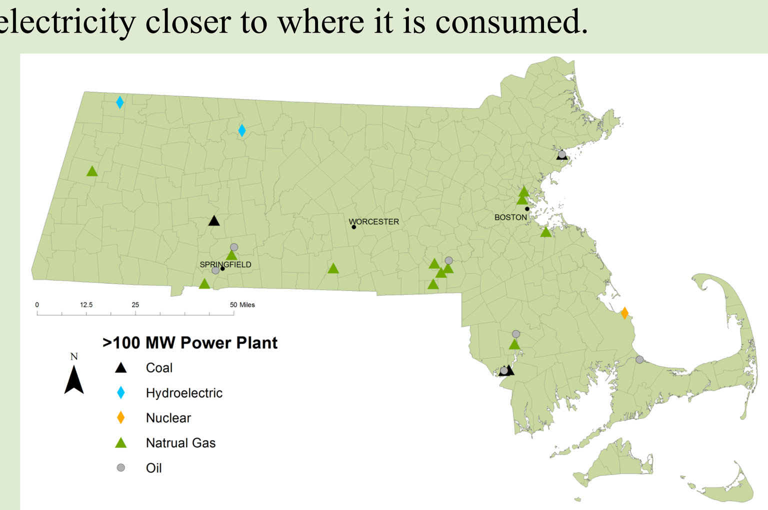
A Spatial Analysis of Potential Renewable Electricity Generation Sites in Massachusetts

Introduction

Globally, electricity generation is still very dependent on nonrenewable fuels. In order to reduce the consumption of electricity and the use of non-renewable technology for its production, electricity generating systems need to become more efficient and incorporate renewable electricity generation technology.

For electricity production to be most efficient, it should be designed to reduce losses in transmission. On average, in the United States, about 7% of electricity generated is lost in transmission. While 7% might seem like a small figure, when taking into account that in 1999 the United States generated 3,617 billion kWh of electricity, the amount of resources that could be saved from preventing losses in transmission is quite significant (EIA). Some transmission loss will always be inevitable due to resistance in the wires, but it can be significantly reduced if the electricity is generated as close to the point of consumption as possible.

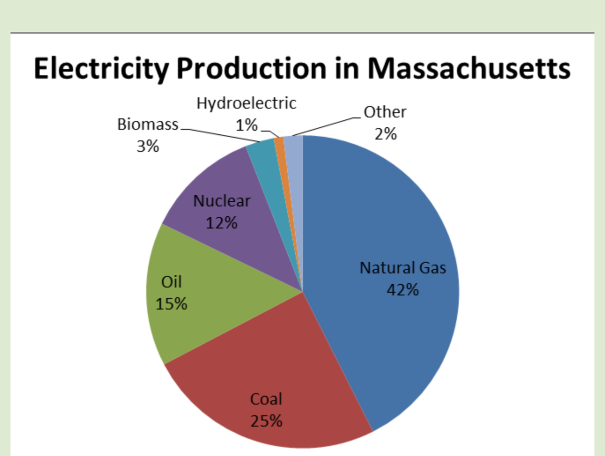
For this study, I explored the use of various spatial analysis methods to consider how Massachusetts can reduce its dependence on nonrenewable fuels. I used ArcGIS to spatially analyze the existing relationship between where electricity is generated and where it is most consumed. The goal of the study was to experiment how GIS can be used to identify possible sites where additional renewable electricity generators can be placed that will generate electricity closer to where it is consumed.



