Geoprocessing for the NYC Solar Map

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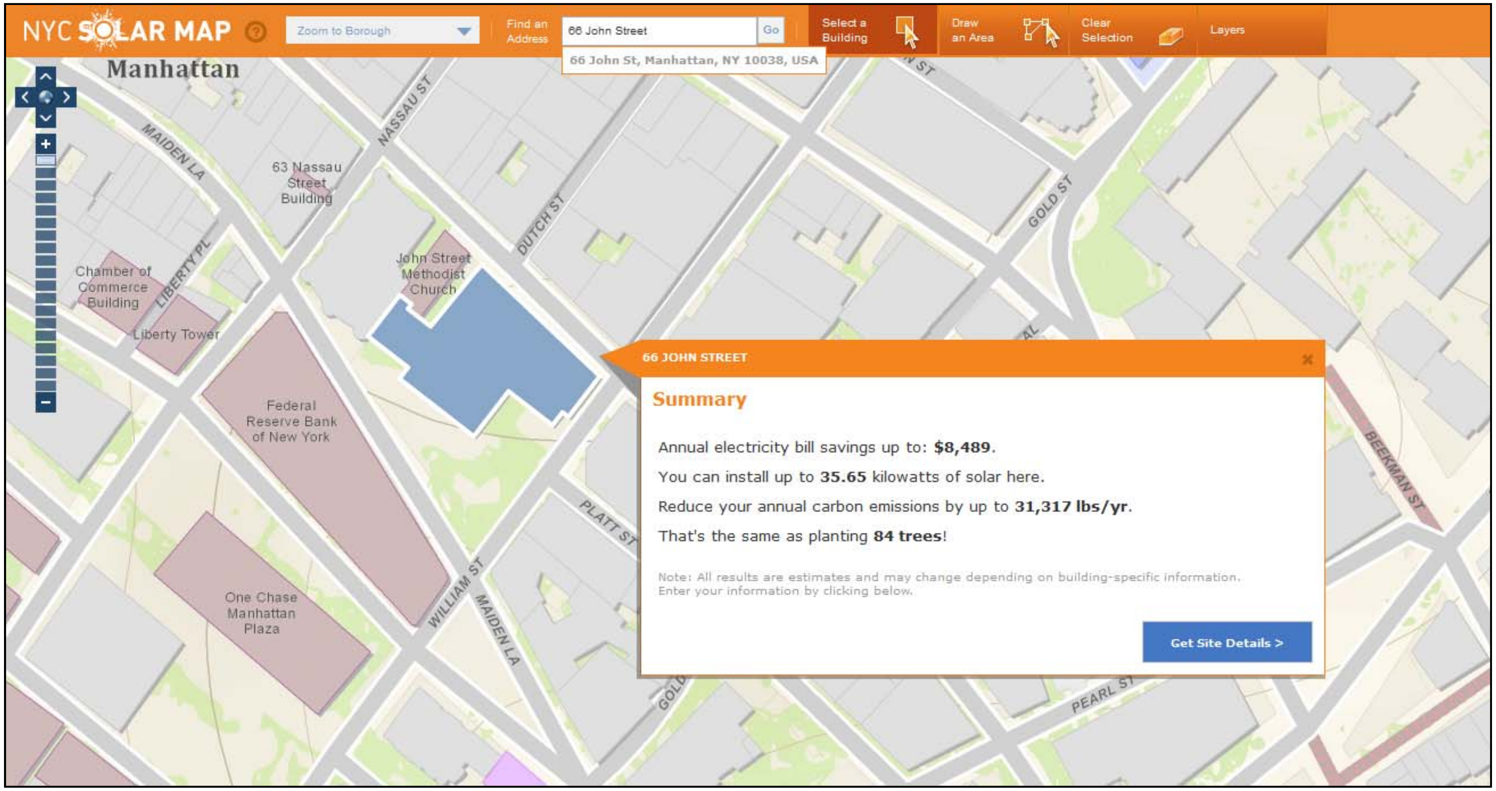
Solar Map

