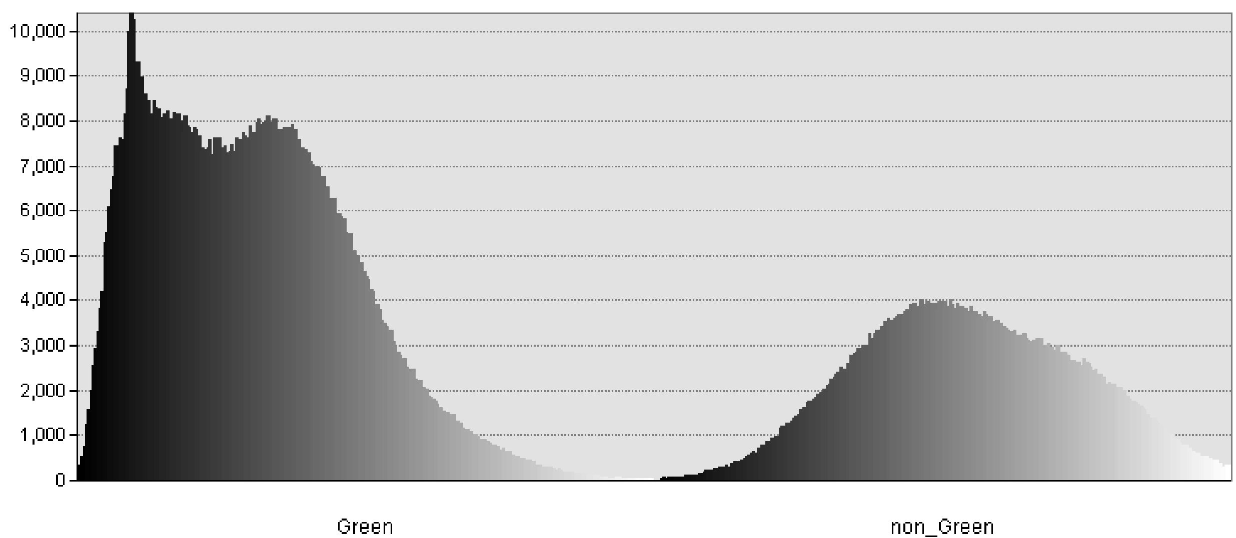
Mecklenburg County (Charlotte City) - Investing in its future

Heat Sinks

From an environmental standpoint, an urban area's greatest threat is the rising temperatures that it both contributes to and is impacted by. Loss of green cover bakes the land/concrete and inturn increases the energy needed to cool buildings and transport. This is evident from the mean LST which is at least 3 degrees higher in the non-green areas of the county. This encourages the need for green/water belts threaded into the county's infrastructure to create a cooling effect, and either coating a majority of the remaining areas with highly reflective sheets or installing energy capture systems (eg: solar panels).

Zone	Area (sq miles)	mean_LST	std_LST
Green	361	27.15	2.27
non-Green	184	30.28	2.58

The below histogram (y-axis shows frequency) exhibits the distribution of temperature readings across the two zones. We see that the non-green zone charts higher frequencies of high temperatures (far right of graph). This histogram also agrees with the standard deviation of LSTs shown above.



Analysis Steps:

- Calculate the LST using landsat's band 4, band 5, and thermal band images. More literature on LST available here and here.
- Compute the mean LST using Zonal Statistics as Table and chart the histogram using Zonal Histogram tool (the zones were defined via a separate classification step)

Data Sources:

- Landsat images: EarthExplorer (usgs.gov)
- EPA Air Data: Daily Air Temperatures

Energy Savings - Commutes

A singular downtown leads to a proportional uptick in average commutes with an increase in population. Creation of secondary downtown areas can reduce this energy expense. We performed a suitability analysis prior to this step to identify the potential urban hubs. We have leveraged those new urban hubs as the centers for any relevant households within a 2.5 mile radius. For each of these households, we computed their distance to the current downtown location, and the distance to their new urban hub. We calculated their commute savings per day as the difference between the two distances. To set a benchmark, we are assuming only one daily commute (two way route) from each of these households and that only 20% of these households are re-routed to the new hubs.

