 0.23% of the more than 2.7 million acres of forested land in the Commonwealth. In other words, less than one-quarter of one percent of forested land would be used for solar in the foreseeable future. Fully one-half of the 5.2 million-acre total land area of Massachusetts – 2.7 million acres – remains forest.

Extrapolating this data further enables us to examine the potential impacts of solar or other forms of development. In weighing the pros and cons of what will be required to reach Massachusetts' renewable energy and climate obligations, this can be especially useful. For example, if SMART is expanded by an additional 3,200 MW and one assumes that half of that (1,600 MW) would be built exclusively on forested lands, that means that 0.52% of all forests or just over one-half of one-percent would be used for solar.

### HOW MUCH OF MASSACHUSETTS' LAND IS PROTECTED?

According to the Massachusetts GIS system (MASSGIS), 26% of all land in the state (about 1.5M acres) is protected open space. This equates to fully 40% of all open space in the Commonwealth. This represents a significant and important protection of open space. Table 2 provides a comprehensive breakdown of the different types of developed and protected land in Massachusetts.

Table 2:

Category	SubCategory	Acres	Additional Acres Not Previously Counted	Percentage of the State	Percent of Undeveloped Land	Source
Total Area		5,172,799	-	100%		
<b>Developed Land</b>	Urban area	1,063,399	1,063,399	21%		USGS NCLD2016
	Roads Outside Urban Area	151,679	151,679	3%		USGS NCLD2016
	Development Outside Urban Area	68,034	68,034	1%		USGS NCLD2016
	150ft from Bldg Center	1,353,281	483,949	9%		BLE
	<i>Total Developed Land</i>		1,767,061	34%		
<b>Protected Land</b>	Protected Open Space	1,485,074	1,330,196	26%	39%	MassGIS
	National Heritage Priority Habitats	723,839	296,489	6%	9%	MassGIS
	Wetlands, Streams*	1,145,357	454,264	9%	13%	MassGIS & BLE
	Forest Cores	325,450	77,970	2%	2%	MassGIS
	<i>Total Protected Land</i>		2,158,920	42%	63%	
<b>Difficult Land</b>	Slopes Greater than 20%	342,355	116,780	2.3%	3%	USGS NED13
	FEMA 100yr Flood Zones A AE VE	462,231	15,759	0.3%	0.5%	FEMA
	<i>Total Land Difficult for Solar</i>		132,539	2.6%	3.9%	
<b>Remaining Land</b>	Greater Than 15 Contiguous Acres Per Parcel		744,413	14%	22%	BLE
	Land Less than 15 Contig. Acres Per Parcel		369,866	7%	11%	BLE
	<i>Total Land Technically Feasible for Solar</i>		1,114,279	22%	33%	
<b>Total Undeveloped Land:</b>			3,405,714			

\*Wetlands include a 50ft buffer and Streams include a 100ft buffer per the Wetlands Protection Act

The column “Additional Acres not Previously Counted” in the above table reflects the care the researchers took not to double-count land when charting which types of protection address what amounts of acreage in the Commonwealth. EEA has done a remarkable job over the years protecting land through various preservation programs. The private sector has also played a key role in protecting and preserving lands. The parcels of land protected are clearly shown in MassGIS under the “Protected Open Space” data layer. There are 1.485 million acres of land in those parcels, 1.330 million acres of which are not considered by USGS as a road, or a small development outside an urban area.

## POLICIES AND REGULATIONS THAT GOVERN LAND USE IN MASSACHUSETTS

Solar projects are subject to all of the same regulations as other forms of development. The most notable of such regulations address wetlands, endangered or protected species, and local zoning.

### Species & Habitat

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The Massachusetts Division of Fisheries & Wildlife (“DFW” or “MASSWildlife”) administers the National Heritage & Endangered Species Program (NHESP), in compliance with the Massachusetts Endangered Species Act (MESA). This program puts in place numerous restrictions on development, and protects almost 750,000 acres, 300,000 of which are not already protected by the other conservation/preservation programs. Proposed development that would take place in any of these areas that are identified as “estimated or priority habitat” must submit an application to DFW for review under the MESA program. This review results in a determination by DFW of whether the proposed development would affect any protected habitat or species populations. DFW can allow certain development the option of moving forward under specific conditions and/or mitigations.

### Wetlands

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The Massachusetts Department of Environmental Protection (MASSDEP) administers the Massachusetts Wetlands Protection Act (WPA). This law protects important water-related lands such as wetlands, floodplains, riverfront areas, and other areas from destruction or alteration. This includes commonly understood wetlands, such as cattail marshes and red maple swamps, as well as intermittent streams, floodplains, and other areas that may be dry for a significant portion of the year. Also covered by the WPA are floodplains as well as banks, dunes, beaches, vernal pools, land under lakes and ponds, and riverfront area (land under or within 200-feet of rivers and streams.) WPA specifically regulates activities in or near all of these areas. Many cities and towns in Massachusetts have enacted local zoning or other

wetland ordinances/bylaws that are stricter than the WPA. These ordinances are administered by the local Conservation Commission, which would issue a permit known as an “Order of Conditions” if approval is granted. Such permits are also reviewed by MASSDEP, which has the authority to intervene if it believes that a local Conservation Commission has not properly applied the WPA. These regulations also limit development within certain “buffer areas,” typically within 50 feet of a wetland and 100 feet of a stream. These regulations protect an additional 500,000 acres from development.