- Displays solar energy generation potential for NYC, including solar potential by rooftop or user-drawn polygon, and financial estimates



Source Data

- Lidar digital surface model at 1ft resolution
- Monthly solar radiation from ESRI model
- Building footprints

Sample monthly solar radiation as modeled by the ESRI area solar radiation tool

Methodology

- Pre-calculate monthly solar radiation
- Extract insolation information for each building into database
- Estimate usable roof area based on lidar
- Summarize per-pixel solar radiation information for user-drawn polygons
- Use insolation information as basis for solar energy potential and energy costs, adjusting for system size, type, tilt angle, system costs, financial incentives, and other factors.

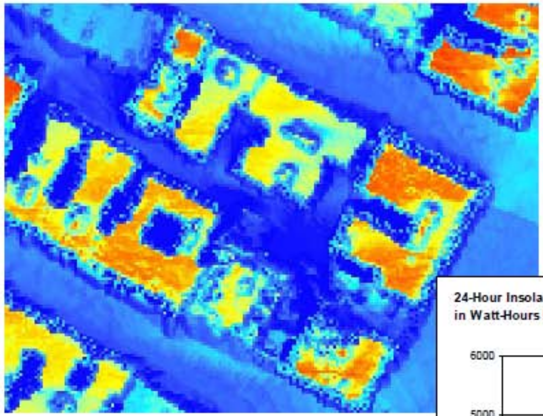
Insolation = incident solar radiation

Issues / Outline

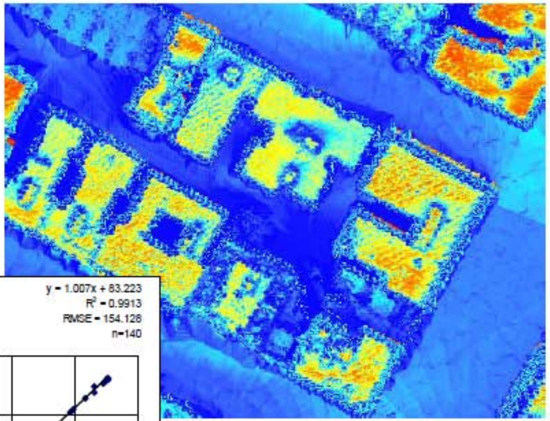
- **Performance:** Area solar radiation calculation is **slow**, and there are over 1000 1km^2 tiles
- **Tile boundaries:** Shadows may be cast across tile boundaries
- **Calibration and Validation:** Solar radiation ground truth for calibration and validation is scarce
- **Usable roof area:** estimate involves factors that cannot be easily discerned using an automated process; manual process is not possible on over 1 million buildings

Solar Radiation - Performance

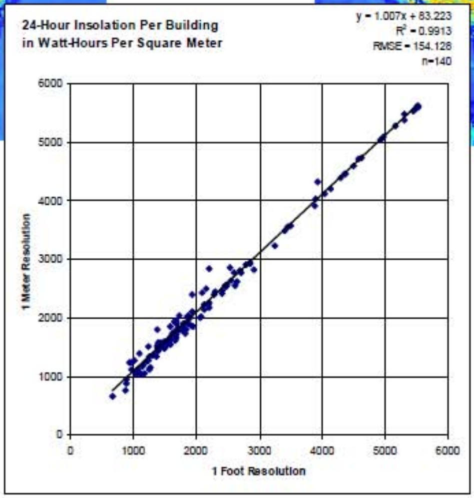
- Solar radiation calculated at 1 m resolution rather than 1 ft. Per-building results are similar but can be calculated more quickly.



