Solar Maps for Sustainable Cities

IFC/ESMAP Renewable Energy Training Program: Photovoltaics - April 2012

Danielle Murray
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San Francisco Department of Environment

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SF Environment Programs:

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Energy Efficiency & Renewables

Recycling & Composting

Toxics Reduction

Transportation & Clean Air

Environmental Justice

Outreach and School Education

Urban Forestry

Green Building

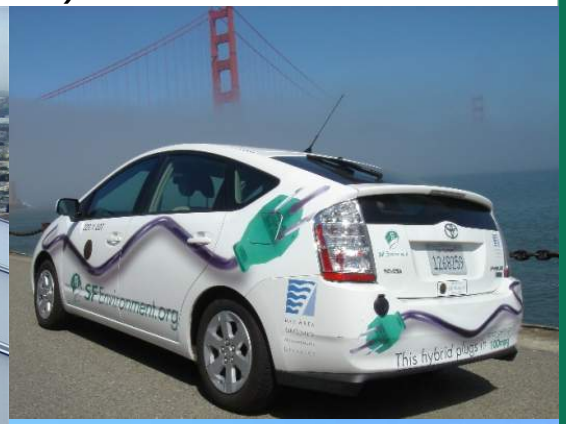
Renewable San Francisco

Goal: 100% Renewable Electricity Supply in 10 years

Current: 41% renewable

Local Renewable Generation: 1%

(22 MW from 2,900 PV installs and
biogas from wastewater treatment plants)

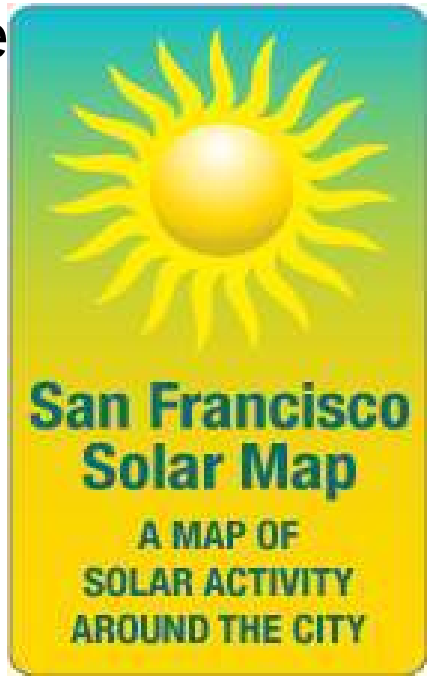


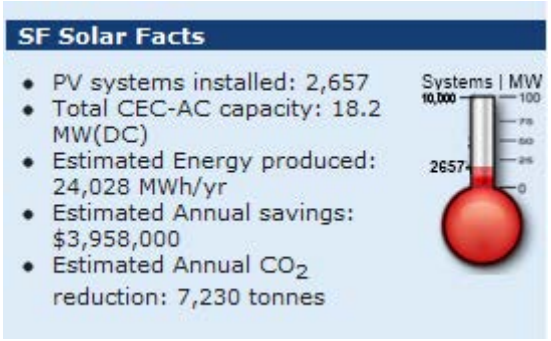
Solar Energy

- Awareness building / marketing
- Technical assistance
- Streamlined Permitting
- Targeted outreach - Large commercial rooftops & schools
- Finance facilitation
- Aggregating small & medium-sized solar customers
- Solar for multi-tenant buildings

SF Solar Map Goals

- Promote more widespread use of renewable energy, develop local solar market
- Provide easy-to-use tool for home and business owners to estimate how much power could be generated on their rooftop, provide cost estimates, and explain how to purchase/install
- Show the public that renewable energy projects are feasible in their community and demonstrate the success of renewable energy technology marketing efforts
- Track progress toward City's energy & climate goals

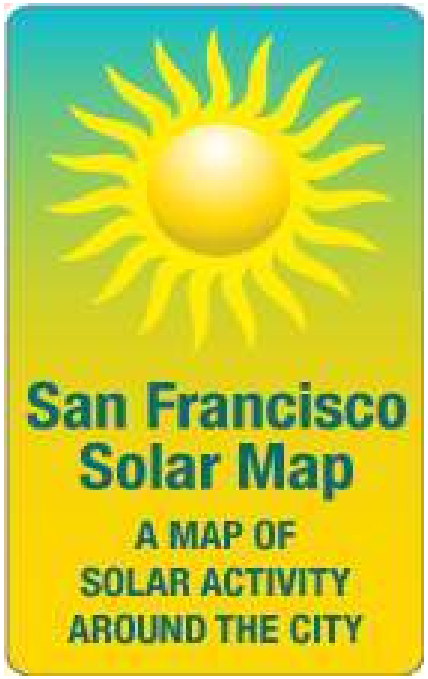




SF Solar Map

Shows users:

- All PV and SWH installs in city, with case studies
- Estimated rooftop PV potential (KW and KWh)
- Estimated electric bill savings
- Estimated CO2 reduction
- Rebates & tax credit info
- Cost estimator / financial analysis
- Link to local solar installers



- **Developed 2006-2007**
- **First US City to Create Solar Map**
- **Won 2008 IREC Innovation Award**
- **Other city solar maps modeled on SF's**
  - Berkeley, Los Angeles, San Diego, Sacramento, Portland