On the federal level, any person, firm, or agency (including federal, state, and local government agencies) planning to work in navigable waters of the United States, or discharge (dump, place, deposit) dredged or fill material in waters of the United States, including wetlands, must first obtain a permit from the US Army Corps of Engineers (USACE).

## Local Zoning

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Municipalities in Massachusetts utilize two primary methods to govern the required permitting of solar facilities: solar bylaw/overlay district or town special permit. Some towns have, through the process set forth in their town charter and/or bylaws, adopted a “solar bylaw/ordinance.” Such an ordinance would prescribe the standard requirements for an application to permit a solar facility, similar to other forms of development such as building a house. Such ordinances typically set forth necessary set-backs of the installation from property boundaries, driveway requirements, and other details. In some such cases, the ordinance also defines a “solar overlay district” which defines which areas of the town such projects are allowed in. Such bylaws/ordinances are discussed and voted on by local citizens, which most often requires a vote at a town meeting. Other towns have decided to review all solar projects on a case-by-case basis, and therefore have not adopted a solar bylaw. In those cases, a solar project must seek a “town special permit” (TSP) via the process set forth in that town’s bylaws. This typically requires an application that is reviewed by the Planning Board in the town, and may also require application either first, or simultaneously, to the Zoning Board of Appeals (ZBA). These processes include providing public notice and conducting public hearings, just as with any type of development. This approach is quite often preferred by members of the community since it avoids a “broad brush” approach and instead looks at each proposed project individually. Permit approvals issued to projects typically include a number of conditions requiring certain things that the town officials want to ensure are done. In all cases, should any wetlands resources be present, application must be made to the local Conservation Commission, as outlined earlier in this report, which also includes public notice and public

hearing activities. These permitting processes provide local communities the ability to decide what types of development they wish to allow, and the conditions under which they wish to allow it.

Looking again at Table 2, we see that the lands protected as wetlands and as natural heritage priority habitats, brings the total to over 2 million acres of land that is protected from development. This equates to 40% of Massachusetts' land mass, and 61% of undeveloped land.

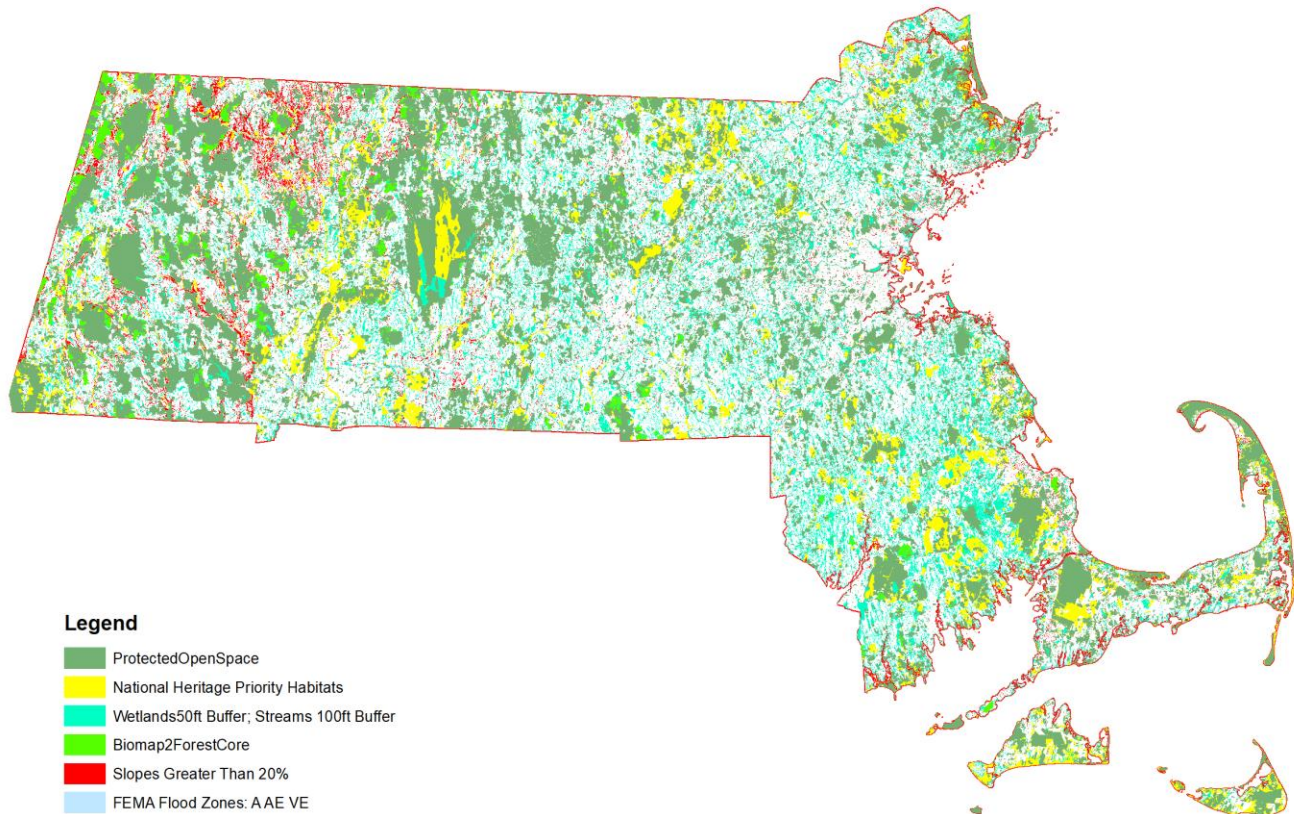
Table 2 also denotes land that is identified as "forest cores" as identified by the "BioMap2" project.<sup>6</sup> While the BioMap2 is designed as a tool to guide strategic biodiversity conservation in the state, and is thus not a regulatory tool, we believe it is important to list "forest cores" in Table 2 in order to draw attention to them so their existence is made part of the discussion regarding land use. If there was a way to address protection of forest cores from all forms of development, this would protect another 77,000 acres, which is another 2% of land in the state, and another 2% of undeveloped land.

