Prioritizing Green Investments for Local Governments: Tree Canopies vs. Solar Canopies

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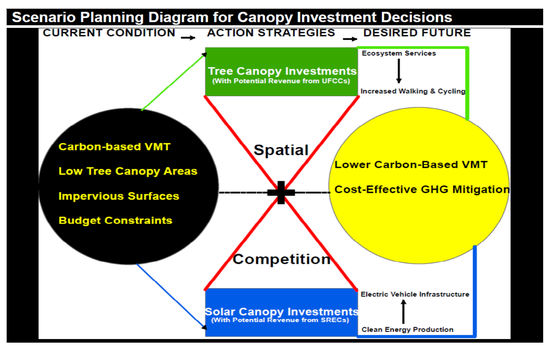
ABSTRACT

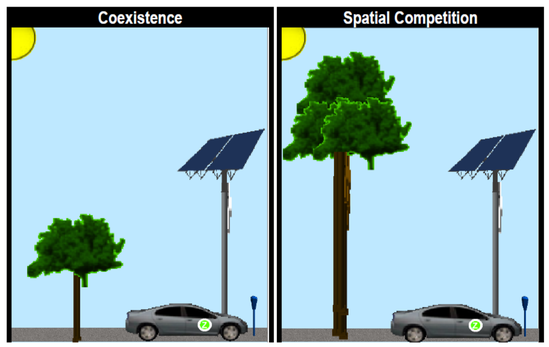
Many America cities are planning concurrently for expanding their urban forest and building a solar infrastructure as part of the portfolio of strategies to address climate change in metropolitan areas. A competitive landscape for tree canopy and solar canopy investments resides along city streets and in parking lots. In general, these green investments are in competition because, if and when the two converge, they are competing for access to sunlight. This project covers some of the factors that would help local governments to prioritize green investment opportunities. Spatial analyses were conducted for case study cities to identify CO_2 dense areas and potential locations for canopy investments. The spatial analyses, if integrated with a comprehensive plan, may provide a foundation for cities to develop GHG mitigation ordinances that concurrently address tree and solar siting. GIS-based prioritization metrics were developed for this project to address transportation CO_2 reductions and decision-making for optimizing green investments in high need areas. The primary products of the study are prioritization metrics, maps that depict VMT intensity zones, build-outs for minimal or no tree canopy areas, and a framework for establishing a GHG mitigation ordinance.

BACKGROUND

Tree canopy and solar canopy investments are not the answer to avoiding climate change. However, these green investments can be part of a comprehensive abatement strategy that local governments can implement to address transportation CO_2 mitigation. Annually, urban forests in the lower 48 states of the U.S. sequester about 22.8 million tons of CO_2.[1] The average urban forest carbon density in the U.S. is slightly above 25 tons per hectare.[2] The amount of solar radiation that hits the Earth in 1 hour is 4.3 x 10^{20} joules (J) and this makes solar energy the most abundant renewable energy source.[3] Tree canopy and solar canopy investments along city streets and in parking lots can be structured to reduce CO_2 from both mobile and stationary sources.

Reducing CO_2 from mobile sources is important because 33% of U.S. carbon emissions come from the transportation sector. [5] Tree canopies can produce moderated temperatures for cyclists and reduce CO_2. About 72% of all trips in the U.S. that are less than 3 miles in length are made by car but these distances can be covered by cyclists and provide a reduction in carbon-based vehicle miles traveled (VMT).[4] Solar canopies can provide an infrastructure for electric vehicles (EV). Cities can conduct spatial analyses and build-out scenarios to visualize opportunities. The utilization of geographic information system (GIS) decision-making can help cities to create CO_2 intensity overlay zones for optimizing the siting of projects. The process of developing GIS-based prioritization metrics is the key to establishing targeted CO_2 reduction strategies, understanding local market opportunities, optimizing selection criteria for high priority areas, and providing a framework for GHG mitigation ordinances.