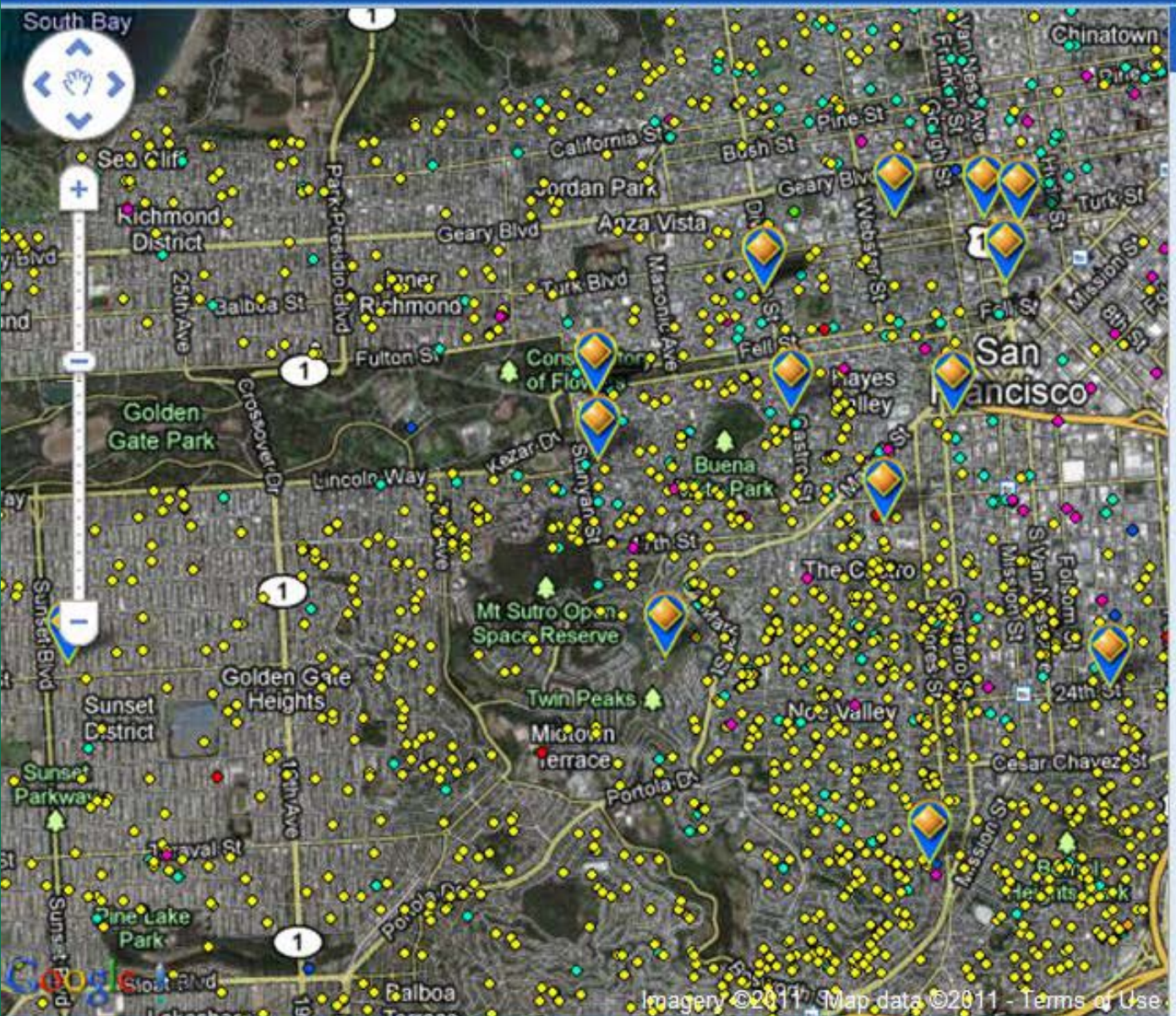
sf.solarmap.org

San Francisco Solar Map

A MAP OF SOLAR ACTIVITY AROUND THE CITY

SF Environment

Reset Map | Back | Map | Satellite | Hybri



Welcome | Legend

Markers

Solar Installations

- Municipal
- Residential
- Commercial
- Schools/libraries
- Non-profits
- Monitoring station
- Environmental Justice Program
- Case Study
- Solar Hot Water

Don't see your solar installation on t map?

What Can Solar Do For You?