Background

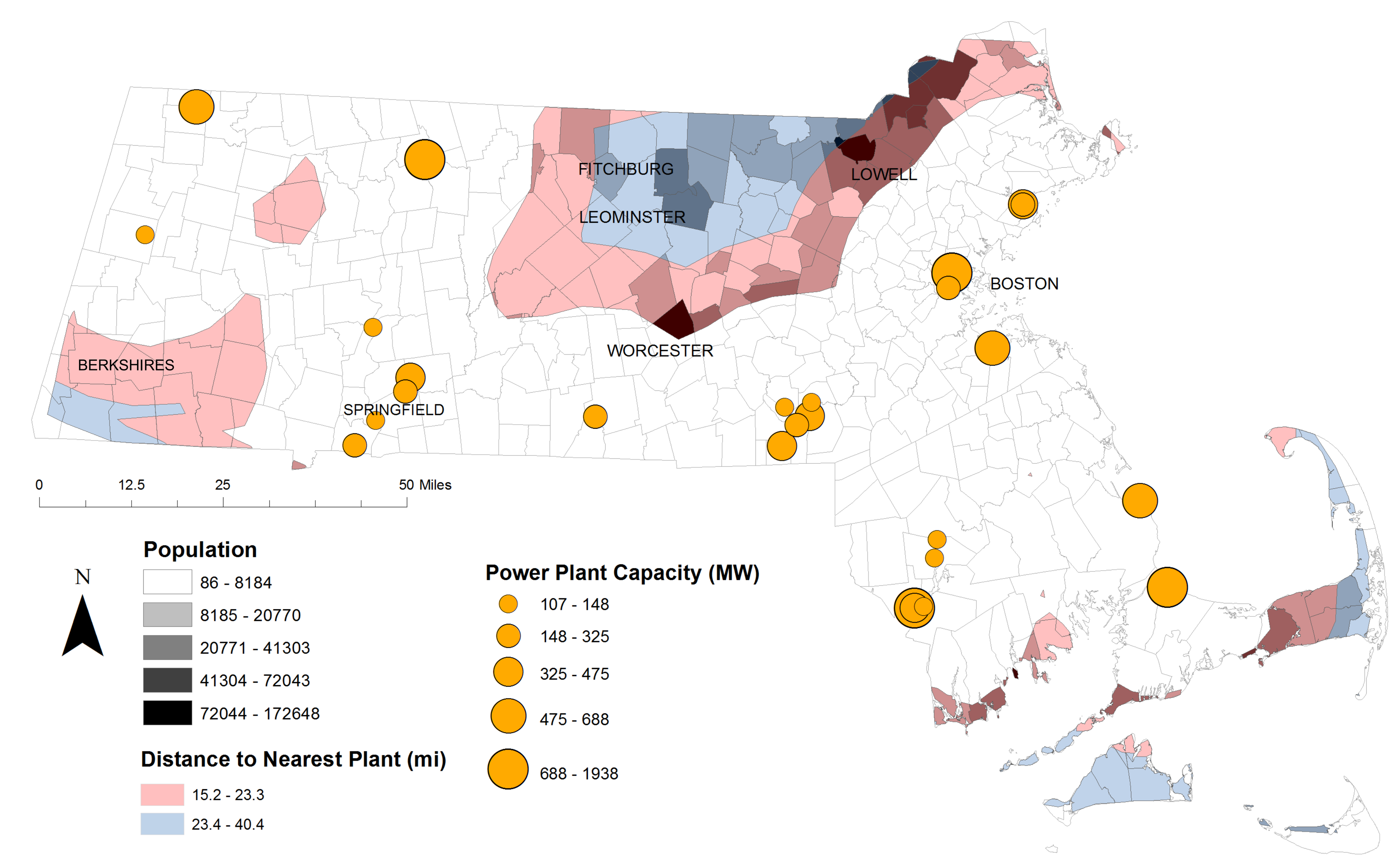
Currently, Massachusetts is one of the leading states in terms of lowest per capita energy consumption, listed by the Energy Information Administration as 49th nationally in 2009. This is in large part due to the state economy not being very energy-intensive and the relatively low use of air conditioners in the summer (EIA). While this is a positive aspect of Massachusetts' energy profile, in order to reduce its dependence on nonrenewable fuel sources, Massachusetts still has work to do.

Since the mid 1990's, Massachusetts has done a good job of shifting from a state mostly powered by petroleum to one that uses natural gas for 43% of its electricity generation (EIA). While natural gas produces fewer pollutants and particulates during combustion, and is an improvement from petroleum, it is still a nonrenewable fuel. In addition to natural gas, Massachusetts still uses coal and petroleum for about 25% and 15% respectively of its electricity generation (Figure 1). Since Massachusetts has no natural reserves of these fossil fuels, many resources go into transporting these non-renewable fuels and bringing them to Massachusetts for use.