Figure 6 shows the above-described protected lands, as well as two other factors that typically preclude solar development in these areas. These are "slopes greater Than 20%" and "FEMA Flood Zones A, AE, and VE."

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<sup>6</sup> <https://www.mass.gov/service-details/biomap2-conserving-the-biodiversity-of-massachusetts-in-a-changing-world>

**Fig. 6: Forty percent of Massachusetts' land area, and 61% of all open space, is currently protected from development through local, state and federal regulations, or through other means.**



*Note: Only the unshaded (white) areas above are lands available for potential solar development.*

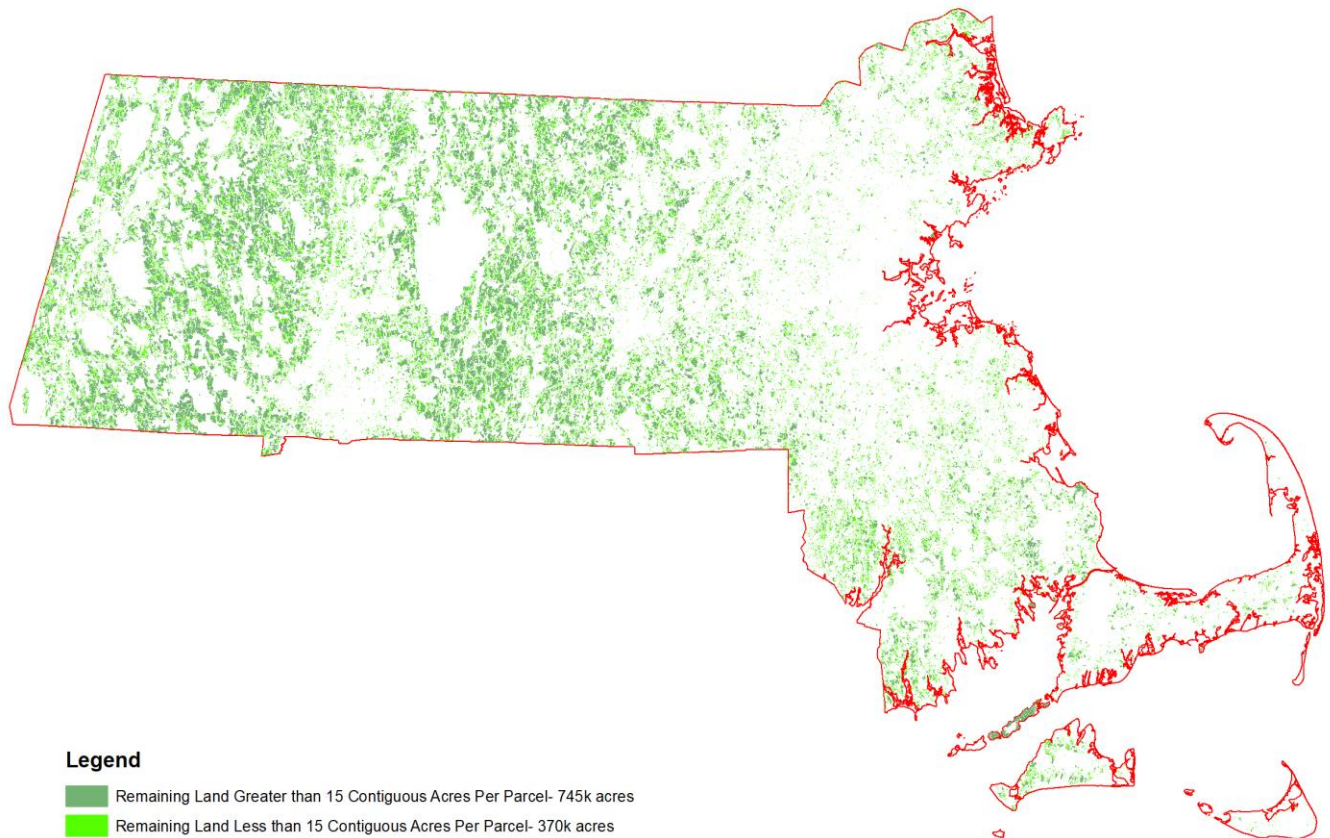
## LAND AVAILABLE FOR SOLAR DEVELOPMENT

After excluding the above land use categories, approximately 1.1 million acres of land are potentially available for solar development. Of that land, one-third are comprised of parcels that are less than 15 contiguous acres, while about two-thirds are parcels greater than 15 contiguous acres. These parcels are shown in two shades of green in Figure 9. While these areas are potentially suitable for solar development, they are not necessarily viable or available for solar.

### Viability of Zoning & Permitting

The potentially available lands depicted in Figure 7 are shown without regard to whether or not those lands might be specifically excluded from potential solar development by nature of individual town bylaws, and/or their solar overlay districts. For sites not specifically excluded, some are no doubt not viable sites for solar due to other reasons that would result in them likely to be denied a Town Special Permit, or other necessary town approval.

**Fig. 7: Parcels of land potentially viable for solar are very limited**



### Viability of Utility Interconnection

The potentially available lands depicted in Figure 7 are also shown without considering the feasibility of utility interconnection. Distributed generation (DG) projects such as solar require a three-phase distribution line in order to be able to interconnect to the grid. Many of the areas shown are not in close enough proximity to a road, and/or a three-phase circuit, to be potentially viable sites for solar projects. In addition, some of the areas that contain potentially available land are in places where the distribution grid has already reached, or is likely to reach,

its maximum capacity for interconnection of DG. In such areas any potential to accommodate additional DG could be as much as three to five years out, according to the respective utility.

### Landowner Interest

For land that isn't already off-limits for solar as listed and described above, and which has the potential for viable utility interconnection, and is permissible under local zoning and permitting rules, there is one key element still required for the land to be potentially viable to host a solar facility. The landowner has to decide that they want to lease (or sell) their land for a potential solar facility. Many landowners have no interest in solar on their land. Others may have interest but are unwilling to agree to the three-year option periods that are typically required in order for a solar developer to get through the full permitting and utility interconnection processes.

As we can see, there are a great many variables that must all align for any particular site to be viable to host a solar facility. Developers can't simply site solar facilities wherever they choose.