METHODS & ANALYSIS

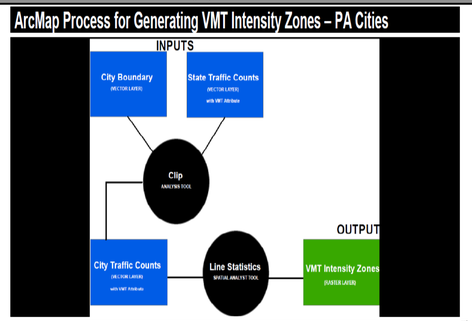
GIS software (ArcGIS– v10), software extension (CommunityViz), and tools from the U.S. Forest Service (i-Tree Design) and U.S. Department of Energy (IMBY) were used for data aggregation, computation, visualization, and insight extrapolation. A SWOT analysis matrix was used to analyze strengths, weaknesses, opportunities, and threats of public policy, economic, environmental, and social factors. The objective of the GIS analyses was to identify streets and parking lots that have no tree canopy or minimal tree coverage and are near streets with relatively moderate to high levels of vehicle miles traveled (VMT). Composite maps with VMT intensity zones were generated for a few cities to identify potential canopy investment sites. CO_2 estimates were calculated for the VMT intensity zones.

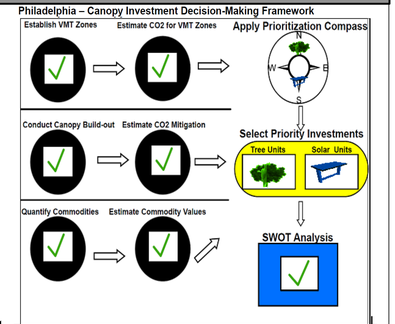
In this project, reducing carbon-based VMT was the primary aim. Tree canopy datasets were important but datasets for traffic counts provided the basis for the prioritization metrics that were developed to pinpoint high priority areas. The prioritization metrics are based on a 4-class map layer of VMT intensity zones that were developed using spatial analyst tools in ArcMap. A concept called the "prioritization compass" was also defined for this project and applied to the VMT intensity zones to provide allocation and prioritization recommendations for tree canopy and solar canopy investments. The compass is set to provide recommendations based on an integration of the absolute cardinal positions for the VMT intensity zones and their positions relative to each other.

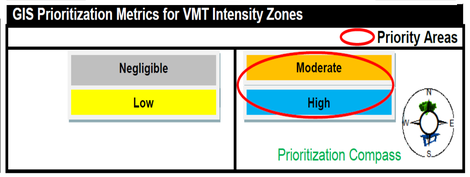
The spatial analyses also served as a foundation for 2 types of build-out scenarios that were conducted using the CommunityViz extension of ArcGIS. The build-out scenarios were simulated for areas with low tree canopy and high VMT criteria. A high unit density build-out was simulated for tree investments and a low unit density build-out was simulated for solar investments. The build-out results were multiplied by outputs from the i-Tree Design and IMBY tools to estimate CO_2 mitigation for moderate and high VMT intensity zones in residential and commercial areas. The results also provided the basis for estimating the number of environmental commodities from the potential canopy investments. The commodities can be used for partial project financing.

PHILADELPHIA ANALYSIS

49% of the city is available for canopy investments and 24% of this area is impervious.[6]







Philadelphia: Annual Average Daily VMT per Street & CO_2 (lbs) per Vehicle

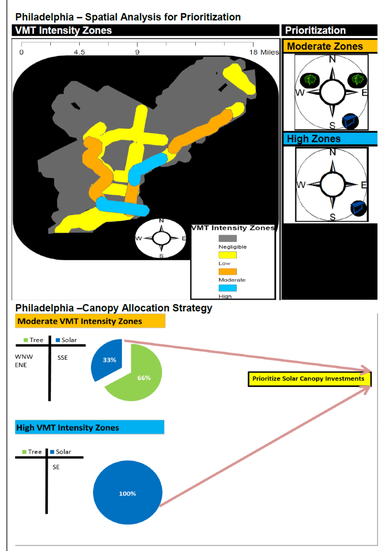
	Negligible	Low	Moderate	High
VMT per Street	< = 40,719	40,720 – 107,654	107,655 – 204,299	204,300 – 318,130
CO_2 per Vehicle	< = 39,252	39,253 – 103,777	103,778 – 196,941	196,942 – 306,672

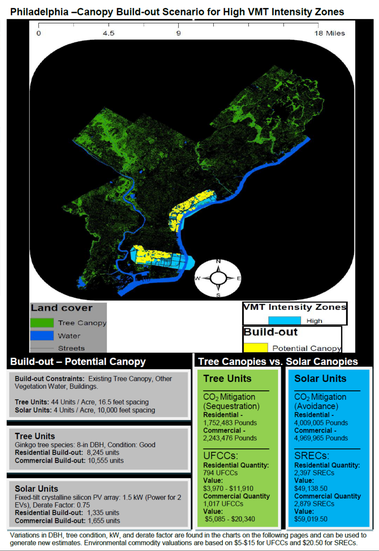
CO_2 Estimates- Based on the EPA Green Power Equivalency Methodology: (VMT / A) x C = CO_2 per Vehicle
A = Average U.S. Fuel Economy in 2007 (20.4 mpg); C = CO_2 Emitted per Gallon of Gasoline Consumed (.00892)
CO_2 estimates were converted from metric tons to pounds by a conversion factor of 2204.62262 pounds per metric ton.