While the current power generation in Massachusetts is primary driven by nonrenewable fuels, Massachusetts is a state with a lot of potential for nonrenewable energy production. Already, the Pilgrim Nuclear Generating Station provides about 12% of the state's electricity. More important to this study, however, Massachusetts has one of the highest wind energy resources in the country along its eastern Atlantic coast, as well as relatively significant wind energy potential in the south western quadrant in the Berkshire Mountains. Part to of the purpose of this study was also to identify towns with high population located far away from existing power plants that could also specifically be candidates for wind-energy installations.

Map 4. Intersection of areas in Massachusetts located relatively distant from existing power plants with towns of relatively high population. This map shows that this study produced several towns ("target towns" shown in table) that might be potential candidates for additional local renewable power supply. According to this map, towns with greatest need of additional power supply are located in north-central Massachusetts. Additionally, it shows that while the Berkshires region is isolated from power plants, towns have small populations and are therefore not ideal locations for additional renewable power plants.



Target Towns	Population
ANDOVER	31247
BILLERICA	38981
BREWSTER	10094
CHELMSFORD	33858
DARTMOUTH	30666
DENNIS	15973
DRACUT	28562
FITCHBURG	39102
HARWICH	12386
HAVERHILL	58969
HOLDEN	15621
LAWRENCE	72043
LEOMINSTER	41303
LOWELL	105167
MARLBOROUGH	36255
METHUEN	43789
NORTH ANDOVER	27202
ORLEANS	6341
SHREWSBURY	31565
TEWKSBURY	28847
WORCESTER	172648
YARMOUTH	24807

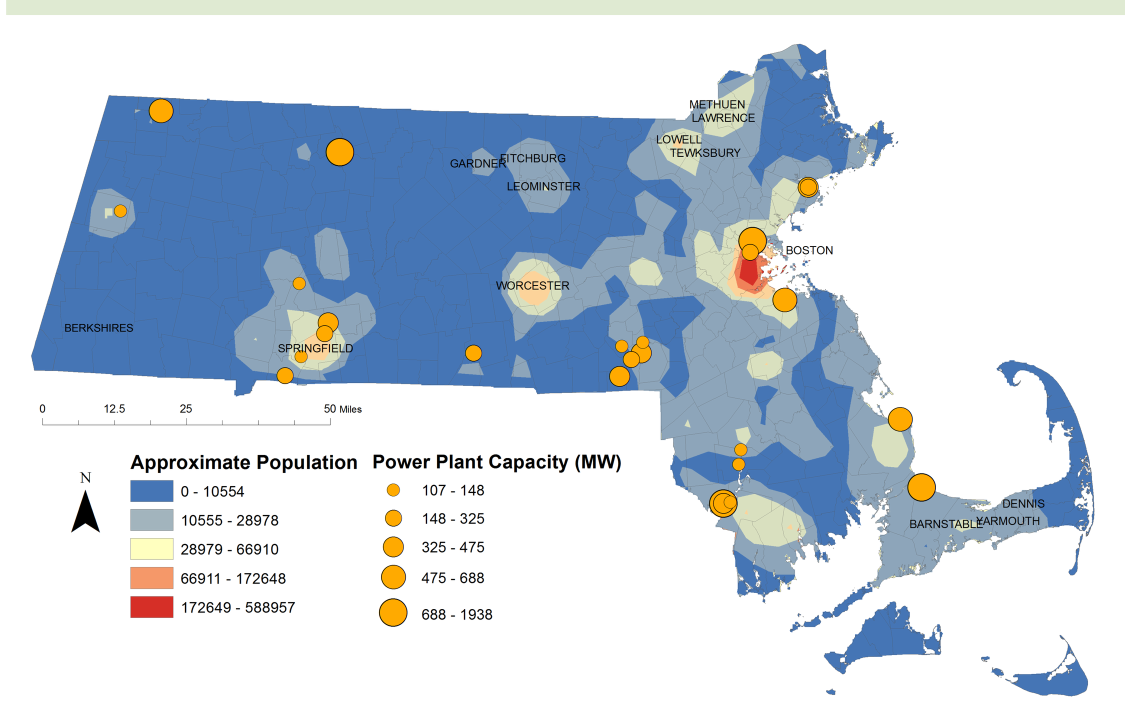
Methods

In order to carry out this study, there are several GIS techniques were used. Because I wanted to investigate the relationship between where electricity is currently generated and consumed in Massachusetts, I primarily used proximity analysis and interpolation tools to generate relevant maps. These tools allowed me to qualify and quantify spatial relationships between towns and their nearest power plant. Additionally, because I had to create my own shapefile for the existing power plants in Massachusetts, I used geocoding and address locators.