## WHAT ABOUT LANDFILLS & ROOFTOPS?

### Landfills

Massachusetts is a national leader in clean energy generation on brownfield sites. The Commonwealth accounts for roughly 40 percent of the 253 renewable energy installations listed by the U.S. Environmental Protection Agency's RE-Powering America's Land Initiative, which is about 258 of the 1,398 total megawatts brought online through October 2017.

The fact that the rate of installation of landfill projects has slowed under SMART is not surprising, and in fact was predicted by the study that DOER conducted during its formation of the SMART program. That report, entitled, "Developing a Post-1,600 MW Solar Incentive Program: Evaluating Needed Incentive Levels and Potential Policy"<sup>7</sup> makes the following finding:

*"Affordable Housing > 1 MW and Landfills > 1 MW are examples of project types which respondents believe that future development will be significantly limited or more expensive (i.e., the low-hanging fruit has been picked). These responses are*

<sup>7</sup> <https://archives.lib.state.ma.us/handle/2452/433084>

*understandable; for example, there are only so many large off-takers for affordable housing projects, and there are only so many suitable large closed landfills that are easily developable in the Commonwealth.” (page 14)*

There is broad agreement that any of the remaining landfills and brownfields that could feasibly host a solar or other renewable energy installation should be developed for such a purpose. And the fact that Massachusetts is already a major leader in this regard proves that the programs and incentives provided to ensure such development takes place have been arguably the most successful in the nation. Additional analysis is needed to identify these remaining feasible sites and determine what the obstacles are to their development.

### Rooftops

Residential and commercial rooftops are an obvious and important part of the picture when it comes to our energy future. Small- and medium-sized roofs can be ideal locations for “behind the meter” solar installations that allow the owner to offset the electricity they use on site. But approximately 75% of the rooftops in Massachusetts aren’t suitable for solar.<sup>8</sup> For some, the direction and pitch of the roof is such that it doesn’t get enough sunlight. For others, the roof is too significantly shaded by trees or by other buildings. Many are simply not capable of supporting the additional weight of the solar panels, along with the snow that can build up on top of them. There are other challenges as well. For the many residential and commercial buildings that are not owner-occupied, they would most often need to lease their rooftop to a solar developer. For such a lease to make sense, the developer typically needs a 20-year lease term. But for many building owners, such a long-term commitment is unacceptable because it limits their options regarding the building. They often say, “what if someone makes me a significant financial offer on my building? I don’t want to choose between breaking my contract with you and giving up the deal of a lifetime.” Others cite concerns involving insurance and potential liability. The amount of money that a solar developer can afford to pay for a rooftop lease is often not enticing enough for a building owner to overcome these obstacles.