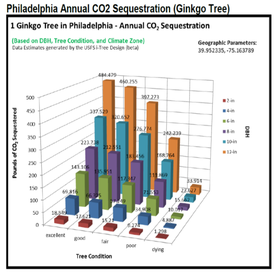
Philadelphia: VMT CO_2 Neutrality Estimates for VMT Intensity Zones

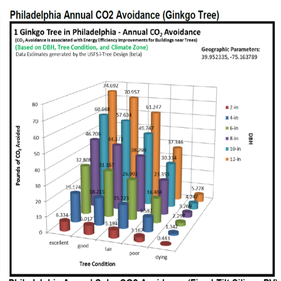
	Moderate	High
Annual CO_2 per Vehicle (lbs)	37,878,970 – 71,883,465	71,883,830 – 111,935,260
Tree Units necessary for Neutrality	178,211 – 338,194	338,196 – 528,628
Solar Units necessary for Neutrality	12,614 – 23,937	23,937 – 37,274

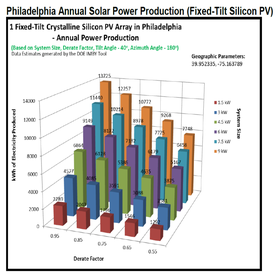
CO_2 neutrality estimates for tree units are based on the Ginkgo tree species (8-in DBH, Condition: Good). Estimates for solar units are based on fixed-tilt crystalline silicon PV array (1.5 kW, Derate Factor: 0.75).

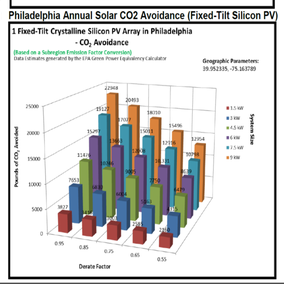








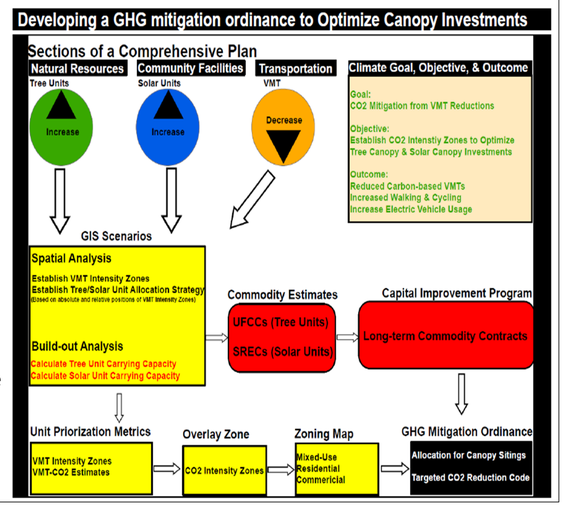




CONCLUSION / FUTURE ANALYSES

The final product of this study that can be used by any municipalities is a framework for "Developing a GHG mitigation ordinance to Optimize Canopy Investments". Local governments with recent urban tree canopy assessments and datasets for traffic counts can use this framework as a guideline for planning reductions in carbon-based VMTs. The case studies conducted for this project suggests that cities may discover many spatial opportunities that support the prioritization of solar canopy investments over tree canopy investments to establish a clean EV infrastructure.

Analyses that cities might want to consider for maintaining optimized CO_2 mitigation from canopy investments involve modeling tree growth, increased shading, and the associated effects on efficiency for adjacent solar canopy structures. Once the shading from tree growth begins to derate the efficiency of solar power production, cities might want to consider replacing the overgrown tree with a smaller tree to sustain solar access. The scenarios for the case studies suggest that a tree replacement cycle of every 10-15 years should be used to optimize solar access. A replacement cycle can help to insure that locations are constantly optimized for CO_2 reductions across both canopy investment options.



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