1 meter



1 foot



Comparison

Solar Radiation - Performance

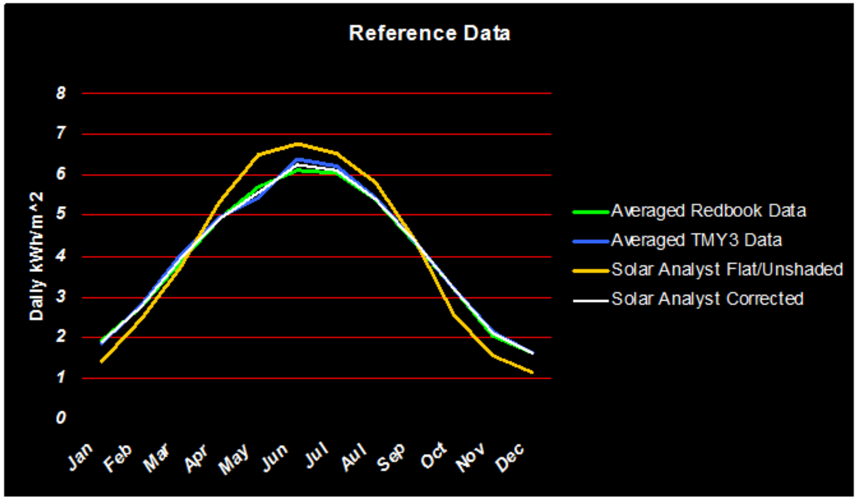
- Solar radiation tool run in parallel on a multi-core Linux machine (courtesy of CUNY High-Performance Computing Center), using ArcGIS server
- Time per tile slightly better than Windows PC, but parallel processing reduces time dramatically (~30 hours total versus estimated ~500 hours)
- Easy to run using python scripts – tiles partitioned into per-processor scripts, each script in its own session.
- For user-drawn polygons, efficiency boosted using pre-calculated solar radiation tiles – no real time geoprocessing.

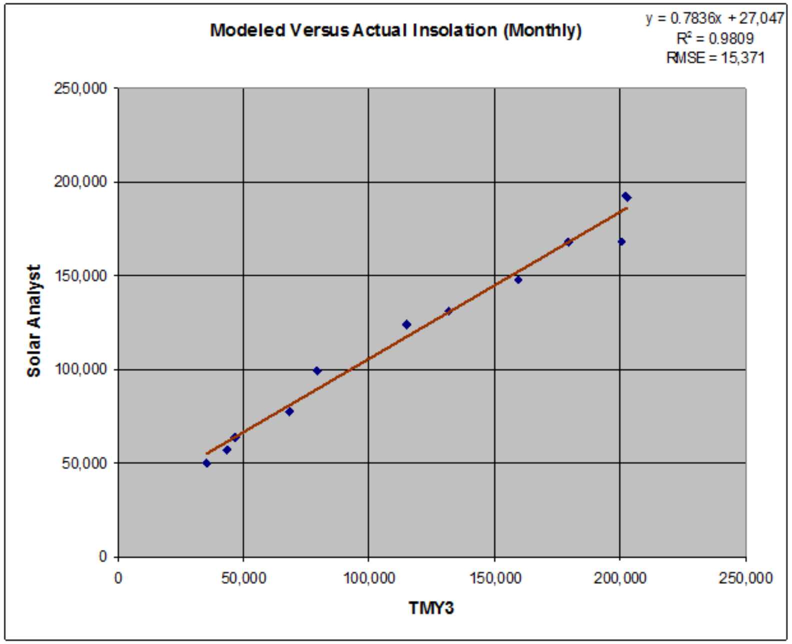
Solar Radiation - Tile Boundaries

- Mosaic 1 m tiles into boroughs, interpolating mosaic gaps
- Include borough perimeter in mosaics (tiles may be in more than one borough)
- When calculating area solar radiation, set the geoprocessing extent outside each tile boundary, with a larger extent to the south
- Calculate area solar radiation for each tile
- Clip tile back to original boundaries