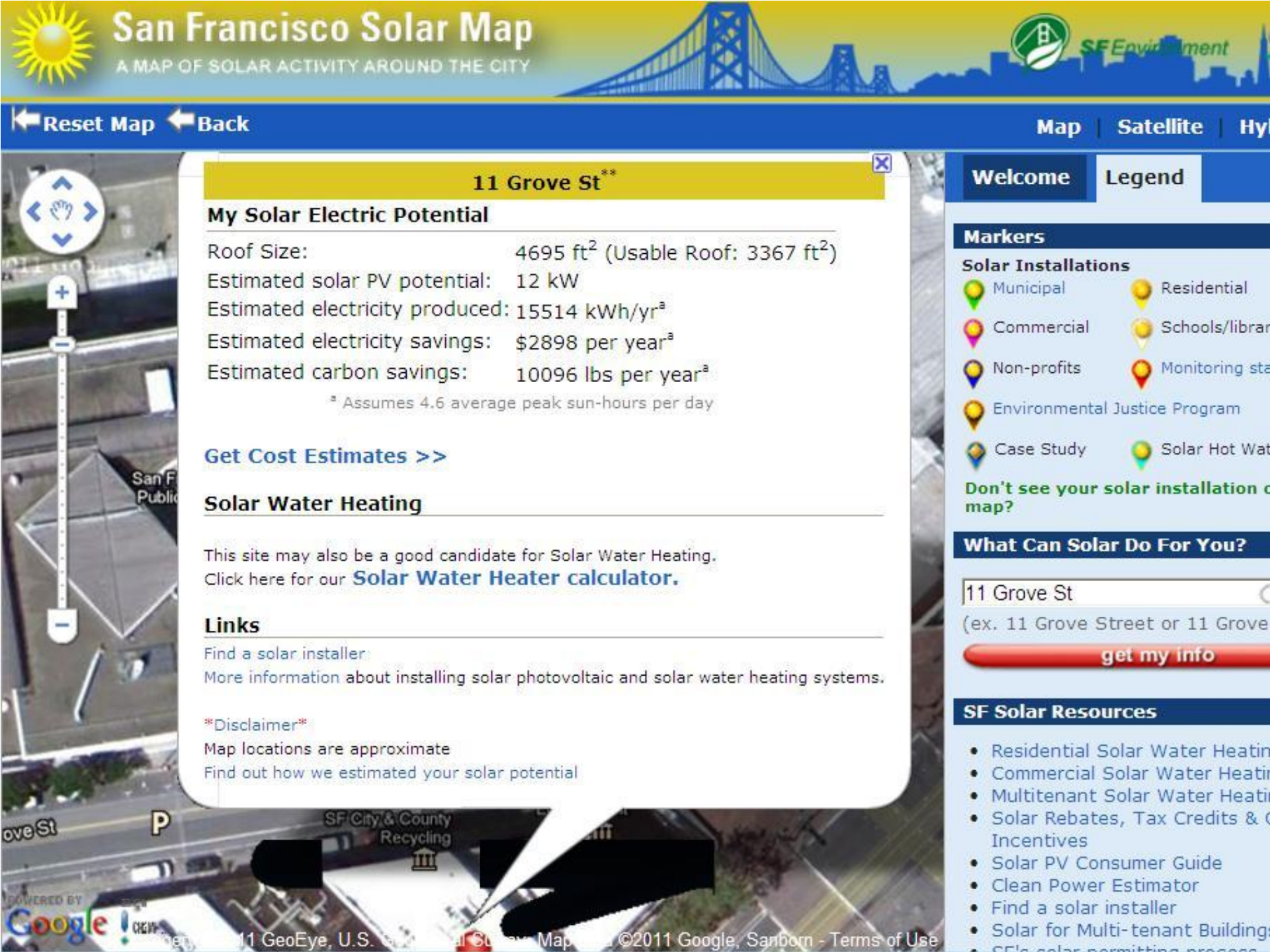
Enter your address

(ex. 11 Grove Street or 11 Grove St

get my info

SF Solar Resources

- Residential Solar Water Heating
- Commercial Solar Water Heating
- Multitenant Solar Water Heating
- Solar Rebates, Tax Credits & Oth Incentives
- Solar PV Consumer Guide
- Clean Power Estimator
- Find a solar installer
- Solar for Multi-tenant Buildings
- SF's solar permitting process
- Free Solar Classes


San Francisco Solar Map
A MAP OF SOLAR ACTIVITY AROUND THE CITY
SF Environment
Reset Map
Back
Map | Satellite | Hy
11 Grove St**
My Solar Electric Potential
Roof Size: 4695 ft² (Usable Roof: 3367 ft²)
Estimated solar PV potential: 12 kW
Estimated electricity produced: 15514 kWh/yr[a]
Estimated electricity savings: $2898 per year[a]
Estimated carbon savings: 10096 lbs per year[a]
[a] Assumes 4.6 average peak sun-hours per day
Get Cost Estimates >>
Solar Water Heating
This site may also be a good candidate for Solar Water Heating.
Click here for our Solar Water Heater calculator.
Links
Find a solar installer
More information about installing solar photovoltaic and solar water heating systems.
Disclaimer
Map locations are approximate
Find out how we estimated your solar potential
Welcome
Legend
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Municipal
Residential
Commercial
Schools/libra
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SF City & County Recycling
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Quick Solar Cost Estimate

- Contact solar installers for a more detailed estimate of costs and savings.

How much would solar cost for my building?

PV System Information

System Size:	3.0 kW
Property Type:	Residential
System Cost:	$7,000 per kW-dc
System Tilt:	30°
System Orientation:	South

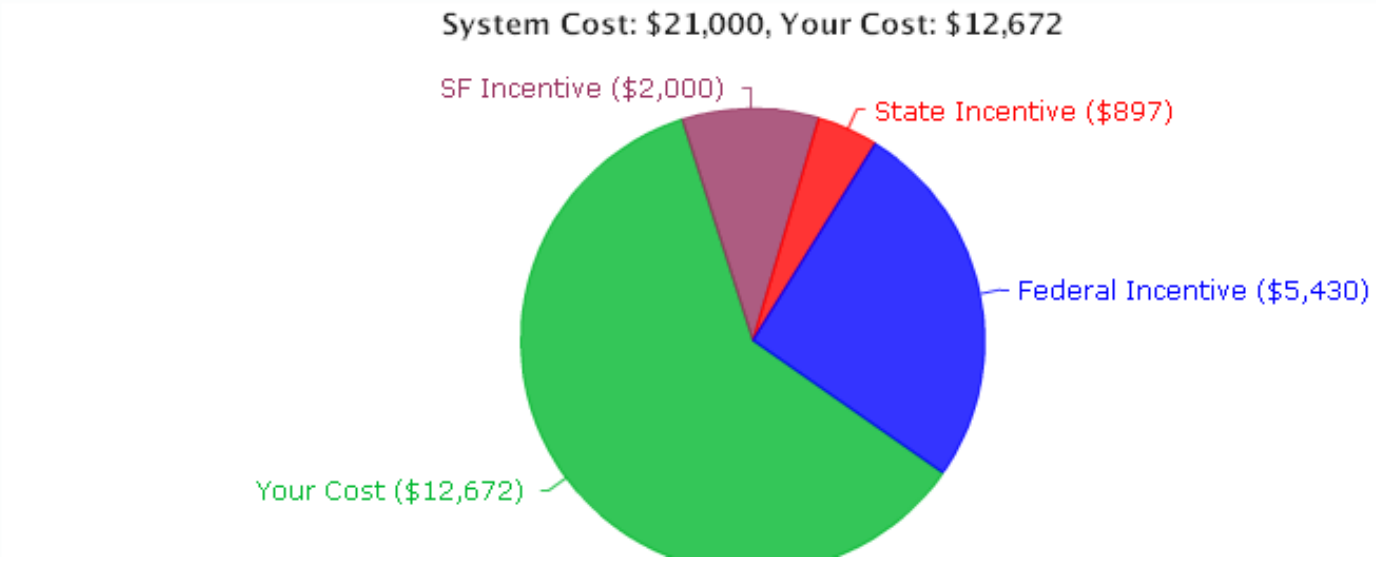
PV Finanical Information

Electric Bill:	$200 per month
Escalation Rate:	5.0% per year
Payment:	Pay Cash

Recalculate

Summary | Utility Bill | Electricity Budget | Output | Cash Flow | Pollution

Financial Summary



SF Solar Map
Creation and Development

City Inputs

- Assessor-Recorder property database
- Insolation data from SFPUC solar monitoring stations
- Zoning and setbacks guidance
- Verification through manual rooftop measurements
- Solar installation data (address, size, installer) from incentive program, installers/owners, & permitting database
- Case studies, educational materials