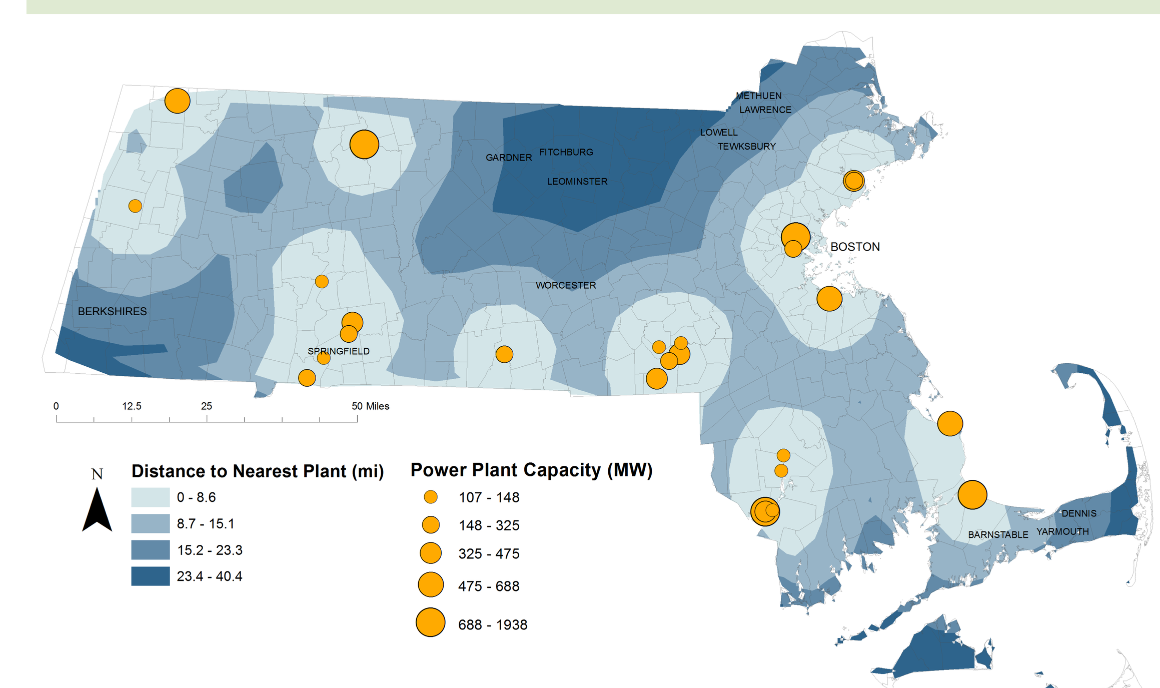
It should be noted that due to a lack of data on individual town electricity consumption, for this study I used town population as and approximate representation of electricity consumption throughout Massachusetts.