Policymakers should encourage the continued installations of rooftop solar projects and continue addressing and removing the obstacles to doing so. But rooftops alone won’t enable Massachusetts to reach its clean energy and climate goals.

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<sup>8</sup> <https://votesolar.org/policy/policy-guides/shared-renewables-policy/csvisionstudy/>

## BEYOND LAND USE:

### The Broader Environmental Importance Of Accelerating Solar

Beginning in the 1970s and into the '80s, the public dialogue around air quality impacts of fossil fuel extraction and combustion began to intensify. Around this same time, the primary answer to reduced environmental impacts was thought to be replacing aging fossil fuel plants with nuclear-powered plants, while requiring new technologies to reduce industrial and transportation-related emissions. It is helpful to briefly revisit a few of the primary energy-related environmental factors to help put the examination of land use into context.

#### Acid Rain

Emissions from power plants, industry, and vehicles react with water in the air, which then falls to the ground as rain or snow containing nitric and sulfuric acids. Acid rain is a product of sulfur dioxide (SO<sub>2</sub>) and nitrogen oxides (NO<sub>x</sub>) mixing with water in the atmosphere, then falling to the ground as rain or snow. SO<sub>2</sub> emissions are released from power plants that burn oil or coal to generate electricity and from industrial combustion of fossil fuels. NO<sub>x</sub> emissions come from the same sources, as well as from motor vehicles with gasoline- and diesel-powered engines. Acid air pollutants lower the pH levels of lakes, rivers and soils, and damage forests, leading to a range of environmental problems. Specifically, acid deposition:

- Can make lakes and streams so acidic that survival becomes difficult if not impossible for many species of fish and invertebrates.
- Makes plants, their leaves, and their root systems more likely to dry out or accumulate dangerous toxic metals.
- Dissolves and washes away calcium and other minerals from the soil, thereby robbing ecosystems of nutrients essential for plant growth.

The U.S. Congress in 1990 created a federal Acid Rain Program to reduce the adverse effects of acid rain through annual emission reductions from power plants that burn fossil fuels. Massachusetts also established emission limits on power plants. In addition, as a member of the Conference of New England Governors and Eastern Canadian Premiers, Massachusetts committed to a 50 percent reduction in regional SO<sub>2</sub> emissions by 2010 and a 20 percent to 30 percent reduction in regional NO<sub>x</sub> emissions by 2007 (which was achieved). According to EPA, electric power sector emissions of both SO<sub>2</sub> and NO<sub>x</sub> emissions decrease by more than half since 1990. These and other emission reductions have led to a significant decrease in acid deposition. But monitoring data collected in Massachusetts indicates that bodies of water have been slow to recover, showing only

slight improvement, so long-term monitoring is needed to assess how quickly their ecosystems bounce back.<sup>9</sup>

### Air Quality and Human Health Impacts

An excerpt from the US Department of Energy’s 2017 report entitled, “Environmental Quality and the U.S. Power Sector: Air Quality, Water Quality, Land Use and Environmental Justice,” reads as follows:

*“Pollutants emitted by the electric power sector cause damage to human health (increased morbidity and mortality), to crops and timber production (productivity losses), and to materials (deterioration and increased maintenance costs). Table 1 lists the major impacts, by sector, of air pollutants. Health impacts constitute the largest fraction of economic damages of air pollution. In order to be comprehensive, estimated health impacts include reduced organ functionality; increased asthma attacks; doctor visits, school and work absences; emergency room visits, hospital admission and heart attacks; and premature death. Emissions of coarse particulate matter (PM10-2.5—i.e., particulate matter that is between 10 and 2.5 µm in diameter) cause chronic obstructive pulmonary disease, asthma, and hospital respiratory and cardio-vascular admissions but have not been associated with increased mortality. However, fine particles (PM2.5) are more harmful because they translocate from the lungs to blood and accumulate in other parts of the body, increasing short-and long-term mortality and morbidity. Human exposure to ground-level ozone reduces lung function, generates inflammation of the airways, and causes symptoms such as chest pain, coughing, wheezing and shortness of breath, even for people with no pre-existing respiratory ailments.”<sup>6</sup>*

TABLE 3:

SUMMARY OF THE PHYSICAL IMPACTS OF THE MOST COMMON POLLUTANTS <sup>6</sup>					
	Human Health	Crops & Timber	Materials	Visibility	Recreation
NO <sub>x</sub>	Chronic Pulmonary Obstructive Disease Ischemic Heart Disease		Material deterioration		Algae blooms (eutrophication)
SO <sub>2</sub>	Asthma Cardiac	Damages to forests	Material deterioration		Damages to forests

<sup>9</sup> Massachusetts Department of Environmental Protection, “Acid Rain,” <https://www.mass.gov/service-details/acid-rain>