Clean Power Estimator

- Web service feeds the PV calculator
- Provides up to date utility rates & analysis

Consultant Inputs

- CH2M Hill's proprietary SAFE Technology (Solar Automated Feature Extraction)
- Utilizes Google Maps base, combined with aerial flyover imagery, GIS technology

Costs and Impact

Cost to SF:

$150,000 Map Development

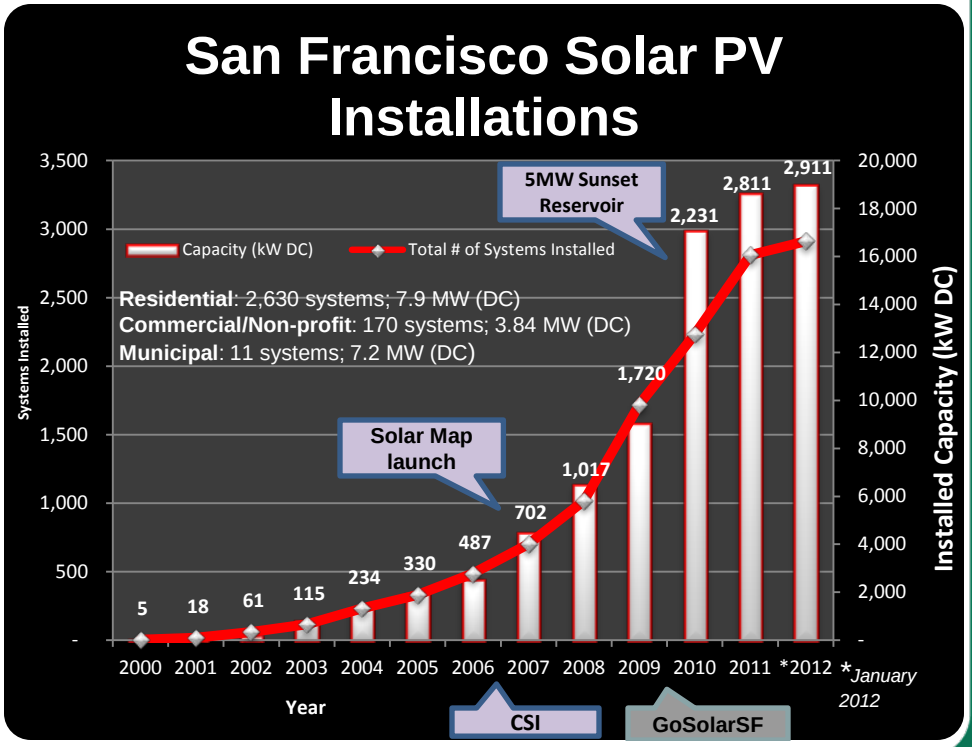
+$8,000/yr Hosting & Maintenance

- Funded through USDOE "Solar America Cities" Grant
- Included pro-bono work by CH2M on software development; SF map used to promote tool to other clients
- City staff time not included

SAFE-based map cost estimates

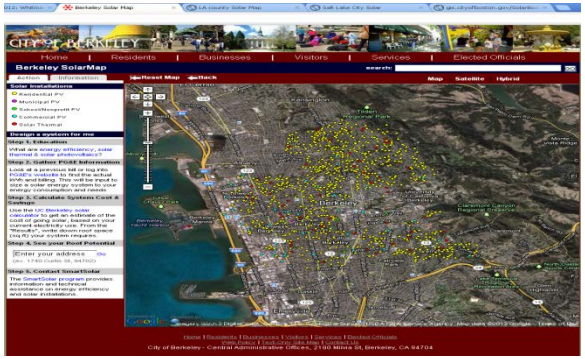
- $4,000-5,000/square mile
- $20,000-$200,000 total / city, depending on size & resolution

- **~50 visitors/day** (58,143 unique visitors and >80,000 page views March 2008 - August 2011)
- **4-fold increase in PV installs**



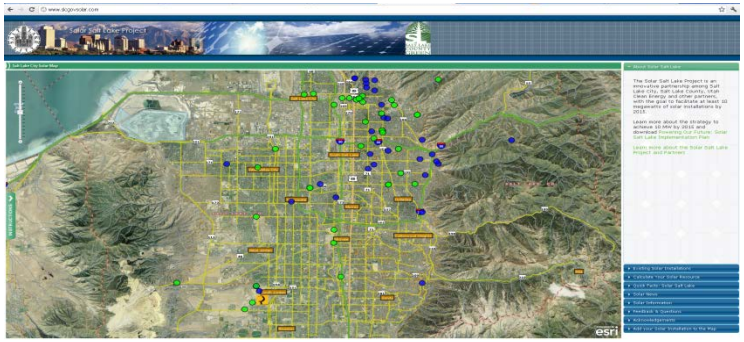
Solar Maps in “Solar America Cities”

- **Berkeley, CA**
  - Created by CH2M
  - Utilized SAFE Technology



http://berkeley.solarmap.org/solarmap_v4.html

- **Salt Lake City, UT**
  - Developed by CH2M &Critigen
  - SAFE & LiDAR combination



http://www.slcgovsolar.com/

- **Los Angeles County, CA**
  - Created by CH2M in 2009
  - Shows color gradient for solar intensity

http://solarmap.lacounty.gov/

- **Boston, MA**
  - GIS tool created by Boston Redevelopment Authority and Boston Office of Innovation