Solar Radiation - Calibration

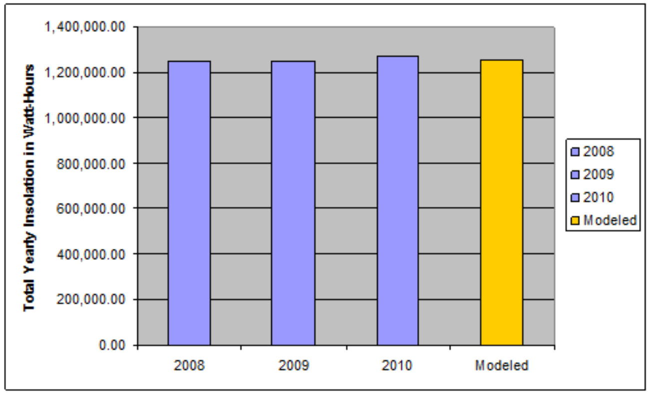
- Adjusted model parameters to match Typical Meteorological Year data for unshaded flat surfaces
- Next, calibrated flat surface results to match TMY3. Calibration applied to all output.
- Problem – little reference data for shaded or sloped areas.

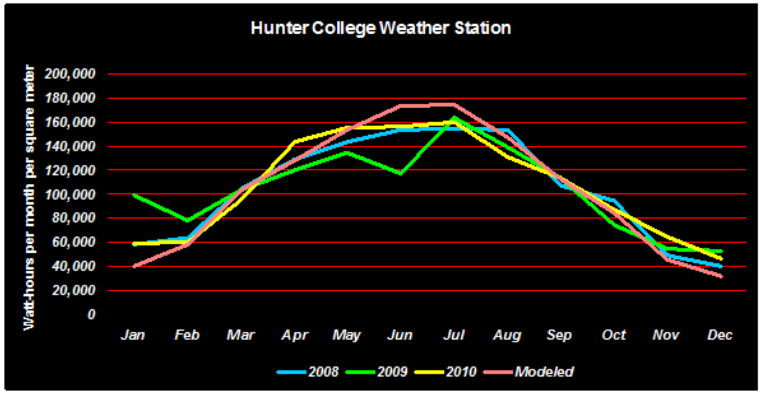




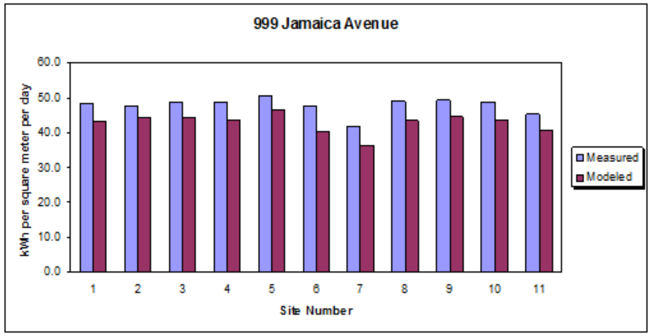
Solar Radiation - Calibration

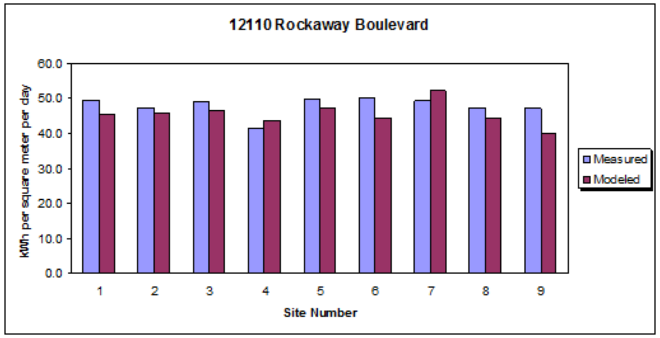
- Hunter College weather station





- Hemispheric rooftop radiation calculations (Solar Pathfinder)