Results

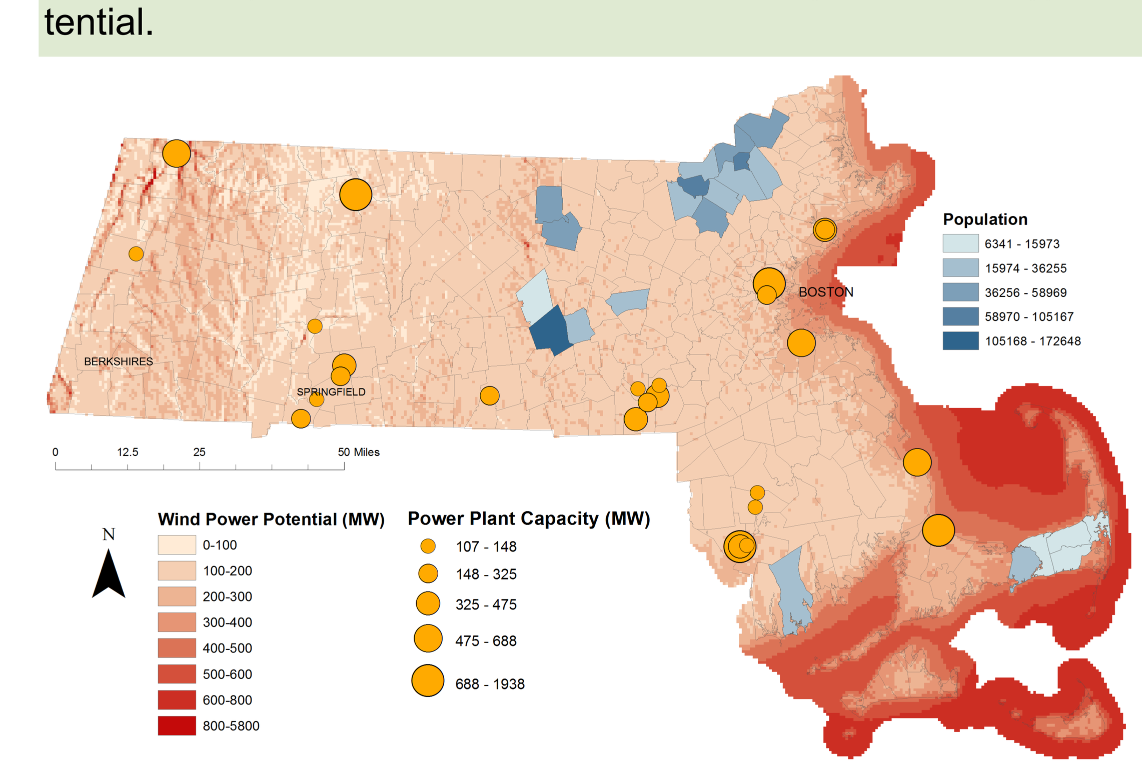
Map 1. Approximate population in Massachusetts. This map gives a qualitative analysis of the relationship between areas of high population and the location of existing power plants. It shows that north-central Massachusetts has relatively high population and lacks nearby power supply.



Map 2. Distances to nearest power plant. This map shows three distinct regions in Massachusetts that are relatively isolated from power supply: the Berkshires, north-central Mass, and Cape Cod.



Map 3. Comparing areas of wind-energy potential to towns that have relatively high population and are located relatively far from existing power plants. This map shows that some towns in Cape Cod have relatively high populations, are relatively isolated from power supply, and are located in areas with high wind-energy potential.



Conclusion

There are several conclusions that can be drawn from this study. To begin with, the study generated several methods of making maps that could potentially be used to analyze electricity generation in Massachusetts or in other regions. The maps produced in the study spatially relate where electricity is currently generated and where it is consumed. In addition to maps, the study generated a list of towns that fit the criteria set at the beginning of the study for areas that could be causing energy loss in transmission. If powered by additional local renewable energy, these towns could potentially reduce Massachusetts' nonrenewable electricity generation. Finally, the study identified an area in Massachusetts (Cape Cod) that would be a good candidate for wind-energy installations. This last outcome of the study correlates with current intentions of installing a 420 MW wind farm off the coast of Nantucket.

For this study, it is crucial to understand that it was carried out as an exploration of analysis methods and not as an attempt to provide sound evidence for locations in Massachusetts where new power plants should be installed. The purpose of the project was to propose a means of analyzing electricity production and consumption through a GIS toolset.

There were many shortcomings of the project that make it unsuitable for use in real life. The most obvious of these is amount of approximation needed for the study. Due to a lack of available information, I was not able to map out energy consumption in Massachusetts. Instead, I had to assume that mapping population would be an accurate enough approximation of electricity consumption. Another simplification I had to make in this study is that I did not take into account every single power generator in Massachusetts, only the major power plants with a capacity greater than 100 MW. This can potentially deviate the results from reality because areas shown in this study as located far away from existing power plants might actually have nearby power generators that are smaller than 100 MW.

In conclusion, despite its various shortcomings, this study produced approximate visuals representing the spatial relationship between electricity production and consumption in Massachusetts. More importantly however, the study exemplifies a possible application of spatial analysis for the purpose of solving energy resource problems.

Cartographer: Mariana Liebman-Pelaez

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