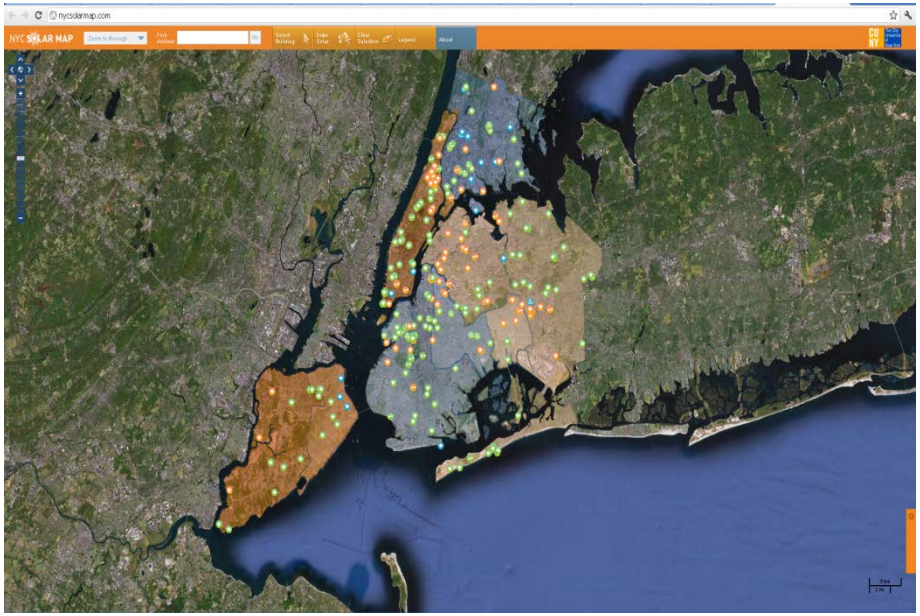
http://gis.cityofboston.gov/SolarBoston/#

New York City Solar Map

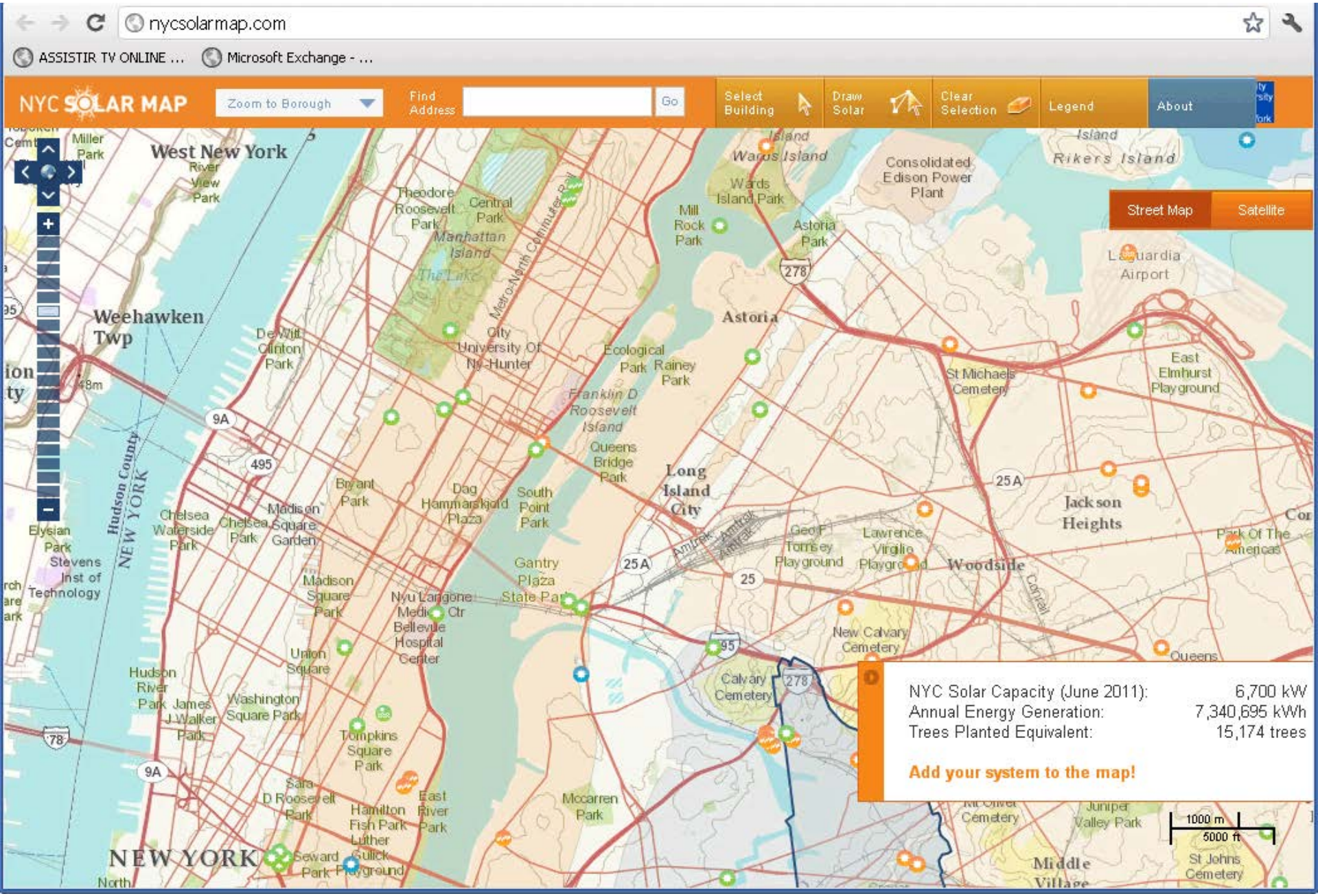
- Developed 2010-11 by City of New York and City University New York (CUNY) Center for Advanced Research of Spatial Information
- Technical support from National Renewable Energy Lab
- Collaboration with ConEdison (local electrical utility)
  - Identified “Solar Empowerment Zones” where PV is most beneficial
- Uses Light Detection and Ranging (LIDAR) technology
  - Also used to for enviro, emergency management & climate adaptation plans (e.g. identified priority tree-planting areas)