Solar Radiation - Calculation

- Results show fairly good agreement, but we need more reference data to increase confidence in the estimates
- Solar panel data acquisition systems often include solar radiation measurements, as well as actual power generated
- Next phase of map will incorporate data from these systems
- This will allow map to be more thoroughly validated

Usable Roof Area

- Candidate areas for PV panels must meet requirements based on:
  - Slope
  - Obstructions
  - Minimum insolation
  - Fire department setback rules
  - Rooftop doors
  - Minimum contiguous usable area
- These factors are each difficult to discern even using high-resolution lidar

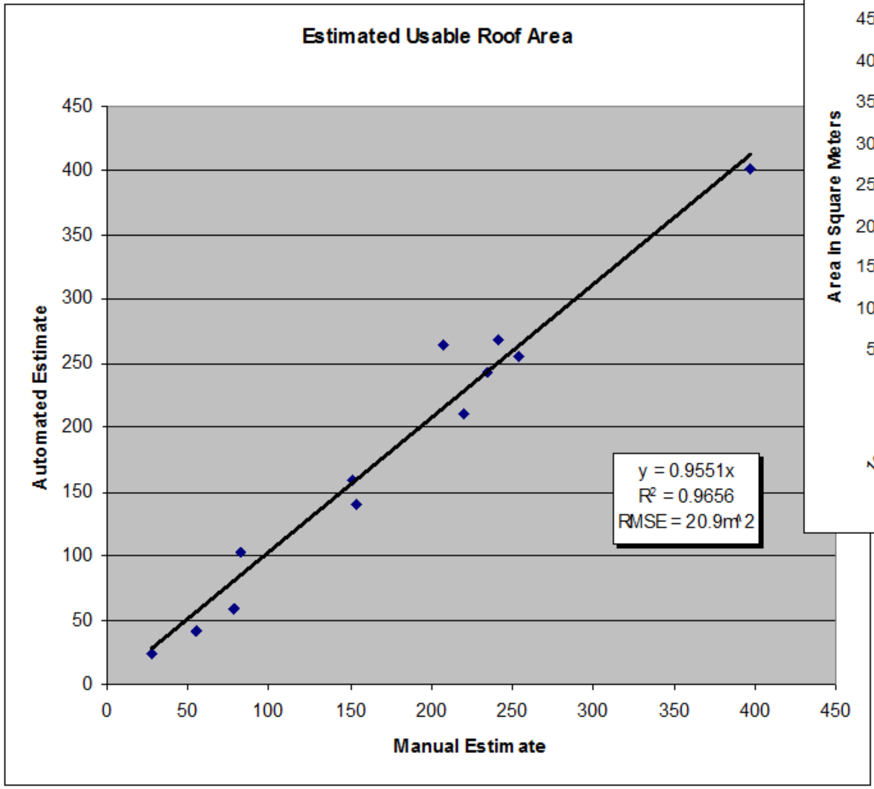
Usable Roof Area

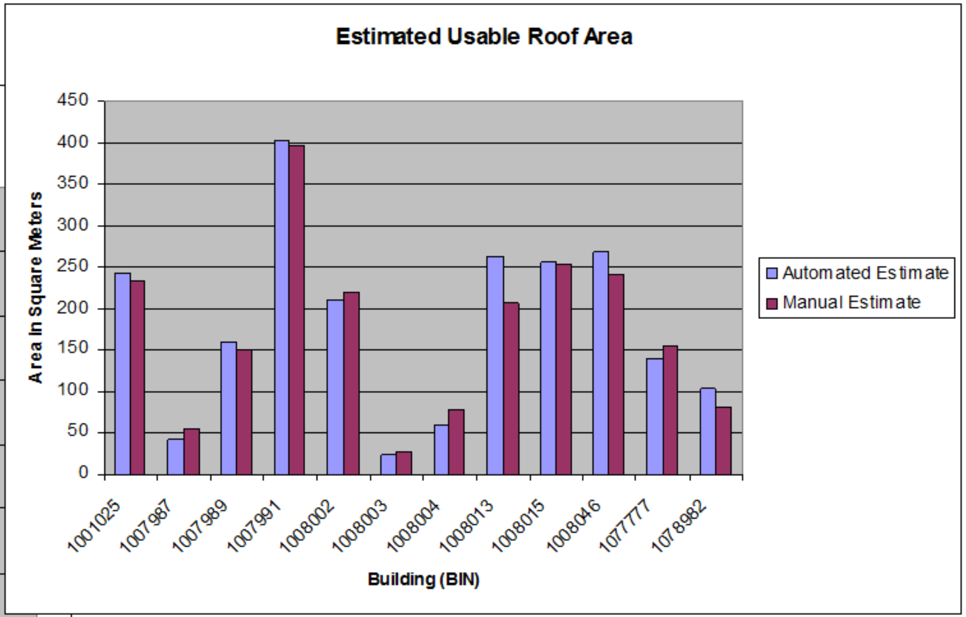
- Solution:
  - Manually calculate usable roof area for a sample set of buildings based on aerial photography
  - Use some of this data to train a usable roof area algorithm
  - Use the remainder to test the algorithm
- Factors most useful for the algorithm:
  - Building footprints, buffered to approximate setback requirements
  - Height, slope, and slope standard deviation thresholds (roughness)
  - Insolation threshold
  - Minimum contiguous area

Sample slope raster

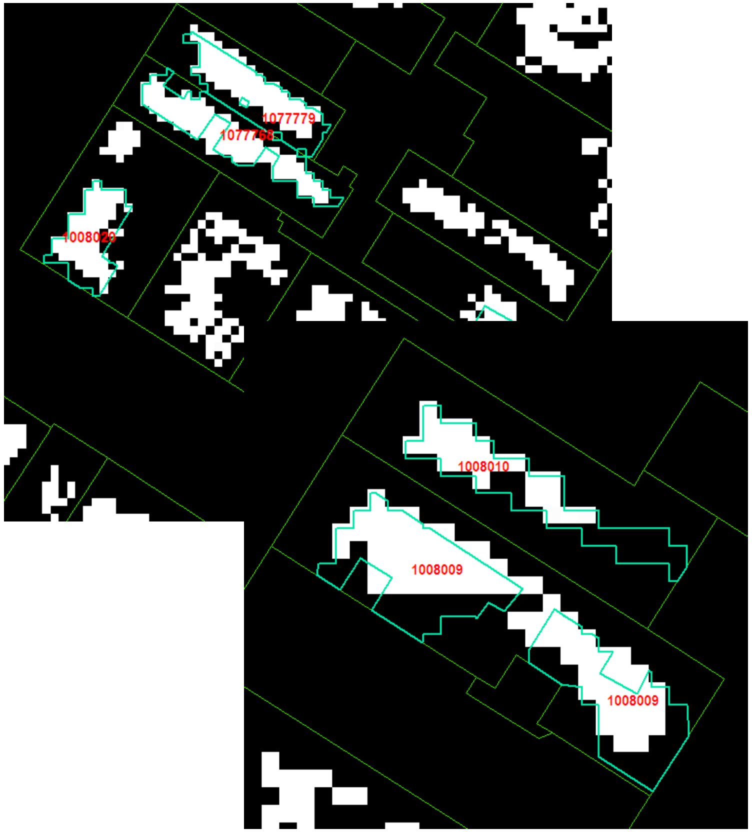
Usable Roof Area

- Results for testing set:

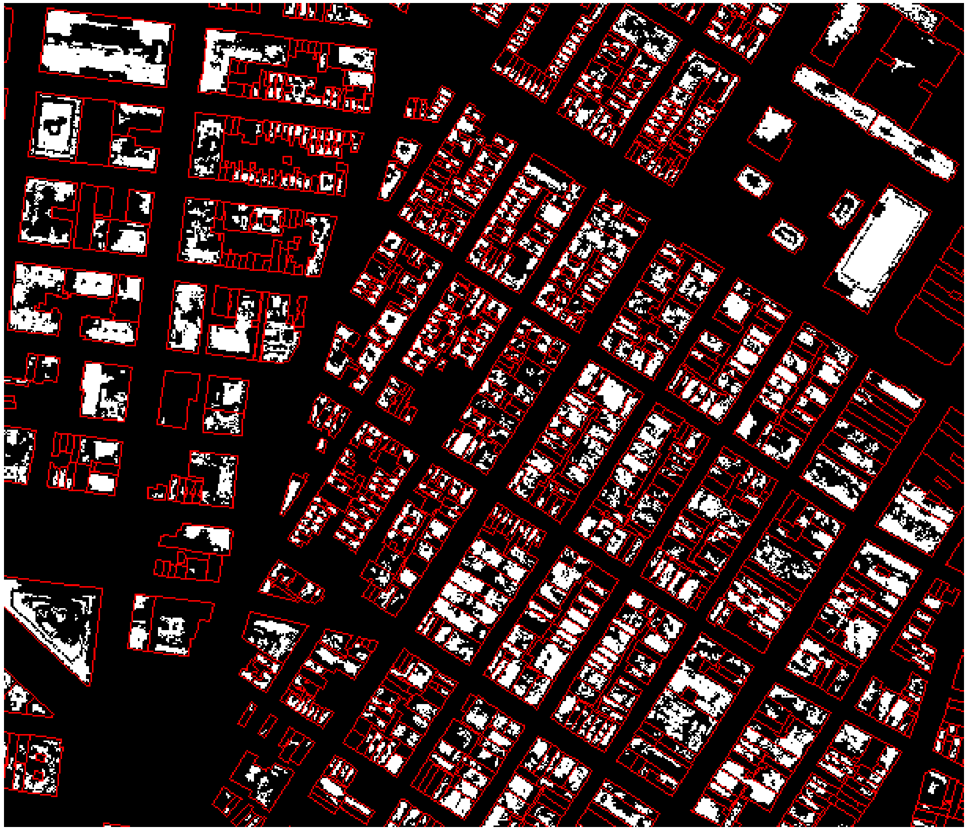




Usable Roof Area



Manual (blue) versus automated (white) estimates



Automated estimates

Calculator

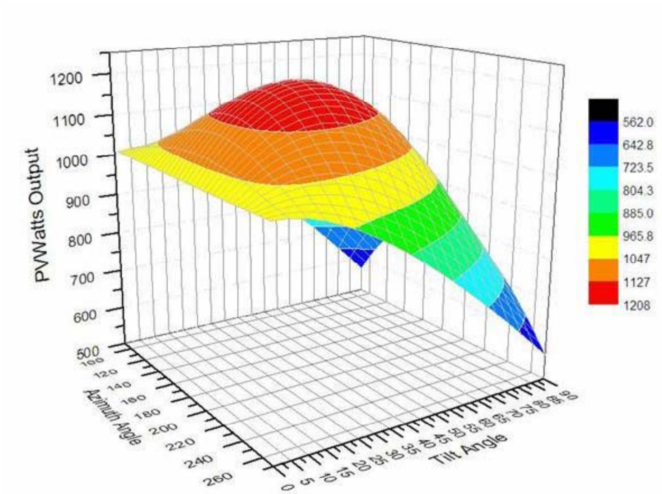
- Estimates used as input for calculator
- Shading derate factor - ratio of modeled solar radiation to TMY3 reference solar radiation for usable area
- Shading combined with PV Watts generation and usable area for (editable) estimated system size
- These drive financial calculations