<b>O<sub>3</sub></b>	Chronic Asthma Acute-exposure mortality Respiratory problems Acute asthma attacks	Crop loss Timber loss	Robber deterioration		Damages to forests and wilderness areas
<b>PM<sub>2.5</sub></b>	Premature deaths Nonfatal heart attacks Hospital Admissions ER Visits for asthma, acute bronchitis, upper & lower respiratory symptoms			Loss of visibility	
<b>PM<sub>10-2.5</sub><sup>bb</sup></b>	Chronic bronchitis				

### Impacts on Water

What is often not considered in the discussion of the impacts of energy production – specifically electricity production – is the impact on water resources. The vast majority of electricity is produced via thermoelectric means, whether that takes place in a plant fueled by coal, nuclear, or natural gas. USGS reported that in 2005, 53% of all of the fresh, surface water withdrawn from the environment for human use went to operating our electric grid.<sup>10</sup> It is also notable that water behind dams is not included in this USGS data, so the water impacts of hydroelectric facilities are not included these figures. In its 2012 report, The River Network provided these startling statistics:

- In 2009, U.S. electricity production required approximately 42 gallons of water per kilowatt hour of electricity.
- The average U.S. household’s monthly energy use requires 39,829 gallons of water – *five times more water* than the direct water use of that same household.

Any discussion of electricity generation and its impacts must take care not to ignore impacts on our freshwater resources both regionally and locally.

### Climate Change

We are currently at a pivotal time in history when it comes to climate change. While the overall topic of climate change involves a variety of factors, and is beyond the scope of this report, a few factors are important to keep in mind. Greenhouse gas (“GHG”) emissions are of particular importance and are generated via both energy production and energy usage. We should also remember that when it comes to the concerns that arise from climate change and global

<sup>10</sup> “Environmental Quality and the U.S. Power Sector: Air Quality, Water Quality, Land Use and Environmental Justice,” ORNL/SPR-2016/772. Prepared by OAK RIDGE NATIONAL LABORATORY Oak Ridge, TN 37831-6283 managed by UT-BATTELLE, LLC for the US DEPARTMENT OF ENERGY under contract DE-AC05-00OR22725. Published January 4, 2017.

warming, increased water temperature is of particular concern. As such, the impacts of hydroelectric generation on freshwater resources should be considered – regardless of whether they are located in other states or in Canada. According to The River Network’s report, “On average, approximately 5.1 million gallons of water goes through a hydro plant for every MWh of electricity produced. Much like water used for thermoelectric cooling, water behind dams is affected by thermal gain, reduced water quality, and loss of aquatic biodiversity. In total, approximately 9 billion gallons of water evaporate behind hydroelectric facilities per day, enough to meet the daily demands of over 50 million Americans.”<sup>11</sup> From a climate perspective, hydroelectric generation is certainly preferable to certain other forms of generation, but is not without environmental impacts that must be considered. These figures only consider US-based hydropower and don’t include Canadian hydropower generation.

## THE FUTURE OF ENERGY IN MASSACHUSETTS

If our current times have taught us anything, it’s that actions in any one place have a global impact. Dumping plastics into the ocean in Asia creates an environmental disaster in California. Emissions from coal-powered plants in the Midwest create acid rain in the Northeast. We cannot turn a blind eye to the impacts that our energy needs have beyond the borders of any one state.

A significant amount of the electricity-generating resources that have powered Massachusetts during the last few decades will be reaching their end of life during the next decade or two. What will replace them? Most agree that a healthy mix of resources, which includes in-state solar, wind, and other renewables along with energy storage and imports of hydropower is the answer. One thing for certain is that home-grown electricity from renewable sources such as solar and wind provides the greatest security in our energy supply. Should some catastrophic reliability event render large, out-of-state resources or transmission lines unavailable, the impact could be severe and long-lasting. As such, over-reliance on such long-distance resources should be avoided.

### Electrification

One promising strategy to reduce harmful effects on our state and global environment – as well as reduce public health risks – is to decrease the use of combustion engines and transition to electric-powered engines. This increased “electrification” of our energy needs has the potential to dramatically reduce harmful emissions from sectors such as transportation, improving air quality at the local level. The forests, wetlands, and coastal areas of Massachusetts will experience significant environmental benefit from the reduction of combustion pollutants that reach these areas through prevailing winds and rainfall. In order to transition our electric grid

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<sup>11</sup> “Burning Our Rivers: The Water Footprint of Electricity”, Published by © River Network, April 2012, Portland, Oregon.

to a more balanced and secure mix of clean generation, distributed generation is a vital part of the equation.

### Distributed Generation

Distributed Generation, or “DG,” refers to energy generation that feeds into the local distribution grid that is typically overseen by a utility company. The distribution grid is what brings power from local substations in a community to the homes and businesses in the area. These substations receive their power from transmission lines that transport electrons from larger generating facilities, or “centralized generation,” that are sometimes hundreds of miles away. Thus, DG reduces the reliance of the local grid on far-away resources. While the pros and cons of distributed and centralized generation is worthy of its own report (of which there are many) there is little doubt that DG will play an increasingly important role in a balanced and secure energy mix. What is most important to recognize is that generation facilities seeking to interconnect to the distribution grid are required to pay for the costs of doing so. Connecting a DG facility requires “three-phase” electric service – something most often not found in rural areas. Most of our local distribution lines run along roadways. At a cost of approximately \$500,000 per-mile to install a new three-phase line, it is rare that a DG facility would locate very far from a roadway that has existing three-phase lines along it. By far the most common form of DG is solar.