Costs

$450,000 for LiDAR flights (paid by City)
+$205,000 Solar map development (from DOE Solar America Cities grant)



New York’s 5-borough Solar Map: http://nycsolarmap.com


nycsolarmap.com
ASSISTIR TV ONLINE ...
Microsoft Exchange - ...
NYC SOLAR MAP
Zoom to Borough
Find Address
Go
Select Building
Draw Solar
Clear Selection
Legend
About
Street Map
Satellite
NYC Solar Capacity (June 2011): 6,700 kW
Annual Energy Generation: 7,340,695 kWh
Trees Planted Equivalent: 15,174 trees
Add your system to the map!
West New York
Weehawken Twp
Astoria
Long Island City
Jackson Heights
Woodside
NEW YORK
Hudson County
Manhattan Island
Roosevelt Island
Wards Island
Rikers Island
LaGuardia Airport
Consolidated Edison Power Plant
Astoria Park
Mill Rock Park
Theodore Roosevelt Park
Central Park
DeWitt Clinton Park
City University Of Ny-Hunter
Ecological Park
Rainey Park
Franklin D Roosevelt Island
Queens Bridge Park
Dag Hammarskjold Plaza
South Point Park
Bryant Park
Madison Square Garden
Chelsea Waterside Park
Chelsea Park
Elysian Park
Stevens Inst of Technology
Madison Square Park
Nyu Langone Medl Ctr Bellevue Hospital Center
Gantry Plaza State Park
Union Square
Hudson River Park
James J Walker Park
Washington Square Park
Tompkins Square Park
Sara D Roosevelt Park
Hamilton Fish Park
East River Park
Luther Gulick
Seward Park
Playground
Mccarren Park
St Michaels Cemetery
East Elmhurst Playground
Geo F Tomney Playground
Lawrence Virgilio Playground
Park Of The Americas
New Calvary Cemetery
Calvary Cemetery
Queens
Juniper Valley Park
St Johns Cemetery
Middle Village
Miller Park
River View Park
Amtrak
Conrail
1000 m
5000 ft

NYC Solar Map Technical Details

- Considers rooftop shape, obstructions, solar resource & NYC Fire Code
  - Shading from digital surface model derived from **LIDAR data** (captures the surface elevation of the ground, buildings and trees)
  - Usable roof area estimates based on slope, roughness, modeled incident solar radiation, and building height and shape.
  - Azimuth and tilt angle effects estimated using **NREL's PVWatts** solar model
- Web app built using **OpenLayers**, **PostGIS**, and **jQuery**.
- Map display uses **ESRI World Topographic Map** and **Bing aerial imagery**; **building and tax lot data** from the New York City Department of Information Technology and Telecommunications; address locator (**geocoding**) services from **Google**
- Model output calibrated & validated using available ground measurements (incl **Typical Meteorological Year data from NREL**, Hunter College **weather station data**, and other available ground measurements)

Mapping Technology Options

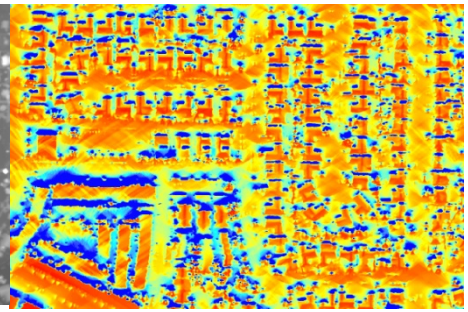
LIDAR

- Laser-based mapping from flyovers
- Normally only 1 meter resolution - can miss details (like HVAC systems) but very accurate topographic and shading data (tree, hill, building heights)
- Can be processed as one continuous dataset; results show seamless output
- Harder to integrate with other data types
- Main cost is aerial photography (est. ~$500/sq mi); little additional modeling needed

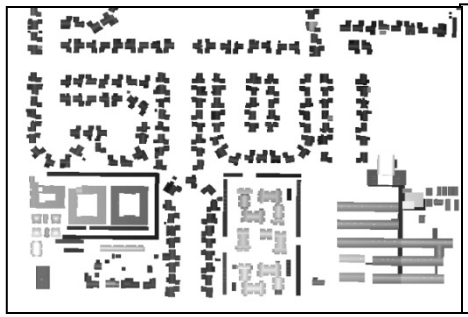
S.A.F.E.

- Photogrammetric 3D modeling method
- Very detailed 6 inch resolution
- Only captures modeled buildings; lower topographic accuracy, no tree shading
- Analysis done in blocks, may miss some shading from tall structures in adjacent analysis block
- Various forms of output data types (shape, KML, DXF, raster, etc) makes it easier to integrate
- Can be more expensive due to substantial modeling (est ~$4,000/sq mi)

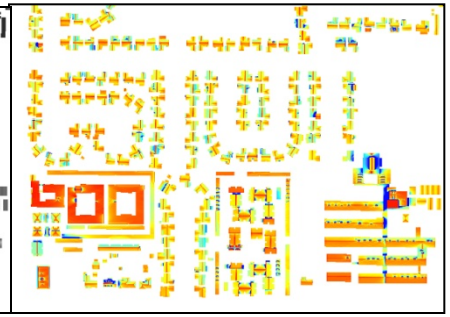
RAW LIDAR DATA



SOLAR ANALYSIS FROM LIDAR



RAW BUILDING HEIGHTS FROM SAFE



SOLAR ANALYSIS FROM SAFE

(SOURCE; CRITIGEN)

Considerations

Goals

- Education/outreach, market development, tracking installs & carbon reductions, identifying solar opportunities and resource potential, grid planning, other?

Audience

- Residents/businesses, Solar Installers, City staff, Funders?
- Are they online? Who is purchasing solar?

Costs & Resources

- What's your budget? What staff/expertise is available?
- What maps, images, datasets are already available?