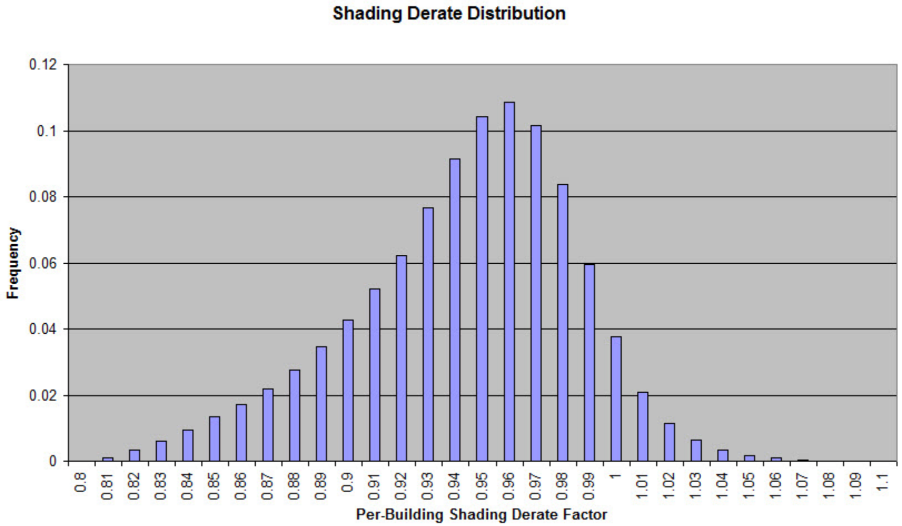
Other Adjustments

- Estimated baseline power generation factors from PV Watts (NREL) web service for different tilt and azimuth angles.
- Distribution of building shading factors reflecting minimum insolation threshold

Solar Panel Tilt and Azimuth Angle Adjustment

This plot shows the estimated yearly output for a 1kW system in NYC based on the tilt and azimuth angles of the panels, from the NREL PVWatts system. Solar potential is the product of the monthly estimated output from PVWatts, the usable area, and the shading derate factor, which is the ratio of modeled radiation (using lidar) to reference radiation for a flat unshaded surface.





NREL = National Renewable Energy Laboratory

Thank you for listening!

Calculator Output

Cost*	
System Size	35.65 kW-DC
Total System Cost, Before Incentives	$249,550
Cost After All Incentives	$25,735

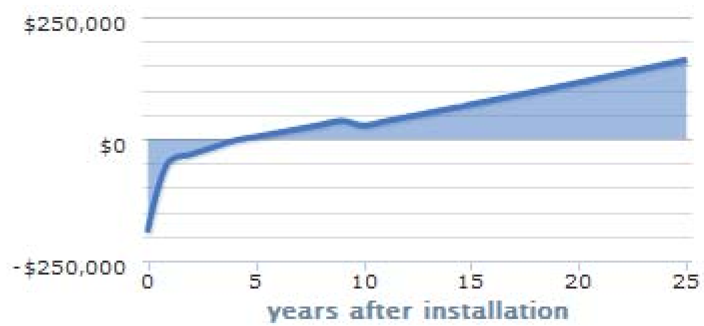
Financial Metrics	
Payback Period	5 yrs
Net Present Value	$16,329
Internal Rate of Return	13%
Levelized Cost of Electricity w/Incentives	0.16 $/kWh

Electricity Bill Savings	
Energy Production	40,567 kWh/yr
Savings	$8,519/yr

Environmental Impact	
CO2 Emissions Reductions	27,931 lbs/yr
Trees Planted Equivalent	75 trees

*Note: A solar lease or power purchase agreement can reduce your upfront cost to zero! Ask your installer for details.

Cumulative Net Cash Flow



Incentives	
NYSERDA/LIPA Incentives	$62,388
Federal Tax Credit / Treasury Grant	$74,865
NY State Tax Credit	$0
Federal Income Taxes Due on Incentives	$34,937
NYC Property Tax Abatement	$37,433
100% Year One Bonus Depreciation	$74,241

Steps for Installing Solar in NYC

GO TO MAP

Calculation results