### Solar PV

Solar photovoltaics, or “PV,” convert sunlight directly into electricity using solid state semiconductors. Metal posts are driven into the ground, with metal racks mounted to them

*Ground Mounted solar projects like this 1.38MW array in Swansea, MA, can serve as rich vegetative habitats for various animals, birds, and insects. As with many arrays operating in Massachusetts, this one was planted with a pollinator-friendly seed mix.*



with the solar panels on top. The panels are typically warranted for 25 years by the manufacturer and require very little maintenance. Solar DG installations produce no audible noise and are monitored remotely making the only maintenance visits either routine or in response to some event. As such, the grassy areas around the panels are typically only cut a few times per year, creating habitats for a variety of species, including birds, bees, and other pollinators. Solar DG installations are typically built

on land leased for around 20 years. These leases typically require that they be removed, or “decommissioned,” after operations cease thus enabling the land to either return to its former use or be used for something else.

## RECOMMENDATIONS

To capture the significant environmental benefits to procuring additional solar generation in Massachusetts, we believe policymakers should act to ensure careful land use as the need for clean energy increases in the years and decades ahead. As such, this report recommends policymakers act to:

- 1) **Protect Important Land Resources.** While most of the state’s important natural resources are already protected and governed by effective regulations and agencies, policymakers should make necessary improvements to eliminate “loopholes” or insufficiencies in any of these resource protections. One example that has been the subject of recent discussions is that certain interior forest areas, often referred to as “Forest Cores,” may need to be more specifically regulated in terms of development. These areas generally refer to areas that are less likely to be impacted by roads and other development. As such they provide important habitat for species sensitive to forest fragmentation.
- 2) **Enhance the Collection and Tracking of Data and Use Cases.** The state should track specific data regarding the use of different types of forestlands for solar and other purposes. This approach can provide specific, accurate, and timely data that can be used to inform future discussions regarding land use and siting of renewable energy. Engaging stakeholders in such discussions on an ongoing basis is also recommended. The Office of Energy and Environmental Affairs (EEA) should form and administrate a Working Group that will assess land use issues on an ongoing basis and make recommendations to the Department of Energy Resources (DOER) commensurate with observable and documented findings.
- 3) **Require “Greenfield Practices”.** The DOER should adopt a set of “Greenfield Practices” to be utilized in the construction of solar projects on previously undeveloped land. Such practices include minimizing grading, protecting soils, banning herbicides, and seeding with pollinator friendly mixes. The adoption of such practices can ensure that when previously undeveloped land is utilized for solar, that the solar is installed and maintained in a manner that will enable

the land to be utilized for farming or forest in the future, once the panels are removed.

- 4) **Restructure the “Greenfield Subtractor.”** The state should not increase penalties for solar projects on previously undeveloped land at this time, but instead implement the steps listed above. It could consider replacing the subtractor with a new conservation fund that applicable projects would pay into – on a \$/acre impacted basis.
- 5) **Simplify the “Agricultural Dual-Use Adder.”** Policymakers should make incentives for agricultural dual-use projects more effective and practical for host farmers and ensure that farmers can continue to host large-scale, ground mounted solar projects to help Massachusetts farms remain economically viable. We believe that inviting farmers to share their ideas on how to enhance the concept of agricultural dual-use will result in more opportunities to help Massachusetts farmers while achieving the Commonwealth’s energy goals.
- 6) **Better Support Home Rule & Municipalities.** Participation in the state’s solar program(s) should be contingent upon compliance with “conditions” imposed upon projects in permits issued by municipalities. We believe this is an important step to protect the authority of local permitting jurisdictions. Further, the state should provide resources to assist municipalities – especially smaller towns - in addressing solar in their local bylaws and permitting processes. Involving the Green Communities program and Regional Planning coordinators is also recommended.

## METHODOLOGY + DATA

### Calculation of Percent of Forest Developed in Total and by Solar

To calculate the percent of forest, and fields, shrub, and barren land developed by solar and other forms of development from 2001 to 2016, we first had to map all of the solar built in the Commonwealth. This was accomplished by tracing all of the ground-mounted solar built in MA through the end of the study period in Google Earth. The solar projects were mapped as geospatial polygons, tracing the fence-line of the solar project in the latest imagery provided by Google Earth. To determine the rest of the open space developed in the Commonwealth during that time period, we utilize the USGS 2016 National Land Cover Database, a 30-meter resolution dataset that provides a land surface classification of the entire United States. Part of that database is a raster layer that describes the type of impervious surface, or developed land. We extracted all nonroad impervious surface as a separate layer. We then extracted the various open space classifications from the 2001 NLCD as a separate raster layer, measuring the acreage of each classification. We then intersected the 2016 nonroad impervious surface layer with the 2001 open space layer to determine the acreage of each type of open space developed during that time period. We intersected the solar project outline dataset with the 2001 open space dataset to determine acreage of each type of 2001 open space used for solar.