Partners

- Utility/grid operator; GIS / data / IT departments or orgs; universities & research centers; solar companies; energy / enviro / housing / construction / urban planning agencies

Considerations

Privacy & Security Issues

- High-res maps, solar install locations, grid details → concern from gov’ts, system owners, utilities

Integrated Planning Opportunities

- Opportunity to support urban planning (zoning, shading analysis for new development), grid planning, analysis of existing building stock, building energy benchmarking, mapping & analysis of other renewable energy resources
- Desired co-benefits may determine type & level of analysis

Monitoring & Evaluation opportunities

- Track progress toward GHG and energy goals (tons GHG avoided, MW installed solar capacity and MWh solar generation); supports reporting for project funders

Municipal Solar Map Websites

Berkeley, California -Berkeley Solar Map: http://berkeley.solarmap.org

Boston, Massachusetts - Solar Boston: http://gis.cityofboston.gov/solarboston

Denver, Colorado: www.solarmap.drcog.org

Los Angeles, California - LA County Solar Map: http://lacounty.solarmap.org

Houston, Texas - Solar Houston Map: www.solarhoustontx.org/Experience/InteractiveMap/tabid/1164/Default.aspx

Milwaukee, Wisconsin - Milwaukee Shines: www.city.milwaukee.gov/milwaukeeshines/Map.htm

New Orleans, Louisiana: www.neworleanssolarmap.org

New York City - NYC Solar Map: http://nycsolarmap.com

Orlando, Florida: www.gis.ouc.com/solarmap

Portland, Oregon - Oregon Clean Energy Map: http://oregon.cleanenergymap.com

Sacramento, California - Solar Sacramento: http://smud.solarmap.org/map.html

San Diego, California - San Diego Solar Map: http://sd.solarmap.org/solar

San Francisco, California - SF Solar Map: http://sf.solarmap.org

Salt Lake City, Utah: www.slcgovsolar.com

Resources

Case Studies

Jesse Dean et al, Analysis of Web-Based Solar Photovoltaic Mapping Tools, NREL, June 2009. www4.eere.energy.gov/solar/sunshot/resource_center/sites/default/files/analysis_of_web_based_solar_pv_mapping_tools.pdf

Michael Hyams, “Mayor's Training Program Case Study 1. San Francisco Solar Map,” Columbia University, 2009. http://energy.sipa.columbia.edu/researchprograms/urbanenergy/documents/SF%20solar%20map%20FINAL.pdf

Lyle Leitelt and Todd BenDor, “Developing a Solar Energy Potential Map,” APA Planning Advisory Services Memo, Nov/Dec 2010. www.planning.org/audioconference/solar/pdf/0110PASMemo.pdf

Mapping Resources

ESRI ArcGIS Resource Centers, Sample solar radiation analysis and widget, 2009.

http://resources.esri.com/arcgisserver/apis/flex/index.cfm?fa=codeGalleryDetails&scriptId=16110

USGS LiDAR Information: http://lidar.cr.usgs.gov

NREL Solar Radiation & Data Manual: http://rredc.nrel.gov/solar/pubs/redbook/PDFs

Thank you!

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www.sf.solarmap.org

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SOLAR AMERICA CITY
Committed to a Sustainable Solar Future
A Partnership Program with the U.S. Department of Energy

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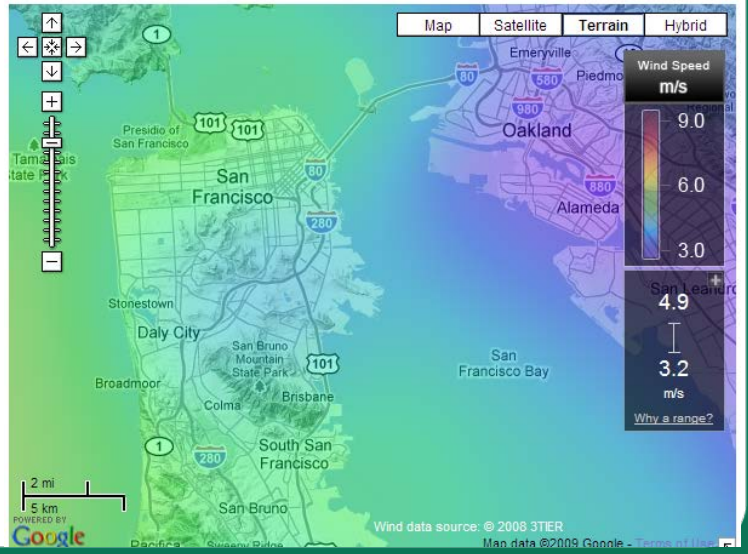
Extra Slides