distances of households that are within a 2.5 mile radius	
3,660,118	to current downtown
247,194	to new urban hub
3,412,924	saved miles (20% households, 2 way route)

The ~3 million miles not traveled would yield 140k gallons of gas saved per day (assuming 25 miles per gallon). This would in turn lead to nearly $1,200 saved per commuter per year on gas (assuming $4 per gallon and 165k households in scope). It would also lead to 1.65 billion KWh of energy if the fuel was instead used to generate electricity (assuming 1 gallon of gas produces 33 KWh). Note that this is a fairly conservative estimate for a few reasons: 1) the suitability analysis performed in a prior step identified urban hubs closer to the edges of the county. There should be more commuters residing outside the county limits that can benefit from these new hubs. 2) the savings mentioned would easily double if the price of carbon emissions, time in traffic congestion and car resale values are taken into account. The amount would be far higher if the long term health of our planet is also considered. 3) we apply only the euclidean distance which should be lower than the actual travel route for each commuter.

Analysis Steps:

- For each potential urban hub identified, select households that are within a 2.5 mile radius
- Compute the euclidean distance from each household to the current downtown location and to its assigned new urban hub
- Take 20% of the difference between the above computed distances and double it to represent two way routes

Data Sources:

- Sentinel images: Copernicus Open Access Hub
- US Census Housing: 2019 estimates
- KWh in gasoline: JDPower car shopping guide

Energy Generation - Renewables

Renewable energy is growing fast, and the setup/storage costs are getting cheaper. This along with local government incentives should accelerate its household adoption. We considered NREL's locality based estimation of solar and wind energy. Average annual solar GHI is directly reported in KWh, while annual average wind speed at 10m (33 feet) is measured in meters/sec off which we estimate the KWh generated. We analyzed the potential rooftop solar and wind energy against two of the county's zones: green and non-green. Given that non-green includes roads, pavements etc and that not every house/building's rooftop angle is optimal for solar panels, we are assuming that only 5% of potential energy can be captured from the sun. Wind turbines (rooftop or stand alone) require unobstructed expanses and can capture energy only within a certain range of wind speeds. Due to this, we are assuming that only 1% of potential wind energy can be harnessed. With these limitations in place, the below are the average estimates per year of potential renewable energy for this county.

Zone	Area (sq miles)	Solar GHI (5% KWh/year)	Wind 10m (1% m/s/yr)
Green	361	n/a	245,334
non-Green	184	1,113,816	125,477

If we assume an average of 10m/s winds generates 25,000 KWh annually, then the above aggregate should generate more than 900 million KWh annually. Combined with the solar power of 1 million+ KWh, we would be able to power 77 thousand homes for an entire year (assuming 1000 KWh powers a house for a month). That is nearly 17% of all homes in the county (the 2019 Census estimated 466k homes in total). Note that these energy estimates are conservative and can be used as a benchmark.

The combination of yearly renewable energy generation (0.9 billion KWh) and energy savings from commutes (1.65 billion KWh), should ease the load on our grid as we move into the new era of electrifying most of the energy consumed by our supply chain (manufacturing, transportation, heating etc).

Analysis Steps:

- Downloaded the NREL shape files for locality based potential energy for solar GHI and wind speeds at a 10m height (we assumed that most housing in the county is suburban in nature, with homes generally topping at 40 feet above ground and turbines needed at least 30 feet above that to capture unobstructed wind, so we are capturing wind at 20m, but used the estimates published at 10m as we would like to set a benchmark).
- Tabulated the solar and wind energy for the housing area using the Zonal Statistics as Table and applied the limitation percentages (5% for solar and 1% for wind).

Data Sources:

- Sentinel images: [Copernicus Open Access Hub]
- Solar and Wind Energy Shapefiles: [NREL Supply Curves]
- Calculating Wind Energy: [Energy from the Wind]
- US Census Housing: [2019 estimates]