### Acreage Calculations of Developed and Protected Areas

To determine the acreage of developed land and protected land by the various levels and types of protection mentioned in this report, we started with a geospatial dataset of the outline of MA provided by MassGIS. We intersected that dataset with the USGS 2016 Impervious Surface descriptor raster layer to determine the types of development, road, urban, nonurban in the Commonwealth. As the 2016 Impervious Surface dataset is 30 meter resolution, and this report centers around the use of forests and open space in the Commonwealth, we sought to characterize anthropogenically disturbed open space that doesn't register on a 30 meter resolution, satellite-imagery derived national database. To do this we built a layer of 150ft buffers around the centroid of every building in MA. We chose 150ft as the buffer distance because most rural and suburban homes have clearing around their immediate house footprint that should not count toward open space the same way a forest 500 feet from that home should. This buffer layer contributed another 485,000 acres toward our calculation of 1.75 million acres of developed or disturbed acres in the Commonwealth. From there, we layered in successive datasets & corresponding policies of land use protection, measuring their total acreage, and additional acres not previously counted in order to put land use development, protection policies, and solar development potential in context with one another. This data is shown in Table 3 above.

## APPENDIX

### Historical Development and Status of Massachusetts' Community Solar Policy

Massachusetts solar capacity has grown significantly the past decade, resulting in over 2,500 MW installed today and accounting for nearly 12% of the state's electricity.<sup>12</sup> The growth of this sector has been supported by a robust industry, with over 10,000 jobs<sup>13</sup>, and by underlying policies aimed at meeting market demand and interests.<sup>14</sup> The Solar Massachusetts Renewable Target (SMART) Program is the newest program established to continue the state's support for solar development while also incorporating more targeted objectives associated with that development, such as ensuring a diversity of project types.<sup>15</sup> Since launching in late 2018, the SMART program has received over 11,000 applications for over 1000 MW of capacity.<sup>16</sup> The rapid influx demonstrates pent-up demand in the market while also raising concerns with regards to the sustainability of the SMART program's current policy framework of 1,600 MW.<sup>17</sup>

Community solar has become an increasingly important part of Massachusetts' solar story. Although it accounts for less than 1/6<sup>th</sup> of capacity currently installed in the state, it represents about 70% of the total capacity applied into the SMART program.<sup>18</sup> The rapid shift toward community solar makes sense for policy makers and customers. These projects can leverage economies of scale while also benefiting the distribution system. More importantly, community solar ensures the SMART program provides an equitable opportunity for participation by Massachusetts customers, regardless of their income level or property ownership status. Indeed, the addressable market for community solar accounts for nearly three quarters of all Massachusetts households when accounting for financial constraints, renters, and suitable rooftop space.<sup>19</sup>

<sup>12</sup> Solar Energy Industries Association. *Solar Spotlight – Massachusetts*. (September 9, 2019). See: [https://www.seia.org/sites/default/files/2019-09/Factsheet\\_Massachusetts.pdf](https://www.seia.org/sites/default/files/2019-09/Factsheet_Massachusetts.pdf)

<sup>13</sup> The Solar Foundation. *Solar Jobs Census 2018*. See: <https://www.solarstates.org/#state/massachusetts/counties/solar-jobs/2018>

<sup>14</sup> The state's Renewable and Alternative Energy Portfolio Standards have been central to several iterations of policies implemented in Massachusetts that support renewable energy development. See: <https://www.mass.gov/service-details/program-summaries>

<sup>15</sup> See: <https://www.mass.gov/info-details/solar-massachusetts-renewable-target-smart-program#general-information->

<sup>16</sup> Massachusetts Department of Energy Resources. *SMART Program 400 MW Review*. (September 5, 2019). See: <https://www.mass.gov/files/documents/2019/09/04/400%20MW%20Review%20DRAFT%20090419.pdf>

<sup>17</sup> Vote Solar. *Clouds over the Solar Industry in Massachusetts: Inconsistent Policy Slows Growth*. September 2019. See: [https://votesolar.org/files/8615/6754/1556/V\\_S\\_MA\\_SMART\\_RPRT\\_FINAL\\_09.3.19Web.pdf](https://votesolar.org/files/8615/6754/1556/V_S_MA_SMART_RPRT_FINAL_09.3.19Web.pdf)

<sup>18</sup> Smart Program queue. (August 19, 2019) <https://www.mass.gov/media/1980301/download>

<sup>19</sup> Based on an analysis using the U.S. Census Bureau Quickfacts for Massachusetts (<https://www.census.gov/quickfacts/MA>) and data points from the National Renewable Energy Laboratory report: *Rooftop Solar Technical Potential for Low-to-Moderate Income Households in the United States* (April 2018), found here: <https://www.nrel.gov/docs/fy18osti/70901.pdf>