SF Wind Map

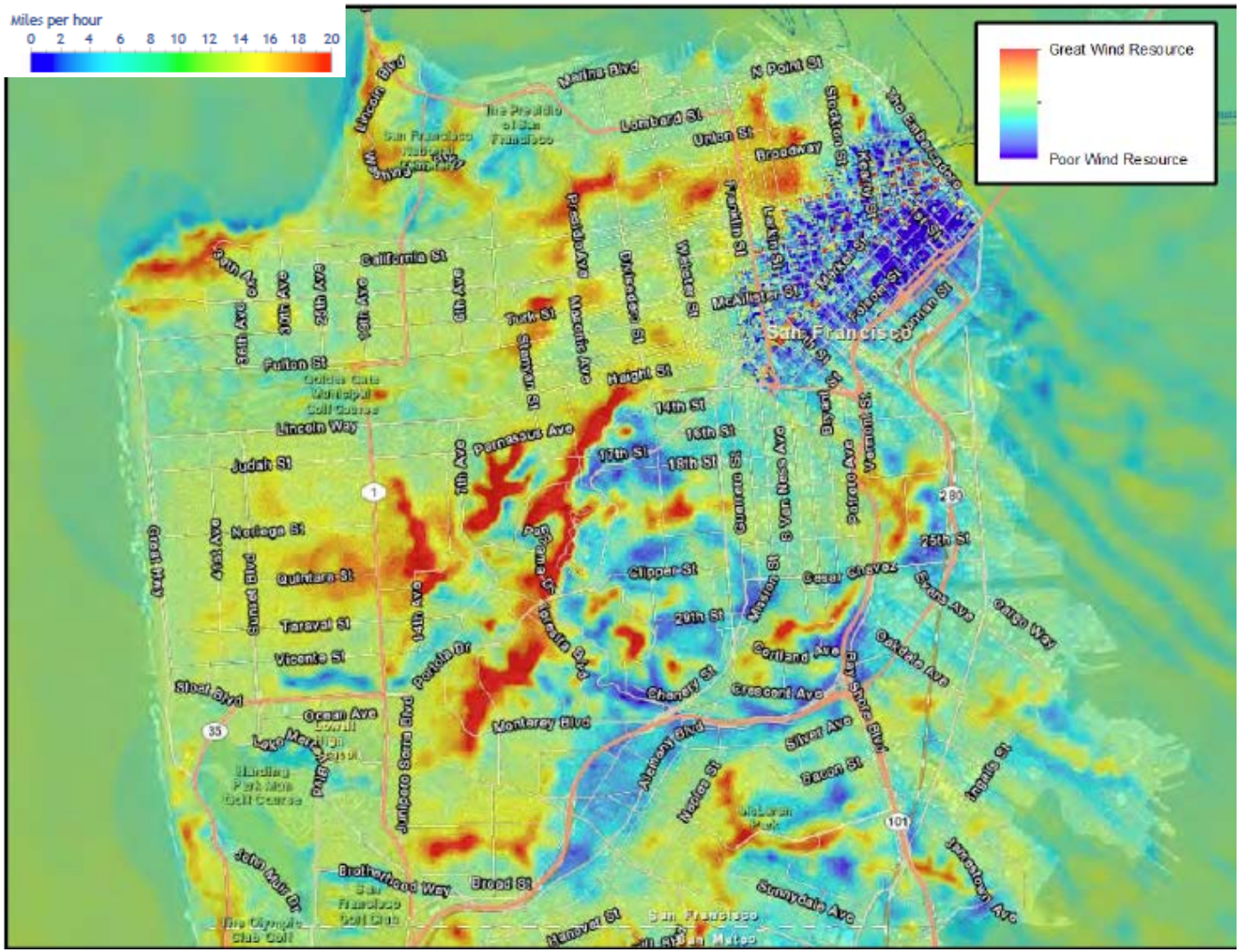
OBJECTIVES

- Develop accurate urban wind resource model for San Francisco
- Collect high-quality, neighborhood-specific data for wind map
- Identify locations in city with high wind power potential
- Help San Francisco property owners decide if a small wind generator (SWG) may be appropriate for their site
- Reduce cost and confusion related to wind resource analysis for property owners
- Improve public understanding and perception of wind energy
- Provide a model for other cities interested in better understanding their urban wind resource, and the technical potential for local wind-based electricity generation



3Tier – FirstLook 20m hub height

SF Wind Map



CH2MHILL

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Building Energy Efficiency

Current Programs

- Net Zero Homes, SF Home Improvement & Performance Program
- Residential Green Building Resolution
  - endorses Cal Model Green Home Building Guidelines
- Commercial Green Building Ordinance
  - LEED Gold priority permitting → requirement in 2012
- SF Energy Watch
  - Small commercial energy retrofit incentive program

- Multi-family Residential Boiler Replacement Program
- Solar America Cities: SWH outreach
- Existing Commercial Building Ordinance
  - Requires annual building benchmarking and energy audits every 5 years

Electric Vehicles

Current Programs

- Bay Area EV Corridor Project, “EV Capital of America”
- Public Charging Stations
- Streamlined Home Charger Permit/Installation Process
- Home Charger Incentive Program (BAAQMD EV infrastructure grant program)

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Municipal Solar Installations

- 9 projects completed, totaling 7 MW, including:
  - Sunset Reservoir: 5 MW
  - Moscone Convention Center: 675 kW
  - San Francisco International Airport: 500 kW
- Under development: City Hall (100 kW) and Davies Symphony Hall (200 kW)

Moscone Center – 675 kW (2004)

Sunset Reservoir – 5MW (2010)

GoSolarSF City Rebate Program

- Local incentive for PV installs (residential, commercial, and non-profit)
  - Began in 2008
  - $5 million annual funding
  - Additional incentives for Environmental Justice neighborhoods, low-income applicants, and local installers
  - Now only available through installers who participate in the City's Workforce Development Program

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GoSolarSF (www.solarsf.org)

2010/11 Incentive Levels:

- Residential incentive: $2,000 base
  - Additional $1,000 for environmental justice installs, CARE customers
  - Additional $7,000 for low-income
  - Additional $750 for SF-based installer
- Commercial: $1,500/W (up to $10,000)
- Non-profit:
  - $1,500/kW (up to $120,000)
  - $3,500/kW for affordable housing non-profit (up to $60,000)

Results to date (August 2011):

- 5.7 MW solar power installed or in progress (~1,800 systems)
- $12.2m in incentives paid out
- >60 new green-collar jobs through Workforce Development

Solar Financing

- Creating financing opportunities, reducing project risk, leveraging municipal credit ratings

Solar America Cities Project

Innovative Financing Options:

- GreenFinanceSF
- CleanPowerSF
- Standardized PPAs and aggregation
- Solar@Work aggregated commercial lease program
- Green Retrofit Initiative for multi-tenant, low-income housing

GreenFinanceSF

Saving You Money, Energy and Water

- Property Assessed Clean Finance (PACE) model
- Uses Mello-Roos special tax districts for on-tax bill financing
- Residential program on hold due to FHFA objections
- Commercial PACE program moving forward as a pilot project in SF.

City or county creates type of land-secured financing district or similar legal mechanism

Property owners voluntarily sign-up for financing and install energy projects

Proceeds from PACE bond or other financing provided to property owner to pay for energy project

Property owner repays bond through property tax bill (up to 20 years)

SF Solar Map

Creation and Development

Consultant Inputs

- CH2M Hill's proprietary SAFE Technology (Solar Automated Feature Extraction)
- Utilizes Google Maps base, combined with aerial flyover imagery, GIS technology

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